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Programs, Policies & Courses

This online academic catalog provides the latest information on all graduate areas of study and degree programs at the University of Massachusetts Lowell and supersedes all previous versions of the catalog.

Bachelor’s to Master’s Programs

Earn Two Degrees in as Little as Five Years

- Eligibility
- Course Credits
- How to Apply

In order to encourage outstanding UMass Lowell undergraduate degree students to continue their studies towards an advanced degree, qualified students may apply for the Bachelors to Masters Degree Option (Bachelor’s to Master’s programs include the Fast Track to Teaching and Plus 1 programs.)

This option carries distinct benefits. Graduate Record Examination (GRE) scores are not required (except in the Graduate School of Education), GMAT is waived for applicants for the Masters in Business Administration (MBA) with a 3.2 or higher GPA and the application fee is waived. In addition, many departments offer course credit benefits. (For detailed information regarding specific course credit benefits, please see the Graduate Coordinator in the respective masters degree granting department.)

- Information on the GRE / GMAT / MAT Waivers (https://www.uml.edu/Grad/gre-mat-waivers.aspx)

Eligibility

Any UMass Lowell undergraduate junior or senior with a grade point average of 3.0 or better may apply to a Masters degree program at UMass Lowell under the Accelerated Bachelors to Masters Degree Option. However, to be accepted into this option the following minimum conditions must be met (individual departments may have more stringent requirements):

1. The student must have a cumulative grade point average of 3.0 or above at the time the baccalaureate degree is conferred in order to maintain eligibility for this option.
2. The student must apply for and receive his/her baccalaureate degree before matriculating into the graduate program.

3. Once accepted a student is expected to begin his/her graduate studies in the semester immediately following conferral of the baccalaureate degree unless the student submits a written request for deferral. A student is allowed to defer for a maximum of one year from the date of acceptance. For example, if accepted for the Spring 2015 semester, an individual can defer to either the Fall 2015 or Spring 2016 semesters. A student defers acceptance by submitting a written request to the Office of Graduate Admissions (mailto:Graduate_Admissions@uml.edu). All deferral requests must specify which semester the student wishes to enroll. Any applicant accepted to the Bachelors to Masters Degree Option who opts not to enroll in at least one course within the graduate department to which they have been accepted in the semester immediately following conferral of the bachelors degree and who does not submit a deferral request forfeits his/her rights to benefits under this program. Should the student decide to begin his/her studies at a later time he/she will be required to take the GRE, pay an application fee, and have his/her application reassessed.

Course Credits

The graduate degree granting department may allow course credit benefits; however, the following requirements apply:

1. Any graduate courses taken by a baccalaureate degree student that are credited towards the Masters degree must have been obtained with a grade of B or better.
2. Only courses of 500 level or higher may count toward the Masters degree.
3. As defined by the graduate degree granting department, a maximum of 12 graduate credits (5000 level or above) may be used for the masters degree provided these graduate credits were taken in excess of the university minimum of 120 baccalaureate degree credits, or, for programs requiring fewer than 33 credits, a maximum of up to six credits of graduate (5000 level or higher) courses may be used by a student in the Accelerated
Bachelor’s to Master’s Degree Option for both the graduate and undergraduate degrees; or, for program requiring 33-35 credits, at the discretion of the affected department, a maximum of up to nine credits of graduate (5000 level or higher) courses may be used by a student in the Accelerated Bachelor’s to Master’s Degree Option for both the graduate and undergraduate degrees; or, for programs requiring 36 or more credits, at the discretion of the affected department, a maximum of up to twelve credits of graduate (5000 level or higher) courses may be used by a student in the Accelerated Bachelor’s to Master’s Degree Option for both the graduate and undergraduate degrees.

4. Students must petition to have specific courses (5000 level or above) taken during their undergraduate career apply towards their graduate degree via an Academic Petition.

How to Apply

Applicants are requested to use the standard paper application form (https://www.uml.edu/docs/July%202014%20Bachelor-Master%20Application_tcm18-159702.pdf)(pdf) and submit requisite materials to the Office of Graduate Admissions (https://www.uml.edu/Grad/default.aspx) (Cumnock Hall - North Campus), normally in the second semester of their third year as an undergraduate (up until the last day of classes in their final semester before graduation). Application forms and details on applying may also be obtained by contacting the Graduate Admissions Office at 978-934-2390.

Master's Programs Offered

Listed by Degree Earned

- Master of Arts
- Master of Business Administration
- Master of Education
- Master of Music
- Master of Public Health
- Master of Science
- Master of Science in Engineering
- Education Specialist

Master of Arts (MA)

- Community Social Psychology
- Criminal Justice
- Economic & Social Development of Regions - This program is no longer accepting students.
- Peace & Conflict Resolution
- Security Studies

Master of Business Administration (MBA)

- General Business
- Accounting
- Finance
- Information Technology
- Marketing
- International Business

Master of Education (M.Ed.)

- Curriculum & Instruction
  - Autism Studies
  - Curriculum & Instruction: Initial Certification
  - Curriculum & Instruction: Science Education, beyond initial
  - Curriculum & Instruction: Math Education, beyond initial
  - Teaching English to Speakers of Other Languages
- Educational Administration
- Higher Education
- Reading & Language

Master of Music (MM)

- Music Education
- Community Music
- Sound Recording Technology

Master of Public Health (MPH)

- Public Health (https://www.uml.edu/catalog-AY16/pdf/Graduate.pdf)
- Epidemiology
- Global Environmental Sustainability & Health
- Healthcare Management
- Nutrition
- Population Health
Master of Science (MS)

- Accounting
- Autism Studies
- Biological Sciences
  - Applied Biotechnology (PSM)
  - Biotechnology Biosafety (PSM)
  - Environmental Biotechnology (PSM)
  - Project Management for Life Sciences (PSM)
- Biomedical Engineering & Biotechnology
  - Biomedical & Biotechnology (PSM)
- Business Analytics
- Chemistry
  - Chemistry & Polymer Science (PSM)
  - Pharmaceutical Biochemistry (PSM)
- Clinical Laboratory Sciences
  - Clinical Lab Science (PSM)
- Computer Science
  - Bio/Chemical Informatics Software Entrepreneurship (PSM)
- Engineering Management
- Environmental Studies
  - Atmospheric Sciences (PSM)
  - Environmental Engineering Sciences (PSM)
  - Environmental Geoscience (PSM)
- Finance
  - Pharmaceutical Sciences (PSM)
- Public Health
  - Radiological Science & Protection
  - Medical Physics
- Security Studies
  - Critical Infrastructure Protection
  - Cybersecurity
- Work Environment
  - Cleaner Production & Pollution Prevention (MS, PSM)
  - Ergonomics & Safety (MS, PSM)
  - Epidemiology (MS, PSM)
  - Occupational & Environmental Hygiene (MS, PSM)

Master of Science in Engineering (M.S.E.)

- Chemical Engineering
- Civil Engineering
- Computer Engineering
- Electrical Engineering
- Energy Engineering
- Mechanical Engineering
- Plastics Engineering

Education Specialist (EdS)

- Administration, Planning & Policy
- Curriculum & Instruction
  - Education of Diverse Populations
- Reading & Language

About Graduate Certificates

Most graduate certificates are comprised of four courses designed to provide specific knowledge and expertise vital to
today's changing and complex needs in the work place. In most cases courses may be applied toward a degree program.

Requirements to Complete a Graduate Certificate

The courses to complete the certificate must be completed within a five year period with a minimum 3.0 grade point average, and with no more than 3 credits below B. Courses completed for one certificate may not be used for another certificate.

Certificate Application Process

Individuals must complete a simplified application and provide an official undergraduate transcript indicating that a baccalaureate degree has been awarded. GRE’s are not required. NOTE: If your bachelor’s degree is from outside of the U.S., you may be required to take the TOEFL examination.

- Graduate Certificate Application Form
  (https://www.uml.edu/docs/Post%20Bachelor%20Certificate%20Application_tcm18-229777.pdf) (pdf)

Gainful Employment Disclosure Information

Completion rates, median loan debts and program costs are outlined for each certificate program and available in PDF format.

- Graduate Programs

Doctoral Programs Offered

Listed by Degree Earned

- Doctor of Education
- Doctor of Engineering
- Doctor of Nursing Practice
- Doctor of Philosophy
- Doctor of Physical Therapy
- Doctor of Science

Doctor of Education

- Leadership in Schooling
- Language Arts & Literacy

- Mathematics & Science Education

Doctor of Engineering (D.Eng./Ph.D)

- Business Management Curriculum
- Chemical Engineering
- Civil Engineering
- Electrical Engineering
- Energy Engineering
- Mechanical Engineering
  Mechanical Engineering/Chemical Engineering
  Mechanical Engineering/Civil &Environmental Engineering
  Mechanical Engineering/Energy Engineering
  Mechanical Engineering/Manufacturing Engineering

- Plastics Engineering

Doctor of Nursing Practice (DNP)

- Nursing

Doctor of Philosophy (Ph.D.)

- Applied Psychology and Preventative Science
  (http://www.uml.edu/Catalog/Graduate/FAHSS/Psychology/DoctoralAppliedPsychology.aspx)
- Biomedical Engineering & Biotechnology
- Business Administration
  Technology
  Management
  International
  Business
  Accounting
  Leadership
  Finance
  Management
  Information Systems
- Chemistry
  Biochemistry
  Environmental Studies
  Green Chemistry
- Computer Science
  Bio/Chemical Informatics
  Computational Mathematics
- Criminology and Criminal Justice
  Crime, Criminals &Community
  Global Perspectives on Crime &Justice
  Justice System &Policy
  Technology
  &Criminal Justice
  Victims, Crime &Justice
- Global Studies

Socio-
Economic Development
Comparative Cultures

- **Marine Sciences & Technology**
- **Nursing**
- **Pharmaceutical Science**
- **Physics**
  - Applied Mechanics
  - Energy
  - Engineering
  - Atmospheric Sciences
  - Radiological Sciences
- **Polymer Science**
  - Polymer Science/Plastics Engineering

**Doctor of Physical Therapy (DPT)**
- **Physical Therapy**

**Doctor of Science**
- **Work Environment**
  - Cleaner Production & Pollution Prevention
  - Ergonomics
  - Epidemiology
  - Hygiene
  - Policy

**Graduate Certificates Offered**

- Applied Statistics
  ([link](https://www.uml.edu/Catalog/Graduate/sciences/Mathematical-Sciences/Graduate-Certificates.aspx))
- Behavioral Intervention in Autism
  ([link](https://www.uml.edu/Catalog/Graduate/FAHSS/psychology/Certificate-Program.aspx))
- Biomedical Engineering
  ([link](https://www.uml.edu/Catalog/Graduate/Engineering/ Electrical-Computer-Engineering/Graduate-Certificates.aspx))
- Biotechnology & Bioprocessing
  ([link](https://www.uml.edu/Catalog/Graduate/sciences/Biology/Graduate-Certificate.aspx))
- Chemistry
  ([link](https://www.uml.edu/Catalog/Graduate/sciences/Chemistry/Graduate-Certificates-in-Chemistry.aspx))
- Clinical Pathology
  ([link](https://www.uml.edu/Catalog/Graduate/Health-Environment/Clinical-Lab-Nutritional-Sci/Certificate-Program.aspx))
- Communications Engineering
  ([link](https://www.uml.edu/Catalog/Graduate/Engineering/Electrical-Computer-Engineering/Graduate-Certificates.aspx))
- Composites and Materials
  ([link](https://www.uml.edu/Catalog/Graduate/Engineering/Mechanical-Engineering/Graduate-Certificates.aspx))
- Criminal Justice Leadership & Policy Development
  ([link](https://www.uml.edu/Catalog/Graduate/FAHSS/Criminal-Justice/Certificate-Program.aspx))
- Medical Plastics Design and Manufacturing Engineering
  ([link](http://www.uml.edu/Catalog/Graduate/Engineering/Mechanical-Engineering/Graduate-Certificates.aspx#1))
- Diversity in the Workplace
  ([link](https://www.uml.edu/Catalog/Graduate/FAHSS/psychology/Certificate-Program.aspx))
- Domestic Violence Prevention
  ([link](https://www.uml.edu/Catalog/Graduate/FAHSS/Criminal-Justice/Certificate-Program.aspx))
- Energy Conversion
  ([link](https://www.uml.edu/Catalog/Graduate/Engineering/Electrical-Computer-Engineering/Graduate-Certificates.aspx))
- Environmental Atmospheric Science
- Environmental Biotechnology
  ([link](https://www.uml.edu/Catalog/Graduate/sciences/Biology/Graduate-Certificate.aspx))
- Environmental GeoScience
- Family Studies
  ([link](https://www.uml.edu/Catalog/Graduate/FAHSS/psychology/Certificate-Program.aspx))
- Field Programming Gate Array
- Financial Management
  ([link](http://www.uml.edu/Catalog/Graduate/Business/Graduate-Certificate.aspx))
- Forensic Criminology
  ([link](https://www.uml.edu/Catalog/Graduate/FAHSS/Criminal-Justice/Certificate-Program.aspx))
- Foundations of Business
• Health Informatics
(https://www.uml.edu/Catalog/Graduate/Health-Environment/Community-Health-Sustainability/Graduate-Certificate.aspx)

• Health Management
(https://www.uml.edu/Catalog/Graduate/Health-Environment/Community-Health-Sustainability/Graduate-Certificate.aspx)

• Integrated Engineering Systems
(https://www.uml.edu/Catalog/Graduate/Engineering/Electrical-Computer-Engineering/Graduate-Certificates.aspx) (interdisciplinary)

• Criminal Justice: Leadership & Policy Development

• Materials Sciences & Engineering
(https://www.uml.edu/Catalog/Graduate/Engineering/Chemical-Engineering/Graduate-Certificates-in-Chemical-Engineering.aspx)

• Mathematics for Teachers
(https://www.uml.edu/Catalog/Graduate/sciences/Mathematical-Sciences/Graduate-Certificates.aspx)

• Medical Plastics Design & Manufacturing
(https://www.uml.edu/Catalog/Graduate/Engineering/Plastics-Engineering/Certificate-Programs.aspx)

• Microelectromechanical Systems/Nano electromechanical Systems (interdisciplinary)
(https://www.uml.edu/Catalog/Graduate/Engineering/Mechanical-Engineering/Graduate-Certificates.aspx)

• Microwave and Wireless Engineering
(https://www.uml.edu/Catalog/Graduate/Engineering/Electrical-Computer-Engineering/Graduate-Certificates.aspx)

• Modeling, Simulation, and Control of Systems and Processes
(https://www.uml.edu/Catalog/Graduate/Engineering/Chemical-Engineering/Graduate-Certificates-in-Chemical-Engineering.aspx)

• Molecular & Cellular Biotechnology
(https://www.uml.edu/Catalog/Graduate/sciences/Biology/Graduate-Certificate.aspx)

• Network Security
(https://www.uml.edu/Catalog/Graduate/sciences/Computer-Science/Graduate-Certificate.aspx)

• New Venture Creation
(https://www.uml.edu/Catalog/Graduate/Business/Graduate-Certificate.aspx)

• Nutritional Sciences
(https://www.uml.edu/Catalog/Graduate/Health-Environment/Clinical-Lab-Nutritional-Sci/Certificate-Program.aspx)

• Peace and Conflict Studies
(https://www.uml.edu/Catalog/Graduate/FAHSS/PACS/Graduate-Certificate.aspx)

• Pharmaceutical Science

• Photonics & Opto-Electronic Devices
(https://www.uml.edu/Catalog/Graduate/sciences/Physics/Graduate-Certificates-in-Physics.aspx)

• Plastics Design
(https://www.uml.edu/Catalog/Graduate/Engineering/Plastics-Engineering/Certificate-Programs.aspx)

• Plastics Engineering Fundamentals
(https://www.uml.edu/Catalog/Graduate/Engineering/Plastics-Engineering/Certificate-Programs.aspx)

• Plastics Materials
(https://www.uml.edu/Catalog/Graduate/Engineering/Plastics-Engineering/Certificate-Programs.aspx)

• Plastics Processing
(https://www.uml.edu/Catalog/Graduate/Engineering/Plastics-Engineering/Certificate-Programs.aspx)

• Professional Leadership
(http://www.uml.edu/Catalog/Graduate/Programs/Professional-Leadership.aspx)

• Public Health Laboratory Sciences
(https://www.uml.edu/Catalog/Graduate/Health-Environment/Clinical-Lab-Nutritional-Sci/Certificate-Program.aspx)
Public Health Studies  
(http://www.uml.edu/Catalog/Graduate/Health-Sciences/Public-Health/graduate-certificate-phs.aspx)

Radiological Health Physics & General Work  
Environment Protection  
(http://www.uml.edu/Catalog/Graduate/sciences/Physics/Graduate-Certificates-in-Physics.aspx)

Renewable Energy Engineering (interdisciplinary)  
(http://www.uml.edu/Catalog/Graduate/Engineering/Mechanical-Engineering/Graduate-Certificates.aspx)

Security Studies  
(http://www.uml.edu/Catalog/Graduate/FAHSS/Criminal-Justice/Certificate-Program.aspx)

Structural Dynamics and Acoustic Modeling Techniques  
(http://www.uml.edu/Catalog/Graduate/Engineering/Mechanical-Engineering/Graduate-Certificates.aspx)

Supply Chain and Operations Management  
(http://www.uml.edu/Catalog/Graduate/Business/Graduate-Certificate.aspx)

System Models and Management  
(http://www.uml.edu/Catalog/Graduate/sciences/Computer-Science/Graduate-Certificate.aspx)

Telecommunications  
(http://www.uml.edu/Catalog/Graduate/sciences/Computer-Science/Graduate-Certificate.aspx)

VLSI & Microelectronics  
(http://www.uml.edu/Catalog/Graduate/Engineering/Electrical-Computer-Engineering/Graduate-Certificates.aspx)

Victim Studies  
(http://www.uml.edu/Catalog/Graduate/FAHSS/Criminal-Justice/Certificate-Program.aspx)

Professional Science Master’s (PSM)

What differentiates the PSM from the core Master’s degree?

The Professional Science Master’s (PSM) is an innovative, non-thesis degree option designed for students to pursue advanced training in science, health or engineering while simultaneously developing professional leadership skills highly valued by employers. PSM programs typically consist of 8 core courses in science, health or engineering, 3 professional courses in leadership, communication and project management, a paid internship or professional development project and a reflective seminar. PSM programs have been developed in concert with industry in response to employer demands for specific skills and knowledge above and beyond the core science curriculum.

In contrast to typical Masters degrees, which require a thesis as a step toward preparation for an academic career, PSM programs are designed as terminal degrees that prepare candidates to compete in the global market. In essence, PSM programs are the MBAs of the 21st century. The National PSM Association offers networking and professional workshops to promote continued career development for PSM alumni across the country.

What PSM programs are available at UMass Lowell?

UMass Lowell offers 19 PSM programs. Graduates earn a Masters degree in Science with a PSM Option in the fields indicated below.

**Biological Sciences**  
(http://www.uml.edu/Catalog/Graduate/Sciences/Biology/Default.aspx)

- Applied Biotechnology
- Environmental Biotechnology
- Biosafety
- Project Management in Life Sciences

**Biomedical Engineering and Biotechnology**  
(http://www.uml.edu/Catalog/Graduate/Sciences/Biology/Masters-Programs.aspx)

**Chemistry**  
(http://www.uml.edu/Catalog/Graduate/Sciences/Chemistry/Default.aspx)

- Chemistry and Polymer Science
- Pharmaceutical Biochemistry

**Clinical Laboratory Sciences**  
(http://www.uml.edu/Catalog/Graduate/Health-Sciences/Clinical-Lab-Nutritional-Sci/Default.aspx)
Environmental Sciences
(http://www.uml.edu/Catalog/Graduate/Sciences/Environmental/Default.aspx)

- Atmospheric Sciences
- Geosciences

Marine Sciences
(http://www.uml.edu/Catalog/Graduate/Sciences/Marine/Default.aspx)

- Costal and Ocean Administration, Science and Technology

Mathematics
(http://www.uml.edu/Catalog/Graduate/Sciences/Mathematical-Sciences/Default.aspx)

- Industrial Mathematics

Physics
(http://www.uml.edu/Catalog/Graduate/Sciences/Physics/Default.aspx)

- Radiological Sciences

Professional Leadership
(http://www.uml.edu/Catalog/Graduate/Programs/Professional-Leadership.aspx)

Work Environment
(http://www.uml.edu/Catalog/Graduate/Health-Sciences/Work-Environment/Default.aspx)

- Cleaner Production & Pollution Prevention
(http://www.uml.edu/Catalog/Graduate/Health-Sciences/Work-Environment/Default.aspx)
- Environmental Epidemiology
- Ergonomics and Safety
- Occupational & Environmental Hygiene

For more information regarding PSM programs at UMass Lowell contact William Smith (mailto:william_smith@uml.edu).

Recommended PSM Science Courses:

Students should consult with faculty advisers to determine best course choice for their career advancement needs. All PSM students should include at least 1 course (basic or enhanced) that incorporates communication into their curriculum. Course descriptions can be found on the Recommended Courses (https://www.uml.edu/docs/PSM%20Online%20Course%20Descriptions%2007012014_tcm18-149327.pdf) (pdf).

Doctoral Degree Requirements

Doctoral Research

Dissertation Committee
Dissertation Credits
Dissertation Preparation
Dissertation Defense
Doctoral Degree Requirements
Procedure for Opting Out with a Master’s Degree

Doctoral Research

In addition to the other requirements of the University, a candidate for a doctoral degree must complete an acceptable dissertation. The dissertation must satisfy the following criteria:

1. It should demonstrate the candidate’s intellectual competence and maturity in the field of concentration;
2. It should make an original and valid contribution to knowledge; and
3. It should be an individual achievement and the product of independent research.

Although doctoral dissertations may result from a project involving collaboration of several scholars, the individual contribution of each doctoral candidate must be substantial, clearly identifiable, and presented separately. The Committee will judge the completed dissertation in terms of the candidate’s ability to review and make critical use of the literature; to formulate a problem, develop appropriate methodology, and work systematically toward a solution; and to summarize the material or data and draw conclusions from them. The writing should be of publishable quality.

Dissertation Committee

After a student has chosen an area of research and a research supervisor, a Dissertation Committee is selected by the student and his or her research advisor in accordance with the policy of the department. The Dissertation Committee shall consist of at least three members, one of whom is the research supervisor and at least two of whom shall be from the student’s major department. An outside expert from industry or another university may be a member of the committee, but that individual must possess academic credentials which would qualify him or her to serve as a member of the University of Massachusetts Lowell faculty. The responsibilities of the Dissertation Committee shall be to:

1. Approve the research topic;
2. Supervise the progress of the dissertation;
3. Read, evaluate, and approve or disapprove of the written dissertation;
4. Hear, evaluate and approve or disapprove of the oral defense of the dissertation;
5. Report the completion of all dissertation requirements to the department and the Registrar’s Office.


Dissertation Credits

If the graduate student requires the use of University resources to continue his or her dissertation but has completed the required number of credits for doctoral research, he or she may sign up for 3, 6, or 9 credits of Continuing Graduate Research (see General Policies).

Graduate students who have completed all the requirements except the writing and defense of the dissertation and who do not need to use university resources must register for Continued Matriculation (CM.601.201) and pay a fee each semester until they graduate.

Note: International students on F-1 or J-1 visas must be registered for a minimum of nine credits each semester. Contact the International Students and Scholars Office for more information.

Dissertation Preparation

Every graduate student who completes a dissertation is required to bear the cost of binding two copies of the manuscript for the University’s files. Copywriting is optional and available for an additional fee.

Dissertation Defense

One week prior to the dissertation defense, announcements of the defense, listing the graduate student’s name, dissertation title, and place and time of the defense, must be submitted to the chairperson of the department, the college dean, the Registrar’s Office and posted and distributed throughout the University. The defense is open to the public.

Doctoral Degree Requirements

The doctoral degree is conferred upon graduate students who have met all the requirements listed below:

1. The student must successfully complete the graduate courses in the major field, including the GPA requirement, and the number of course and dissertation credits required by the particular program.
2. If indicated, the language requirement specified by the major department must be satisfactorily completed.
3. A qualifying examination, oral and/or written, conducted by the major department, must be passed before any work is begun on the dissertation. If the student fails the qualifying examination he or she may, at the discretion of the department, be permitted a second and final opportunity. At this point, having completed steps 1 through 3, the student is admitted to candidacy for the doctorate.
4. A dissertation based upon the results of original research, and which is satisfactory to the Dissertation Committee of the major department, must be completed.
5. A final oral dissertation defense conducted by the Dissertation Committee, based primarily upon, but not necessarily limited to, the contents of the candidate’s dissertation must be passed. The examination cannot be scheduled until all members of the Dissertation Committee have had seven working days in which to read the dissertation. The oral examination is to be conducted by the Dissertation Committee, whose membership may be augmented by the non-voting faculty. In order to pass the defense, the candidate may not receive more than one dissenting vote from the members of the Dissertation Committee.
6. All financial obligations (tuition, fees, and expenses) must be satisfied as evidenced by the completion and submission of a Graduate Degree Clearance form to the Registrar’s Office.

Procedure for Opting Out with a Master’s Degree

Students accepted into a doctoral program who elect to instead obtain the master’s degree and leave the university must follow the following procedure:

1. The student must file an Academic Petition requesting to be changed from the doctorate to the master’s degree program.
2. The student must complete all required courses for the master's degree, compile a minimum 3.0 grade point average, successfully defend his/her thesis, and complete the clearance process at the Registrar’s Office.

3. All graduate courses (and undergraduate course work used for graduate credit), whether taken for the original doctoral program or for the master’s degree, will be included in the grade point average and listed on the student’s graduate transcript.

Financial Information

University-related costs include tuition and mandatory fees. Please contact the Student Financial Services (https://www.uml.edu/thesolutioncenter/bill/tuition-fees/default.aspx) at 978-934-3570 for more information.

- New England Regional Program
- Health Insurance
- Veterans
- Residency Classification
- Overdue Accounts
- Payment Plans
- University Charges

New England Regional Student Program

Massachusetts and the University participate in a reciprocal program in which qualified and legal residents of other New England states may attend graduate school in an approved program at the University of Massachusetts Lowell and pay 150% of the Massachusetts in-state tuition charges. (All other applicable fees apply.) Applicants are considered for unique and distinctive graduate level studies not available in their home state university system. Full details regarding eligible programs are available from the New England Board of Higher Education, 45 Temple Place, Boston, Massachusetts 02111 (617-357-9620), or at the University Graduate Admissions (https://www.uml.edu/grad/default.aspx) office (www.uml.edu/grad (https://www.uml.edu/grad/default.aspx)).

*UMass Lowell also participates in the Proximity Allowance of the New England Regional Program. This program allows New Hampshire residents from selected towns within a 20 mile radius of UMass Lowell to be eligible for a tuition discount for most majors. Please visit www.uml.edu/admissions/proximity (http://www.uml.edu/Grad/Costs/default.aspx) for details.

Health Insurance (https://www.uml.edu/student-services/Health/default.aspx)

Mandatory on-campus (accident) insurance is charged to all graduate students. All graduate students enrolled in 9 or more credit hours will be charged for health insurance as required by state law. Graduate students may waive student health insurance charges if they maintain comparable insurance coverage and complete an insurance waiver form by the required deadline. Forms are available in the Office of Graduate Admissions and Accounts Receivable Office, Dugan Hall, UMass Lowell South. Family health insurance plans are also available with options for coverage of spouses and/or spouses and dependent children.

International Students: As authorized under the insurance laws for higher education students in Massachusetts (section 275 of Chapter 151 of the Acts of 1996), the University of Massachusetts Lowell requires that all international students must enroll in the University’s Student Health Insurance Plan.

Veterans

The Veterans Administration has approved the University of Massachusetts Lowell for undergraduate study. For details regarding veteran tuition benefits, refer to the Registrar’s Office (https://www.uml.edu/registrar/default.aspx) website (www.uml.edu/registrar/ (https://www.uml.edu/registrar/default.aspx)).

RESIDENCY CLASSIFICATION

Rules for Determination of Domicile

University tuition rates are established on the basis of official state residency as determined by a student's true "domicile." "Domicile" is defined as a person's true, fixed and permanent home and place of habitation where he or she intends to remain permanently or for an indefinite time. Massachusetts residency for tuition purposes is not acquired by mere physical presence in Massachusetts while a person is carrying on a course of study at the University. A student’s residency status is based on a determination of one’s domicile at the time of entry or re-entry to the University. A student may apply to be reclassified at any time and must provide detailed documentation to support the claim that he or she met the requirements for Massachusetts residency for tuition purposes at the time of his or her entry as a student. One notable exception is made for students who marry Massachusetts residents while enrolled in a course of studies. The complete set of rules are attached to the application for reclassification. These applications are available from the Residency Officer in Dugan Hall (978-934-2596).

Payment of Bills
Graduate students will be permitted to attend classes and to utilize University facilities only after they have cleared all their financial obligations to the University. Financial obligations include indebtedness for library and parking fines, rental payments, and repayment of emergency loans. All bills are payable in advance by check or money order and are due as specified on the student invoice. Major credit cards are also accepted. All payments of fees and tuition should be made payable directly to the University of Massachusetts Lowell. A student in debt to the University at the end of any semester or summer session is not permitted to register again at the University until his or her indebtedness has been discharged. In addition, student transcripts and diplomas will not be released unless all indebtedness has been discharged.

Overdue Accounts

Should it be necessary to utilize the services of a collection agency or attorney for an overdue student account, the student will be liable for any and all legal fees, commissions, and associated service charges.

Payment Plans

The University of Massachusetts Lowell offers a low-cost, interest-free payment option administered by Academic Management Services (AMS). This plan allows students to budget the annual cost of tuition and fees over a ten month period. Please call AMS directly at 1-800-635-0120 or contact the Financial Aid Office, Dugan Hall, UMass Lowell South (978-934-3570) for more information.

University Charges

University-related costs include tuition and mandatory fees. Please contact the Student Financial Services for more information.

Doctoral Degree Credit Requirements

<table>
<thead>
<tr>
<th>COLLEGE/PROGRAM</th>
<th>COURSE/SEMINAR CREDITS</th>
<th>DISSERTATION CREDITS</th>
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<tr>
<td>COLLEGE OF SCIENCES</td>
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<tr>
<td>CHEMISTRY (Ph.D.) All Options</td>
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<td>18</td>
<td>45-48</td>
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<td>COMPUTER SCIENCE (Ph.D.) All Options</td>
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<td>42 (Beyond M.S.)</td>
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<td>PHYSICS (Ph.D.) All Options</td>
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<td>POLYMER SCIENCE (Ph.D.)</td>
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</table>

Financial Assistance & Assistantships

FINANCIAL ASSISTANCE

- Applying for Financial Aid
- Other Types of Assistance
- Tuition and Fees

Financial Aid
Applying for Financial Aid:

The University requires students to file a Free Application for Federal Student Aid (FAFSA). Students may apply for the FAFSA online at www.FAFSA.ed.gov. It is recommended that students save time by requesting personal identification numbers called Federal Student Aid PINs before the student applies for aid. The PIN can be used to electronically sign the FAFSA, electronically sign certain loan contracts, and access online information about federal student aid the student has received. The PIN must be requested online at www.pin.ed.gov.

Copies of students and spouses federal income tax, W2 forms and other forms may be requested by the Financial Aid Office to verify information provided on the FAFSA. Many forms requested are available on the financial aid website at www.uml.edu/financialaid. All information requested by the Financial Aid Office is required to complete the application process and is held in strictest confidence.

Eligibility Requirements

To receive financial aid from the various student aid programs, a student must:

- Have demonstrated financial need to qualify for need-based aid programs. Need is defined as the cost of attendance minus the expected family contribution derived from filing the FAFSA. Students may also be eligible for non-need based aid programs, such as the Federal Direct Unsubsidized Loan program and meritocratic awards.
- Be a U.S. citizen or eligible non-citizen.
- Have a valid Social Security Number.
- Make satisfactory academic progress.
- Have a high school diploma or a General Education Development (GED) certificate, pass a test approved by the U.S. Department of Education, meet other standards the state of Massachusetts establishes that are approved by the U.S. Department of Education, or complete a high school education in a home school setting that is treated as a home school or private school under state law.
- Be a matriculated student enrolled in a degree granting or approved certificate program. Students enrolled in non-degree programs are not eligible for financial aid.
- Be enrolled at least half-time each semester. (Minimum of six credits for graduate students).
- Cannot be in default or in over payment on a federal student loan.
- Register with the Selective Service, if required.

Determining Financial Need:

Demonstrated financial need is the difference between the cost of attendance and the expected family contribution. The cost of attendance (COA) includes direct expenses such as tuition and fees, and also includes indirect such as room, board, books and transportation. The expected family contribution (EFC) is determined by the federal needs analysis formula and is calculated by completing a Free Application for Federal Student Aid (FAFSA).

Types of Financial Aid:

William D. Ford Federal Direct Subsidized/Unsubsidized Loan Program: The primary source of financial aid recommended for graduate students is the William D. Ford Federal Direct Student Loan Program. This program allows the student to borrow up to $20,500 per year at a low interest rate in subsidized and/or unsubsidized loans. Eligibility for a ?subsidized? or ?unsubsidized? direct loan is determined from the information provided on the FAFSA. A student may receive a subsidized loan and an unsubsidized loan for the same enrollment period. A ?subsidized? loan is awarded on the basis of financial need. A student will not be charged any interest before repayment begins or during authorized periods of deferment. A ?unsubsidized? loan is not awarded on the basis of need. A student will be charged interest from the time the loan is disbursed until it is paid in full. If a student allows the interest to accumulate, it will be capitalized?that is, the interest will be added to the principal amount of the loan and additional interest will be based upon the higher amount. For more information about graduate student aid contact the Financial Aid Office at 978-934-4220 or visit the website at www.uml.edu/financialaid.
William D. Ford Federal Direct PLUS Loan Program:

A non-need based federal loan offers up to the cost of attendance minus financial aid per academic year to qualified graduate students and parents/stepparents of undergraduate dependent students. Interest rate is fixed and repayment begins 45-60 days after the second disbursement. Refer to the Direct Loan web site (http://www.ed.gov/offices/OSFAP/DirectLoan/index.html) for current interest rates. A FAFSA is not required to apply for the PLUS loan; however, students are encouraged to file a FAFSA so that they can receive the maximum aid available. Parents may download an application online from the financial aid webpage www.uml.edu/financialaid (https://www.uml.edu/thesolutioncenter/financial-aid/default.aspx) by clicking on forms. Applications should be returned to the financial aid for processing. This is a loan that needs to be repaid by the parent/stepparent.

Other Types of Assistance:

Federal Professional Nurse Traineeship Grant Program:
Federally funded grant available to graduate nursing students. Award amounts vary and are dependent upon funding. Please contact the School of Nursing for more information.

Federal Teach Grant:
Federally funded grant available to qualifying graduate education majors enrolled in coursework or plan to complete coursework toward a career in teaching in a high need subject area. Contact the Graduate School of Education for more information.

Deans Fellowships:
$2,000 awards granted to eligible, newly admitted full-time, in-state Masters candidates not receiving a teaching or research assistantship.

Provosts Fellowships:
$4,000 awards granted to eligible, newly admitted full-time, out-of-state and international Masters candidates not receiving a teaching or research assistantship.

ASSISTANTSHIPS

Teaching and Research Assistantships

A limited number of teaching and research assistantships are available for matriculated, full-time (minimum of 9 credits/semester) graduate students. All assistantships are subject to the agreement between UMass Lowell and UAW/Graduate Employees Organization. Teaching assistantships are assigned by the student’s department; therefore, queries regarding teaching assistantships should be directed to the departmental graduate coordinator (https://www.uml.edu/Grad/Accepted-Students/coordinators.aspx) or chairperson (see www.uml.edu/Grad/coordinators.aspx) for a list. Research assistantships are available through special arrangements with individual research advisers. Individuals interested in research assistantships should contact departmental faculty members concerning the availability of this form of financial aid.

Qualifying for an Assistantship

To ensure that assistantships are awarded to the most qualified individuals, the University 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 who fails to maintain good academic standing (a grade point average under 3.0 on the official transcript). See the Academic Standing information at www.uml.edu/catalog/graduate/policies/Academic_Standing.htm.
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 III 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.

Teaching and Research Assistants are awarded either a semester or a yearly contract. The current negotiated agreement between The University of Massachusetts Lowell Board of Trustees and the Graduate Employee Organization is posted on the Human Resources website. Current stipend levels may be found there as well.

Graduate Student Assistantships

A limited number of student assistantships may be available in the departments. Students in this category are paid an hourly rate and are obligated to pay their own tuition and fees. All queries concerning assistantships should be directed to the graduate coordinator (https://www.uml.edu/Grad/Accepted-Students/coordinators.aspx) or chairperson (see www.uml.edu/Grad/coordinators.aspx) in the student’s department.
Tuition and Fees

Please see the Student Financial Services [website](https://www.uml.edu/thesolutioncenter/bill/tuition-fees/default.aspx) for current tuition and fee information. Your tuition rate is determined by your residency status: in-state, out-of-state (which would include international students), New England Regional or Proximity.

Master's Degree Requirements

- Advising
- General Requirements for the Master's Degree
- Research Option for the Master's Degree
- Research Project
- Thesis

Students Continuing on to a Doctoral Program

Advising

An entering graduate student should meet with the departmental graduate coordinator as soon as possible after arrival on campus. The coordinator will:

1. Help design and then approve the student's complete program leading to the master's degree.
2. Recommend course credits from within and outside the University for transfer into the student's degree program.
3. Monitor the student's progress toward the degree, which must be completed within a five-year time period in most programs (See Time for Limit for Degree Completion).

General Requirements for the Master's Degree

To be recommended for a masters degree, a candidate must satisfy all requirements of the University and the specific requirements of the department in which he or she is enrolled. The requirements of the University are listed below, and the specific requirements established by the various departments may be found in the section describing the particular programs.

A candidate for the master's degree must complete the following within five years of matriculation in order to receive the degree: (Note: Master's degrees which require 45 or more credits have a limit of six years.)

1. A course of study designed by the department in which he or she is enrolled and approved by the University. The course of study must have a minimum of 30 credit hours of graduate work including, where applicable, a thesis or project in the student's chosen field.
2. A student must successfully pass an oral or written examination on his or her complete master's program if required by the department.
3. Satisfactory grades in all subjects offered for the degree must be earned (See Academic Standing).
4. All financial obligations, including tuition, fees, and expenses, must be satisfied as evidenced by completion and submission of a signed Graduate Degree Clearance form to the Registrar's Office.

Research Option for the Master's Degree

If required by the program, a student must complete a master's project or a thesis. The proposal must be approved by the department in which the student is enrolled and the final project or thesis must be of graduate level quality.

Project

The project must consist of a scholarly investigation, such as a review, report, synthesis, design or experiments in the student's field resulting in a comprehensive written document. Usually, if a student chooses the project option, he or she is required to take additional course credits. Each project is awarded only three to four credits and is intended to be completed within the time limit of one semester. If the work for a project is not completed by the end of the semester, the instructor will give the student an Incomplete which is to be treated the same as an incomplete for a regular course.

Thesis

The requirements for a thesis are much more extensive, including the completion of acceptable research and its defense before a thesis committee. The completed thesis must conform to the format specified in the "Thesis Guide" which is available in the Registrar's Office. The time required for completion may vary; if a student has not completed the thesis by the end of the semester, but is making satisfactory progress, he or she is given the grade of "PR". If the student requires the use of university resources to continue thesis research, but has completed the required number of credits for the master's thesis, he or she may sign up for 3, 6, or 9 credits of Continuing Graduate Research (see "Course
Descriptions). However, if the student is not using University resources, but is in the process of writing the thesis, he or she may register for Continued Matriculation for the semester(s) during which the work is completed. Continued Matriculation is available to international students only under special circumstances. International students should contact the International Student Office (https://www.uml.edu/ISSO/default.aspx) for more information and to make sure they comply with visa and immigration regulations.

Upon successful completion of the thesis, the grade of "S" will be awarded for all semesters in which the student is registered for thesis research. Only the Registrar’s Office can issue this grade.

**Thesis Committee**

As soon as a student has chosen an area of research, a Thesis Committee is selected by the student and his or her research advisor in accordance with the policy of the department. The Thesis Committee shall consist of at least three members, at least two of whom shall be from the student’s major department. One member of the committee shall be the student's thesis advisor. An outside expert, such as the supervisor of a research project conducted at an industrial setting or a faculty member from another institution, may be a member of the committee, but that individual must possess academic credentials which would qualify him or her to serve as a member of the University of Massachusetts Lowell faculty.

The responsibilities of the Thesis Committee shall be to:

1. Approve the research topic.
2. Supervise the progress of the thesis.
3. Read, evaluate and approve or disapprove of the written thesis.
4. Hear, evaluate and approve or disapprove of the oral defense of the thesis.
5. Report the completion of all thesis requirements to the department and the Registrar’s Office.

**Thesis Preparation**

Every graduate student who completes a thesis is required to bear the cost of binding two copies of the manuscript for the University’s files. Copy writing is optional and available for an additional fee.

**Thesis Defense**

One week prior to the thesis defense, announcements of the defense listing the candidate’s name, thesis title, and place and time of the defense, must be submitted to the chairperson of the department, the college dean, and the Registrar’s Office, and posted and distributed throughout the University. The defense is open to the public.

**For Students Continuing on to a Doctoral Program**

Students accepted into a master’s degree program who decide to continue on for the doctorate but want to first complete their master’s degree must adhere to the following procedure.

1. The student must complete all required courses, compile a 3.0 grade point average, and successfully defend his/her thesis, if required.
2. The student must complete the Registrar’s Office clearance process for the master’s degree.
3. A student is prohibited from enrolling in doctoral research until he or she has completed the clearance process for the master’s degree.
4. The student must then apply to the doctoral program by completing the standard Graduate Admissions application process.
5. Official admission into a doctoral program and receipt of a letter of acceptance are contingent upon completion of the clearance process for the master’s degree.

**Master's Degree Credit Requirements**

**College of Sciences**

<table>
<thead>
<tr>
<th>COLLEGE/PROGRAM</th>
<th>COURSE OR SEMINAR CREDITS</th>
<th>THESIS OR PROJECT CREDITS</th>
<th>TOTAL CREDIT REQUIREMENT</th>
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<tbody>
<tr>
<td>BIOLOGICAL SCIENCES (M.S.)</td>
<td>The sis</td>
<td>18-24</td>
<td>6-12</td>
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<tr>
<td>Project</td>
<td>24-27</td>
<td>3-6</td>
<td>30</td>
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<tr>
<td>Non - The sis</td>
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<td>0</td>
<td>30</td>
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<tr>
<td>PS M options</td>
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<tr>
<td>CHEMISTRY (M.S.)</td>
<td>The sis</td>
<td>18</td>
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<td>0</td>
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</table>
### COMPUTER SCIENCE (M.S.)
- **Thesis**: 24, 6, 30
- **Non-Thesis**: 30, 0, 30

### COMPUTER SCIENCE (M.S.) ENTREPRENEURS HIP option
- **Thesis**: 27, 6, 33
- **Non-Thesis**: 33, 0, 33

### MATHEMATICS (M.S.) [all options except PSM]
- **Thesis**: 24, 6, 30
- **Non-Thesis**: 30, 0, 30

### MATHEMATICS (M.S.) PSM option
- **PSM**: 37, 0, 37

### PHYSICS (M.S.)
- **Thesis**: 18-24, 6-12, 30
- **Project**: 27, 3, 30

### RADIOLOGICAL SCIENCES (M.S.)
- **Thesis**: 21, 9, 30
- **Project**: 27, 3, 30

### PSYCHOLOGY (M.A.)
- **Thesis**: 30, 6, 36
- **Project**: 33, 3, 36

### ECONOMIC THEORETIC DEVELOPMENT OF REGIONS (M.A.)
- **Thesis**: 27, 3, 30
- **Project**: 30, 0, 30

### MUSIC EDUCATION (M.M.)
- **Thesis**: 27, 3, 30
- **No-Thesis**: 30, 0, 30

### MUSIC TEACHING (M.M.)
- **Thesis**: 27, 3, 30
- **No-Thesis**: 30, 0, 30

### SOUND RECORDING TECHNOLOGY (M.M.)
- **Thesis**: 27, 3, 30
- **No-Thesis**: 30, 0, 30

### COLLEGE OF FINE ARTS, HUMANITIES & SOCIAL SCIENCES

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<tr>
<th>COLLEGE/PROGRAM</th>
<th>COURSE or SEMINAR CREDITS</th>
<th>THESIS or PROJECT CREDITS</th>
<th>TOTAL CREDIT REQUIREMENT</th>
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### GRADUATE SCHOOL OF EDUCATION

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<th>THESIS or PROJECT CREDITS</th>
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<th>THESIS or PROJECT CREDITS</th>
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<td>CIVIL (M.S.E.)</td>
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<tr>
<td>ENERGY (M.S.E.)</td>
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### COLLEGE OF HEALTH SCIENCES

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<th>THESIS or PROJECT CREDITS</th>
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<tr>
<td>Thesis</td>
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**GRADUATE CERTIFICATES**

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<th>COLLEGE/PROGRAM</th>
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<th>TOTAL CREDIT REQUIREMENT</th>
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<tr>
<td>BUSINESS ADMINISTRATION (M.B.A.) [all options]</td>
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</tbody>
</table>

[Note: While most graduate certificates are 12 credits, some are as many as 18 credits. Courses completed for one graduate certificate may not be used for another graduate certificate.]

**Graduate Admissions**

- Admissions Requirements
- Departmental Requirements

**Find Us**

The Office of Graduate Admissions (www.uml.edu/grad) (https://www.uml.edu/Grad/default.aspx)

University of Massachusetts Lowell

Cumnock Hall, Suite 110

31 University Ave.

Lowell, MA 01854

978-934-2390 or 1-800-656-GRAD

**Admission Requirements**
The general requirements for admission to graduate study at the University are listed below.

1. The applicant must show official evidence of having earned a baccalaureate degree or its U.S. equivalent from an accredited college or university. If an international transcript does not adequately demonstrate that an applicant has the equivalent of an American bachelor’s or master’s degree, the Office of Graduate Admissions will require such verification by an independent service such as the Center for Educational Documentation (http://www.cedevaluations.com), Boston, MA (617-338-7171).

2. The degree must have been earned with a satisfactory scholastic average to demonstrate that the applicant has had adequate preparation for the field in which graduate studies are to be undertaken.

3. The applicant must have obtained a satisfactory score on the appropriate entrance examination required for admission by the program or department to which admission is sought. The official score report must be submitted; a photocopy of the examinee’s report is unacceptable. Unless otherwise stated under a specific program description, the required examination is the Graduate Record Examination General Test.

4. The Commonwealth of Massachusetts requires that all full-time graduate students (9 or more credits) must be immunized against measles, mumps, rubella, tetanus, and diphtheria. In addition, all students in programs in the health professions, regardless of age or enrollment status, must show proof of immunization. Students will not be permitted to register for courses at the University unless proof of immunization has been sent directly to the Director of Health Services (http://www.uml.edu/student-services/health/), University of Massachusetts Lowell, Lowell, MA 01854 (978-934-4991).

**Departmental Requirements**

The rules, regulations, and policies delineated by the University constitute only the minimum requirements for admission, retention, and graduation. Each department may have additional requirements mandated by the unique nature of its programs. It is the responsibility of the graduate student to be aware of the minimum requirements of the University and, in addition, to fulfill the special requirements of the particular program in which he or she is enrolled.

**Learning Outcomes Assessment Policy**

In keeping with the University’s commitment to excellent educational experiences and high-quality programs for its students, and consistent with practices at other institutions within the state and nationally, UMass Lowell routinely engages in the assessment of student learning at the course, program, institution ans systems levels. The learning outcomes assessment process may include a variety of methods such as standardized tests, student surveys and focus groups, campus developed instruments, and a review of student work will be protected. In circumstances beyond the individual course level, the identity of the student will be protected. The student’s name, grade or other identifying information will be removed before the student work is reviewed. Selected student work may be subject to review by a limited cohort of higher educational personnel, primarily faculty. Assessment of student learning is undertaken primarily for the purpose of improving student learning, curriculum development, instructional improvement, and enhancing student academic success. Assessment activities will have absolutely no effect on a student’s grade, academic standing, ability to transfer, or ability to be graduated. UMass Lowell will take all necessary steps to ensure the confidentiality of all student records and student work reviewed through this process in accordance with FERPA regulation.

**Application Procedure**

- Departmental Requirements
- Application Procedure for Graduate Admissions
- Conventional Application
- Application Deadline
- Types of Admission
- Status as a Graduate Certificate Candidate
- Non Degree Status
• Graduate Readmission/Deferral Policy

General Admissions Requirements

The general requirements for admission to graduate study at the University are listed below.

1. The applicant must show official evidence of having earned a baccalaureate degree or its U.S. equivalent from an accredited college or university. If an international transcript does not adequately demonstrate that an applicant has the equivalent of an American bachelor’s or master’s degree, the Office of Graduate Admissions will require such verification by an independent service such as the Center for Educational Documentation (http://www.cedevaluations.com/), (www.cedevaluations.com) Boston, MA (617-338-7171).

2. The degree must have been earned with a satisfactory scholastic average to demonstrate that the applicant has had adequate preparation for the field in which graduate studies are to be undertaken.

3. The applicant must have obtained a satisfactory score on the appropriate entrance examination required for admission by the program or department to which admission is sought. The official score report must be submitted; a photocopy of the examinee's report is unacceptable. Unless otherwise stated under a specific program description, the required examination is the Graduate Record Examination General Test.

4. The Commonwealth of Massachusetts requires that all full-time graduate students (9 or more credits) must be immunized against measles, mumps, rubella, tetanus, and diphtheria. In addition, all students in programs in the health professions, regardless of age or enrollment status, must show proof of immunization. Students will not be permitted to register for courses at the University unless proof of immunization has been sent directly to the Director of Health Services, University of Massachusetts Lowell, Lowell, MA 01854 978-934-4991.

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The rules, regulations, and policies delineated by the University constitute only the minimum requirements for admission, retention, and graduation. Each department may have additional requirements mandated by the unique nature of its programs. It is the responsibility of the graduate student to be aware of the minimum requirements of the University and, in addition, to fulfill the special requirements of the particular program in which he or she is enrolled.

Application Procedure for Graduate Admission

Applicants to graduate programs are encouraged to apply online. Apply now with our Online Application. (https://sa-webapp-prd.erp.umasscs.net/psc/webapp/EMPLOYEE/HRMS/c/UM_WEBAPP_MENU.UM_ADMIN_APP_LOGIN.GBL&institution=UMLOW&CareerGRAD&CenterGRAD%27?&

- Conventional Application
- Application Deadline
- Types of Admission
- Status as a Graduate Certificate Candidate
- Non-Degree Status
- Graduate Readmission/Deferral Policy
- Acceptance of Foreign or American Master’s Degree Toward Doctoral Requirement
- Transfer Credit
- Graduate Equivalency Credit

Conventional Application

Application forms and materials may be obtained from:

The Office of Graduate Admissions

University of Massachusetts Lowell
Cumnock Hall, Suite 110
One University Avenue
Lowell, MA 01854
978-934-2390 or 1-800-656-GRAD

www.uml.edu/grad (https://www.uml.edu/Grad/default.aspx)

A non-waivable and non-refundable application fee must be received before the application is processed. Each applicant must file the following documents:

1. A completed application form.
2. Official transcripts of all undergraduate and graduate...
records.

3. Three letters of recommendation written by individuals qualified to judge the ability of the applicant to carry on graduate work and research.

4. Official scholastic test scores specified for various degree programs at the University (see individual departmental requirements). An applicant who has earned a graduate degree from an accredited university may petition the department graduate coordinator to waive the scholastic test requirements (e.g. GRE).

5. The official score report for the “Test of English as a Foreign Language” (TOEFL) for students from countries where English is not the national language. If the TOEFL bulletin cannot be obtained locally, students should write well in advance to:

Test of English as a Foreign Language
Box 6151
Princeton, NJ 08541-6151, U.S.A.

All test scores must be official and sent directly by the testing agency.

Application Deadline

The University of Massachusetts Lowell Graduate Admissions Office has a "rolling admissions" policy. However, some programs have early, fixed application deadlines. Consequently, the applicant is strongly urged to contact the department of interest to determine the last date on which applications may be received. In general, early applications will ensure that all materials are processed on time and that a student who wishes to apply for a teaching assistantship will be given due consideration. Many programs will fill available openings several months before the beginning of the semester. A student who has been accepted into a graduate program must attend within a year of acceptance or may, at the discretion of the department, be required to submit a new application. Application files for individuals who do not matriculate will be retained for only two years from the date of application.

Types of Admission

A student may be admitted to graduate study at the University of Massachusetts Lowell under one of the two classifications listed below.

1. Matriculated status: A student who has met all requirements for admission to a degree program and who has been recommended by the department in which he or she proposes to study as a degree candidate.

2. Matriculated with conditions: A student who has not fully met the requirements stipulated by the program may be admitted as a prospective candidate for a degree with specified conditions to be met in the future. Such a student must have as an initial objective the satisfactory completion of all requirements for full matriculation.

Status as a Graduate Certificate Candidate

Graduate certificate programs are designed for students holding a baccalaureate degree in a field related to the certificate program. A student who wishes to apply to a certificate program must complete the Graduate Certificate Application (https://www.uml.edu/Grad/programs/about-certificates.aspx), submit the appropriate application fee, and submit an official transcript indicating the conferral of a Bachelor’s degree. The graduate record exam (GRE) is not required.

A student in a certificate program who wishes to enroll in a master’s or doctoral program is ineligible to receive credit towards a degree until he or she files a formal application and is then admitted as a matriculated student.

The maximum number of graduate credits a student may complete while enrolled in a graduate certificate is 12 credits.

Non-Degree Status

An individual without advanced degree objectives may take courses in certain programs with non-degree status. A student who wishes to take courses as a non-degree student must submit an official transcript indicating the conferral of a Bachelor’s degree. A student in non-degree status is ineligible to receive credit towards a degree until he or she files a formal application and is then admitted as a matriculated student.

The maximum number of graduate credits a student may complete with non-degree status is 12 credits.

NOTE: International students are not eligible for non-degree status.

Graduate Readmission/Deferral Policy

1. A matriculated student who formally withdraws in good standing from the university may request readmission within two years by completing only the cover page of the
graduate application.
2. A newly accepted student dropped from a graduate program for failure to register may be re-admitted by submitting a new application cover page and fee within two years of acceptance date.
3. A matriculated student who fails to maintain continuous enrollment and has not formally withdrawn may be readmitted by submitting a new application cover page and fee within two years of being dropped from the program.
4. A student may request a deferment of enrollment up to one year beyond the date when he or she was scheduled to begin his or her graduate program. If the one-year time period is exceeded, the student must submit a new application and fee. Deferral must be requested before the start of the semester for which the student is accepted.

Professional Leadership Certificate

About the Program
The Professional Leadership certificate is a useful credential for science, engineering and technology professionals in the private and public sectors who wish to advance to managerial and/or move to more business related positions within their organizations. This is a 12 credit (four courses, three credits per course) program.

Admission Requirements
1. Bachelors degree in science, engineering, technology or mathematics.
2. Minimum of two years post-baccalaureate work experience.

Curriculum
This program consists of four masters level courses (3 credits each), with three courses in the professional leadership area and one advanced course in the individuals field of expertise. For qualified individuals, the 12 earned graduate credits are transferable to a related Professional Science Masters graduate program with the approval of the appropriate graduate program coordinator.

Required Professional Courses: (three credits each all are online courses)
- PSM 535 Project Management for Science Professionals
- PSM 545 Professional and Scientific Communication
- PSM 555 Professional Science Leadership

Contact
Deborah White
(mailto:Deborah_White@uml.edu)

UMass System Graduate Programs
UMass Lowell offers two intercampus programs drawing on the strengths of the whole UMass System.

Marine Science
- Biomedical Engineering & Biotechnology Program

Colleges & Degrees of Graduate Study
- Manning School of Business
- Graduate School of Education
- College of Engineering
- College of Fine Arts, Humanities & Social Sciences
- School of Health & Environment
- College of Sciences
- UMass System Graduate Programs

Graduate Programs
UMass Lowell offers more than three dozen master’s programs, including Education Specialist (Ed.S.) post-graduate programs. Many of our programs have non-thesis options. If you’re not ready to matriculate into a full program, consider our certificate programs. If you are looking for a doctoral
program, we offer more than two dozen in a wide range of disciplines.

**Online Graduate & Undergraduate Degrees & Part-Time Programs**

UMass Lowell offers a number of graduate degrees and certificates (http://continuinged.uml.edu/degrees/Graduate.htm) and part-time undergraduate degrees and certificates (http://continuinged.uml.edu/degrees/Undergraduate.htm) entirely online, or as a mix of online and on-campus courses through its Division of Online and Continuing Education. By making the courses available online - during the evening and on weekends - the University makes it easier for busy professionals to fit education into their lives.
General Regulations for Graduate Students

Each University student is subject to two sets of academic regulations - those of the University as a whole, which are cited in this section, and the academic rules of the college and program in which he or she is enrolled. The academic rules of colleges and programs are listed in sections devoted to college programs.

In registering for courses, each student assumes full responsibility for knowledge of and compliance with the definitions, regulations, and procedures for the University, as set forth in this publication. Moreover, in accepting admission to the University, each student assumes responsibility for knowledge of and compliance with the definitions, regulations, and procedures of the University pertaining to his or her student status as set forth in the appropriate UML publications.

Students who have questions about the interpretation or application of University academic policy should consult the dean of their college or the Vice Provost for Graduate Education.

Academic Integrity Policy

UNIVERSITY OF MASSACHUSETTS LOWELL POLICY AND PROCEDURES RELATING TO STUDENT ACADEMIC INTEGRITY AND MISCONDUCT

I. Statement of Principles: The University has a responsibility to promote academic honesty and integrity and to develop procedures to deal effectively with instances of academic dishonesty. Students are responsible for the honest completion and representation of their work, for the appropriate citation of sources, and for respect of others' academic endeavors. Academic dishonesty is prohibited in all programs of the university.

II. Academic Misconduct Subject to Disciplinary Action:

(1) Academic misconduct is an act in which a student:

(a) Seeks to claim credit for the work or efforts of another without authorization or citation;
(b) Uses unauthorized materials or fabricated data in any academic exercise;
(c) Forges or falsifies academic documents or records;
(d) Intentionally impedes or damages the academic work of others;
(e) Engages in conduct aimed at making false representation of a student's academic performance; or
(f) Assists other students in any of these acts.

(2) Examples of academic misconduct include, but are not limited to: cheating on an examination; collaborating with others in work to be presented, contrary to the stated rules of the course; submitting a paper or assignment as one's own work when a part or all of the paper or assignment is the work of another; submitting a paper or assignment that contains ideas or research of others without appropriately identifying the sources of those ideas; getting unauthorized access to examinations or course materials; submitting, without the permission of the current instructor, work previously presented in another course; tampering with the laboratory experiment or computer program of another student; knowingly and intentionally assisting another student in any of the above, including assistance in an arrangement whereby any work, classroom performance, examination or other activity is submitted or performed by a person other than the student under whose name the work is submitted or performed.

III. Possible Disciplinary Sanctions:

(1) The following are the disciplinary sanctions that may be imposed by an instructor for academic misconduct:

(a) An oral or written notice of misconduct;
(b) An assignment to repeat the work, to be graded on its merits;
(c) A lower or failing grade on the particular assignment or test;
(d) A lower grade in the course;
(e) A failing grade in the course;

In addition, an instructor or the Academic Dean may recommend the following sanctions:

(f) A non-deletable failing grade in the course;
(g) Suspension from the University; (h) Expulsion from the university.

Sanctions f h are imposed by the Office of the Provost.

(2) One or more of the disciplinary sanctions listed above may be imposed for an incident of academic misconduct.

IV. Definitions

As used herein:

(1) Office of the Provost means the Provost, Vice Provost or a designee.

(2) Days means academic calendar days and excludes Saturdays, Sundays, legal holidays and days upon which the university is closed.

(3) Academic Dean means the Academic Dean or designee for the college in which the subject course is taught.

(4) Instructor refers to the Instructor of Record.

(5) Minor Disciplinary Sanction means a disciplinary sanction, identified in paragraph III (1) (a)-(e) and imposed, for academic
misconduct, upon a student by an instructor.

(6) Major Disciplinary Sanction means a disciplinary sanction, identified in paragraph III (1) (f)-(h) and imposed, for academic misconduct, upon a student by the Office of the Provost or the Academic Integrity Appeals Board upon the recommendation of the instructor or the Academic Dean or imposed at the discretion of the Office of the Provost.

(7) Notice to the student, whenever required herein, shall be e-mailed to the students official student.uml.edu e-mail address or mailed to the student by regular first class United States mail at his or her current address as maintained by the university.

V. Imposition of Disciplinary Sanctions by the Instructor:

(1) Where an instructor concludes that a student enrolled in one of his or her courses has engaged in academic misconduct, the instructor may impose one or more of the following disciplinary sanctions, as listed under paragraph III, subsections (a) through (e):

(a) An oral or written notice of misconduct;
(b) An assignment to repeat the work, to be graded on its merits;
(c) A lower or failing grade on the particular assignment or test;
(d) A lower grade in the course;
(e) A failing grade in the course.

(2) When possible, prior to imposing a minor sanction, the instructor shall notify the student that the instructor believes an act of academic misconduct has occurred, that a sanction may be imposed, and that a Notification of Academic Dishonesty Form will be filed with the Office of the Provost.

(3) Upon the imposition of a minor sanction under this section, the instructor shall notify the Office of the Provost. Notification to the Office of the Provost shall occur within 10 days, using the Notification of Academic Dishonesty Form (http://www.uml.edu/docs/notificationofacademicdishonesty_tc m18-3543.pdf). Notification to the Office of the Provost shall include identification of the student, a description of the misconduct and a specification of the sanction imposed.

(4) Within 10 days following receipt of such notice, the Office of the Provost shall provide notice of the imposed discipline to the student, the instructor and to the Academic Dean. Notification to the student shall include a statement of the misconduct, specification of the sanction imposed, a statement indicating the students right to an appeal before the Academic Dean and a link to the policy and procedures set forth herein.

(5) A student who receives notice of a disciplinary sanction imposed under this section has the right to a hearing before the Academic Dean to contest the determination that academic misconduct occurred or the disciplinary sanction imposed or both. If the student desires such a hearing, he or she must file a written request with the Office of the Provost and the Academic Dean within 10 days of receipt of notice from the Office of the Provost.

VI. Recommendation of Major Disciplinary Sanction by the Instructor:

(1) Where an instructor concludes that a student enrolled in one of his or her courses has engaged in academic misconduct in the course, the instructor for that course may recommend one or more of the following disciplinary sanctions:

(f) A non-deletable failing grade in the course;
(g) Suspension from the University
(h) Expulsion from the university.

(2) When possible, prior to the recommendation of a major sanction, the instructor shall notify the student that the instructor believes an act of academic misconduct has occurred, that a major sanction is being recommended, and that a Notification of Academic Dishonesty Form will be filed with the Office of the Provost.

(3) Upon the recommendation of a major sanction under this section, the instructor shall notify the Office of the Provost using the Notification of Academic Dishonesty Form (http://www.uml.edu/docs/notificationofacademicdishonesty_tc m18-3543.pdf). Notification to the Office of the Provost shall occur with 10 days and shall include identification of the student, a description of the misconduct and a specification of the sanction recommended.

(4) Within 10 days following receipt of such notice, the Office of the Provost shall provide notice of the recommended discipline to the student, the instructor, and the Academic Dean. Notification to the student shall include a statement of the misconduct, specification of the sanction recommended, a statement indicating the students right to an appeal before the Academic Dean and a copy of the policy and procedures set forth herein.

(5) A student who receives notice of a disciplinary sanction recommended under this section has the right to a hearing before the Academic Dean to contest the determination that academic misconduct occurred or the disciplinary sanction recommended or both. If the student desires such a hearing, he or she must file a written request with the Office of the Provost and the Academic Dean within 10 days of receipt of notice from the Office of the Provost.

(6) In the event that the student does not file a written request for an appeal within 10 days, the Office of the Provost shall review the matter with respect to the subject student and may, at his or her discretion, uphold the recommended sanction or impose a major sanction. In any event, the Office of the Provost shall, within a reasonable time, provide notice of the outcome to the student, the instructor and to the Academic Dean.
modify the sanction recommended. In any event, the Office of the Provost shall, within a reasonable time, provide notice of the outcome to the student, the instructor, and to the Academic Dean.

VII. Appeal to the Academic Dean: When an appeal to the Academic Dean is commenced in accordance with the provisions set forth in Paragraphs V(5) or VI(5), the Academic Dean shall proceed in accordance with this section to consider one or more of the disciplinary sanctions listed in paragraph IV, subsections (1) (a) through (h).

(1) Conference With Student: The Academic Dean shall offer to discuss the matter with the student. The purpose of this discussion is to permit the Academic Dean to review with the student the charges levied against him or her and to afford the student an opportunity to respond.

(2) Conference With Instructor: The Academic Dean shall attempt to discuss the matter with any involved instructor. This discussion may occur either before or after the conference with the student. It should include consultation with the instructor on the facts underlying the alleged academic misconduct and on the appropriateness of the imposed or recommended sanction.

(3) Determination that No Academic Misconduct Occurred: If, as a result of discussions under subsections (1) and (2), the Academic Dean determines that academic misconduct did not in fact occur or that the disciplinary sanction is not appropriate under the circumstances, the Academic Dean shall notify the instructor and the Office of the Provost. The Office of the Provost shall promptly thereafter notify the student and take appropriate action with respect to the student records.

(4) If, as a result of discussions under subsections (1) and (2), the Academic Dean determines that academic misconduct did occur and that one or more of the disciplinary sanctions listed under paragraph III, subsections (1) (a) through (h) is appropriate, the Academic Dean shall prepare and forward to the Office of the Provost, within 10 days, a written Finding of Misconduct which shall include identification of the student, a description of the alleged misconduct, a summary of evidence, findings of fact and a specification of the disciplinary sanction imposed.

VIII. Appeal to the Office of the Provost

The decision reached by the Academic Dean may be appealed to the Provost Office of the Provost if the student believes that he or she did not receive due process.

Grounds for Appeal of Due Process

An appeal to the Office of the Provost shall be limited to a review of supporting documents and the process and outcome of the Academic Dean or designee for one or more of the following grounds:

- Bias by the Instructor, Academic Dean, or designee substantially influenced the outcome of the process to the detriment of the student.
- New, relevant information has come to light that was not available at the time of the hearing by the Academic Dean.
- Unusual procedures were followed or the procedures outlined herein were not followed, to the detriment of the student.
- If the student desires such a hearing, he or she must file a written request with the Office of the Provost and the Academic Dean within 10 days of receipt of notice from the Office of the Provost. The request must be based upon the Grounds for Appeal listed above.

(2) When an appeal to the Office of the Provost is commenced in accordance with this paragraph, the Office of the Provost shall review the matter with respect to the subject student and may, at his or her discretion, uphold, vacate or modify the discipline imposed or direct such appeal to be heard by the Academic Integrity Appeals Board. In any event, the Office of the Provost shall, within a reasonable time, provide notice of the outcome to the student, instructor, and to the Academic Dean.

(3) In the event that the student does not file a written request for an appeal within 10 days, the Office of the Provost shall review the matter with respect to the subject student and may, at his or her discretion, uphold, vacate or modify the discipline imposed. In any event, the Office of the Provost shall, within a reasonable time, provide notice of the outcome to the student, instructor and to the Academic Dean.

IX. Role of the Academic Integrity Appeals Board:

(1) The Academic Integrity Appeals Board is an ad hoc committee appointed by the Office of the Provost and consists of a minimum of three faculty members chosen by the Office of the Provost with no two members selected from the same College; the board shall not include a faculty member from within the department initiating charges of academic dishonesty. The Board is chaired by the Office of the Provost who shall vote only in the case of a tie. [Or One member shall serve as Chair at the direction of the Office of the Provost. The Chair shall vote only in the case of a tie.]

When an appeal is directed to the Academic Integrity Appeals Board by the Office of the Provost in accordance with the provisions set forth in Paragraphs VIII, the Academic Integrity Appeals Board shall schedule the hearing, within a reasonable time period, at a time that is mutually agreed upon by the student, Office of the Provost and members of the Academic Integrity Appeals Board.

(2) Reasonably in advance of the hearing, the Academic
Integrity Appeals Board shall obtain from the Academic Dean, in writing, a full explanation of the facts upon which the determination of misconduct was based and shall provide to the student a copy of the policy and procedures set forth herein.

(3) The hearing before the Academic Integrity Appeals Board shall be conducted in accordance with the following requirements:

(a) The Academic Integrity Appeals Board shall consider relevant evidence including documentary evidence and testimony of the instructor, student, Chair and/or Dean where appropriate.

(b) The student shall have the right to be heard and to present relevant evidence, including documentary evidence and the testimony of witnesses, in his or her own behalf.

(c) The Academic Integrity Appeals Board shall maintain a record of the hearing including any and all pleadings and documentary evidence presented.

(d) The Academic Integrity Appeals Board shall prepare written findings of fact and a written statement of its decision based upon the record of the hearing.

(e) The Academic Integrity Appeals Board may find academic misconduct and impose a sanction of suspension or expulsion only if the proof of such misconduct is clear and convincing. In other cases, a finding of misconduct must be based on a preponderance of the credible evidence.

(f) The Academic Integrity Appeals Board may impose a disciplinary sanction that differs from the recommendation of the Academic Dean.

(g) The instructor or Academic Dean may be witnesses at the hearing conducted by the Academic Integrity Appeals Board, but shall not have responsibility for conducting the hearing.

(4) Determination that No Academic Misconduct Occurred: If, after the hearing, the Academic Integrity Appeals Board determines that there is insufficient evidence that academic misconduct occurred or that no disciplinary sanction is appropriate under the circumstances, the Academic Integrity Appeals Board shall notify the instructor, the Academic Dean and the Office of the Provost. The Office of the Provost shall promptly thereafter notify the student and take appropriate action with respect to the student records.

(5) Process Following Determination by the Academic Integrity Appeals Board that Academic Misconduct Occurred:

(a) If, after the hearing, the Academic Integrity Appeals Board determines that academic misconduct did occur and that one or more of the disciplinary sanctions listed under paragraph III, subsections (1) (a) through (h) is appropriate, the Academic Integrity Appeals Board shall prepare and forward to the Office of the Provost, within 10 days, a written Finding of Misconduct which shall include identification of the student, a description of the misconduct and a specification of the disciplinary sanction to be imposed.

(b) Within 10 days following receipt of the written Finding of Misconduct from the Academic Integrity Appeals Board, the Office of the Provost shall provide written notice of the imposed discipline to the instructor, the Academic Dean and the student.

Academic Standing

- Warning Notice
- Probation
- Academic Dismissal and Reinstatement
- Graduate Fresh Start

GPA Minimum

No more than 6 course credits of grades below a B may be counted toward the master’s degree; no more than 9 credits of the same grades may be counted toward the doctorate. No graduate degree will be awarded to any student whose overall cumulative grade point average falls below 3.0.

Academic Standing

Graduate academic standing is run three times per year - Fall, Spring and Summer.

The consequences of the academic standing of warning or suspension will not apply for students completing degree requirements for that semester.

Warning Notice

Any graduate student whose semester grade point average (GPA) falls below 3.0 will automatically receive a warning notice which will also be sent to the graduate coordinator, and filed with the student’s record in the Registrar’s Office. The student will be strongly advised to meet with the graduate coordinator or his/her designee within 30 days of receipt of the warning notice and develop an academic plan to bring his or her GPA to a level above 3.0.

Probation

Any graduate student whose semester GPA falls below 3.0 for a second time, will automatically receive a letter of probation from the Vice Provost for Graduate Education. Copies of the
letter will be sent to the graduate coordinator, chairperson, college dean, and also placed on file with the student’s record in the Registrar’s Office. Within 30 days, the department graduate committee, chaired by the graduate coordinator or his/her designee, will meet with the student and decide whether to recommend loss of degree candidacy. Such a decision or other course of action will be fully documented in writing with copies sent to the chairperson, and college dean. A recommendation of loss of degree candidacy and dismissal are subject to the approval of the college dean.

Academic Dismissal and Reinstatement

Any student whose semester GPA falls below 3.0 for a third time, and whose cumulative GPA is below 3.0, will automatically be dismissed from his or her graduate program and the University. Reinstatement will be considered if the student provides a detailed justification and academic plan concerning how he or she will correct this academic deficiency. The plan must be attached to a Graduate Academic Petition and approved by the appropriate graduate coordinator and/or department chair of the degree granting department, and must be filed with the University Registrar. In addition, the student must submit a personal statement which addresses personal and professional growth during the period of time in which the student was absent from the University which supports the student’s potential for academic success. If admitted, credits and GPA start at zero. Transfer courses may count towards the degree, but are not included in the GPA.

All courses taken and grades achieved during earlier periods of enrollment will appear on the transcript along with a notation that they are not included in the cumulative grade point average. Once this change is made to the academic record, the change can NOT be reversed.

Acceptance of Foreign or American Master’s Degree toward Doctoral Requirements

Students accepted into a doctoral program who hold a master’s degree in the same or a closely related discipline from a U.S. or foreign academic institution will have their transcripts and supporting documentation reviewed by the department graduate committee.

The committee may choose one of the following actions:

1. Approve all coursework and thesis for the master’s degree up to the total number of credits granted by the University of Massachusetts Lowell department for its master’s degree, and thereby require the student to complete only “beyond the master’s” course/thesis credits for the doctorate.

2. Accept the U.S. or foreign master’s degree, but because of deficiencies in the student’s master’s program, require a limited number of graduate courses to be added to the total credits required for doctoral degree completion “beyond the master’s”.

3. Require that a student with a U.S. or foreign master’s degree obtain a University of Massachusetts Lowell master’s degree before proceeding to the doctorate.

All coursework for U.S. or foreign master’s degrees considered for approval by the department must be at a grade level of B or
better. Official, documented verification of the degree awarded must also be provided.

Commencement

Conferring of Degrees

Diplomas are awarded three times a year:
1. In June for students completing degree requirements during the spring semester.
2. In October for students completing degree requirements during the summer term.
3. In February for students completing degree requirements during the fall semester.

Individuals who wish to submit verification of degree completion to employers or to graduate schools during the period between the end of their final grading period and the awarding of diplomas may obtain a letter of completion from the Registrars Office.

Academic Honors

Due to the many fields and diversity of study at UMass Lowell, academic honors for graduate students are discipline-based and vary within respective colleges. Honors for graduate students are not listed on transcripts.

Replacement Diploma

Replacement diplomas may be ordered through University Alumni Relations for an additional fee.

Course Credit

Maximum Semester Credit Limit

Graduate Credit for Undergraduate Courses

Undergraduate Credit for Graduate Courses

Maximum Semester Credit Limit

The usual course load for full-time graduate students is 9 credits/semester. Depending upon the program requirements and abilities of the student, individuals may carry more than 9 credits each semester. However, the absolute maximum number of total credits (combined undergraduate and graduate) for which a graduate student will be allowed to register is 18 credits/semester. The maximum number of thesis or dissertation credits for which a student may enroll in any semester is nine credits.

During the summer term students are classified as full-time when they are registered for a minimum of 9 credits which may combine courses/credits from the different sessions within the summer term. Students who enroll in only one of the accelerated summer session (summer I or summer II) may be considered by the institution as the equivalent to full-time for the specific time period of that session only when registered for a minimum of 6 credits. This is for enrollment purposes only. Please note: Financial aid, veterans benefits or other types of aid define 9 credits for full-time study.

Navitas Summer Pathway Program

The University of Massachusetts Lowell (UMass Lowell) offers a 10-week summer session to its Pre Undergraduate and Pre Masters international students. These students are admitted into a Bachelors or Masters program with the condition of a preparatory semester(s) which could encompass the summer session. The Pre Undergraduate and Pre Masters summer session consists of intensive academics of 18-22 clock hours per week in English, Mathematics and Cultural Support.

Graduate Credit for Undergraduate Courses

UMass Lowell courses at the 400 level are designed for seniors but under certain circumstances may be taken by graduate students for graduate credit. A maximum of 6 credits of 400 level courses may be used for credit toward the graduate degree with the permission of the degree granting department. Three hundred level courses and below are never counted toward a graduate degree. If a graduate student takes certain undergraduate courses to make up for background deficiencies or to satisfy language requirements, the course credit hours are not used as part of the graduate degree program but will appear on the graduate transcript.

Undergraduate Credit for Graduate Courses

A qualified junior or senior may take a course at the 500 level for undergraduate credit in accordance with the policy and procedures of the department or college in which the course is offered. The grade received in any such course is used in
calculating the undergraduate’s cumulative grade point average. Counting of graduate credits for both the bachelors and masters degrees is subject to departmental requirements. At no time may grades computed in an undergraduate GPA be used toward a graduate GPA.

Course Designations

- Course Numbering System
- Continuing Graduate Research
- Course Prefixes
- Audit

Maximum Semester Credit Limit

The usual course load for full-time graduate students is 9 credits/semester. Depending upon the program requirements and abilities of the student, individuals may carry more than 9 credits each semester. However, the absolute maximum number of total credits (combined undergraduate and graduate) for which a graduate student will be allowed to register is 18 credits/semester. The maximum number of thesis or dissertation credits for which a student may enroll in any given semester is nine credits.

Course

Numbering System and Designation:

- 4000-4999 - Undergraduate courses usually designed for juniors or seniors; no more than six credits may be taken for graduate credit with the permission of the graduate coordinator.
- 5000-5999 - Courses for graduate credit, but which may be taken by advanced undergraduates with the advisor’s permission.
- 6000-6999 - Graduate courses which are open only to graduate students.
- 7000-7999 - Seminars, special topic courses, projects, or thesis research for advanced candidates in master’s and doctoral degree programs.

Each course offering is designated by a four letter prefix and a four-digit course number (e.g., BIOL.5290).

Continuing Graduate Research

Once a student has completed the required number of credits for master’s or doctoral thesis/dissertation research with grades of PR or S (see summary of degree credit requirements), he or she will not be allowed to sign up for additional thesis/dissertation research credits. Instead, if required for teaching/research assistantships or immigration/visa purposes, the student may enroll in 3, 6, or 9 credits of Continuing Graduate Research designated _ _763, 766, or 769_ _ _ where the first two blanks represent the departmental designation, 3, 6, and 9 indicate the respective number of credits, and the last three blanks are the standard numbers which code to a particular faculty member in the department.

The two digit college prefix identifies a college department and/or special area. The three-digit course number identifies the course level.

Course Prefixes

Each college department and/or special subject area has been assigned an identifying two digit number within the numerical ranges specified as follows:

- Education - EDUC
- Engineering - CHEN, CIVE, EECE, ETEC, ENVE &MECH, MTEC, ENGY, ENGN, PLAS
- Health - PUBH &AREO, HSCI, NURS, DPTH, NUTR, HSCI, MLSC, EXER
- Humanities/Social Sciences, Fine Arts - AMST, LGST, ENGL, HIST, CRIM, PHIL, POli, PSYS, ASP, SOCI, ECON, WLFT, WLGE, WLIT, WLAR, WLKH, WLCH, WLPO, WLAN, WLSI, WLSP, WLLA, ARHI, FAHS &ARTS, MUTH, MUAP MUED, MUHI, MUPF, MUEN, MUBU, MUSR, AEST
- Management - ACCT, FINA, MKTG, POMS, MIST, ENTR, MGMT, BUSI
- Science and Math - BIOL, LIFE, CHEM, ATMO, ENVI, GEOL, INFO, COMP, MATH, MSIT, PHYS, POLY, RADI
- Biomedical Engineering - BMBT
- Marine Science - im

Audit

A graduate student may, upon approval of the advisor and the instructor, register for a course on an audit basis, but must pay the full amount of tuition and fees. An audit student is not required to take tests or the final examination. A change in registration from audit to credit or credit to audit must be done during the add/drop period. Under no circumstances can a
course taken for audit be given credit at a later date.

Equal and Fair Treatment

Under federal and state laws, all students are protected from discrimination based on race, color, religion, national origin, disability, gender, (including sexual harassment), age, sexual orientation, marital or veteran status. If you feel that you have been discriminated against based upon any one of these areas, you must contact Equal Opportunity and Outreach (EOO). These protections also include retaliation for filing complaints of discrimination. Concerns regarding course offerings, instructor and student attitudes should also be directed to EOO staff at 978-934-3565.

Students are responsible for adhering to the policies of the University regarding equal and fair treatment.

Graduate Grading Policies

Grading System
Grade Exclusion
Grades for Projects, Theses/Dissertations and Seminars
Incompletes
Course Listing on the Graduate Transcript
Audited Courses
Grade Appeal Process

Grading System

The grading system uses grades:

- A+(4.0), A(4.0), A-(3.7)
- B+(3.3), B(3.0), B-(2.7)
- C+(2.3), C(2.0)
- F(0.0)
- FX (0.0) Failed due to Academic Misconduct (May not be replaced or deleted)

The following special grades are also used:

- INC (Incomplete)
- S (Satisfactory, B or better)
- U (Unsatisfactory) for projects, theses/dissertations, and seminars only
- AU (Audit)
- W (Withdrawal from a course or from the University)
- X (Withdrawal because of illness or personal emergency)
- Y (University withdrawal for non-academic reasons)
- Q (Never attended but did not withdraw. This grade requires a letter from the instructor to the University Registrar stating the student never attended the class.)
- PR (In Progress for theses or dissertations)
- NC (No Credit for theses or dissertations where no progress has been made).

A student registering for research will do so each semester up to the total number recommended. No graduate degree will be awarded to a student whose cumulative average for course work in his or her program is below 3.0. Some programs may require a higher grade point average for graduation. The cumulative grade point average is computed from all graduate level courses taken for a grade at the University of Massachusetts Lowell.

Grade Exclusion

A request may be submitted to omit a specific course (grade and credits) from the GPA for matriculated students. Such a request must be presented on an Academic Petition, provide detailed justification for the specific action, and certify that the action has been approved by a majority of the departmental graduate committee. Only one grade exclusion in total, including a grade for a repeated course, will be permitted for each degree sought by the student as recommended by the departmental graduate committee. However, the official transcript will list grades for all undergraduate and graduate courses taken at the University with the notation that the grade and credits are excluded from the GPA. Once a grade exclusion has been processed it may not be reversed. Additionally, grade substitutions are not permitted.

Grades for Projects, Theses/Dissertations and Seminars

- Projects (Enrollment Restricted to Matriculated Graduate Students):
  - Only one of three grade designations will be allowed for projects:
    - S for projects completed at a satisfactory level
    - U for unsatisfactory completion of a project (no credit toward degree requirements)
    - INC Incomplete
- Theses/Dissertations (Enrollment Restricted to Matriculated Graduate Students):
  - PR will be given for thesis/dissertation research if the student has made satisfactory progress during the semester.
  - NC will be given if the student has made no progress during the semester on thesis/dissertation research.
  - U Unsatisfactory (no credit toward degree requirements)

After successful defense of the thesis/dissertation, a grade of "S" (Satisfactory) will be given for all semesters of the thesis/dissertation research. Only the Registrar's Office can issue this grade.
• Seminars
  
  S - Satisfactory
  
  U - Unsatisfactory (no credit toward degree requirements)
  
  INC - Incomplete

Under no circumstances will letter grades (A, B+, etc.) be allowed for projects, theses/dissertations, or seminars.

Incompletes

If, because of unusual circumstances, a student is unable to meet all the requirements of the course by the end of a semester, the grade of Incomplete (INC) may be given. Responsibility for making arrangements with an instructor to complete all outstanding coursework rests entirely with the student, who must complete all outstanding coursework by the date listed on the Graduate Academic Calendar (https://www.uml.edu/Registrar/Calendars/default.aspx) (www.uml.edu/Registrar/Calendars/default.aspx) (www.uml.edu/Registrar/Calendars/default.aspx). Under no circumstances will a student be allowed to graduate with incomplete(s) on his or her transcript.

Prior to completion of the missing work, the incomplete will not be computed into the grade point average (GPA). If the student completes the missing work within the specified period, the instructor must evaluate the work and turn in a grade change form to the Registrar’s Office before the deadline for instructors to submit final grades for incomplete courses as specified on the Graduate Academic Calendar (https://www.uml.edu/Registrar/Calendars/default.aspx) (www.uml.edu/Registrar/Calendars/default.aspx) (https://www.uml.edu/Registrar/Calendars/default.aspx). Under no circumstances will a student be allowed to graduate with incomplete(s) on his or her transcript.

1. The student may file an appeal of his or her complaint, in writing, to the instructor within 30 days after a final grade is posted to the student’s record. The instructor must respond within 14 days of receiving the appeal.

2. If the student remains dissatisfied by the decision of the instructor under step (1), he or she may, within 14 days after formal receipt of the instructor’s final decision, appeal, in writing, to the chairperson of the program (or the Dean of the College if the instructor is the chairperson) in which the course or other exercise or registration from audit to credit or credit to audit must be done during the add/drop period. Under no circumstances can a course taken for audit be given credit at a later date.

**Graduate Clearance**

To apply for Graduation, graduate students must fill out a Declaration of Intent to Graduate (DIG) form and have it approved by their Graduate Coordinator and (if applicable), Thesis/Dissertation Advisor.

The Registrar’s Office will verify number of credits, final grades, GPA requirements an if applicable submission of thesis/dissertation prior to awarding the degree.

**Additional Requirements for Students Completing a Thesis or Dissertation**

All students who are completing a thesis or dissertation must also submit one clean copy (NOT the original) of the signature page for the thesis or dissertation. The signature page must be signed and dated by the thesis/dissertation advisor and all committee members. Copies of the Thesis or Dissertation must be submitted to the Library for binding and microfilming by the deadline date. In addition, doctoral students are required to complete the "Survey of Earned Doctorates" online, you will be emailed the information when your submit your DIG form.

**Graduate Grade Appeal Process for Students**

The instructor of the class is the primary authority with respect to a students proficiency and final grade in that course. A student who believes that his or her final grade reflects an erroneous, capricious, arbitrary, or prejudiced academic evaluation may appeal the grade. The academic judgment used in determining the merits of the grade to be awarded shall not be reviewable. This process does not apply to cases of academic dishonesty, which are adjudicated through the "academic dishonesty process."

A graduate student may, upon approval of the advisor and the instructor, register for a course on an audit basis, but must pay the full amount of tuition and fees. An audit student is not required to take tests or the final examination. A change in
activity is offered. The chairperson must respond within 14 days of receiving the appeal. The decision may be: (a) that the appeal be dismissed; (b) if there is demonstrable evidence of an erroneous, arbitrary, capricious, or prejudiced academic evaluation, then the chairperson will recommend appropriate remedies that a grade be changed or the student be allowed an opportunity to retake an examination or other exercise; or (c) that another appropriate remedy be administered.

3. If no satisfactory resolution is reached in step (2) then the student or the instructor may appeal, in writing, to the Dean of the College within 14 days after formal receipt of the chairperson’s final decision.

4. The Dean, after discussion with the appropriate parties, may resolve the grievance by agreement or render a decision within 21 days of receipt of the written appeal. The decision may be: (a) that the appeal be dismissed; (b) if the student provides demonstrable evidence of an erroneous, arbitrary, capricious, or prejudiced academic evaluation, then the Dean will recommend appropriate remedies that a grade be changed or the student be allowed an opportunity to retake an examination or other exercise; or (c) that another appropriate remedy be administered.

5. The decision of the Dean is final and not subject to additional appeal by either student or instructor. The appeals process ends at this step.

6. The Department chair or his/her designee is responsible for keeping a record of the appeal on file in accordance with University Records Retention Policy.

Registration and Enrollment Policies

Continuous Registration
Changing Program

Registration and Enrollment Policies

Continuous Registration
Dropping Classes and Refund Policy
Changes in Registration
Change of Program

Continuous Registration
In order to maintain continuity of enrollment, a matriculated student must register each fall and spring until the program of study is complete and the degree has been earned. A graduate student who plans to receive his/her graduate degree in the summer term (awarded in October) must register during the previous summer session in order to maintain continuous matriculation.

If for any reason a student is not registered for a course (because of a leave of absence or because the thesis or dissertation has been successfully defended, but the final manuscript has not been submitted to the library), the student must register for CONT.6010 (Continued Matriculation) in order to maintain continuous registration. Since students are not allowed to register if they have outstanding financial obligations to the university, it will be necessary for them to clear their financial record in order to register for Continued Matriculation.

Continued Matriculation does not entitle a student to any use of university facilities, services or resources, but only maintains an active record and provides for appropriate mailings. Students who are engaged in academic work necessary to complete their thesis or dissertation, participate in a required full time internship or curricular practical training, or otherwise engage in or make use of University facilities or other resources must register for a minimum of 1 credit. (Note: Specific internship/CPT requirements will vary by department and students may be required to register for 3, 6, or 9 credits depending upon their program of study.)

The rules regarding the Statute of Limitations for the completion of master’s and doctoral degrees still apply to students registered for Continued Matriculation.

All international students on F-1 or J-1 visas must register as full-time students (9 credits) each semester until their degree requirements are completed. Any variance from this policy must be approved by the International Student and Scholars Office.

A student who fails to maintain continuous matriculation loses the status of a degree candidate and must reapply to the Graduate Admissions Office for readmission and for renewal of candidacy.

Dropping Classes and Refund Policy

Graduate students may drop courses during the first ten days of classes and receive a refund. No refund will be given after these time periods. To formally withdraw from a course during this period, or thereafter, the student must drop the course through SiS self service. If the student fails to officially drop a course, he or she will remain enrolled and be required to pay for tuition and fees. In
addition, if the student does not drop a course and does not attend classes, he or she will receive an "F" on the official transcript.

Changes in Registration

Courses may be added or dropped through self-service in SiS (https://www.uml.edu/Enrollment/SiS/default.aspx). Students who wish to add a course during the sixth through 10th day of classes will need a permission number from the instructor of the course. Permission numbers are not needed to drop a course. In addition, students may change from audit to credit or from credit to audit during this period. Courses dropped during the first 10 academic days will not appear on the student's permanent record. No new courses may be added and no course may be changed from audit to credit after the tenth academic day. Thereafter, a student wishing to drop courses must do so by the date indicated in the Graduate Academic Calendar (http://www.uml.edu/Registrar/Calendars/default.aspx).

No refund of tuition and fees is allowed after the tenth day of the semester. The grades for courses dropped after the tenth day will appear as W on the student's record.

Change of Program

A graduate student wishing to change departments or transfer to a doctoral program upon completion of his or her master's degree must follow the steps listed below:

1. No transfers will be considered until the student has been in the original department in which he or she was accepted for at least one semester.
2. All sections of a new application sheet must be completed.
3. If so desired, the student may request that all test scores, letters of recommendation, etc., in his or her original file be used as part of his or her new application package.
4. The student must specify on the application form when his or her master's degree will be completed and when he or she will actually begin doctoral studies (for students applying to a doctoral program).
5. A check made payable to University of Massachusetts Lowell to cover the application fee must be included, or payment must be made by credit card when applying online.

Right of Access to Student Records

Access

The Family Educational Rights and Privacy Act of 1974 (FERPA) grants any student currently in attendance, or any former student, the right of access to inspect or review his or her educational files, records, or data. Students who wish to inspect their records must file a Right of Access form with the office or department in which the desired record is kept. Right of Access forms are available in the Office of Student Services or through student self service. Wherever practical, within ten days of receipt of the Right of Access form, the office or department will notify the student as to the date, time, and location when the desired record will be available for inspection. If a student believes that circumstances effectively prevent inspecting and reviewing the records at the designated date, time, and location when the desired record will be available for inspection. If a student believes that circumstances effectively prevent inspecting and reviewing the records at the designated date, time, and location when the desired record will be available for inspection, he or she may request alternative inspection arrangements or copies of the records instead, subject to a fee for copies. The Dean of Students or the Deans designee will consider the request.

University Student Records

The University maintains the following general records on students:

**Admission File** - Admissions Office (https://www.uml.edu/Grad/default.aspx) - www.uml.edu/grad

**Permanent Academic Records** - Registrar’s Office (https://www.uml.edu/Registrar/default.aspx) - www.uml.edu/registrar


**Health Records** - Health Services Office - www.uml.edu/student-services/health/

**Account and Payment Records** - Student Financial Services Office (https://www.uml.edu/thesolutioncenter/bill/tuition-fees/default.aspx) - www.uml.edu/Tuition-fees/
The file of each student must contain a record of all non-University affiliated individuals or organizations requesting access to information in the file, plus statements that specify the legitimate educational purposes for which access was requested.

Except as otherwise permitted under FERPA, information or records concerning individual students may not be released to any individual or agency without the students written permission. Any request for such information received without such written permission will not be honored and will be returned with a request for a written release from the student.

Release of Student Records

FERPA allows release of a students education records without the students written permission under certain circumstances, including the following:

1. To personnel of the University, i.e., faculty, administrators, or staff for legitimate educational purposes only.
2. To officials of other institutions in which the student seeks admission or intends to enroll, provided that the student is notified of the release.
3. To federal or state officials in connection with the audit and evaluation of programs funded by federal or state governments, with the enforcement of legal requirements that relate to such programs, or in connection with the students application for or receipt of financial aid.
4. To accrediting organizations in order to carry out their accrediting functions.
5. To parents who claim the student as a dependent on their IRS statement.
6. In connection with an emergency, to appropriate persons if revealing such information is necessary to protect the health or safety of the student or other persons.
7. In response pursuant to a validly issued subpoena, subject to advance notification of the student unless such notice is prohibited by court order.
8. As otherwise permitted under or consistent with FERPA.

The following data are considered informational in nature and may be released without the permission of the student, at the discretion of the University: students name, major, acknowledgement of a student’s participation in officially recognized activities and sports, weight and height of members of athletic teams, date(s) of attendance; degrees, certificates, awards received; the most recent previous educational agency or institution attended by the student and appointment as a Resident Assistant or Community Development Assistant. For graduate students who are teaching credit courses, work department, office address, and employment category are also defined as directory information.

Release Exclusions

Any student who wishes to have some or all of his or her directory information excluded from release by the University without prior permission must complete the appropriate selections available thru student self service.

Additional Information

Any student who believes that his or her records are inaccurate or misleading may request a hearing with the Dean of Students to discuss the contents of such records and whether or not they need to be changed. Additional information on procedures or policies relating to University compliance with the Family Rights and Privacy Act can be obtained from the Office of Student Services or the Registrar’s Office.

Statute of Limitations (Time Limit for Degree Completion)

A graduate degree, at either the master’s or doctoral level, implies a significant mastery of a discipline within a specified time period. A well designed curriculum is not a mere collection of classes that add up to a set number of credits. It is, rather, a coherent selection of courses with an overall educational achievement that is greater than the sum of its parts. However, this coherence is lost if the program is completed over a long time span.

Master’s degree requirements must be completed within a five-year period from the semester of admission. For those master’s programs requiring 45 or more credits, the time limit is six years.

The doctoral degree must be completed within an eight-year period beginning with the semester of admission as fully matriculated or matriculated with conditions.

A student may obtain an extension of one year by filing an Academic Petition.
signed by his or her coordinator, department chair, and college dean, and which is then submitted to the Registrar’s Office.

Time Extension Appeal Procedure

In exceptional cases, an additional extension may be granted by the Graduate Policy and Affairs Committee (GPAC). In this case, the student must submit an Academic Petition, a letter of explanation accompanied by a detailed schedule for degree completion, and a letter from the student’s coordinator or thesis advisor in support of the request.

Transcripts

In order to obtain a transcript, a student may print an unofficial transcript or order an official copy through self-service in ISIS (https://www.uml.edu/Enrollment/SiS/default.aspx). If ISIS is not available, a transcript may be ordered by filling out a Transcript Request Form (www.uml.edu/docs/transcriptrequest_tcm18-3516.pdf) and submitting it to the University of Massachusetts Lowell Registrar’s Office at 883 Broadway Street, Lowell, MA 01854.

Course Listing on the Graduate Transcript

All graduate courses for which a student registers (including repeated courses) are listed on the transcript and are used to calculate the student’s grade point average whether or not they are taken to fulfill degree requirements. In addition, undergraduate courses which a student takes to fulfill prerequisite requirements before or during matriculation in a graduate program, or courses taken for personal enrichment, will also be listed on the transcript.

Transfer Credit

The following are minimal guidelines for transfer of credit. Individual departments are free to impose more stringent requirements. Only courses completed elsewhere within five years prior to the date of admission to a graduate degree program at the University of Massachusetts Lowell may be considered by the faculty of the department for transfer in accordance with the following regulations.

1. A maximum total of 12 graduate credits earned with a grade of B or better may be transferred to a doctoral program. The limits of 12 credits toward a masters and 24 toward a doctoral degree do not apply to any credits earned at UMass Lowell by students while in a non-degree or undergraduate BA/MA or BS/MS status, provided the courses were taken within the department offering the masters or doctoral degree.
2. Grades of C or better for courses taken at UMass Lowell when the student held non-degree status may also be transferred (by Academic Petition) into a degree program. However, the 6 and 9 credits with grades below a B (graduation limit) for master’s and doctoral degrees, respectively, (see Retention Policy) and calculation of the cumulative grade point average based on all graduate courses taken at the University (see Academic Grades) remain in effect.
3. An official transcript and description of the course(s) must be submitted with the written request.
4. The courses presented must be from an accredited U.S. or Canadian institution authorized to grant graduate degrees.
5. The courses presented for a master’s degree must not have been used in earning another master’s degree.
6. The courses presented must be appropriate to the degree program for which the applicant is applying.
7. The courses presented must be graduate level.
8. Transfer credit may not be granted for research seminars, clinical courses, practica, internships, or special projects.
9. Transfer credit from another U.S. or Canadian institution must not exceed equivalent course credit (typically 3) at UMass Lowell, and will be based on UMass Lowell’s standard of 37.5 semester contact hours being equal to 3 credits. One and two course credit transfers will also be considered providing they are proportional to the 37.5 semester contact hour standard.
10. Students who wish to transfer credit must file (within the first semester of matriculation) the Academic Petition form available from the Registrars Office.
11. With the approval of the department, a maximum of 6
University Appeals Process Regarding Academic (Non-Grade Appeal and Non-Misconduct) Issues

The underlying purpose of the University's appeals procedure is to guarantee due process and to protect the rights of both students and faculty in graduate programs.

The following procedure provides a mechanism for formal adjudication of any academic issues (non-misconduct and not related to grade appeal) which may arise. (For information regarding the process for grade appeals, see the Graduate Grade Appeal Process.)

Responsibility for initiation of each of the steps belongs to the appellant.

Step 1. If an informal discussion between the student and the instructor or individual with whom the student has a conflict does not resolve the issue, the resolution of an academic appeal of a student should begin within the department. The first step in the resolution of a problem or disagreement should be a discussion between the instructor, the student, and his/her faculty advisor or the coordinator of the program.

Step 2. If the matter cannot be resolved after such a discussion, a formal appeal, in writing and containing the pertinent facts, should be presented by the student to the chairperson/head of the department within two months of the occurrence that precipitated the appeal. Any appeal made outside this time period shall not be considered by any University body. The chairperson of the department will appoint committee composed of faculty members in the department. Within 7 working days, this committee shall convene and discuss the appeal with the student and the instructor, coordinator, or individual with whom the student has a conflict. The student may be accompanied by his or her faculty advisor or a faculty representative during the discussion of the appeal. The committee, by a majority vote after deliberations with only members of the committee present, shall render a decision within five working days and notify the appropriate parties in writing with the rationale for the decision included in the notification.

Step 3. If the decision of the departmental committee is not satisfactory to all parties, the appeal may be forwarded to the College Dean within two weeks of the decision of the departmental committee. The Dean will appoint a college committee composed of area coordinators of all graduate programs within the college or a suitable committee of faculty. The committee will be chaired by the college dean, or his/her designee. Within seven working days, the committee shall convene and discuss the appeal with the student. At this level the student may request to be present at the committee meetings, that discussions or proceedings be tape recorded, and that a transcript be prepared from the tape. The request for a recording must be made at the time the appeal is made to the college committee. The college committee shall render a decision by majority vote after deliberations with only members of the college committee present within five working days and notify the appropriate parties in writing with the rationale for the decision included in the notification.

Step 4. If the decision of the college committee is not satisfactory to all parties, the appeal may be forwarded to the Graduate Policy and Affairs Committee (GPAC) within ten working days after the decision of the college committee. The committee shall convene within 10 working days after the GPAC chairperson has received a written request for a hearing from the appellant, and discuss the appeal with the student and faculty advisor or representative. A request for recording and preparing a transcript of the discussions with the student present may be made at the time of appeal. The committee shall render a written decision within five working days and notify the appropriate parties. The decision of the Graduate Policy and Affairs Committee shall be final, and the information accumulated during the appeal procedure shall be forwarded to the Provost to be kept on file. If any decision involving the awarding of a degree is made and the official deadline for graduation exercises has passed during the appeal, the degree date will reflect the initiation of the appeal.

The above time periods define working days as days when classes are in session for the fall and spring semesters. Efforts will be made to honor the same time periods during intercession and June - August although some flexibility must be accepted by the appellant because of potential difficulties in assembling committee members during these periods.

The GPAC chairperson may modify the Step 4 hearing time framework at his/her discretion to coincide with regularly scheduled GPAC meetings. In either of the above cases, the appellant must be notified in writing by the hearing officer (along with an explanation) of any modification of the hearing time schedule. The chairperson may recommend that final voting/discussion of Step 4 cases be done in Executive Session with only committee members present.
Students

Academic Dishonesty - Academic Integrity Policy

Administrative Dismissal from the University

Administrative dismissal may be invoked when a student fails to comply, after due notice, with an administrative regulation of the University. Examples of some conditions which justify administrative dismissal are listed in the Undergraduate Catalog at www.uml.edu/catalog/undergraduate/policies/administrative_dismissal.aspx (https://www.uml.edu/catalog-AY16/pdf/Undergraduate.pdf) and apply to all students, undergraduate and graduate.

Non-Academic Misconduct


Withdrawal Policies

Withdrawal from a Course
 Withdrawal from the University

Withdrawal from a Course

A student finding it necessary to withdraw from a course must do so within the time specified in the graduate academic calendar (https://www.uml.edu/Registrar/Calendars/default.aspx) (www.uml.edu/Registrar/Calendars/default.aspx). The student's permanent record will indicate a grade of W for the course(s) from which he or she has withdrawn unless the withdrawal has taken place within the first 10 class days of the semester during which time no record will be kept. (See Dropping Classes and Refund Policy in this Catalog for information on dropping a course.)

Withdrawal from the University

A student who wishes to withdraw from the University must submit his/her request in writing to the Registrar’s Office. This procedure ensures that the student’s academic and financial obligations are cleared before leaving the University. If a student officially withdraws from the University by the withdrawal date indicated in the graduate academic calendar, the permanent record will indicate a grade of W. If the student fails to follow the official withdrawal procedure and does not withdraw in good standing, the student will not be permitted readmission to a graduate program at the University except under extenuating circumstances.

All previous application materials will remain on file for a two year period. At any time during this period, a student who has officially withdrawn may request readmission by completing and submitting only the cover page of the graduate application and paying the application fee. After two years, a student must file a new, complete application and submit the appropriate fee to the Graduate Admissions Office (https://www.uml.edu/Grad/default.aspx) (www.uml.edu/grad (https://www.uml.edu/Grad/default.aspx)) in order to be readmitted.
Francis College of Engineering

The education of engineers in state-of-the-art areas of advanced technology and the UMass Lowell’s commitment to national and regional economic development are the major premises upon which the graduate programs in the College of Engineering are based. These programs are intended to produce engineers whose education not only develops expertise in the design, development and production of products, but also an understanding of the management involved in the creation of new products, companies and service organizations. Thus, the graduate programs in engineering are intended to educate engineers capable of keeping abreast with the rapidly changing technology that characterizes the high technology economy of the Northeast and for research careers in academia, industry and government. These graduate programs lead to degrees of Master of Science in Engineering, Master of Science, Doctor of Philosophy, and Doctor of Engineering. The College is led by Joseph Hartman (https://www.uml.edu/Engineering/faculty/Hartman-Joseph.aspx), Ph.D., Dean of the Francis College of Engineering (http://www.uml.edu/Engineering/default.aspx). The graduate programs for the College are overseen by James A. Sherwood, Associate Dean of Graduate Studies.

On this page you will find:

- Graduate Programs Offered
- Common Admission Requirements
- Common Doctoral Degree Requirements
- Dissertation Proposal
- Nontechnical/Management Courses for Doctor of Engineering
- Other Doctoral Programs
- Links to department catalog section
- Engineering College-Wide Courses (https://www.uml.edu/catalog-AY16/pdf/Graduate.pdf)
- Faculty in the College of Engineering (https://www.uml.edu/docs/ENGG%20Faculty%20List_tcm18-90421.pdf) (pdf)

Graduate Programs Offered

The Master of Science in Engineering (M.S. Eng.) degree awarded in the following fields:

- Chemical Engineering
- Civil Engineering - Options: Environmental, Geotechnical, GeoEnvironmental, Structural,
- Transportation
- Computer Engineering
- Electrical Engineering
- Energy Engineering - Options: Nuclear, Solar
- Mechanical Engineering
- Plastics Engineering

The Master of Science (M.S.) degree awarded in the following fields:

- Engineering Management
- Environmental Studies

The Doctor of Philosophy (Ph.D.) degree awarded through the College of Engineering in the following options:

- Chemical Engineering
- Civil and Environmental Engineering
- Computer Engineering
- Electrical Engineering
- Energy Engineering
- Mechanical Engineering
- Plastics Engineering

The Doctor of Engineering (D.Eng.) degree awarded through the College of Engineering in the following options:

- Chemical Engineering
- Civil and Environmental Engineering
- Computer Engineering
- Electrical Engineering
- Energy Engineering
- Mechanical Engineering
- Plastics Engineering

The intent of the Doctor of Engineering/Doctor of Philosophy (D.Eng./Ph.D.) programs is to prepare engineers for leadership and research positions in industry, academia and government. The doctoral programs include advanced graduate course work in engineering and allied subjects and research culminating in a doctoral dissertation. The Ph.D. degree is oriented more towards academic research, while the D.Eng. degree is oriented more toward industry.

A total of 63 credit hours of graduate level courses are required for both the Ph.D. and D.Eng. degrees. These credits are composed of the following components:
The Ph.D. degree must involve a traditional research-based dissertation, plus: A minimum of 30 approved credit hours of graduate-level engineering including associated science and math courses. A minimum of 21 credit hours of doctoral dissertation. The balance of the remaining 12 credits can be a mix of graduate-level engineering including associated science and math course and dissertation credits at the discretion of the department, faculty advisor and dissertation committee.

The D.Eng. degree must involve a dissertation, which can be either a traditional research-based dissertation or an industry-based project, plus: 33 approved credit hours of graduate-level engineering including associated science and math courses. 21 credit hours of doctoral dissertation. 9 credit hours of approved management-type courses.

In addition to this 63 semester hours of approved graduate courses and dissertation:

- The student must have a minimum grade point average of 3.25 to graduate.
- The student is required to take and pass the doctoral qualifying examination.

Dissertations which are industrial in orientation should use the D.Eng. degree, based upon discussion with the supervising faculty advisor. Students may elect either degree designation with the consent of the faculty advisor, subject to the requirements of each degree.

Options are offered in the following areas:

- Computer Engineering
- Electrical Engineering
- Mechanical Engineering
- Plastics Engineering
- Civil and Environmental Engineering
- Chemical Engineering
- Energy Engineering (jointly administered by Mechanical Engineering and Chemical Engineering)

Common Admission Requirements

- Graduate Record Examination (GRE) scores
- TOEFL (Test of English as a Foreign Language) exam scores are required for international students
- Three letters of recommendation
- Statement of Purpose
- Application fee
- Application form
- Official transcripts.

Transfer Credits

1. A student with a masters degree in Engineering or a closely related field may apply to have coursework for the master’s degree up to a total of 24 credits.
2. A student with graduate-level work completed at a credited US or Canadian university may apply for transfer of up to 24 semester credits in acceptable graduate engineering courses (with grade of B or better) towards the doctoral program, upon approval by the Department Graduate Coordinator.
3. In cases where a student has an M.B.A., or has completed the Business Administration Minor for Engineering students, in addition to a B.S. in engineering or a closely related field, portions of the management component of the Doctor of Engineering program may be waived upon review by the administering department.

Common Doctoral Degree Requirements

1. The student must have a minimum grade point average of 3.25 to graduate.
2. Students are required to take and pass a doctoral qualifying examination before they are officially classified as a doctoral candidate.

Doctoral Qualifying Examination

1. The doctoral qualifying examination is administered on a declared schedule, usually twice each year. The timing and format of the doctoral qualifying examination may vary by department.
2. The student is permitted two attempts at passing the doctoral qualifying examination.

3. If this first attempt at the doctoral qualifying examination is unsatisfactory, a second and final attempt at passing the exam must occur at the next offering of the qualifying exam. Failure to schedule or to participate in the qualifying exam process as outlined will be considered a failed attempt.

4. Students failing the doctoral exam twice will automatically be dismissed from the doctoral program.

5. Students who do not take the examination at the prescribed time may lose all their financial support, if any, and may be dismissed from the doctoral program.

6. The decision of each administering Department regarding whether a student has passed the qualifying exam is final.

Doctoral Dissertation Proposal

Dissertation

1. Approve the research topic;
2. Supervise the progress of the dissertation;
3. Read, evaluate, and approve or disapprove of the written dissertation;
4. Hear, evaluate and approve or disapprove of the oral defense of the dissertation;
5. Report the completion of all dissertation requirements to the department and the Registrar’s Office.

Other Doctoral Programs

The Doctor of Philosophy in Physics (Ph.D.) degree awarded through the College of Arts and Sciences in the following fields:

- Applied Mechanics
- Energy Engineering
- Radiological Sciences

The Doctor of Philosophy in Chemistry (Ph.D.) degree awarded through the College of Arts and Sciences in the following fields:

- Biochemistry
- Environmental Studies
- Polymer Science/Plastics Eng. Option

The Doctor of Science (Sc.D.) degree awarded through the College of Health Sciences in the following field:

- Work Environment - Options: Occupational Ergonomics, Industrial Hygiene, Epidemiology, Work Environment Policy

Links to Department Sections in This Graduate Academic Catalog:

- Chemical Engineering
- Civil & Environmental Engineering
- Electrical & Computer Engineering
- Energy Engineering
- Mechanical Engineering
- Plastics Engineering

Nontechnical/Management Courses for Doctor of Engineering

Approved nontechnical/management graduate courses from the College of Engineering (3 credits each):

Approved management graduate courses from the College of Management (3 credits each):

The Thesis Guide

Links to Department Sections in This Graduate Academic Catalog:

Engineering Management

Master of Science in Engineering Management

- Program Overview
- Admissions Requirements
- Accelerated Bachelors to MSEM Masters
- Graduate Program Curriculum Outline

Program Overview

The Master of Science in Engineering Management (MSEM) is
designed for technical professionals who have opted for the management track in technical and engineering services enterprises. The program is 31 credits in length. Some courses will be offered both on campus and online and the MSEM is open to both full-time and part-time students.

Students have the choice of three concentrations: (a) design and manufacturing, (b) engineering services/infrastructure management and (c) operations and supply management. The three concentrations encompass the non-research and development (non R &D) part of technical enterprises that are needed for new technical projects and product realizations.

Besides preparing engineering or business bachelor degree undergraduates for careers in engineering management, this program also serves non-engineering or business undergraduates who wish to pursue a technical management career. These candidates may be required to complete prerequisite courses that provide an introduction to basic engineering economy concepts needed for courses in the curriculum, at the discretion of the MSEM program coordinator. After successful completion of these prerequisite courses, students with non-engineering or business undergraduate degrees can pursue the remaining MSEM curriculum in the same way as students with engineering undergraduate degrees.

Admissions Requirements
General Admission Requirements

The Following are general admission requirements. Admission to the program will be based on review by Graduate Admissions and by the Admission Committee of the MSEM Department. Applicants are required to submit the results from the Graduate Record Examination (GRE) to the Graduate School. In addition, international students must obtain the results of the Test of English as a Foreign Language (TOEFL) examination. Depending on the option selected, students may be required to make up prerequisite courses which they lack in comparison to the equivalent Engineering curriculum at the University of Massachusetts Lowell. In cases where a student has an M.B.A. or has completed the Business Administration Minor for Engineering students, in addition to a B.S. in engineering or its equivalent, certain requirements the MSEM program may be waived upon review by the MSEM Admissions Department. However, all MSEM students are expected to fully complete the 31 credit program requirements.

Specific Admission Requirement for MSEM

1. BS in any engineering or science discipline, or a BS in Industrial Management or Operations Research
2. Graduate Admissions Application
3. Application Fee
4. GPA of 3.0 or better in the respective undergraduate program
5. GRE scores minimum to be determined by the MSEM admission committee
6. Three letters of Recommendation
7. Statement of Purpose
8. TOEFL =>79 or IELTS =>6.5 for international students.

Students with industrial or management experience and a bachelor’s degree in another area can be admitted on a case-by-case basis, e.g. BA in English or History. In such cases, a resume is requested to assist in the decision process.

In some cases, an applicant may be required to satisfactorily complete up to three undergraduate engineering/science courses to ensure that the student has the necessary background knowledge to succeed in the MSEM program.

Accelerated Bachelors to MSEM Masters

The College of Engineering will offer a combined BSE/MSEM program in Engineering Management for UMass Lowell undergraduate students based on a BS in any engineering or science discipline. The admission requirements and benefits of the accelerated MSEM are as specified by the University. Applications from UMass Lowell undergraduates may be submitted in the junior year and must include the following:

1. UMass Lowell Undergraduate Degree: Official Transcripts. (A minimum overall GPA of 3.0 at the time of conferral of the undergraduate degree is required. Students who do not meet this requirement at the end of their undergraduate studies will not qualify for the Bachelors to Master’s benefits; however, they may reapply to the program via the regular application process.)
2. The GRE can be waived for UMass Lowell undergraduates with a GPA of 3.0 and above an upon receipt of a recommendation by an UMass Lowell faculty member.
3. Successful Completion of all other University admissions requirements, including three letters of recommendation.
4. Statement of Purpose.

Graduate Program Curriculum Outline

The core courses are a blend of engineering and business fundamentals, while the three concentrations allow students to narrow their course selection into well thought out collection of courses into each concentration, while leveraging the expertise of the faculty in these topics.

Note: Students may choose to do either a professional-practice
capstone (6 credits) or take additional courses (6 credits minimum) in an Engineering Management concentration. For the non-capstone option, students must submit a plan of study to the MSEM graduate coordinator and obtain his/her approval during the first year of the program. Any change to the submitted plan requires the approval of the MSEM graduate coordinator.

<table>
<thead>
<tr>
<th>Required (Core) Courses</th>
<th>Course Number</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECH.5760</td>
<td>Engineering Project Management</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>CIVE.5810</td>
<td>Engineering Systems Analysis</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>ACCT.5010</td>
<td>Financial Accounting</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>FINA.5010</td>
<td>Business Financial Analysis</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>MKTG.5010</td>
<td>Marketing Fundamentals</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>POMS.5010</td>
<td>Operations Fundamentals</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>MGMT.5010</td>
<td>Organizational Behavior</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Sub-Total # Core Credits Required: 16

One of the three Concentration Course Choices (Total Min. credits required = 9) (attach list as needed)

- **a. Design and Manufacturing Concentration**
  - CIVE.5210: Reliability Analysis in Engineering (3 credits)
  - MECH.5490: Cooling of Electronic Equipment (3 credits)
  - MECH.5530: MEMS & Microsystems (3 credits)
  - MECH.5710: Collaborative Engineering (3 credits)
  - MECH.5750: Industrial Design of Experiments (3 credits)
  - MECH.5790: Robotics (3 credits)
  - PLAS.5180: Plastic Product Design (3 credits)
  - PLAS.5900: Survey of Intellectual Property (3 credits)

- **b. Engineering Services/Infrastructure Management Concentration**
  - CIVE.5110: Inspection and Monitoring of Civil Infrastructure (3 credits)
  - CIVE.5300: Urban Transportation Planning (3 credits)
  - CIVE.5440: Transportation Economics and Project Evaluation (3 credits)
  - CIVE.5210: Reliability Analysis in Engineering (3 credits)
  - CIVE.5760: GIS Application in Civil and Environmental Engineering (3 credits)

- **c. Operations and Supply Management Concentration**
  - PUBH.5300: Ergonomics and Work (3 credits)
  - PUBH.5310: Occupational Biomechanics (3 credits)
  - PUBH.5400: Occupational Safety Engineering (3 credits)
  - PUBH.5510: Work Environment Policy and Practice (3 credits)
  - PUBH.6381: Methods of Work Analysis (3 credits)
  - PLAS.5150: Lean Plastics Manufacturing (3 credits)
  - PLAS.6060: Plastics Manufacturing Systems Engineering (3 credits)
  - MGMT.5110: Global Enterprise and Competition (3 credits)
  - POMS.6010: Operations Management (3 credits)
  - POMS.6020: Global Supply Chain Management (3 credits)

Sub Total # Concentration Credits Required: 9

Professional Capstone Practice or Non-Capstone Option (Total credits required = 6)*

<table>
<thead>
<tr>
<th>Professional capstone</th>
<th>Capstone topic to be completed under the direction of an advisor and defended to a committee of at least three</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non capstone</td>
<td>Any two courses from any one of the --------------------------</td>
</tr>
</tbody>
</table>

*For the non-capstone option, students must submit a plan of study to the MSEM graduate coordinator and obtain his/her approval during the first year of the program. Any change to the submitted plan requires the approval of the MSEM graduate coordinator.
Biomedical Engineering & Biotechnology Program

The Boston, Dartmouth, Lowell and Worcester campuses of the University of Massachusetts offer joint Masters of Science in Biomedical Engineering and Biotechnology.

Admission Requirement
Transfer of Credits/Advanced Standing
Academic Program
General Program Requirements
Core Course Requirements
Specialization Course Requirements
Capstone Requirement
Earning the Master of Science Degree
Professional Science Master’s Option
Combined Bachelors to Master’s Degree Program

Admission Requirements

Applicants from many different science/engineering undergraduate programs are invited to apply. Because the degree brings together biomedical engineering with biotechnology, it is designed equally for students with life sciences or engineering/physical science backgrounds. One’s specific background will be of less interest in determining qualification for entrance than will be one’s personal and career goals, demonstrated ability an research potential and commitment to an interdisciplinary, team-work approach.

Applicants will be accepted from individuals holding appropriate bachelor’s degrees or master’s degrees (or the US baccalaureate equivalents from a foreign institution). Applicants should have a background in life science, physical science or engineering. All applicants must have taken a full year (two semester or three quarter sequence) of calculus and the successful applicants will normally have had undergraduate coursework in statistics/experimental design and in life science/biomedical science.

Applicants are encouraged to contact participating faculty to explore how they might fit into a specific specialization option before submitting their application and to report on the results of those contacts in their Statement of Purpose (see below). A personal interview with the applicant by the campus Advising/Admissions/Curriculum Committee (AACC) may be recommended but is not required.

Applicants submit the following and are expected to meet the standards indicated:

- Generally students with an overall undergraduate grade point average of 3.0 or higher will considered for admission. Applicants must present official undergraduate and graduate transcripts from all schools attended.

- Applicants accepted into the program should present a minimum Graduate Record Exam (GRE) combined verbal and quantitative score of 300 (1100 for tests taken prior to August 1, 2011). The AACC will also pay particular attention to the applicant’s score on the GRE analytical writing section of the general examination because of the emphasis placed on strong writing skills in this program. Only official GRE scores form Educational Testing Service will be considered acceptable.

- Applicants must have a minimum of two semesters of calculus and have strong quantitative skills.

- International applicants should present a minimum Test Of English as a Foreign Language (TOEFL) score of 79 (internet version), 213 (computer version) or 550 (paper version). Only official TOEFL scores from Educational Testing Service will be considered acceptable.

- Three Letters of recommendation, from individuals familiar with the applicants academic ability and potential to conduct original research at the doctoral level, will be required.

- Applicants will also be required to submit a Statement of Purpose (personal essay). This statement is an important element in the application packet. It has two related topics:

1) Indication of an applicants qualifications an motivation for the program. Applicants should indicate their qualifications for and motivation to undertake this program as well as their personal and career goals. Specifically, the statement should indicate the applicant's background, research credentials and career plans as they relate to the multidisciplinary nature of the doctorate and discuss your research experience (academic, industrial) and include an publications and grants/patents, and

2) Indication of how an applicant will fit into the program. Applicants should indicate their specific areas
of interest within Biomedical Engineering and Biotechnology, so that a fit between their interests and qualifications and the specific specialization options that the program offers can be determined. If the applicant has a specific interest in working with one or more of the program’s faculty, they should describe that specific interest and identify those faculty member(s). The Statement of Purpose should also exemplify the applicant’s writing skills.

- We invite applicants also to submit a personal resume.

Individual circumstances can be taken into account and extraordinary qualifications in some areas can be used to outweigh weaknesses in others.

Along with an admissions decision comes consideration of the appropriate program of courses for the applicant. The interdisciplinary nature of our program gives special importance to the advising relationship in forming a specific academic program to meet each student’s specific goals. Applicants may be offered admission with a number of courses identified as conditional requirements that they will need to take to fill in for gaps in preparation or knowledge. Each admitted student is assigned to a faculty advisor, who is identified in the letter of admission. Acceptance into the program is subject to the availability of appropriate advisors.

**Transfer of Credits/Advanced Standing**

For students who have previously completed graduate course work, the admission committees on each campus may approve the transfer of graduate credits for courses from an accredited United States college or university that received a grade of B (not B-) or better if those courses were not already used in the degree requirements of another earned degree. The graduate school at each campus will govern the maximum number of credits that may be transferred into the program. The transfer credit may replace core or specialization course requirements. The project/directed studies, seminar and dissertation research credits will not be accepted for transfer from institutions outside of the UMass system.

Students may also have core courses waived without transfer of course credit. Students would still be responsible for the full credits required of each degree (31 credits for the MS and 63 credits for the Ph.D.), but would not have to take the waived course.

Students who join the program with an earned master’s degree may receive Advanced Standing in the doctoral program. The number of credits required to complete the Ph.D. will be determined by the home campus AACC, but at a minimum 9 course (core or specialization) credits, the capstone project course (3 credits), doctoral seminar (taken twice, 1 credit each) and 30 dissertation research credits will be required. The capstone project may be waived for students who have completed a master’s thesis or research project at one of the UMass campuses. These students will be required to complete a minimum of 12 course (core or specialization) credits. Students with Advanced Standing will be required to pass the Qualifying Examination before progressing to the dissertation stage. Doctoral students who enter the program with advanced standing will not earn the MS. To earn the MS, a student must complete or transfer in credit to meet the core (16 credits), specialization (12 credits) and capstone project course (3 credits) requirements.

**Academic Program**

The curriculum is organized around common experiences, including common core courses, a capstone project and intercampus graduate research presentations. The program makes some use of distance learning/on-line/faculty exchange for delivery of courses and seminars and the campuses are close enough to permit commuting between them. The program encourages a multidisciplinary team approach during the Instrumentation and Laboratory Experience &the capstone project. Industry representation occurs in the introductory core course, in the capstone project and from an outside advisory group. In addition, each student pursues a sequence of courses and then completes a capstone project in a specialization option.

**Biomedical Engineering Specialization Options**

- Biomaterials: Tissue Engineering, Polymer/Plastics, Fibers/Textiles, Nanotechnology
- Biomedical Information Systems: Bioinformatics, Cheminformatics, Genomics, Proteomics
- Biomedical Instrumentation: Sensors, Signal Processing, Clinical Sciences
- Biomechanics: Joint/Muscle Mechanics
- Integrative Physiology: Cardiovascular and Pulmonary Modeling
- Medical Imaging: Optics, NMR, MRI, Acoustics, Cell Imaging
- Medical Physics: Radiation Therapy, Nuclear Medicine, Diagnostic Imaging, Nuclear Instrumentation

**Biotechnology Specialization Options**

- Agricultural and Marine Biotechnology: Therapeutics, Pharmacology, Nutritional Biochemistry, Food Science Technology
• Bioprocessing/Applied Microbiology: Bioremediation, Fermentation, Biocatalysis, Applied Genetic Engineering, Biopharmaceutical Sciences
• Molecular Biotechnology: Clinical Sciences, Biochemical Applications, Diagnostics, Therapeutics

General Program Requirements

The program of courses includes a core requirement, specialization requirement and capstone requirement. As students advance, they will have to meet requirements in addition to satisfactory completion of courses, lab experience and capstone project.

The Master of Science requires completion or transfer of at least 31 total credits. Students must meet the specific requirements of their "home campus" for such matters as grade averages, documentation of completion of requirements and registration for program continuation if needed. No courses receiving a grade below C (2.0) can receive credit. Grades earned below C are still calculated in the student’s grade point average.

Students are limited in the number of Directed or Independent Study courses credits that they can apply toward their program. No more than 6 credits of coursework below the level of dissertation registrations may be in the form of Directed or Independent Study. All courses must be conducted at the graduate level.

Students must pursue and complete a program of study approved by their assigned advisor. The interdisciplinary nature of this program makes close contact between each student and his or her advisor important.

Core Course Requirements (16 credits)

The core courses provide a common foundation for all students, either from life science or physical science/engineering backgrounds. Proposed core courses must be approved by the IACC.

1) Introduction to Biomedical Engineering &Biotechnology (3 credits)

This course should be taken in a students first semester in the program if possible. Team-taught introductory course that emphasizes a multidisciplinary approach to current topics in the range of academic disciplines and gives students their first exposure to faculty research areas. The course, as much as possible, will involve faculty from all participating campuses. We will also invite outside industry speakers to present topics of contemporary importance and offer joint lectures from guest speakers.

Approved UMass Lowell course: IB 500: Introduction to Biomedical Engineering &Biotechnology (3 credits)

2) Laboratory Experience (3 credits)

This course is designed to be a practical, hands-on lab rotation course and give students exposure to cutting-edge research methodology in a number of different areas, with a balance between biomedical engineering and biotechnology areas. A team approach will be encouraged as students employ various laboratory techniques to carry out short-term projects. Students will either rotate through a number of different experimental procedures within a single investigator's laboratory or rotate through multiple faculty laboratories, learning a particular type of methodology for with the laboratory may be noted and uses frequently. The course may also provide laboratory experiences/demonstrations at sister campuses and industrial sites where faculty members have affiliations.

Approved UMass Lowell course BMBT-5500 BMEBT Laboratory Experience (3 credits), Students must satisfactorily complete at least one lab-based course. This could be BMBT-5500 or a lab-based course within their specialization.

3) Advanced Mathematics (3 credits)

The core mathematics requirement offers two options:

1) Advanced Numerical Methods, for those from a physical science, engineering or mathematics background, or

2) Applied Mathematics for Life Scientists.

Advanced Numerical Methods uses differential equations and statistics to examine engineering problems with biomedical examples/applications. Applied Mathematics for Life Scientists provides an intense treatment of the subject matter designed to achieve applied math literacy for students with life science and related backgrounds. An on-line version of this course will be available to all campuses.

Approved UMass Lowell courses:

• CHEN.5390 Math Method for Engineers*
• PLAS.5480 Numerical Methods in Plastics Processing
• MATH.5300 Applied Mathematics I
• MATH.5310 Applied Mathematics II
• MATH.5550 Applied Math for Life Sciences+
• RADI.5820 Numerical Methods in Radiological Sciences and Protection

* Recommended for students with a Biomedical Engineering specialization
+ Recommended for students with a Biotechnology specialization

3) Quantitative Physiology (3 credits)

This course presents physiology at the organ system level with a quantitative approach. It helps integrate the curriculum for
students from a number of different disciplines, post-doctoral
will join in a team-based, collaborative effort involving
supervision of one faculty member, it is expected that students
cases this project may be done individually under the
cross-field interdisciplinary cooperation. Although in some
brief but detailed experimental study, which also involves
synthesizes course knowledge and experimental skills into a
designed to be a culminating experience in which the student
experience, they undertake a capstone project course. This is
As students transition from coursework to some real time
require more than 12 credits of additional course work.
fulfill this requirement. Many specialization options will
the approval of their advisor, students will select 12 credits of
structure to the course selection allowed within the area. With
selection of specialization courses. They may announce some
appropriate combination of depth and breath in the student's
found a selection of appropriate graduate courses.
biotechnology or biomedical engineering, within which are
focused areas. Each specialization option represents an area in
Specialization Courses will help the student attain depth in
biotechnology or biomedical engineering, within which are
found a selection of appropriate graduate courses.
Faculty involved in each specialization will see to an
appropriate combination of depth and breath in the student's
selection of specialization courses. They may announce some
structure to the course selection allowed within the area. With
the approval of their advisor, students will select 12 credits of
course work (minimum) from within one or the specializations.
Any graduate course approved by the advisor may be used to
satisfy this requirement. Many specialization options will
require more than 12 credits of additional course work.

Specialization Course Requirements (12 credits)
Specialization courses will help the student attain depth in
focused areas. Each specialization option represents an area in
biotechnology or biomedical engineering, within which are
found a selection of appropriate graduate courses.

4) Bioethics (1 credits)
Current ethical issues in biomedical research will be included,
with a review of legal/regulatory (e.g. FDA) considerations in
the development of biological products and bringing them to
market. This course is offered in seminar format with multi-
campus participation and biotechnology industry guest
speakers. Equivalent courses on the campuses may be
substituted, although these might have additional credits. An
on-line version of this course will be available to all campuses.

Approved UMass Lowell course: BMBT-5200 Ethical Issues in
Biomedical Research (1 credit)

5) Advanced Cell and Molecular Biology (3 credits)
Rigorous treatment of topics in advanced cell and molecular
biology, illustrating applied research through examples and
presenting biochemistry concepts at the cell/molecular level.

Approved UMass Lowell course: BIOL-6660 Special Topics:
Molecular and Cellular Biology (3 credits)

Specialization Course Requirements (12 credits)
Specialization courses will help the student attain depth in
focused areas. Each specialization option represents an area in
biotechnology or biomedical engineering, within which are
found a selection of appropriate graduate courses.
Faculty involved in each specialization will see to an
appropriate combination of depth and breath in the student's
selection of specialization courses. They may announce some
structure to the course selection allowed within the area. With
the approval of their advisor, students will select 12 credits of
course work (minimum) from within one or the specializations.
Any graduate course approved by the advisor may be used to
satisfy this requirement. Many specialization options will
require more than 12 credits of additional course work.

Capstone Requirements (3 credits)
As students transition from coursework to some real time
experience, they undertake a capstone project course. This is
designed to be a culminating experience in which the student
synthesizes course knowledge and experimental skills into a
brief but detailed experimental study, which also involves
cross-field interdisciplinary cooperation. Although in some
cases this project may be done individually under the
supervision of one faculty member, it is expected that students
will join in a team-based, collaborative effort involving
students from a number of different disciplines, post-doctoral
fellow and industry representatives; with intercampus
participation.

Approved UMass Lowell course: BMBT-6000 Capstone Project
(3 credits)

Annually in May, a Biomedical Engineering and Biotechnology
Research Symposium will be held, rotating each year to a
different campus, at which the students from all four campuses
will present their projects in a poster session and/or orally.
Participation in this non-credit activity is required.

Earning the Master of Science Degree
Following successful presentation of the capstone project and
with a minimum of 31 credits completed or transferred in
required an approved courses, the student will be awarded the
Master of Science degree as a credential along the way toward
the doctorate. Students must have at least a cumulative B
average to receive the Master of Science degree and advance to
the Qualifying Examination. (Students not working up to that
level are subject to review for dismissal from the program.
Specific standards are set for graduate students on each "home
campus" for continuation in graduate programs.)

Abstracts International.

Professional Science Master's Option
The Professional Science Master's (PSM) option
(http://www.uml.edu/Catalog/Graduate/UMass-system/Biomedical-engineering-biotech/Professional-Science-
Masters.aspx) is a two-year program designed to enhance core
science curriculum with business fundamentals, communications,
ethics and project management. Students put their skills and
knowledge into practice during a required internship. (Students
who are employed full-time may be able to substitute a project
for the required internship.) The program provides its
graduates with the following knowledge, skills and abilities:

- Competency in cutting-edge
technical/laboratory/computer skills related to a wide
range of instrumentation/procedures;
- The application of research in solving current
biomedical/health problems especially in relationship to
new discoveries in nanoscience and technology;
- The ability to function as interdisciplinary collaborators
with strong critical thinking, inquiry-based analytical skills;
- The ability to work on integrated problems in
multidisciplinary research teams;
- The development of written and oral presentation skills
which will allow them to adapt highly scientific material to
a variety of audiences;
• The development of advanced problem solving skills using a multidisciplinary approach;
• Appreciation of the challenges of conducting/publishing research associated with contemporary biomedical ethical issues;
• Grantsmanship skills that will allow them to collaborate with researcher to obtain extramural private/federal research funding;
• Knowledge about intellectual property/patents/regulatory issues;
• The understanding of how theory/concepts are related to applied research
• The understanding of how applied research is conducted in an industrial setting;
• The understanding of how industry applies experimental research to equipment design/manufacturing/product development;

As well as the skills listed above, the

Ph.D. program
(https://www.uml.edu/Catalog/Graduate/UMass-system/Biomedical-engineering-biotech/Doctoral-Program.aspx) aims to provide its doctoral recipients with the following additional knowledge, skills and abilities:

• The ability to formulate/test multiple, original scientific hypotheses related to their dissertation research based on careful observations and a comprehensive review of past and current literature in their field;
• The ability to design/carry out detailed experiments or develop theoretical models/numerical simulations;
• The application of their research in solving current biomedical/health problems especially in relationship to new discoveries in nanoscience and technology;
• The ability to function as independent researchers with strong critical thinking, inquiry-based analytical skills;
• The ability to critically interpret their research results, synthesizing findings from other investigators/previous studies, that will serve as the basis for developing new hypotheses;
• Written/Oral presentation skills resulting in publication of their findings and presentation of results at professional research conferences; and
• Grantsmanship skills that will allow them to obtain pre-doctoral and post-doctoral extramural private/federal research funding.

Combined Bachelor's and Master's Degree Program

The program participates in the University’s effort to encourage outstanding graduate students to begin study toward an advanced degree while still undergraduates. Arrangements are possible for joint programs, that combine a bachelor’s degree in one of the other departments in the University with a master’s degree in the Biomedical Engineering and Biotechnology program. Such arrangements are made for eligible students after discussions with graduate coordinators in both departments (see eligibility requirements (http://www.uml.edu/Catalog/Graduate/Bachelors-Masters.aspx)).

Master of Science in Biomedical Engineering and Biotechnology

Master of Science in Biomedical Engineering and Biotechnology, Professional Science Master's (PSM) Option

• Program Description
• Admissions Requirements
• Curriculum
• Professional Internship

Program Description

The intercampus Biomedical Engineering and Biotechnology (BMEBT) program offers a 34-credit Master of Science Degree in Biomedical Engineering and Biotechnology, Professional Science Masters (PSM) option. This non-thesis program prepares students for a professional career and may be completed on either a full-time or part-time basis. In lieu of a research component, the PSM option requires PLUS courses in business, a communications course, and a professional internship in a specialization area of Biomedical Engineering or Biotechnology.
Individuals interested in the program include graduates of BS programs in biology, chemical engineering, chemistry, clinical laboratory science, computer science, electrical engineering, mathematics, mechanical engineering, physics, plastics engineering and polymer science. Other interested clientele include professionals that are currently employed in the pharmaceutical, biotechnology or medical device industries as well as medical and research labs who are interested in expanding and updating their knowledge in biomedical engineering/biotechnology while concurrently obtaining communication and business skills required for greater job opportunities. The combination of science and business training provided by this program meets the workforce needs of the Massachusetts economy, where healthcare, as well as biomedical and medical device companies, are leading industries.

Admission Requirements

1. Have earned an appropriate Baccalaureate degree from an accredited university or college with a recommended GPA of 3.0 or better.
2. Have successfully completed prerequisite technical courses: Applicants must have completed the equivalent of two semesters of calculus. Successful applicants will normally have also had undergraduate coursework in statistics/experimental design and in life science/biomedical science.
3. Have earned the following minimums: Graduate Record Examination (GRE) combined verbal and quantitative score of 295 (1000 for tests taken prior to August 1, 2011) and TOEFL score of 79 (internet based) for international applicants.

Curriculum *

The Master of Science in Biomedical Engineering and Biotechnology is a 34 credit hour program. Twenty-four credit hours of STEM courses, 9 credits of PLUS courses and a 1 credit internship and seminar are required.

STEM Required Courses (12 credits):

- BMBT.5000 Introduction to Biomedical Engineering & Biotechnology (3 credits)
- BMBT.5750 Quantitative Physiology (3 credits)
- BIOL.6660 Special Topics: Molecular and Cellular Biology (3 credits)

And one of the following 3 credit courses

- ENGY.5090 System Dynamics
- ENGY.5390 Math Methods for Engineers*
- PLAS.5480 Numerical Methods in Plastics Processing
- MATH.5300 Applied Mathematics I
- MATH.5310 Applied Mathematics II
- MATH.5550 Applied Math for Life Sciences (Online)+
- RADI.5820 Numerical Methods in Radiological Sciences and Protection

* Recommended for students with a Biomedical Engineering specialization.

+ Recommended for students with a Biotechnology specialization.

Additional STEM required courses may be chosen with advisor approval.

STEM Electives (minimum 12 credits)

STEM electives are chosen with advisor approval from the available science and engineering courses offered at the participating campuses. Electives are chosen from within a defined specialization option. Available options are listed below:

Biomedical Engineering Specialization Options

- Biomaterials: Tissue Engineering, Polymers/Plastics, Fibers/Textiles, Nanotechnology
- Biomedical Information Systems: Bioinformatics, Cheminformatics, Genomics, Proteomics
- Biomedical Instrumentation: Sensors, Signal Processing, Clinical Sciences
- Biomechanics: Joint/Muscle Mechanics
- Integrative Physiology: Cardiovascular and Pulmonary Modeling
- Medical Imaging: Optics, NMR, MRI, Acoustics, Cell Imaging
- Medical Physics: Radiation Therapy, Nuclear Medicine, Diagnostic Imaging, Nuclear Instrumentation

Biotechnology Specialization Options

- Agricultural and Marine Biotechnology: Therapeutics, Pharmacology, Nutritional Biochemistry, Food Science
Technology
- Bioprocessing/Applied Microbiology: Bioremediation, Fermentation, Biocatalysis, Applied Genetic Engineering, Biopharmaceutical Sciences
- Molecular Biotechnology: Clinical Sciences, Biochemical Applications, Diagnostics, Therapeutics

PLUS courses (Business and Communication 9 credits)

PLUS Required Courses (4 credits)
- BIOL.6040 Professional Communication in Science and Technology (3 credits) OR MGMT.6540 Advanced Professional Communication (3 credits)
- BMBT.5200 Bioethics (1 credit)

PLUS Elective Courses (minimum 5 credits)
- ACCT.5010 Financial Accounting (2 credits)
- FINA.6400 Financing Innovation and Technology Ventures (3 credits)
- MKMT.5010 Marketing Fundamentals (2 credits)
- MKMT.6300 Market Research for Entrepreneurs (3 credits)
- POMS.5010 Operations Fundamentals (2 credits)
- ENTR.6500 Innovation and Emerging Technologies (3 credits)
- MGMT.5010 Organizational Behavior (2 credits)
- MGMT.6010 Managing Organizational Design and Change (3 credits)
- MGMT.6300 New Product Development (3 credits)
- MGMT.6510 Organizational Behavior (3 credits)
- MGMT.6520 Human Resources Management (3 credits)
- MGMT.6910 Strategy Formation and Implementation (3 credits)

Additional PLUS electives may be chosen with advisor approval.

Professional Internship in Biomedical Engineering or Biotechnology (1 credit)

A Professional Internship is required for students in the PSM option and is expected to be a minimum of 350 hours and have 3-6 month duration. The internship is designed to provide students with an opportunity to obtain real-world experience in business, government agencies, non-profit organizations or research laboratories. Internships or research project experiences will typically take place in clinical, pharmaceutical, diagnostic, biotechnological or medical device companies or institutions. Research experience can also be obtained at the University or other research centers.

Internships have to be approved in advance by the Advising/Admissions/Curriculum Committee (AACC) on each campus, including approval of a qualified supervisor for off-campus internships. The AACC will provide oversight of all internships. A written report, signed by the internship supervisor, must be submitted by the student upon completion of the internship. An oral presentation by the intern at a BMEBT seminar also is required. For students already employed in a BMEBT industry, the professional internship will be tailored to meet the needs of both employer and employee. A new project experience will be required that adds to the students current set of skills.

To be eligible for the Professional Internship, students will be required to have:
1. completed a minimum of 12 credits of STEM courses,
2. completed a minimum of 6 credits of PLUS courses,
3. attained an overall minimum GPA of 3.0 and
4. have AACC permission.

All students will be required to submit a final written report and give oral presentation on their work at a seminar. All post-internship students will participate in this seminar. All Professional Internships require supervision by program faculty.

Professional Science Masters curriculum includes the following courses as part of the internship requirement:

- PSM 500 Professional Science Masters Internship (0 credits)
  Professional Science Masters students who are preparing to participate in an internship enroll in this Professional Development Seminar prior to the semester of their work period. This seminar will provide them with resources and skills to manage an internship search; secure a position; and work successfully in a professional environment.
- PSM 501 Professional Science Masters Reflective Seminar (1 credit)
  Reflective seminar concurrent with the internship enables Professional Science Masters (PSM) students to share and
learn from the experiences of colleagues in other settings. Students evaluate and compare individual internship experiences, explore career opportunities and gain further knowledge about functioning in a professional environment. The seminar may be conducted online, on campus, or in a blended mode and may include writing and oral presentation of experience.

**Total (34 credits)**

* Note: Courses listed are available at UMass Lowell. Other STEM and PLUS courses are available at the other campuses involved in the BMEBT program and may be used towards the degree with the approval of the graduate coordinator.

### Biomedical Engineering & Biotechnology Doctoral Program

The Boston, Dartmouth, Lowell and Worcester campuses of the University of Massachusetts offer a joint Ph.D. degree program in Biomedical Engineering and Biotechnology. Students in the Ph.D. program may elect to receive the MS degree along the way to the doctorate.

- Admission Requirements
- Academic Advisor
- Transfer of Credits/Advanced Standing
- Academic Program
- General Program Requirements
- Core Course Requirements
- Specialization Course Requirements
- Capstone Requirement
- Earning the MS Degree
- Selection of the Doctoral Dissertation Committee
- Qualifying Examination
- Doctoral Credit Requirements
- Dissertation Defense
- Professional Science Master’s Option
- Combined Bachelors to Masters Degree Program

### Admission Requirements

Applicants from many different science/engineering undergraduate programs are invited to apply. Because the degree brings together biomedical engineering with biotechnology, it is designed equally for students with life sciences or engineering/physical science backgrounds. One’s specific background will be of less interest in determining qualification for entrance than will be personal and career goals, demonstrated academic ability and research potential, and commitment to an interdisciplinary, team-work approach.

Applications will be accepted from individuals holding appropriate bachelor’s degrees or masters degrees (or the US baccalaureate equivalents from a foreign institution). Applicants should have a background in life science, physical science, or engineering. All applicants must have taken a full year (two semester or three quarter sequence) of calculus, and the successful applicants will normally have had undergraduate coursework in statistics/experimental design and in life science/biomedical science.

Applicants are encouraged to contact participating faculty to explore how they might fit into a specific specialization option before submitting their application and to report on the results of those contacts in their Statement of Purpose (see below). A personal interview with the applicant by the campus Advising/Admissions/Curriculum Committee (AACC) may be recommended but is not required.

Applicants submit the following and are expected to meet the standards indicated:

- Generally students with an overall undergraduate grade point average of 3.0 or higher will be considered for admission. Applicants must present official undergraduate and graduate transcripts from all schools attended.
- Applicants accepted into the program should present a minimum Graduate Record Exam (GRE) combined verbal and quantitative score of 300 (1100 for tests taken prior to August 1, 2011. The AACC will also pay particular attention to the applicants score on the GRE analytical writing section of the general examination because of the emphasis placed on strong writing skills in this program. Only official GRE scores from the Educational Testing Service will be considered acceptable.
- Applicants must have a minimum of two semesters of calculus and have strong quantitative skills.
- International applicants should present a minimum Test of English as a Foreign Language (TOEFL) score of 79 (internet version), 213 (computer version) or 550 (paper version). Only official TOEFL scores from the Educational Testing Service will be considered acceptable.
- Three letters of recommendation, from individuals familiar
with the applicants academic ability and potential to conduct original research at the doctoral level, will be required.

- Applicants will also be required to submit a Statement of Purpose (personal essay). This statement is an important element in the application packet. It has two related roles:

1. Indication of an applicants qualifications and motivation for the program. Applicants should indicate their qualifications for and motivation to undertake this program as well as their personal and career goals. Specifically, the statement should indicate the applicants background, research credentials, and career plans as they relate to the multidisciplinary nature of the doctorate, and discuss your research experience (academic, industrial) and include any publications and grants/patents, and

2. Indication of how an applicant will fit into the program. Applicants should indicate their specific areas of interest within Biomedical Engineering and Biotechnology, so that a fit between their interests and qualifications and the specific specialization options that the program offers can be determined. If the applicant has a specific interest in working with one or more of the program’s faculty, they should describe that specific interest and identify those faculty member(s). The Statement of Purpose should also exemplify the applicants writing skills.

- We invite applicants also to submit a personal rsum.

Individual circumstances can be taken into account, and extraordinary qualifications in some areas can be used to outweigh weaknesses in others.

Along with an admissions decision comes consideration of the appropriate program of courses for the applicant. The interdisciplinary nature of our program gives special importance to the advising relationship in forming a specific academic program to meet each students specific goals. Applicants may be offered admission with a number of courses identified as conditional requirements that they will need to take to fill in for gaps in preparation or knowledge. Each admitted student is assigned to a faculty advisor, who is identified in the letter of admission. Acceptance into the program is subject to the availability of appropriate advisors.

Academic Advisor

Campus AACC’s are responsible for overseeing the advising components of the program, which are initiated while each student is still an applicant. Students will be assigned a faculty advisor when they are accepted into the program. The initial faculty advisor will either be a member of the AACC or a program faculty determined based on the applicants Statement of Purpose. After the student’s first year in the program, the student may want to change to a new advisor that fits the student’s research interest and is likely to become the chair of the student’s dissertation committee.

Transfer of Credits/Advanced Standing

For students who have previously completed graduate course work, the admissions committees on each campus may approve the transfer of graduate credits for courses from an accredited US college or university that received a grade of B (not B-) or better if those courses were not already used in the degree requirements of another earned degree. The graduate school at each campus will govern the maximum number of credits that may be transferred into the program. The transfer credit may replace core or specialization course requirements. The project/directed studies, seminar and dissertation research credits will not be accepted for transfer from institutions outside of the UMass system.

Students may also have core courses waived without transfer of course credit. Students would still be responsible for the full credits required of each degree (31 credits for the MS and 63 credits for the PhD), but would not have to take the waived course.

Students who join the program with an earned masters degree may receive ?Advanced Standing? in the doctoral program. The number of credits required to complete the PhD will be determined by the home campus AACC, but at a minimum 9 course (core or specialization) credits, the capstone project course (3 credits), doctoral seminar (taken twice, 1 credit each) and 30 dissertation research credits will be required. The capstone project may be waived for students who have completed a masters thesis or research project at one of the UMass campuses. These students will be required to complete a minimum of 12 course (core or specialization) credits. Students with Advanced Standing will be required to pass the Qualifying Examination before progressing to the dissertation stage. Doctoral students who enter the program with advanced standing will not earn the MS. To earn the MS, a student must complete or transfer in credit to meet the core (16 credits), specialization (12 credits), and capstone project course (3 credits) requirements.

Academic Program

The curriculum is organized around common experiences, including common core courses, a capstone project, and
intercampus graduate research presentations. The program makes some use of distance learning/on-line/faculty exchange for delivery of courses and seminars, and the campuses are close enough to permit commuting between them. The program encourages a multidisciplinary team approach during the Instrumentation and Laboratory Experience, the capstone project, and in the selection of the dissertation committee. Industry representation occurs in the introductory core course, in the capstone project, in the doctoral seminar series, and from an outside advisory group. In addition, each student pursues a sequence of courses and then completes a focused research project leading to a doctoral dissertation in a specialization option.

**Biomedical Engineering Specialization Options**

- Biomaterials: Tissue Engineering, Polymers/Plastics, Fibers/Textiles, Nanotechnology
- Biomedical Information Systems: Bioinformatics, Cheminformatics, Genomics, Proteomics
- Biomedical Instrumentation: Sensors, Signal Processing, Clinical Sciences
- Biomechanics: Joint/Muscle Mechanics
- Integrative Physiology: Cardiovascular and Pulmonary Modeling
- Medical Imaging: Optics, NMR, MRI, Acoustics, Cell Imaging
- Medical Physics: Radiation Therapy, Nuclear Medicine, Diagnostic Imaging, Nuclear Instrumentation

**Biotechnology Specialization Options**

- Agricultural and Marine Biotechnology: Therapeutics, Pharmacology, Nutritional Biochemistry, Food Science Technology
- Bioprocessing/Applied Microbiology: Bioremediation, Fermentation, Biocatalysis, Applied Genetic Engineering, Biopharmaceutical Sciences
- Molecular Biotechnology: Clinical Sciences, Biochemical Applications, Diagnostics, Therapeutics

**General Program Requirements**

The program of courses includes a core requirement, specialization requirement, and capstone requirement. As students advance, they will have to meet requirements in addition to satisfactory completion of courses, including participation in seminars and symposiums, passing a qualifying examination, defending a dissertation proposal, completing a dissertation, and a dissertation defense.

The PhD requires completion or transfer of at least 63 total credits (or a minimum of 44 credits for students with advanced standing due to an existing MS degree). Students must meet the specific requirements of their "home campus" for such matters as grade averages, documentation of completion of requirements, registration for program continuation if needed, and submitting the final dissertation to the library. No course receiving a grade below C (2.0) can receive credit. Grades earned below C are still calculated in the students grade point average.

Students are limited in the number of Directed or Independent Study course credits that they can apply toward their program. No more than 6 credits of coursework below the level of dissertation registrations may be in the form of Directed or Independent Study. All courses must be conducted at the graduate level.

Students must pursue and complete a program of study approved by their assigned advisor. The interdisciplinary nature of this program makes close contact between each student and his or her advisor important.

**Core Course Requirements**

The core courses provide a common foundation for all students, either from life science or physical science/engineering backgrounds. Proposed core courses must be approved by the IACC.

1. Introduction to Biomedical Engineering & Biotechnology (3 credits)

This course should be taken in a students first semester in the program if possible. Team-taught introductory course that emphasizes a multidisciplinary approach to current topics in the range of academic disciplines and gives students their first exposure to faculty research areas. The course, as much as possible, will involve faculty from all participating campuses. We will also invite outside industry speakers to present topics of contemporary importance and offer joint lectures from guest speakers.

Approved UMass Lowell course: BMBT.5000, Introduction to Biomedical Engineering & Biotechnology (3 credits)

2. Instrumentation and Laboratory Experience (3 credits)

This course is designed to be a practical, hands-on lab rotation course and give students exposure to cutting-edge research methodology in a number of different areas, with a balance between biomedical engineering and biotechnology areas. A team approach will be encouraged as students employ various laboratory techniques to carry out short-term projects. Students will either rotate through a number of different
experimental procedures within a single investigators laboratory or rotate through multiple faculty laboratories, learning a particular type of methodology for which the laboratory may be noted and uses frequently. The course may also provide laboratory experiences/demonstrations at sister campuses and industrial sites where faculty members have affiliations.

Approved UMass Lowell course: BMBT.5500 BMEBT Instrumentation and Laboratory Experience (3 credits) Students must satisfactorily complete at least one lab-based course. This could be BMBT.5500 or a lab-based course within their specialization.

3. Advanced Mathematics (3 credits)

The core mathematics requirement offers two options:

1. Advanced Numerical Methods, for those from a physical science, engineering or mathematics background or

Advanced Numerical Methods uses differential equations and statistics to examine engineering problems with biomedical examples/applications. Applied Mathematics for Life Scientists provides an intense treatment of the subject matter designed to achieve applied math literacy for students with life science and related backgrounds. An on-line version of this course will be available to all campuses.

Approved UMass Lowell courses:

- ENGY.5090 System Dynamics (3 credits)
- ENGY.5390 Math Methods for Engineers (3 credits)*
- ENGY.5480 Numerical Methods in Plastics Processing (3 credits)
- MATH.5300 Applied Mathematics I (3 credits)
- MATH.5310 Applied Mathematics II (3 credits)
- MATH.5550 Applied Math for Life Sciences (3 credits, online) +
- RADI.5820 Numerical Methods in Radiological Sciences & Protection (3 credits)

* Recommended for students with a Biomedical Engineering specialization.
+ Recommended for students with a Biotechnology specialization.

4. Quantitative Physiology (3 credits)

This course presents physiology at the organ system level with a quantitative approach. It helps integrate the curriculum for individuals with life science and engineering undergraduate backgrounds, permitting engineers and physical scientists an appreciation of how organisms function from the organ/system perspective and gives life scientists a more rigorous quantitative approach to physiology than is usual in undergraduate courses.

Approved UML course: BMBT.5750 Quantitative Physiology (3 credits)

5. Bioethics (1 credit)

Current ethical issues in biomedical research will be included, with a review of legal/regulatory (e.g. FDA) considerations in the development of biological products and bringing them to market. This course is offered in seminar format with multi-campus participation and biotechnology industry guest speakers. Equivalent courses on the campuses may be substituted, although these might have additional credits. An on-line version of this course will be available to all campuses.

Approved UMass Lowell course: BMBT.5200 Ethical Issues in Biomedical Research (3 credits)

Advanced Cell and Molecular Biology (3 credits)

Rigorous treatment of topics in advanced cell and molecular biology, illustrating applied research through examples and presenting biochemistry concepts at the cell/molecular level.

Approved UMass Lowell course: BIOL.6660 Special Topics: Molecular and Cellular Biology (1 credit)

6. Advanced Cell and Molecular Biology (3 credits)

Rigorous treatment of topics in advanced cell and molecular biology, illustrating applied research through examples and presenting biochemistry concepts at the cell/molecular level.

Approved UMass Lowell course: BIOL.6660 Special Topics: Molecular and Cellular Biology (3 credits)

Specialization Course Requirements

Specialization courses will help the student attain depth in focused areas. Each specialization option represents an area in biotechnology or biomedical engineering, within which are found a selection of appropriate graduate courses.

Faculty involved in each specialization will see to an appropriate combination of depth and breadth in the students selection of specialization courses. They may announce some structure to the course selections allowed within the area. With the approval of their advisor, students will select 12 credits of course work (minimum) from within one of the specializations. Any graduate course approved by the advisor may be used to satisfy this requirement. Many specialization options will require more than 12 credits of additional course work.

Capstone Requirement
As students transition from coursework to dissertation research, they undertake a capstone project course. This is designed to be a culminating experience in which the student synthesizes course knowledge and experimental skills into a brief but detailed experimental study, which also involves cross-field interdisciplinary cooperation. Although in some cases this project may be done individually under the supervision of one faculty member, it is expected that students will join in a team-based, collaborative effort involving students from a number of different disciplines, post-doctoral fellows, and industry representatives; and with intercampus participation.

Approved UMass Lowell course: BMBT.6000 Capstone Project (3 credits)

Annually in May, a Biomedical Engineering and Biotechnology Research Symposium will be held, rotating each year to a different campus, at which the students from all four campuses will present their projects in a poster session and/or orally. Participation in this non-credit activity is required.

Earning the MS Degree

Following successful presentation of the capstone project and with a minimum of 31 credits completed or transferred in required and approved courses, the student will be awarded the Master of Science degree as a credential along the way toward the doctorate. Students must have at least a cumulative B average to receive the MS degree and advance to the Qualifying Examination. (Students not working up to that level are subject to review for dismissal from the program. Specific standards are set for graduate students on each "home campus" for continuation in graduate programs.)

Selection of the Doctoral Dissertation Committee

As they move through this stage of their program, students will select their Doctoral Dissertation Committee, with one person as the major advisor. A committee must have at least three members (in some cases individual campus requirements may result in a higher minimum). The advisor and at least one other dissertation committee member must be chosen from the approved faculty of the Biomedical Engineering and Biotechnology program. Having one member of a dissertation committee be an outside industry scientist or engineer is encouraged.

Two models are provided for the dissertation committee, the intercampus and the intracampus committee structures:

The intercampus structure, which is strongly recommended, has one faculty member from a campus other than the candidates home campus. It is expected that all three members will not represent the same academic departmental affiliation.

The intracampus committee structure has faculty just from the home campus. It is expected that all three members will not be from the same academic department.

Each students committee is approved by the campus AACC, which will also approve any changes to a previously-approved committee.

Qualifying (Written) Examination

Students must pass a written qualifying examination that will cover questions on course work as well as experimental procedures the student has utilized. All material in the student’s curriculum is subject to examination. The examination must be taken within one year after completion of the MS Biomedical Engineering and Biotechnology requirements, or within two years after entering the program for a student with advanced standing.

Doctoral students, in consultation with their advisor, will identify two topic areas in which to be examined. At least one of the topics must be primarily engineering/technological in nature (for example, solid mechanics), and another primarily biological/medical in nature (for example, pathophysiology of musculoskeletal disorders). Proposals for the qualifying examination must be submitted to the AACC with approval of the students advisor.

For Biomedical Engineering students, the second topic must be biological or medical in nature. This requirement can be fulfilled with an exam that is a combination of material from the core Biology courses (Quantitative Physiology and Advanced Cell and Molecular Biology) and specific biology/medical information related to the student’s specialization or research area.

For Biotechnology students, the second topic must be engineering or technological in nature. This requirement may be fulfilled with an exam that makes use of the skills learned in the core math requirement and tests for an in depth understanding of topics introduced in the Introduction to Biomedical Engineering or Biotechnology course or specific engineering/technological information related to the student’s specialization or research area.

The proposal will outline the material covered by the exam, which may be designated as specific portions of courses, textbooks, and journal articles. Emphasis will be placed on the students ability to integrate information in the areas examined. The AACC will be responsible for approving topic areas covered by the exam.

The examination will be in written form and given during two one-half days within a one-week period. Examinations for a given topic area will be designed to be completed within a three to four-hour period. The qualifying examination will be administered and evaluated by program faculty selected by the AACC. Examinations for a given topic area will be graded Pass or Fail. Students who are unsuccessful in their first attempt in a given topic area may repeat it once. Failure to pass the
examination on any topic area on the second attempt results in overall failure on the Qualifying Examination and dismissal from the Ph.D. program.

Doctoral Credit Requirements

1. Doctoral Seminar (2 credits, minimum)

Doctoral students will present research in progress. The seminar will emphasize not only research but also communication and writing. Every active doctoral candidate will present her or his work in progress in the seminar, and in addition there will be at least two presentations from external speakers. Students will write summaries of each presentation. Course is graded pass-fail or satisfactory-unsatisfactory (depending on grading system in use on the campus). Students must complete this course in at least two different semesters.

Approved UMass Lowell course: BMBT.6010 Doctoral Seminar (3 credits)

2. Dissertation Research (variable credit each semester, 30 credits minimum)

Doctoral students will register for a minimum of 30 credits of doctoral research with their faculty advisor (dissertation chair). They will use these credits during preparation and defense of the dissertation proposal, carrying out their dissertation research and preparation and defense of the doctoral dissertation.

Approved UMass Lowell course: BMBT.7590 Dissertation Research (1-9 credits)

3. Dissertation Proposal (Oral Preliminary Examination)

Students must present for approval a written dissertation proposal and then defend it in an oral presentation to his or her dissertation committee. The dissertation proposal will follow the format established for NIH proposals, including the page limits, and will perform an extensive review of the literature on the student’s chosen topic, present original hypotheses, design experiments to test the hypotheses, document the appropriate methodology that will be used, project anticipated results, and indicate how such results might be interpreted. The proposal must show application to current biomedical/biotechnological problems. After successfully defending the dissertation proposal, the student attains the designation “doctoral candidate”. Failure to pass the defense of the dissertation proposal (oral examination) results in dismissal from the Ph.D. program.

Dissertation Defense

The doctoral candidate will defend his/her written dissertation before the doctoral dissertation committee, the University, and the outside community. The specific format of the defense is usually decided by the committee chair, but a typical format consists of the Ph.D. candidate first presenting an overview of the thesis research, then answering specific questions asked by the committee members. Questions may test anything from knowledge of the existing literature, to scrutinization of the material and methods or experimental design, to the assumptions in the research, to the interpretation of the results, to recommendations for future work. If the candidate has worked closely with his or her advisor, and committee, it is likely that there will be no surprises at this final stage of the process. It is common, however, for the committee to ask that certain minor revisions be made to the written dissertation before final submission. Successful defense of the dissertation and submission of the finished work to the library will result in the awarding of the Ph.D. in Biomedical Engineering and Biotechnology. Dissertations must be filed with Dissertation Abstracts International.

Combined Bachelor’s and Master’s Degree Program

The program participates in the University’s effort to encourage outstanding graduate students to begin study toward an advanced degree while still undergraduates. Arrangements are possible for joint programs that combine a bachelor’s degree in one of the other departments in the University with a master’s degree in the Biomedical Engineering and Biotechnology program. Such arrangements are made for eligible students after discussions with graduate coordinators in both departments (see eligibility requirements).

Graduate Certificate Programs in Biomedical Engineering and Biotechnology

There are six graduate certificates offered by UMass Lowell departments that are associated with the intercampus Biomedical Engineering and Biotechnology Program. With the approval of the degree granting department, graduate certificate course credit may be applied to master’s and doctoral degree programs.

- Biomedical Engineering
- Biotechnology and Bioprocessing
- Disability Outcomes
- Environmental Biotechnology
- Medical Plastics Design and Manufacturing
- Molecular and Cellular Biotechnology

Graduate Certificate Application Form (https://www.uml.edu/docs/Updated%20Certificate%20forms_tcm18-3166.pdf) (pdf)
BMBT.5500 BMBT Laboratory Experience (Formerly IB 550) - Credits: 3
BMBT.5750 Quantitative Physiology (Formerly IB 575) - Credits: 3

This course presents physiology at the organ system level with a quantitative approach. It helps integrate the curriculum for individuals with life science and engineering undergraduate backgrounds, permitting engineers and physical scientists an appreciation of how organisms function from the organ/system perspective and gives life scientists a more rigorous quantitative approach to physiology than is usual in undergraduate courses.

BMBT.7100 Directed Study (Formerly BMBT 710) - Credits: 1-3
BMBT.7110 Directed Studies (Formerly IB 711) - Credits: 1
BMBT.7120 Directed Studies (Formerly IB 712) - Credits: 2-3
BMBT.7200 Independent Study (Formerly IB 720) - Credits: 3
BMBT.7210 Independent Study (Formerly IB 721) - Credits: 1
BMBT.7220 Independent Study (Formerly IB 722) - Credits: 2
BMBT.7590 Dissertation Research (Formerly IB 759) - Credits: 1-9
BMBT.7700 CPT - Co-op Training (Formerly IB 770) - Credits: 1

Course required to perform CPT

BMBT.7800 Thesis Review (Formerly IB 780) - Credits: 1

Thesis Review
Chemical Engineering

Department of Chemical Engineering

The Department of Chemical Engineering at UMass Lowell offers a wide variety of advanced degree programs.

- **Doctor of Engineering (D.Eng.)**
  - Chemical Engineering Option
  - Energy Engineering Option
- **Doctor of Philosophy (Ph.D.)**
  - Chemical Engineering Option
  - Energy Engineering Option
- **Doctorate in Philosophy in Physics (Ph.D.)**
  - Energy Engineering Option (see Physics Dept.)
- **Master of Science in Engineering (M.S.E.)**
  - Chemical Engineering
  - Energy Engineering (Nuclear Option)
- **Graduate Certificates**
  - Biotechnology and Bioprocessing
  - Materials Science and Engineering
  - Modeling, Simulation, and Control of Systems and Processes
  - Combined BS/MS Engineering Program

The departmental programs encompass both traditional areas of chemical and nuclear engineering and modern frontier areas such as advanced engineered materials, biotechnology, and computer aided process design and controls. The department encourages cooperative university-wide efforts, especially in areas such as bioengineering, materials and recycling.

Master’s Program

Master of Science in Chemical Engineering Degree Program

The UMass Lowell program in Chemical Engineering is designed to provide the opportunity for graduate students to study the fundamentals and applications of chemical engineering principles, and to carry out independent research.

Admission Requirements

The Department will consider students for enrollment in the Chemical Engineering program who have a BS degree in engineering or science. Those students who do not have an undergraduate degree in Chemical Engineering are required to take complete CHEN.4030 Chemical Reaction Eng., CHEN.5100 Advanced Separation Processes, CHEN.5200 Advanced Thermodynamics, CHEN.5280 Advanced transport Phenomena, and CHEN.5390 Mathematical Methods for Engineers for a total of 15 credits which, if successfully completed, may be used toward the masters or doctoral degree. These students are expected to prepare adequately for these courses through self-study but CHEN.6310/2 can also be utilized. It is highly recommended that such students complete four years of mathematics through differential equations, one year of organic chemistry and one semester of physical chemistry, prior to enrolling in the graduate program.

All applicants must submit all required application materials and fees as specified by the Graduate Admissions Office.

Advisors and Advisory Committee

The Graduate Coordinator will be the academic advisor for each student, to help remedy deficiencies in prerequisites, select electives if most value and plan the overall study program. For those completing a thesis, the thesis advisor will chair the advisory committee, which will guide the student in his or her research and supervise the completion of thesis requirements.

Plan of Study

Each student shall file an approved plan of study with the Department Chairperson and Graduate Coordinator. This form will contain a listing of the courses, which will make up his or her program. Any changes must have the approval of the Department Graduate Coordinator.

Credit Requirements

The Master of Science degree in Chemical Engineering requires the successful completion of 30 credit hours. Students may elect one of two options 1) 24 credit hours of course work, plus at least 6 credit hours in preparation of an acceptable thesis, or 2) 30 credit hours of course work for the non-thesis option. Students who have received a teaching or research assistantship will be required to submit an acceptable thesis. A thesis must be defended in an oral examination conducted by the student’s thesis committee.

All students must enroll in at least two semesters of graduate seminar (CHEN.601/602) during the period of study. (These are zero credit seminars.)

Core Requirements

The core requirements will consist of one course in advanced mathematics, one course in thermal/fluid processes and one course in solid mechanics. A minimum of four total courses must be taken from the following core areas.

Advanced Mathematics

- CHEN/ENGY.5090 System Dynamics
CHEN/ENGY.5390 Mathematical Methods for Engineers

Thermal/Fluid Processes
- CHEN.5100 Advanced Separation Processes
- CHEN.5200 Advanced Thermodynamics
- CHEN.5280 Advanced Transport Phenomena

Solid Mechanics
- CHEN.5060 Colloidal, Interfacial & Nanomaterials Science and Engineering
- CHEN.5080 Material Science and Engineering (Not for those who graduated from UMass Lowell)
- CHEN.5230 Nanodevices and Electronic Materials
- CHEN.5250 Design and Packaging of Materials
- CHEN.5350 Cell and Microbe Cultivation

Thesis
Each student who chooses to complete a thesis will be required to complete six credits of thesis and must defend the thesis when completed according to University regulations. The research work for the thesis shall be conducted under the supervision of a department faculty advisor and a committee of two others for the thesis. The student must prepare and submit an acceptable proposal for the thesis prior to beginning the work.

During the period the student is enrolled in graduate thesis, he or she may be required to submit to the faculty of the department a brief monthly report, showing progress in his or her thesis or project and approval by his or her advisor.

Elective Requirements
The remainder of the course requirements are to be made up of elective courses. See the elective course listing under the Doctoral Program.

Doctoral Programs
Doctoral Programs in Chemical Engineering

- Doctor of Engineering (D.Eng.) and Doctor of Philosophy (Ph.D.)
- Chemical Engineering Option
- Nuclear Engineering Concentration
- Energy Engineering Option

- Doctorate in Philosophy in Physics
- Energy Engineering Option (see Physics Dept.)

D.Eng. and Ph.D. - Chemical Engineering Option or Energy Engineering Option (Nuclear Engineering Concentration)

Objectives
The Doctor of Engineering/Doctor of Philosophy degree is designed to prepare engineers for leadership positions in industry, academia and government. The program includes advanced graduate course work in engineering and allied subjects.

Admission Requirements
The applicant is required to have at least a B.S. degree in engineering or science. A student may apply to transfer up to 24 credit hours of applicable graduate course work toward the doctoral degree. In cases where a student has an M.B.A., in addition to the B.S. degree or its equivalent, the management portion of the Doctor of Engineering program may be waived. Students who do not have adequate preparation in chemical engineering may be required to take additional courses to make up deficiencies.

Degree Requirements
A total of 63 credit hours of graduate level courses are required for the doctoral degree. The general degree requirements follow:

1. Forty-two (42) approved credit hours of graduate level engineering courses including the core requirements.
2. A two course sequence in advanced mathematics (with approval of the graduate coordinator).
3. For the D. Eng degree, nine (9) credit hours of approved management/non-technical courses is substituted for nine credit hours of engineering courses.
4. Twenty-one (21) credit hours for the dissertation.
5. Students must enroll in at least two semesters of graduate seminar.
6. The student is required to be in full time residence at the University for at least one year.
7. The student must have a minimum grade point average of 3.25 in order to graduate.

Exceptions may be made for students whose Masters Degree is in a discipline other than engineering. Students may register for no more than six credit hours of research in preparing a formal dissertation proposal. This proposal and the students ability to
perform research must be orally defended before the students doctoral committee and other interested parties. This constitutes their candidacy examination. Upon passing this examination and completing all course requirements, the student becomes a candidate for the doctoral degree and may register for additional research credit with the advisors approval.

Core Requirements

The core requirements will consist of two courses in advanced mathematics, two courses in thermal/fluid processes and one course in solid mechanics. The specific courses follow:

Advanced Mathematics:
- CHEN/ENGY.5090 Systems Dynamics
- CHEN/ENGY.5390 Mathematical Methods for Engineers

Thermal/Fluid Processes (select two of the following):
- CHEN.5100 Advanced Separation Processes
- CHEN.5200 Advanced Thermodynamics
- CHEN.5280 Advanced Transport Phenomena

Solid Mechanics (select one of the following):
- CHEN.5060 Colloidal, Interfacial and Nanomaterials Science and Engineering
- CHEN.5080 Material Science and Engineering
- CHEN.5230 Nanodevices and Electronic Materials
- CHEN.5250 Design and Packaging of Materials
- CHEN.5350 Principles of Cell and Microbe Cultivation

Elective Requirements

A total of 27 credits of elective courses must be taken. For the Chemical Engineering Option, the courses will be from either the processing, materials or biotechnology/bioprocessing area. For the Nuclear Concentration in the Energy Option, the courses will be from the nuclear area. The specific courses in those areas follow:

Processing (in addition to the core courses):
- CHEN.5060 Colloidal, Interfacial and Nanomaterials Science and Engineering
- CHEN.5180 Microprocessor Control
- CHEN.5220 Computer-Aided Chemical process Design
- CHEN.5300 Advanced Control Strategies
- CHEN.5330 Macromolecular Science and Engineering
- CHEN.5350 Cell and Microbe Cultivation
- CHEN.5450 Isolation and purification

Materials (in addition to the core courses):
- CHEN.5040 Process Calculations of paper and pulp processes
- CHEN.5060 Colloidal, Interfacial and Nanomaterials Science and Engineering
- CHEN.5080 Material Science and Engineering
- CHEN.5230 Nanodevices and Electronic Materials
- CHEN.5250 Design and packaging of Materials
- CHEN.5290 Advances in Nanotechnology and Green Chemistry
- CHEN.5330 Macromolecular Science and Engineering
- CHEN.5350 Cell and Microbe Cultivation
- CHEN.5410 Nanostructural Characterization by SEM, TEM and AFM
- MECH.5xxx (Any Dept of Mechanical Engineering graduate level materials course approved by the student’s advisor)
- PLAS.5xxx (Any Dept of plastics Engineering graduate level materials course approved by the student’s advisor)

Biotechnology/Bioprocessing (in addition to the core courses):
- CHEN.5350 Cell and Microbe Cultivation
- CHEN.5380 Advanced Separations in Biotechnology
- CHEN.5450 Isolation and purification
- CHEN.5550 Biopharmaceutical Regulatory Compliance
- CHEN.5860 Bioprocessing projects Laboratory
- BIOL.5190 Biochemistry I
- BIOL.5760 Cell Culture
- BIOL.5xxx (Any Dept of Chemistry graduate level materials course approved by the student’s advisor)

Nuclear (in addition to the core courses):
- ENGY.5040 Energy Engineering Workshop
- ENGY.5050 Nuclear Reactor Physics
- ENGY.5060 Special Topics in Nuclear Reactor Physics
- ENGY.5070 Nuclear Reactor Engineering and Safety
Analysis

- ENGY.5080 Special Topics in Nuclear Reactor Engineering
- ENGY.5110 Advanced Reactor Concepts
- ENGY.5140 Hazardous and Nuclear Waste Management
- ENGY.5190 Nuclear Reactor Operator Training I
- ENGY.5200 Nuclear Reactor Operator Training II
- MECH.5xxx (Any Department of Mechanical Engineering graduate level course approved by the students advisor)
- RADI.5xxx (Any Department of Radiological Sciences graduate level course approved by the students advisor)

Qualifying Examination

1. The student is permitted two attempts at passing the qualifying examination which is administered on a declared schedule. Students who fail the qualifying examination the first time must retake the exam at its next scheduled offering. Students failing the doctoral exam twice will automatically be dismissed from the doctoral program. Those who do not take the examination at the prescribed time may lose all their financial support, if any, and may be dismissed from the doctoral program.

2. The qualifying exam will be a closed book examination and will be administered during two specified days. Supplementary material will be provided to the student at the time of the exam. The first day will focus on basic science and engineering concepts and will be similar to the Fundamentals of Engineering (FE) Exam. The student is encouraged to use the FE Exam study guide or take an FE Review Course to prepare for the first day exam. The topics which could be covered are: Chemistry; Fluid Mechanics; Material Science/Structure of Matter; Mathematics; Thermodynamics; Chemical Reaction Engineering; Chemical Thermodynamics; Heat Transfer; Mass Transfer; Material/Energy Balances; and Process Control. The second day will focus on the core areas of Advanced Mathematics and Thermal/Fluid Processes as well as a specialty area selected by the student. For the Chemical Engineering Option the specialty areas are Chemical Processing, Materials and

Biotechnology/Bioprocessing.

3. A student enrolled in the Energy Engineering (Nuclear Engineering Concentration) will follow the qualifying exam guidelines for the Energy Engineering Program.

Dissertation

The research work for the dissertation shall be conducted under the supervision of a departmental faculty advisor and a committee of two others. The student must defend and submit an acceptable proposal for the dissertation prior to beginning the research work.

Graduate Certificates

Graduate Certificates in Chemical Engineering

UMass Lowell offers the following graduate certificates in chemical engineering:

- Biotechnology and Bioprocessing
- Materials Sciences & Engineering
- Modeling, Simulation, and Control of Systems and Processes

Graduate Certificate Application Form (https://www.uml.edu/docs/Updated%20Certificate%20forms_tcm18-3166.pdf) (pdf)

Biotechnology and Bioprocessing

Biological Sciences Department & Chemical and Nuclear Engineering Department

Contact:
Carl Lawton, Ph.D.
978-934-3158
carl_lawton@uml.edu (mailto:carl_lawton@uml.edu)

The certificate is intended for students who hold a baccalaureate degree in science, engineering, health, or related disciplines. The courses emphasize biological and engineering principles, process concepts and the application of these to process design and improvement. Courses deliberately cross disciplinary boundaries and emphasize teamwork in a multidisciplinary environment as well as a result-oriented, document-driven approach to efficient project completion.

Required Courses:

- BIOL.5350 -or- CHEN.5350 Principles of Cell and Microbe Cultivation
• BIOL.5450 -or- CHEN.5450 Isolation and Purification of Biotech Products
• BIOL.5550 -or- CHEN.5550 Biopharmaceutical Regulatory Compliance
• Plus One Approved 3 credit Elective

Materials Sciences &Engineering

Department of Chemical and Nuclear Engineering

Contact:
Zhlyong Gu, Ph.D.
978-934-3540
zhlyong_gu@uml.edu (http://zhlyong_gu@uml.edu)

This 12 credit certificate provides an advanced course of study in materials science and engineering that will broaden and enhance the capabilities and education of experienced professionals and technologists at the graduate level.

Required Course:
• CHEN.5080 Introduction to Materials Sciences (3 credits)

Elective Courses (choose three):
• CHEN.5060 Colloidal, Interfacial & Nanomaterials Science & Engineering (3 Credits)
• CHEN.5230 Nanodevices and Electronic Materials (3 credits)
• CHEN.5240 Self Assembly & Nanotechnology (3 credits)
• CHEN.5290 Recent Advances in Nanotechnology and Green Chemistry (3 credits)
• CHEN.5330 Macromolecular Colloidal Science and Engineering (3 credits)
• ENGY.5370 Nanomaterials Characterization I (3 credits)
• ENGY.5410 Nanomaterials Characterization II (3 credits)

Modeling, Simulation, and Control of Systems and Processes

Department of Chemical and Nuclear Engineering

Contact:
Alfred Donatelli, Ph.D.
978-934-3156
alfred_donatelli@uml.edu (mailto:alfred_donatelli@uml.edu)

The sequence of courses provides advanced training in the modeling and analysis of complex systems with some special focus on thermo-fluid processes and general control system design and analysis. The courses are mathematically intensive and many require the use of modern computer analysis tools (Matlab, Simulink, Aspen, etc.). The graduate certificate program is appropriate for students and professionals interested in gaining skills in mathematical modeling and simulation techniques, and for those individuals interested in updating their knowledge and experience with modern control methods.

This is a 12 credit certificate.

Choose Four Courses:
• ENGY.5090 System Dynamics (3 credits)
• CHEN.5220 Computer-Aided Chemical Process Design (3 credits)
• CHEN.5280 Advanced Transport Phenomena (3 credits)
• CHEN.5300 Advanced Control Strategies (3 credits)
• CHEN.5390 Math Methods for Engineers (3 credits)
• CHEN.5480 Engineering Process Analytics
• A Technical Elective with the Approval of the Coordinator (3 credits)
CHEN.5010 Paper Industry Processes (Formerly 10.501) - Credits: 3
Processes of fiber separation from raw materials, fiber purification and mechanical processing of fiber and sheet formation. Chemical engineering theory is applied to the analysis of these operations.

CHEN.5020 Principles of Chemical Engineering (Formerly 10.502) - Credits: 3
Introduction to the field of chemical engineering and solution of problems involving units and dimensions, mass balances, flow sheets and gas relationships.

CHEN.5060 Colloidal, Interfacial and Nanomaterials Science and Engineering (Formerly 10.506) - Credits: 3
Unifying principle and the three main classes of colloids (dispersions, macromolecular solutions and micelles) are considered. Topics covered include surface tension, work and energy, effect of surface curvature, zeta potential, surface activity and diverse applications of interest to chemical engineers.

CHEN.5080 Material Science and Engineering (Formerly 10.508) - Credits: 3
An advanced overview of solid materials that are likely to be considered for engineering applications in, or be produced by the chemical process industries. They will be discussed from the viewpoints of their unit cell structures, appropriate phase diagrams, their chemical and physical attributes, and the association of these to end use applications. Discussion of metals, ceramics, polymers, and composites. For Non-UML graduates.

CHEN.5100 Advanced Separation Processes (Formerly 10.510) - Credits: 3
This course emphasizes separation processes requiring a rate analysis for adequate understanding, which includes most of the newer separation methods of industrial importance such as membrane, sorption and chromatographic separations. Unifying fundamental relations and concepts are emphasized. Graphical and numerical design procedures are covered.

CHEN.5120 Industrial Chemistry (Formerly 10.512) - Credits: 3
Survey of the major sources and uses of chemicals, industrial chemical processes, fundamental raw materials, and career paths available in the chemical industry. More intensive treatment of selected industrial processes with emphasis of green/sustainable chemical processes.

CHEN.5180 Microprocessor Control (Formerly 10.518) - Credits: 3
Single board computers and single chip controllers and how they are used in chemical process control. Programming methods for using minicomputers as process controllers; interfacing requirements and communications. Laboratory projects include both software and hardware.

CHEN.5200 Advanced Thermodynamics (Formerly 10.520) - Credits: 3
Classical and statistical thermodynamics are applied to develop procedures for obtaining estimates of equilibrium properties required for chemical process design. An introduction to surface energy as an important parameter in the processing of colloids, especially in the nanometer size range, will also be undertaken.

CHEN.5220 Chemical Process Design (Formerly 10.522) - Credits: 3
Process synthesis, definition, and characterization. Introduction to modular process simulation packages such as ASPEN PLUS, Recycle and tear stream analysis. Stream convergence, Unit operations models, Flow sheet manipulation. Data records and physical property estimation techniques.

CHEN.5230 Nanodevices and Electronics Materials Processing (Formerly 10.523) - Credits: 3
Materials processing methods in electronics and related industries; crystal contamination control, growth, diffusion, etching, epitaxy, ion implantation, lithography, and other topics.

CHEN.5240 Self Assembly and Nanotechnology (Formerly 10.524) - Credits: 3
This course will describe two of the most fast-growing area/fields with both fundamental importance and practical relevance: self-assembly and nanotechnology. The first half of the course will discuss the theories and applications of self-assembly phenomena. The second half will focus on nanomaterials and nanotechnology.

CHEN.5260 Advanced Kinetics and Reactor Design (Formerly 10.526) - Credits: 3
The course will cover advanced chemical reaction kinetics, rate laws and reactor design with an emphasis on heterogeneous and catalytic reaction systems involving interphase and mass transfer effects.

CHEN.5280 Advanced Transport Phenomena (Formerly 10.528) - Credits: 3

An advanced study of the mechanisms of the transport processes. Transport equations are developed from both microscopic and macroscopic viewpoints. Analogies and similarities between the transport processes are discussed. Considerable emphasis is placed upon solutions to problems.

CHEN.5290 Recent Advances in Nanotechnology and Green Chemistry (Formerly 10.529) - Credits: 3

This course is designed to expose students to a variety of concepts in chemistry and challenge them to think critically about experiments used to interrogate these concepts. Organic polymer chemistry with an emphasis on electronically conducting polymers will be the main area of focus. Students would first be introduced to scientific subject matter outside their realm of familiarity and be expected to identify new concepts and links to existing experimental paradigms. The course is divided into 3 parts: (i) introduction to nanotechnology and green chemistry with a focus on nanoscale electronic polymers, (ii) green chemistry and the overlap area with nanotechnology, and (iii) green engineering.

CHEN.5300 Advanced Control Strategies (Formerly 10.530) - Credits: 3

An introduction to computer control and to some of the common control strategies applied to the design of complex chemical process control systems.

CHEN.5320 Principles of Chemical Engineering II (Formerly 10.532) - Credits: 3

Continuation of Principles of Chemical Engineering including real gas relationships, humidity, energy balances, and combined mass-energy balance systems. Introduction to the first law of thermodynamics. Note: Non-majors only.

CHEN.5330 Macromolecular Colloidal Science and Engineering (Formerly 10.533) - Credits: 3

This course treats both synthetic and natural macromolecules (i.e., polymers, and biopolymers), Interrelating synthesis commercial manufacture, molecular, macroscopic and application properties as well as the colloidal nature of their solutions. Pertinent fundamental principles are reviewed.

CHEN.5350 Cell and Microbe Cultivation (Formerly 10.535) - Credits: 3

This course presents the principles of biochemical engineering with an emphasis on the unit operation of cell cultivation for production of commercially important products, especially biopharmaceuticals. The bioreactor is viewed as a device for controlling the environment of recombinant and traditional cultures. Major topics include media design, kinetics of growth and production, expression systems, bioreactor types, cell physiology, and bioprocess economics.

CHEN.5370 Nanomaterials Characterization I (Formerly 10.537) - Credits: 3

This lecture course will provide an in-depth introduction to the principles, instrumentation and applications of most common nanomaterial characterization techniques. Nanomaterial imaging, physical, chemical, and optical property analyses are the main focus of this class. Topics covered will include: electron microscopy (SEM/TEM), scanned probe microscopy (AFM), elemental analysis (EDX/XPS), crystal structure analysis (XRD/SAED), thermal analysis (DSC/TGA), laser based characterization (LSCM/DLS/Raman), chromatographic methods (GC), infrared spectroscopy, UV/Vis spectroscopy and contact angle goniometry. The analytical and quantitative applications of these techniques for investigating different types of nanomaterials will also be described. Lab demonstrations will be included in lectures.

CHEN.5380 Advanced Separations in Biotechnology (Formerly 10.538) - Credits: 3

This course provides in depth analysis of the two methods used most often in Bioseparations, filtration and chromatography. For both techniques, basic concepts are reviewed. Membrane, depth, sterile and tangential flow filtration, as well as ion exchange, hydrophobic interaction, and hydroxyapatite chromatography are considered. The emphasis for both methods is on specific applications, scale-up, validation and cleaning.

CHEN.5390 Mathematical Methods for Engineers (Formerly 10/24.539) - Credits: 3

Ordinary and partial differential equations, linear algebra, matrix/vector calculus, numerical methods, introduction to optimization methods, and other topics as time permits. Both analytical and numerical techniques are integrated to give good analytical skills coupled with practical problem solving tools. Extensive computer work with the MATLAB package is required. (Same as 24.539).

CHEN.5400 Nanomaterials Characterization I
This lecture course will provide an in-depth introduction to the principles, instrumentation and applications of most common nanomaterial characterization techniques. Nanomaterial imaging, physical, chemical, and optical property analyses are the main focus of this class. Topics covered will include: electron microscopy (SEM/TEM), scanned probe microscopy (AFM), elemental analysis (EDX/XPS), crystal structure analysis (XRD/SAED), thermal analysis (DSC/TGA), laser based characterization (LSCM/DLS/Raman), chromatographic methods (GC), infrared spectroscopy, UV/Vis spectroscopy and contact angle goniometry. The analytical and quantitative applications of these techniques for investigating different types of nanomaterials will also be described. Lab demonstrations will be included in lectures.

**CHEN.5410 Nanomaterials Characterization II**  
(Formerly 10.541) - Credits: 3

This hands-on laboratory course will cover the practical aspects of light, electron and scanned probe microscopy techniques discussed in Nanomaterials Characterization I (10.540). A variety of nanomaterials samples systems will be characterized using laser scanning confocal microscopy (LSCM), scanning electron microscopy (SEM), transmission electron microscopy (TEM) and atomic force microscopy (AFM). The laboratory experiments will provide practical experience in sample preparation techniques, optimization of instrumental conditions for imaging and spectroscopy, and data analysis and interpretation. Students will work on individual term projects involving real-world samples that are of interest to them, and use the techniques they learned in the course to characterize their samples.

**CHEN.5440 Formulation of Biotherapeutics**  
(Formerly 10.544) - Credits: 3

Biotherapeutics, particularly antibodies, are currently the fastest growing pharmaceuticals. Ideally, biotherapeutics are formulated in aqueous solutions and are often a great challenge due physical and chemical stability issues. This course addresses the latest trends and challenges in biologics formulation with a focus on the important role of preformulation in understanding the biological molecule itself for greater "formulatability" and "developability". The course will feature interactive discussions on early formulation screening, thorough biophysical and analytical characterization, improving the feedback loop in the early formulation-development interface, overcoming aggregation and other heterogeneity challenges, and improving overall product profile. In addition, the course will also cover an optimization of the formulation process through rational iterative approach and in-depth case studies. As a whole, this course focuses on providing you with additional tools and knowledge to help streamline solutions to formulation and stability issues for biologics.

**CHEN.5450 Isolation and Purification**  
(Formerly 81.545) - Credits: 3

Efficient isolation and purification of biological products, especially proteins, from complex natural mixtures.

**CHEN.5480 Engineering Process Analytics**  
(Formerly 10.548) - Credits: 3

This course covers multivariate statistical data analysis and experimental design. Students will learn how to extract information by analyzing various engineering datasets, and how to generate information-rich datasets via minimum experiments. Software for data analysis and experimental design will be utilized during tutorial and practice.

**CHEN.5500 Biomedical Applications of Nanotechnology**  
(Formerly 10.550) - Credits: 3

The course will aim to give students an introduction to the applications of nanotechnology in biomedicine. The course will cover the basics of nanomaterials including synthesis and characterization, use of nanotheranostics platforms for drug delivery and imaging, nanomaterials for tissue engineering; nanobiodevices and nanotoxicology. The course is designed for graduate students in the Chemical Engineering and the Biomedical Engineering/Biotechnology programs as well as seniors in Chemical Engineering.

**CHEN.5520 Directed Study:**  
Chemical Engineering  
(Formerly 10.552) - Credits: 3

**CHEN.5550 Biopharmaceutical Regulatory Compliance**  
(Formerly 10.555) - Credits: 3

This course examines the regulatory framework in which "drugs", biologics" and "cellular therapies" are evaluated in the United States, including the laws, regulations and the state of industrial practice.

**CHEN.5560 Materials for Aerospace and Energy Applications**  
(Formerly 10.556) - Credits: 3

Material requirements for emerging applications in aerospace and energy sectors will be discussed. Mechanical, thermal and electrical and barrier properties of filled polymers and polymer nanocomposites will be studied. The effect of resin structure, filler additives, reactive diluents on the resulting properties will be reviewed. Scale-up issues will be studied using basic principles of chemical engineering.
CHEN.5860 Biotechnology Processing Projects Laboratory (Formerly 10.586) - Credits: 3

Development of manufacturing processes for the products of biotechnology are followed through a series of process unit operations. Following the synthesis, purification and formulation of a specific enzyme throughout the course, students examine interactions between process steps and evaluate the impact of each on the total production process. As a final project, students assume the role of project team leader, developing a commercial-scale production process for the enzyme.

CHEN.5930 Cooperative Education (Formerly 10.593) - Credits: 0
CHEN.6010 Seminar (Formerly 10.601) - Credits: 0
Required for all graduate students.

CHEN.6020 Graduate Seminar (Formerly 10.602) - Credits: 0
Required for all graduate students.

CHEN.6500 Nanoscale Transport Phenomena for Manufacturing Nanodevices (Formerly 10.650) - Credits: 3

An interdisciplinary course taught by faculty from the Chemical, Mechanical and Plastics Engineering Departments, who have special knowledge in nanoscale fluid mechanics and heat transfer. The course on nanoscale transport phenomena constitutes a bridge between existing fluid and heat transfer courses in multiple disciplines and emerging nanoscale science and engineering concepts to reflect the forefront of nanomanufacturing. The course is designed to incorporate recent advances in manufacturing polymer-based nanodevices. Key issues of the implementation and maintenance costs for fabrication will be addressed. Hands-on laboratory experiments will be performed to complement the lectures with the ultimate goal of designing and building a complete nanodevice at the end of the course. The course will prepare graduates for employment focused on designing and manufacturing nano/microfluidic systems, lab-on-a-chip devices, electronics devices, medical devices, and other emerging technologies.

CHEN.7200 Special Projects in Chemical Engineering (Formerly 10.720) - Credits: 3

Special projects undertaken by a student to expand his/her knowledge in specific fields related to his/her master's project.

CHEN.7330 Graduate Project - Chemical Engineering (Formerly 10.733) - Credits: 3

Advanced research project required of students electing non-thesis option performed under the supervision of a senior faculty member in the Chemical Engineering Program. The project must be approved by an examinee committee and the Department Chairperson.

CHEN.7360 Graduate Project - Chemical Engineering (Formerly 10.736) - Credits: 6
CHEN.7410 Thesis Review (Formerly 10.741) - Credits: 1
CHEN.7430 Master's Thesis - Chemical Engineering (Formerly 10.743) - Credits: 3

Advanced research work required of students electing thesis option performed under the supervision of a senior faculty member in the Chemical Engineering Program. The thesis must be approved by an examining committee and the Department Chairperson.

CHEN.7460 Master's Thesis - Chemical Engineering (Formerly 10.746) - Credits: 6
CHEN.7500 Doctoral Dissertation Review (Formerly 10.750) - Credits: 1

Doctoral Dissertation Review

CHEN.7530 Doctoral Dissertation/Chemical Engineering (Formerly 10.753) - Credits: 1-3

Advanced research work required of students performed under the supervision of a senior faculty member in the Chemical Engineering Program. The dissertation topic must be approved by the doctoral committee.

CHEN.7560 Doctoral Dissertation/Chemical Engineering (Formerly 10.756) - Credits: 6
CHEN.7590 Doctoral Dissertation/Chemical Engineering (Formerly 10.759) - Credits: 9
CHEN.7610 Continued Grad Research (Formerly 10.761) - Credits: 1

Continued Grad Research

ENGY.5040 Energy Engineering Workshop (Formerly
24.504) - Credits: 3
A group/individual design project. The design effort will integrate many aspects of the student’s engineering background, including design concepts, technical analyses, economic and safety considerations, etc. A formal report and oral presentation are required.

ENGY.5050 Reactor Physics (Formerly 24.505) - Credits: 3
Advanced treatment of several topics in reactor physics, including cross sections and processing methods, development of transport theory, reduction to diffusion theory, and analyses of analytical and numerical solutions of the resultant balance equations.

ENGY.5070 Reactor Engineering and Safety (Formerly 24.507) - Credits: 3
Modeling and analysis of reactor thermal-hydraulics and safety systems. Topics include nuclear heat generation and transport, single and two-phase flow, boiling crisis, and safety analysis.

ENGY.5090 Dynamic Systems Analysis (Formerly 24.509) - Credits: 3
Mathematical foundation using the state-variable approach. Topics include matrix methods, Laplace and Fourier transforms, transfer functions, frequency response and stability analyses, and distributed/lumped parameter systems. Applications to mechanical and thermo-fluid systems. Modeling and simulation of systems using Matlab are emphasized. A comprehensive project, including formal written and oral reports, is required.

ENGY.5100 Nuclear Fuel Cycle (Formerly 24.510) - Credits: 3
This course will explore the various stages of the nuclear fuel cycle. The nuclear fuel cycle is broadly classified into three stages: front end, service stage, and back end. The course will introduce students to the various sub stages within the three broad stages of the nuclear fuel cycle. The course will explore the technology that is currently being used in these stages, then compare difference in approaches. Further modifications to the fuel cycle management will be discussed to make nuclear energy more sustainable. The course will provide an overview of front end fuel cycle including: mining, milling, enriching, fabrication; back end of the fuel cycle including: waste and recycling (or not); and in core fuel management, burnup calculations; and approaches to balance the cost of electricity production using nuclear reactors. The students will be introduced to nuclear burnup code such as ORIGEN. At the conclusion of the course students will be tasked to design and evaluate an aspect of the nuclear cycle that has been discussed in the class including but not limited to: enrichment plant, in-core fuel management, spent fuel management.

ENGY.5140 Chemical and Nuclear Waste (Formerly 24.514) - Credits: 3
History of nuclear waste disposal; engineering design of disposal systems. Present status of waste and the character and quantities of future wastes. Review of disposal concepts on a generic basis. The national plan for waste disposal.

ENGY.5160 Radiation Shielding and Protection (Formerly 24.516) - Credits: 3
This course will explore the fundamental principles of the interaction of nuclear and atomic radiation with matter and the transport of radiation through materials. The students will learn characterization of radiation fields and sources, and transport radiation through material. The course will discuss radiation exposure, dose, dose equivalent in context of radiation shielding and protection. Consequently, the students will compile each of these topics to learn how to design and analyze radiation shielding and protection. The students will learn how to use both the SOURCES and ORIGEN (or equivalent) code systems for calculating radiation sources and the MCNP (or equivalent) code system for the transport of radiation. At the conclusion of the course the students are expected to develop a shielding design for a given constraints typically encountered in the nuclear field.

ENGY.5190 Reactor Operator Training (Formerly 24.519) - Credits: 3
Training, including in-reactor experience and topical lectures, as given to Reactor Operator Trainees who will undergo Federal testing for a Reactor Operator License.

ENGY.5200 Reactor Operator Training (Formerly 24.520) - Credits: 3
Continuation of 24.519. Upon completion of this course, the student will be given a simulated Reactor Operator examination, including a written test, an oral test about reactor systems, and a controls manipulation test.

ENGY.5310 Selected Topics in Engineering (Formerly 24.531) - Credits: 3
Special problems in nuclear science and engineering assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.
ENGY.5320 Selected Topics: Energy Science (Formerly 24.532) - Credits: 3
Special problems in nuclear science and engineering assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

ENGY.5340 Fundamentals of Nuclear Security and Safeguards (Formerly 24.534) - Credits: 3
This course will include technical and policy matters related to nuclear security and safeguards. The students will explore in interplay between technical and social science disciplines. Students will be introduced to fundamental nuclear physics and engineering, material science, risk assessment, computational techniques, modeling and simulation, information technology, measurement techniques, and detector development. Those technical disciplines will be combined with social science fields such as political science, international relations, international law, energy policies, and regional studies.

ENGY.5360 Reactor Experiments (Formerly 24.536) - Credits: 3
A laboratory-based course using the U Mass Lowell Research Reactor (UMLRR) to illustrate, validate, and expand upon a mix of topics from reactor core physics, reactor operations, and balance-of-plant/energy removal considerations in nuclear systems. Typical experiments may include an approach to critical demo, reactivity measurements, generation of blade worth curves, analysis of various reactor kinetics and dynamic scenarios (including temperature and xenon effects), measurement of axial flux profiles and temperature/void coefficients, analysis of loss of flow and other pump transients, etc. Matlab will be used for data analysis and for reactor simulation. Other analysis tools such as VENTURE, MCNP, or PARET using existing models of the UMLRR may also be used. Comprehensive analysis reports that compare/contrast experimental and simulation data will be required. Oral presentations summarizing the results from the experiments will also be required.

ENGY.7390 Graduate Project - Energy Engineering (Formerly 24.739) - Credits: 9
ENGY.7410 Thesis Review (Formerly 24.741) - Credits: 1
ENGY.7430 Master's Thesis - Nuclear Engineering (Formerly 24.743) - Credits: 3
ENGY.7460 Master's Thesis - Energy Engineering (Formerly 24.746) - Credits: 6
ENGY.7490 Master's Thesis - Energy Engineering (Formerly 24.749) - Credits: 9
ENGY.7530 Doctoral Dissertation/Energy Engineering (Formerly 24.753) - Credits: 3
Advanced research work required of students performed under the supervision of a senior faculty member in the Nuclear Engineering Program. The dissertation topic must be approved by the doctoral committee.

ENGY.7560 Doctoral Dissertation/Energy Engineering (Formerly 24.756) - Credits: 6
ENGY.7590 Doctoral Dissertation/Energy Engineering (Formerly 24.759) - Credits: 9
Advanced research work required of students performed under the supervision of a senior faculty member in the Energy Engineering Program. The dissertation topic must be approved by the doctoral committee.

ENGY.7660 Continued Graduate Research (Formerly 24.766) - Credits: 6
ENGY.7690 Continued Graduate Research (Formerly 24.769) - Credits: 9
Business Administration Minor for Civil & Environmental Engineering

The Business Administration Minor for Civil & Environmental Engineering is a program delivered by the College of Management. It consists of a focused set of 5 courses plus two courses already in the Civil and Environmental Engineering (CEE) core program, of which two may be used as CEE senior year Professional electives. The net additional course work (over and above the 128 credits needed for the CEE degree) is three courses (some of which may be taken during the summer).

This Minor provides management training which is very desirable in industry, and allows an easy transition into a later MBA program.

For students in Civil & Environmental Engineering, the following courses are required in the Business Administration Minor:

- 49.201 Economics I (already in CEE core)
- 60.201 Accounting/Financial *
- 61.301 Business Finance *
- 62.201 Marketing Principles
- 66.301 Organizational Behavior * (may be used as a CEE Professional Elective)
- 14.372 Civil Engineering Systems (already in CEE core)
- 14.475 Construction Management (CEE Professional Elective)

Courses marked with an asterisk * are available during the summer or on-line.

To enroll in this Minor, students need to file a Declaration of Minor form with the College of Management before registering for 300 level courses, and indicate their intention to pursue this Minor with their CEE Faculty Advisor. Immediately after registering for the final courses which complete the minor, the student should file an academic petition, indicating approval by the College of Management, with the Office of Enrollment Services.

This Minor differs from the "regular" Minor in Business Administration offered by the College of Management in that 14.372 Civil Engineering Systems is used in lieu of one of the CoM electives, and 14.475 Construction Management is used in lieu of an MIS course.

Civil & Environmental Engineering

Department of Civil and Environmental Engineering

The UMass Lowell Department of Civil and Environmental Engineering offers a wide variety of graduate programs. Program options include environmental engineering, geoenvironmental engineering, geotechnical engineering, structural engineering, transportation engineering, and environmental studies.

- Doctor of Engineering (D.Eng.) Civil and Environmental Engineering Option
- Doctor of Philosophy (Ph.D.) Civil and Environmental Engineering Option
- Doctor of Philosophy in Chemistry (Ph.D.) Environmental Studies Option
- Master of Science in Civil and Environmental Engineering
- Master of Science in Environmental Studies Environmental Engineering Science Concentration
- Master of Science in Environmental Studies Atmospheric Sciences Concentration
- Graduate Certificate Programs Environmental Biotechnology Nanotechnology Sustainable Infrastructure for Developing Nations
- Bachelor's-Master's Engineering Program

Graduate study in Civil and Environmental Engineering is an intensive program of instruction at an advanced technical level. The program permits students to design, in consultation with their advisor, a plan of study that meets individual goals and career objectives.

Masters Program

Civil & Environmental Engineering Master's Programs

The UMass Lowell Department of Civil & Environmental Engineering offers master's degree programs in Civil & Environmental Engineering and in Environmental Studies. Options within the Master of Science in Civil and Environmental Engineering include: Environmental Engineering, Geotechnical Engineering, Geoenvironmental, Structural Engineering, and Transportation Engineering. There are two concentrations within the Master of Science in Environmental Engineering - one in Atmospheric Sciences, and another in Environmental Engineering Sciences.

- Master of Science in Civil & Environmental Engineering Environmental Engineering Option Geotechnical
Master of Science in Civil & Environmental Engineering

Program Description and General Requirements

Graduate study in Civil and Environmental Engineering is an intensive program of instruction at an advanced technical level. The program permits students to design, in consultation with their advisor, a plan of study that meets individual goals and career objectives.

Program options include environmental engineering, geoenvironmental engineering, geotechnical engineering, structural engineering and transportation engineering.

Admission to a particular engineering option is open to applicants with undergraduate degrees in engineering, mathematics or science. The degree requires successful completion of 30 credit hours of course work, or 24 credit hours of instruction and a publishable thesis, or 27 hours of course work and preparation of a project report.

Courses are scheduled in the late afternoon and evening to provide study opportunities for students with full-time employment. Successful completion of undergraduate prerequisite courses is required before beginning graduate course work.

Applicants who satisfy graduate admission requirements will be assigned to a faculty member who will serve as their academic advisor. Students receiving a teaching or research assistantship will normally be required to submit a publishable thesis. Those admitted to graduate study as non-degree students may apply for matriculated status. However, no more than 12 credits of work completed while in non-degree student status or transferred from another department or college will be used toward a degree. Matriculated status is preferred before initial registration and is mandatory prior to registration for second semester courses. Faculty will review a petitioner’s performance in all courses attempted.

Visit the Civil & Environmental Engineering Department website for more information.

M.S. in Civil Engineering (Environmental Engineering Option)

The program offers an opportunity to pursue a broad range of interests in the fields of environmental and water resources engineering. The course of study is designed to meet an individual student’s interests and career goals. Programs consist of civil engineering courses in water and wastewater treatment, environmental chemistry, hydrology, hydraulics, air pollution control, environmental law and policy and may include courses from allied disciplines such as biological and health sciences, environmental studies, chemistry and work environment. The program of study consists of four core courses and elective courses. Undergraduate core course prerequisites must be completed before beginning graduate course work.

Prerequisite Undergraduate Courses for MS Environmental Engineering Option

In order to obtain the MS Degree in Civil and Environmental Engineering Environmental Engineering Option, a student is required to have completed undergraduate courses in the areas of chemistry, physics, mathematics and engineering. At a minimum, the following courses are required. University of Massachusetts Lowell (UML) course numbers are provided for reference purposes. Course work that is equivalent to the UML courses specified are acceptable. However, an official determination of prerequisite course equivalency will be conducted by UML faculty that teach the specified undergraduate course, or by the Department of Civil and Environmental Engineering Graduate Coordinator, only after the student has applied and been accepted into the graduate program. This list represents the minimum prerequisite course requirements. Additional undergraduate course work may be required to remedy academic deficiencies. Students will be notified of deficiencies in an acceptance letter. All deficiencies must be eliminated before a student can be classified as "fully matriculated".

The undergraduate prerequisite courses are as follows:

- CHEM.1210 Chemistry I
- CHEM.1230L Chemistry I Lab
- CHEM.1220 Chemistry II
- CHEM.1240L Chemistry II Lab
- MATH.1310 Calculus I
- MATH.1320 Calculus II
- MATH.2310 Calculus III
- PHYS.1410 Physics I
Core Courses

- CIVE.5610 Physical and Chemical Treatment Processes
- CIVE.5620 Physical and Chemical Hydrogeology
- CIVE.5670 Environmental Aquatic Chemistry
- CIVE.5680 Environmental Fate and Transport
- CIVE.5780 Biological Wastewater Treatment

Elective Courses

Individual student programs consist of a complement of elective courses usually taken from the following list:

- CIVE.5090 Environmental Engineering Geology
- CIVE.5270 Geotechnical and Environmental Site Characterization
- CIVE.5290 Engineering with Geosynthetics
- CIVE.5700 Small and Alternative Waste Water Treatment
- CIVE.5720 Marine and Coastal Processes
- CIVE.5730 Solid Waste Engineering
- CIVE.5740 Air Quality Modeling
- CIVE.5750 Groundwater Modeling
- CIVE.5950 Hazardous Waste Site Remediation
- ENVE.5010 Wetlands Ecology
- ENVE.5050 Glacial Geology
- ENVE.5060 Regional Hydrogeology
- ENVE.5100 Water Resources Management
- ENVE.5230 Air Pollution Control
- ENVE.5710 Air Pollution Phenomenology
- ENVE.5810 Understanding the Massachusetts Contingency Plan

M.S. in Civil Engineering (Geotechnical Engineering Option)

The master’s degree program in geotechnical engineering encompasses soil mechanics theory and applications in the fields of foundation and soil engineering. Course work emphasizes the engineering behavior of soil, soil property determination, and the use of advanced soil mechanics theory and soil-structure interaction in the solution of soil and foundation engineering problems. Elementary courses in soil mechanics, statics, strength of materials and fluid mechanics are required as prerequisites for graduate core courses. Students receiving a teaching or research assistantship are required to submit a publishable thesis. The program of study consists of five required courses: CIVE.5310 Advanced Soil Mechanics and any four core courses and four elective courses, selected with the consent of a student's faculty advisor. Program and course details are included in the graduate course list and the graduate catalog.

Core Courses

(Select any four of the following as core courses, others may be used as electives)

- CIVE.5290 Engineering with Geosynthetics
- CIVE.5300 Deep Foundations
- CIVE.5320 Theoretical Soil Mechanics
- CIVE.5330 Advanced Foundation Engineering
- CIVE.5340 Soil Dynamics and Earthquake Engineering
- CIVE.5360 Soil Engineering
- CIVE.5370 Experimental Soil Mechanics
- CIVE.5380 Soil Behavior

Additional Elective Courses

- CIVE.5040 Advanced Strength of Materials
- CIVE.5090 Environmental and Engineering Geology
- CIVE.5210 Reliability Analysis in Engineering
- CIVE.5270 Geotechnical and Environmental Site Characterization
- CIVE.5290 Engineering with Geosynthetics
- CIVE.5390 Ground Improvement
- CIVE.5500 Behavior of Structures
- CIVE.5620 Physical and Chemical Hydrogeology
- CIVE.5810 Engineering Systems Analysis
- CIVE.5830 Stochastic Concepts

M.S. in Civil Engineering (Geoenvironmental Option)

The solution of environmental problems related to soil and/or groundwater often requires knowledge of both Geotechnical
and Environmental Engineering. The Geoenvironmental program provides fundamental training in soil mechanics, groundwater hydrology, environmental chemistry, and soil engineering. Course work is offered in each area as well as in courses that combine disciplines generally required in the solution of complex site problems, such as, landfill design, remediation of hazardous waste sites, dewatering and soil improvement.

Core Courses

- CIVE.5310 Advanced Soil Mechanics
- CIVE.5360 Soil Engineering
- CIVE.5620 Physical and Chemical Hydrogeology
- CIVE.5670 Environmental Aquatic Chemistry
- CIVE.5950 Hazardous Waste Site Remediation

Elective Courses

- CIVE.5270 Geotechnical Environmental Site Characterization
- CIVE.5290 Engineering with Geosynthetics
- CIVE.5300 Deep Foundations
- CIVE.5320 Theoretical Soil Mechanics
- CIVE.5330 Advanced Foundation Engineering
- CIVE.5340 Soil Dynamics and Earthquake Engineering
- CIVE.5370 Experimental Soil Mechanics
- CIVE.5380 Soil Behavior
- CIVE.5610 Physical and Chemical Treatment Process
- CIVE.5680 Environmental Fate and Transport
- CIVE.5730 Solid Waste Engineering
- CIVE.5750 Groundwater Modeling
- CIVE.5760 GIS Applications in Civil & Environmental Engineering
- ENVE.5810 Understanding the Massachusetts Contingency Plan

M.S. in Civil Engineering (Structural Engineering Option)

The structural option within Civil and Environmental Engineering offers instruction and research in advanced concepts and techniques in the solution of complex structural engineering problems. A student seeking an MS Engineering in Structural Engineering must have a structural analysis course which includes statically indeterminate structures and junior or senior level courses in the design of steel and concrete structures. Student study programs in structural engineering are developed with a faculty advisor to meet the needs of the individual. These undergraduate courses are core graduate course prerequisites and students deficient in these areas must take these courses before they can take advanced courses.

Core Courses

- CIVE.5040 Advanced Strength of Materials
- CIVE.5510 Design of Steel Structures or CIVE.5520 Design of Reinforced Concrete Structures
- CIVE.5560 Finite Element Analysis (or equivalent)
- CIVE.5570 Structural Dynamics

Elective Courses

- CIVE.5210 Reliability Analysis in Engineering
- CIVE.5500 Behavior of Structures
- CIVE.5510 Design of Steel Structures
- CIVE.5520 Behavior of Concrete Structures
- CIVE.5530 Wood Structures
- CIVE.5540 Prestressed Concrete Design
- CIVE.5550 Seismic Design of Structures
- CIVE.5580 Bridge Design
- CIVE.5310 Advanced Soil Mechanics
- CIVE.5330 Advanced Foundation Engineering
- CIVE.5360 Soil Engineering

Additional geotechnical and geoenvironmental courses and appropriate courses from the Departments of Mathematics (https://www.uml.edu/catalog-AY16/pdf/Graduate.pdf) and Mechanical Engineering (https://www.uml.edu/catalog-AY16/pdf/Graduate.pdf) may also be included in a degree plan.

M.S. in Civil Engineering (Transportation Engineering Option)

The program in Transportation Engineering offers courses in planning, design and operation of multi-modal transportation facilities. It emphasizes the interdisciplinary nature of the subject, supplementing engineering concepts with techniques from management, economics, operations research and environmental studies. It is designed to provide students with advanced technical knowledge for addressing transportation problems in a variety of practical situations. Specialization in a specific area can be achieved through thesis and project work. Graduate study plans are designed based upon student interest, professional needs and undergraduate preparation. Students
are expected to have completed or show proficiency in the following courses in partial fulfillment of degree requirements:

Core Courses

- CIVE.5400 Urban Transportation Planning
- CIVE.5410 Traffic Engineering
- CIVE.5810 Engineering Systems Analysis
- CIVE.5830 Stochastic Concepts

Courses from other appropriate disciplines such as engineering, management, and pure and applied science may be taken to form a coherent program in Transportation Engineering. A graduate plan of study will be designed to meet the professional needs of each student; however, at a minimum, each student. Following is a list of elective courses that are periodically being offered by the Department.

Elective Courses

- CIVE.5220 Statistical Applications in Civil Engineering
- CIVE.5420 Fundamentals of ITS and Traffic Management
- CIVE.5440 Transportation Planning Practice
- CIVE.5450 Public Transit Planning and Design
- CIVE.5460 Pavement Design
- CIVE.5470 Airport Planning and Design
- CIVE.5480 Traffic Management and Control
- CIVE.5490 Traffic Flow Theory Elective

Master of Science in Environmental Studies

Environmental Engineering Sciences Concentration

This interdisciplinary program offers a Master of Science in Environmental Studies with a thesis or a non-thesis track. Enrollment in the program is open to individuals with a baccalaureate degree in technology, biology or a physical science. Others may be admitted with the approval of the Graduate Coordinator. Such students may make up course prerequisite deficiencies while in the program, although those credits will not count toward the total required for the masters degree. Frequently, students entering the program are required to take a number of undergraduate courses to develop analytical skills and to prepare for advanced level course work. Undergraduate courses may include calculus, statistics, chemistry, computer programming or courses designed to develop problem-solving skills. Course requirements are determined by discussion with the Program Coordinator. The thesis track requires completion of an approved program of study involving a minimum of 24 credits of core courses and electives, and 6 credits of thesis, consisting of laboratory research or scholarly investigation, for a total of 30 credits. Students may only register for thesis research with the prior approval of a thesis advisor. The thesis work is to be guided by a principal advisor who is a member of the University of Massachusetts Lowell faculty and by two additional committee members, at least one of whom must be a member of the faculty. Committee selection and the thesis topic are subject to the approval of the graduate coordinator. The non-thesis track requires completion of an approved program of study involving 30 credits of core courses and electives. All individual programs of study must include the core courses listed below:

Prerequisite Undergraduate Courses for M.S. Environmental Studies Option

In order to obtain the M.S. Degree in Environmental Studies, a student is required to have completed undergraduate courses in the areas of chemistry, physics, and mathematics. At a minimum, the following courses are required. University of Massachusetts Lowell (UML) course numbers are provided for reference purposes. Course work that is equivalent to the UML courses specified are acceptable. However, an official determination of prerequisite course equivalency will be conducted by UML faculty that teach the specified undergraduate course, or by the Environmental Studies Graduate Coordinator, only after the student has applied and been accepted into the graduate program. This list represents the minimum prerequisite course requirements. Additional undergraduate course work may be required to remedy academic deficiencies. Students will be notified of deficiencies in an acceptance letter. All deficiencies must be eliminated before a student can be classified as "fully matriculated".

The undergraduate prerequisite courses are as follows:

- CHEM.1210 Chemistry I
- CHEM.1230L Chemistry I Lab
- CHEM.1220 Chemistry II
- CHEM.1240L Chemistry II Lab
- MATH.1310 Calculus I
- MATH.1320 Calculus II
- PHYS.1410 Physics I
- PHYS.1410L Physics I Lab

Core Courses

- ENVE.5100 Water Resources Management
- CIVE.5730 Solid Waste Engineering
- ENVE.5230 Air Pollution Control or
- ENVE.5710 Air Pollution Phenomenology
Elective Courses

- CIVE.5090 Environmental/Engineering Geology
- CIVE.5610 Physical and Chemical Treatment Processes
- CIVE.5620 Physical and Chemical Hydrogeology
- CIVE.5670 Environmental Aquatic Chemistry
- CIVE.5680 Environmental Fate and Transport
- CIVE.5700 Small and Alternative Wastewater Treatment
- CIVE.5720 Marine and Coastal Processes
- CIVE.5740 Air Quality Modeling
- CIVE.5750 Groundwater Modeling
- CIVE.5950 Hazardous Waste Site Remediation
- ENVE.5010 Wetlands Ecology
- ENVE.5020 Limnology
- ENVE.5030 Environmental Toxicology and Risk Assessment
- ENVE.5050 Glacial Geology
- ENVE.5060 Regional Hydrogeology
- ENVE.5270 Environmental Laws
- ENVE.5710 Air Pollution Phenomenology
- ENVE.5720 Energy and the Environment
- ENVE.5750 Physical Chemistry for Environmental Studies
- ENVE.5760 Boundary layer Meteorology
- ENVE.5770 Remote Sensing of the Atmosphere
- ENVE.5780 Advanced Synoptic Meteorology
- ENVE.5790/ATMO.5150 Atmospheric Structure and Dynamics
- ENVE.5800 Implementation of Environmental Policy
- ENVE.5810 Understanding the Massachusetts Contingency Plan
- CHEM.5190 Environmental Chemistry

ATMOSPHERIC Sciences Concentration

Enrollment in this program is open to individuals with a bachelor’s degree in sciences, mathematics and engineering. Others may be admitted with the approval of the Graduate Program Coordinator. Such students may make up course prerequisite deficiencies while in the program, although these credits will not count toward the total required for the masters degree. Frequently, students entering the program are required to take a number of undergraduate courses to develop the analytical skills, and to prepare for the advanced level courses.

The M.Sc. program requires the completion of 30 credits, 9 in core courses, and 15 in elective courses listed below. Six credits may be achieved by completing a Master’s Thesis. The thesis involves original laboratory or theoretical work, usually publishable in accredited and peer reviewed technical journals. With the Graduate Program Coordinators approval, the thesis work may be performed at home or at the students employment facilities. The thesis advisory committee will consist of a Principal Advisor who is the member of the EEAS faculty, and two members chosen from EEAS or associated UMass Lowell faculty. One member may be from outside the University, with the approval of the Graduate Coordinator. Students may elect to take additional courses instead of writing a thesis.

Most of the courses are offered in the evening, usually from 6 to 9 p.m., once per week. This enables working students to complete the course requirements while the student is employed. A maximum of 5 years is allowed for completion of the masters degree, including the thesis.

Core Courses

- ATMO.5010 Boundary Layer Meteorology
- ENVI.5750/CHEM.5750 Physical Chemistry for Environmental Studies
- Chose one of the two following courses:
  - PUBH.527/ENVE.5270 Environmental Law and Policy
  - ECON.615 Environmental and Natural Resources Economics

Elective Courses

- ATMO.5020 Advanced Synoptic Meteorology
- ATMO.5030 Remote Sensing of the Atmosphere
- ATMO.5110 Solar Terrestrial Relations
- ATMO.5150 Atmospheric Structure and Dynamics
- ATMO.5230 Air Pollution Control
- ATMO.5710 Air Pollution Phenomenology
- ATMO.6730/PUBH.6170 Air Pollution Laboratory/Measurement of Airborne Contaminants
- ATMO.6740 Air Quality Modeling
- ENVI.5720 Energy and the Environment
- PUBH.5140 Aerosol Science
- MATH.5500 Mathematical Modeling
- RADI.6130 Environmental Monitoring and Surveillance (Radionuclides)
Doctoral Programs

The UMass Lowell Department of Civil & Environmental Engineering offers three doctoral programs.

- **Doctor of Engineering (D.Eng.)**
  Civil and Environmental Engineering Option

- **Doctor of Philosophy (Ph.D.)**
  Civil and Environmental Engineering Option

- **Doctor of Philosophy (Ph.D.) in Chemistry**
  Environmental Studies Option

D.Eng. and Ph.D. - Civil & Environmental Engineering Option

**Objectives**

The objective of the Doctor of Engineering/Doctor of Philosophy degree in Civil and Environmental Engineering is to develop decision-making, research-oriented engineers with the ability to produce new engineering knowledge and analyze complex, cross-disciplinary issues. Successful applicants are expected to perform advanced research in one or more areas of concentration within the Department of Civil and Environmental Engineering and successfully complete both core courses and electives that may be drawn from a variety of disciplines. Beyond the core courses, the program can be tailored to the needs of each student through a formal arrangement between the student and his or her research advisor.

**Areas of Concentration**

The areas of concentration within the Doctor of Engineering/Doctor of Philosophy in Civil and Environmental Engineering are:

- Environmental Engineering
- Geoenvironmental Engineering
- Geotechnical Engineering
- Transportation Engineering
- Structural Engineering

**Program Curriculum**

In addition to the general degree requirements described earlier, students are required to take the Core Courses in one of the program concentration areas listed below.

- **Core for Environmental Engineering Concentration**
  CIVE.5610 Physical and Chemical Treatment Processes

  - CIVE.5620 Physical and Chemical Hydrogeology
  - CIVE.5670 Environmental Aquatic Chemistry
  - CIVE.5680 Environmental Fate and Transport
  - CIVE.5780 Biological Wastewater Treatment
  - CIVE.5950 Hazardous Waste Site Remediation
  - Core for Geoenvironmental Engineering Concentration
  - CIVE.5310 Advanced Soil Mechanics
  - CIVE.5360 Soil Engineering
  - CIVE.5620 Physical and Chemical Hydrogeology
  - CIVE.5670 Environmental Aquatic Chemistry
  - CIVE.5950 Hazardous Waste Site Remediation
  and at least one of the following:
  - CIVE.5290 Engineering with Geosynthetics
  - CIVE.5380 Soil Behavior
  - CIVE.5270 Geotechnical and Environmental Site Characterization
  - Core for Geotechnical Engineering Concentration
  - CIVE.5310 Advanced Soil Mechanics
  - and any four of the following:
  - CIVE.5270 Geotechnical and Environmental Site Characterization
  - CIVE.5290 Engineering with Geosynthetics
  - CIVE.5300 Deep Foundations
  - CIVE.5320 Theoretical Soil Mechanics
  - CIVE.5330 Advanced Foundation Engineering
  - CIVE.5340 Soil Dynamics and Earthquake Engineering
  - CIVE.5360 Soil Engineering
  - CIVE.5370 Experimental Soil Mechanics
  - CIVE.5380 Soil Behavior
  - CIVE.5390 Ground Improvement
  - Core for Transportation Engineering Concentration
  - CIVE.5400 Urban Transportation Planning
  - CIVE.5410 Traffic Engineering
  - CIVE.5810 Engineering Systems Analysis
  - CIVE.5830 Stochastic Concepts
  - Core for Structural Engineering Concentration
Admissions Requirements

Admission to applicants who have at least one degree in engineering from an accredited university and department requires high academic standing in all prior course work. Admission may be also offered to applicants who hold a Bachelor’s and/or Master’s degree in non-engineering fields. In such cases, the applicant must successfully complete all requirements for a Master of Science in Civil and Environmental Engineering prior to being considered a candidate for the Doctor of Engineering/Doctor of Philosophy degree.

Plan of Study

Within about one academic year of initiation of doctoral study, each student must work with his/her research advisor to develop a Plan of Study that complies with doctoral program and University policies. Courses substitutions in the Plan of Study must be reviewed by the Departmental Graduate Committee. Formal requests for substitutions are made by the student’s Research Advisor. The student’s Research Advisor is the supervisor of the student’s research activities. The Advisor will work with the student to develop Dissertation research focus and request the service of appropriately qualified persons in the student’s Dissertation Committee. The Dissertation Committee will comprise a minimum of 4 persons of which at least 2 will be full time, regular faculty members of the Department of Civil and Environmental Engineering. The function of the Dissertation Committee is to ensure that the final edition of the student's dissertation meets the high technical standards expected in doctoral work and that the student successfully defends his/her findings prior to the award of the Doctor of Engineering degree. Dissertation Committee members are not necessarily co-investigators of the student’s research topic.

Qualifying Examination

Upon the completion of a maximum of 45 credit hours of graduate work that count towards the doctoral degree, the student will apply to the Dissertation Committee to take a Qualifying Examination. In addition, students who were admitted as non-engineering degree holders into the Doctor of Engineering/Doctor of Philosophy program must satisfy all requirements for the award of the M.S. degree in Civil and Environmental Engineering before they are allowed to take the Qualifying Examination. The Qualifying Examination may be written and oral. The Dissertation Committee members will submit their grades to the Doctoral Program Coordinator who will tally them and report the overall grade on a pass/fail basis, to the student and his/her advisor. Students who successfully complete the Qualifying Examination will be designated as Candidates for the Doctor of Engineering/Doctor of Philosophy degree. For each doctoral student, a maximum of two Qualifying Examinations will be allowed. A doctoral student who fails the Qualifying Examination two times will not be allowed to continue in the doctoral program. Shortly after passing the Qualifying Examination, the Doctoral degree candidate will be expected to develop a thesis plan in collaboration with his/her advisor, and defend it successfully before the Doctoral Committee.

Ph.D. Program in Chemistry - Environmental Studies Option

A Ph.D. in Chemistry with an option in Environmental Studies is offered jointly by the Department of Chemistry and the Department of Civil and Environmental Engineering. The program is described in detail in the Chemistry Department section of this catalog.

Graduate Certificates

Graduate Certificates in Civil &Environmental Engineering

The UMass Lowell Department of Civil &Environmental Engineering offers three interdisciplinary graduate certificates.

- Environmental Biotechnology
- Nanotechnology
- Sustainable Infrastructure for Developing Nations

Graduate Certificate Application Form (https://www.uml.edu/docs/Updated%20Certificate%20forms_tcm18-3166.pdf) (pdf)

Environmental Biotechnology

Biology, Chemistry, Civil &Environmental Engineering departments

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Environmental biotechnology refers to the application of biological technologies to monitor, understand, and remediate environmental problems. This certificate combines courses that explore the ecological impact of anthropogenic environmental change with courses that provide training in current biological technologies that can be brought to bear on environmental problems. Recent advances in biotechnology are providing new
avenues for investigating biologically mediated environmental processes, many of which were inaccessible using traditional approaches. New biological technologies are being developed to mitigate environmental problems. These include the biological remediation of pollutants, biological treatment of wastewater and drinking water, source tracking of microbial pathogens, and mitigation of toxic algal blooms. As environmental resources are increasingly strained and new biological technologies with the potential to improve our environment become available, the demand for professionals with training in environmental biotechnology will continue to increase.

**Required Courses (choose two):**
- BIOL.5040 Environmental Microbiology (3 credits)
- BIOL.5230 Biology of Global Change (3 credits)
- CIVE.5780 Biological Wastewater Treatment (3 credits)

**Elective courses (choose six to eight credits):**
- CHEM.5800 Advanced Analytical Biochemistry (3 credits)
- CHEM.5140 Advanced Analytical Chemistry (3 credits)
- BIOL.5050/5070 Bioinformatics (4 credits)
- CHEM.5260 Chromatography (3 credits)
- CIVE.5670 Environmental Aquatic Chemistry (3 credits)
- CIVE.5680 Environmental Fate and Transport (3 credits)
- CIVE.5950 Hazardous Waste Site Remediation (3 credits)
- BIOL.5670 Recombinant DNA Techniques (3 credits)
- BIOL.5690L Recombinant DNA Techniques Laboratory (2 credits)

Total: 12-14 credits

**Nanotechnology**

**Civil & Environmental, Mechanical, Plastics Engineering departments**

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

**Core Course:** (required)
- ENGN.5500 Introduction to Nanotechnology (3 credits)

**Core Courses:** (choose one)
- CHEN.5410 Nanostructural Characterization by SEM, TEM, and AFM (3 credits)
- CHEM.5100 Electron Microscopy of Advanced Materials (3 credits)
- CHEM.5250 Analysis of Advanced Materials (3 credits)

**Elective Courses:** (choose two courses from one of the following topic areas)

**Materials**
- CHEN.5060 Interfacial Science and Engineering and Colloids (3 credits)
- CHEN.5270 Nanomaterials Science and Engineering (3 credits)
- MECH.5780 Advanced Materials (3 credits)
- PLAS.5130 New Plastics Materials (3 credits)
- PLAS.5980 Smart Polymers (3 credits)

**Manufacturing**
- CHEN.5230 Electronic Materials Processing (3 credits)
- CHEN.5240 Self-assembly and Nanotechnology (3 credits)
- CHEN.5350 Cell & Microbe Cultivation (3 credits)
- CHEN.5450 Isolation & Purification of Biotech Products (3 credits)
- EECE.5040 VLSI Fabrication (3 credits)
- ENGN.5510 Nanomanufacturing I (3 credits)
- ENGN.5260 Nanoscale Plastics Processing (3 credits)
- PLAS.5020 New Plastics Processing Techniques (3 credits)

**Design and Devices**
• EECE.5020 VLSI Design (3 credits)
• EECE.5120 Electronic Materials (3 credits)
• EECE.5080 Quantum Electronics for Engineers (3 credits)

**Health and Environmental Impacts**

• PUBH.5030 Toxicology and Health (3 credits)
• PUBH.5140 Aerosol Science (3 credits)
• PUBH.5250 Industrial Hygiene and Ergonomics (3 credits)
• PUBH.5570 Toxic Use Reduction (3 credits)
• PUBH.6100 Exposure Assessment (3 credits)
• PUBH.6170 Measurements of Airborne Contaminants (3 credits)

**Sustainable Infrastructure for Developing Nations**

**Civil and Environmental Engineering Department**

**Contact:**

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This 12 credit certificate prepares engineers and allied professionals for work in developing regions. It develops the special skills and awareness necessary for development of functionally sustainable infrastructure. The technical material provides advanced knowledge fully applicable to situations of both domestic and international infrastructure development.

**Required Courses:**

A pair of closely related courses (6 credits) that develop an area of concentration from among the list of offerings is required. CIVE.5760 Practicum may be taken as one of these.

**Elective Courses:**

The certificate may be completed with any two additional courses from the list below. Individual programs of courses for the certificate will be developed in consultation with faculty.

• CIVE.5270 Geotechnical and Environmental Site Characterization (3 credits)
• CIVE.5590 Design of Masonry Structures (3 credits)
• CIVE.5640 Water Supply Systems and Management (3 credits)
• CIVE.5700 Wastewater Treatment and Storm Water Management Systems (3 credits)
• CIVE.5730 Solid Waste Engineering (3 credits)
CIVE.0538 Soil Behavior - Credits: 3
Study of the physico-chemical and mechanical behavior of soil. Topics include: soil mineralogy, formation, composition, concepts of drained and undrained stress-strain and strength behavior, frozen soils.

CIVE.5010 Civil Engineering Research Seminar - Credits: 0
Research seminar for doctoral and Master's students to listen to researchers from academia, industry, and government of research-related topics in civil and environmental engineering. Invited speakers will present recent research advances in fields of environmental engineering, geotechnical engineering, structural engineering and transportation engineering. Attendance is mandatory for doctoral and MS students with thesis option. Thesis requirements and research methods will be introduced in various talks.

CIVE.5030 Computer Based Analysis of Structures (Formerly 14.503) - Credits: 3
The course is an introduction to the finite element displacement method for framed structures. It identifies the basic steps involved in applying the displacement method that can be represented as computer procedures. The course covers the modeling and analysis of 2-dimensional and 3-dimensional structures, such as cable-stayed structures, arches, and space trusses, space frames, shear walls, and so on. The analysis is done for both static and dynamic loading. The study is done by using MATLAB, GTSTRUDL, and Mathcad software.

CIVE.5040 Advanced Strength Of Material (Formerly 14/10.504) - Credits: 3
Stress and strain at a point; curved beam theory, unsymmetrical bending, shear center, torsion of non-circular sections; theories of failure; selected topics in solid mechanics.

CIVE.5050 Concrete Materials (Formerly 14.505) - Credits: 3
This course introduces fundamental and advanced topics on the properties of concrete materials. Fundamental topics include the formation, structure, mechanical behavior, durability, fracture, and deterioration of concrete. Theoretical treatments on the deformation, fracture and deterioration of concrete are also addressed. Advanced topics include the electromagnetic properties of concrete, high performance concrete (HPC), high-strength concrete (HSC), fiber-reinforced concrete, other special concretes, and the green construction of concrete.

CIVE.5080 Practice of Structural Engineering (Formerly 14.508) - Credits: 3
This course covers the practice of structural engineering as it deals with the design of structures such as buildings and bridges, the identification of loads, and design variables, and design detailing for concrete and steel structures. The emphasis will be placed on the use and interpretation of the ACI318-09, AISD and AASHTO codes and the GTSTRUDL software.

CIVE.5110 Inspection and Monitoring of Civil Infrastructure (Formerly 14.511) - Credits: 3
In this course, principles and applications of inspection and monitoring techniques for the condition assessment of aged/damaged/deteriorated civil infrastructure systems such as buildings, bridges, and pipelines, are introduced. Current nondestructive testing/evaluation (NDT/E) methods including optical, acoustics/ultrasonic, thermal, magnetic/electrical, radiographic, microwave/radar techniques are addressed with a consideration of their theoretical background. Wired and wireless structural health monitoring (SHM) systems for civil infrastructure are also covered. Applications using inspection and monitoring techniques are discussed with practical issues in each application.

CIVE.5120 Structural Stability (Formerly 14.512) - Credits: 3
This course provides a concise introduction to the principles and applications of structural stability for their practical use in the design of steel frame structures. Concepts of elastic and plastic theories are introduced. Stability problems of structural members including columns, beam-columns, rigid frames, and beams are studied. Approaches in evaluating stability problems, including energy and numerical methods, are also addressed.

CIVE.5210 Reliability Analysis (Formerly 14.521) - Credits: 3
A review of the elementary principles of probability and statistics followed by advanced topics including decision analysis, Monte Carlo simulation, and system reliability. In-depth quantitative treatment in the modeling of engineering problems, evaluation of system reliability, and risk-benefit decision management.

CIVE.5270 Geotechnical and Environmental Site Characterization (Formerly 14.527) - Credits: 3
This course is designed to give students a comprehensive understanding of various site investigation and site assessment technologies employed in geotechnical and environmental
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CIVE.5280 Drilled Deep Foundations (Formerly 14.528) - Credits: 3

CIVE.5290 Engineering with Geosynthetics (Formerly 14.529) - Credits: 3
Rigorous treatment in the mechanism and behavior of reinforced soil materials. Laboratory and insitu tests for determining the engineering properties of geosynthetics (geotextiles, geomembranes, geogrids and geocomposites). Design principles and examples of geosynthetics for separation, soil reinforcement and stabilization, filtration and drainage.

CIVE.5300 Driven Deep Foundations (Formerly 14.530) - Credits: 3
design and analyses of driven deep foundations including: Deep foundations classification and historical perspective. Effects of pile installation. Static capacity and settlement analysis of a single pile and a pile group under vertical loads. Insight of pile resistance including soil behavior and interfacial friction. Driven pile load test standards, construction, interpretation, and simulation. Dynamic analysis of driven piles, the wave equation analysis, dynamic measurements during driving and their interpretation. Reliability based design using the Load and Resistance Factor design (LRFD) methodology application for driven deep foundations.

CIVE.5310 Advanced Soil Mechanics (Formerly 14.531) - Credits: 3
Theories of soil mechanics and their application. Drained and undrained stress-strain and strength behavior of soils. Lateral earth pressures, bearing capacity, slope stability, seepage and consolidation. Lab and insitu testing.

CIVE.5320 Theoretical & Numerical Methods in Soil Mechanics (Formerly 14.532) - Credits: 3
Geotechnical practice employs computer programs that incorporate numerical methods to address problems of stability, settlement, deformation, and seepage. These methods are based on theoretical understanding of the behavior of soils, and correct use of commercial software requires that the engineer understand theoretical bases of the numerical algorithms and how they work. This course addresses the description of stress and strain in the context of geotechnical engineering and the basic concepts of numerical and computational methods, including discretization errors, computational procedures appropriate to different classes of problem, and numerical instability. It will then apply the insights to the three major problems of geotechnical analysis: settlement, stability, and fluid flow.

CIVE.5330 Advanced Foundation Engineering (Formerly 14.533) - Credits: 3
Design and analysis of shallow foundations, excavations and retaining structures including: site exploration, bearing capacity and settlement theories, earth pressures, braced and unbraced excavations, rigid and flexible retaining structures, reinforced earth, dewatering methods and monitoring techniques.

CIVE.5340 Soil Dynamics and Earthquake Engineering (Formerly 14.534) - Credits: 3
This course addresses the dynamic properties of soils and basic mechanical theory of dynamic response. It will apply these results to analysis and design of dynamically loaded foundations. A basic understanding of earthquakes - where they occur, their quantitate description, how the complicated patterns of motions are captured by techniques such as the response spectrum, and how engineers design facilities to withstand earthquakes, will be addressed. In particular, the course will consider three topics of current professional and research interest: probabilistic seismic hazard analysis (PHSA),
soil liquefaction, and seismically induced displacements. The emphasis will be on geotechnical issues, but some time will be devoted to structural considerations in earthquake resistant design.

CIVE.5360 Soil Engineering (Formerly 14.536) - Credits: 3
The study of soil as an engineering material, and its use in earth structures (e.g. dams, road embankments), flow control, and compacted fills. Stability of natural and man made slopes, soil reinforcement and stabilization.

CIVE.5370 Experimental Soil Mechanics (Formerly 14.537) - Credits: 3
Application of testing procedures to the evaluation of soil type and engineering properties. Testing for classification, permeability, consolidation, direct and triaxial shear and field parameters. The technical procedures are followed by data analysis, evaluation and presentation. Critical examination of standard testing procedures, evaluation of engineering parameters, error estimation and research devices.

CIVE.5380 Soil Behavior - Credits: 3
Study of the physico-chemical and mechanical behavior of soil. Topics include: soil mineralogy, formation, composition, concepts of drained and undrained stress-strain and strength behavior, frozen soils.

CIVE.5390 Ground Improvement (Formerly 14.539) - Credits: 3
Design and construction methods for strengthening the properties and behavior of soils. Highway embankments, soil nailing, soil grouting, landslide investigation and mitigation, dynamic compaction, stone columns.

CIVE.5400 Urban Transportation Planning (Formerly 14.540) - Credits: 3
Objectives and procedures of the urban transportation planning process. Characteristics and current issues of urban transportation in the United States (both supply and demand). Techniques of analysis, prediction and evaluation of transportation system alternatives. Consideration of economic, environmental, ethical, social and safety impacts in the design and analysis of transportation systems.

CIVE.5410 Traffic Engineering (Formerly 14.541) - Credits: 3
Engineering principles for safe and efficient movement of goods and people on streets and highways, including aspects of (a) transportation planning; (b) geometric design; (c) traffic operations and control; (d) traffic safety, and; (e) management of transportation facilities. Topics include: traffic stream characteristics; traffic engineering studies; capacity and level-of-service analysis; traffic control; simulation of traffic operations; accident studies; parking studies; environmental impacts.

CIVE.5420 Transportation Network Analysis (Formerly 14.542) - Credits: 3
This course is to introduce engineering students to basic transportation network analysis skills. Topics covered include fundamentals of linear and nonlinear programming, mathematical representations of transportation networks, various shortest path algorithms, deterministic user equilibrium traffic assignment, stochastic user equilibrium traffic assignment, dynamic traffic assignment, heuristic algorithms for solving traffic assignment problems, and transportation network design.

CIVE.5430 Traffic Principles for Intelligent Transportation Systems (Formerly 14.543) - Credits: 3
The objective of this course is to introduce the student to the traffic principles that are pertinent for the planning, design and analysis of Intelligent Transportation Systems (ITS). The course is oriented toward students that come from different disciplines and who do not have previous background in traffic or transportation principles. It is designed as an introductory course that will enable the student to pursue more advanced courses in transportation systems subsequently.

CIVE.5440 Transportation Economics and Project Evaluation (Formerly 14.544) - Credits: 3
The course offers an overview of the fundamental principles of transportation economics. Emphasizes theory and applications concerning demand, supply and economics of transportation systems. Covers topics such as pricing, regulation and the evaluation of transportation services and projects. Prerequisites: Students should have knowledge of transportation systems and basic microeconomics.

CIVE.5450 Public Transit Plan and Design (Formerly 14.545) - Credits: 3
Planning and design of public transportation systems and their technical, operational and cost characteristics. Discussion of the impact of public transportation on urban development; the different transit modes, including regional and rapid rail transit (RRT), light rail transit (LRT), buses, and paratransit, and
their relative role in urban transportation; planning, design, operation and performance of transit systems (service frequency and headways, speed, capacity, productivity, utilization); routes and networks; scheduling; terminal layout; innovative transit technologies and their feasibility.

CIVE.5460 Pavement Design (Formerly 14.546) - Credits: 3

Fundamentals of planning, design, construction and management of roadway and airport pavements. Introduction to the theory and the analytical techniques used in pavement engineering. Principal topics covered: pavement performance, analysis of traffic, pavement materials; evaluation of subgrade; flexible and rigid pavement structural analysis; reliability design; drainage evaluation; design of overlays; and pavement distresses.

CIVE.5470 Airport Planning and Design (Formerly 14.547) - Credits: 3

Planning and design of civil airports. Estimation of air travel demand. Aircraft characteristics related to design: payload, range, runway requirements. Analysis of wind data, runway orientation and obstruction free requirements. Airport configuration, aircraft operations, and capacity of airfield elements. Design of the terminal system, ground access system, and parking facilities.

CIVE.5480 Traffic Management and Control (Formerly 14.548) - Credits: 3

The course presents modern methods of traffic management, traffic control strategies and traffic control systems technology. Main topics covered, include: transportation systems management (TSM); traffic control systems technology; control concepts - urban and suburban streets; control and management concepts - freeways; control and management concepts - integrated systems; traveler information systems; system selection, design and implementation; systems management; ITS plans and programs. The course will also include exercises in the use and application of traffic simulation and optimization models such as: CORSIM, TRANSYT and MAXBAND/ MULTIBAND.

CIVE.5490 Traffic Flow Theory (Formerly 14.549) - Credits: 3

Traffic flow theory seeks to describe through precise mathematical models (a) the interactions between the vehicle and the roadway system and (b) the interactions among vehicles. Such theories forms the basis of all the models and procedures used in design and operational analysis of streets and highways. The course examines the fundamental traffic flow characteristics: time headway, flow, time-space trajectories, speed, distance headway and density. In depth treatment of related analytical techniques including traffic stream modeling at both microscopic and macroscopic levels, supply and demand analysis, shock wave analysis, queuing analysis and simulation modeling of traffic systems.

CIVE.5500 Behavior of Structures (Formerly 14.550) - Credits: 3

Classical and matrix methods of structural analysis applied to complex plane trusses. Elementary space truss analysis. Elementary model analysis through the use of influence lines for indeterminate structures. The digital computer and problem oriented languages as analytical tools.

CIVE.5510 Advanced Steel Design (Formerly 14.551) - Credits: 3

Elastic and plastic design of structural steel systems, residual stresses, local buckling, beam-columns, torsion and biaxial bending, composite steel-concrete members, load and resistance factor design.

CIVE.5520 Behavior - Concrete Structure (Formerly 14.552) - Credits: 3

The main objective of this course is to expand the students’ knowledge and understanding of reinforced concrete behavior and design. Advanced topics at material, element, and system level are built on quick reviews of undergraduate level knowledge and are related to current design codes.

CIVE.5530 Wood Structures (Formerly 14.553) - Credits: 3

Review of properties of wood, lumber, glued laminated timber and structural-use panels. Review of design loads and their distribution in wood-frame buildings. Design of wood members in tension, compression and bending; and design of connections.

CIVE.5560 Finite Element Analysis (Formerly 14.556) - Credits: 3

Finite element theory and formulation, software applications, static and dynamic finite element analysis of structures and components.

CIVE.5570 Structural Dynamics (Formerly 14.557) - Credits: 3

Analysis of typical structures subjected to dynamic force or
ground excitation using direct integration of equations of motion, modal analysis and approximate methods.

CIVE.5580 Bridge Design (Formerly 14.558) - Credits: 3
Analysis and design of modern bridges, using computer software for the 3-D modeling of sample bridges under dead and live loading and seismic excitation. AASHTO specifications are used for the design of superstructures and substructures (abutments, piers, and bearings) under group load combinations.

CIVE.5590 Design of Masonry Structures (Formerly 14.559) - Credits: 3
Fundamental characteristics of masonry construction. The nomenclature, properties, and material specifications associated with basic components of masonry. The behavior of masonry assemblages subjected to stresses and deformations. Design of un-reinforced and reinforced masonry structures in accordance with current codes.

CIVE.5610 Physical Chemical Treatment Processes (Formerly 14.561) - Credits: 3
Course provides a theoretical understanding of various chemical and physical unit operations, with direct application of these operations to the design and operation of water and wastewater treatment processes. Topics include colloid destabilization, flocculation, softening, precipitation, neutralization, aeration and gas transfer, packed &tray towers, oxidation, disinfection, reverse osmosis, ultrafiltration, settling, activated carbon adsorption, ion exchange, and filtration.

CIVE.5620 Physical and Chemical Hydrology Geology (Formerly 14.562) - Credits: 3
Well hydraulics for the analysis of groundwater movement. A review of the processes of diffusion, dispersion, sorption, and retardation as related to the fate and transport of organic contaminants in groundwater systems. Factors influencing multi-dimensional contaminant plume formation and migration are addressed. It is the goal of this course to provide environmental scientists and engineers with the technical skills required to understand groundwater hydrology and contaminant transport within aquifers. A term paper and professional presentation in class regarding a relevant topic is required.

CIVE.5640 Hydrology & Hydraulics (Formerly 14.564) - Credits: 3
This course utilizes engineering principles to quantitatively describe the movement of water in natural and manmade environmental systems. Topics include: hydrologic cycle, steam flow and hydrographs, flood routing, watershed modeling, subsurface hydrology, and probability concepts in hydrology, hydraulic structures, flow in closed conduits, pumps, open channel flow, elements of storm and sanitary sewer design will be addressed.

CIVE.5670 Environmental Aquatic Chemistry (Formerly 14.567) - Credits: 3
This course provides environmental understanding of the principles of aquatic chemistry and equilibria as they apply to environmental systems including natural waters, wastewater and treated waters.

CIVE.5680 Environmental Fate and Transport (Formerly 14.568) - Credits: 3
The fate of contaminants in the environment is controlled by transport processes within a single medium and between media. The similarities in contaminant dispersion within air, surface water and groundwater will be emphasized. Interphase transport processes such as volatilization and adsorption will then be considered from an equilibrium perspective followed by the kinetics of mass transfer across environmental interfaces. A professional presentation of a select paper or group of paper concerning a course topic is required.

CIVE.5690 Micropollutants in the Environment - Credits: 3
This course focuses on the generation, fate and transformation, transport, and the impacts of micropollutants in the environment, with emphasis on soil and water matrices. Topics will include nanomaterials and organic micropollutants such as pharmaceuticals, antimicrobials, illicit drugs, and personal care products. Course delivery will be a combination of lectures, experimental analysis, and discussions of assigned reading materials.

CIVE.5700 Wastewater Treatment and Storm Water Management Systems (Formerly 14.570) - Credits: 3
The era of massive subsidies for construction of sanitary sewers and centralized, publicly operated treatment works (POTWs) has passed. Non-point pollution from sources such as onsite disposal systems has become a major focus of concern in our efforts to protect and improve ground and surface water quality. Much of the new construction in areas not already served by centralized collection and treatment must use the alternative technologies. This course is design oriented. The variously available technologies are studied in depth. Students
evaluate various technologies as they may be applied to a complex problem for which information is available, and develop an optimum problem solution.

CIVE.5710 Surface Water Quality Modeling (Formerly 14.571) - Credits: 3
Theory and application of surface water quality modeling will be combined interactively throughout the course. Data from a stream will be utilized in order to bring a public domain model into operation

CIVE.5720 Marine and Coastal Processes (Formerly 14.572) - Credits: 3
This course focuses on the coastal dynamics of currents, tides, waves, wave morphology and their effects on beaches, estuaries, mixing and sediment transport/accretion processes. Generalized global aspects of atmospheric and hydrospheric interactions with ocean currents are also presented.

CIVE.5730 Solid Waste Engineering (Formerly 14.573) - Credits: 3
Characterization, handling and disposal of municipal, industrial and hazardous wastes. Technologies such as landfills, recycling, incineration and composting are examined. A term paper and professional presentation in class regarding a relevant topic is required.

CIVE.5750 Groundwater Modeling (Formerly 14.575) - Credits: 3
Groundwater Modeling is designed to present the student with fundamentals, both mathematical and intuitive, of analytic and numeric groundwater modeling. An introductory course in groundwater hydrology is a prerequisite for Groundwater Modeling, and the student should be familiar with IBM computers in running text editors and spreadsheets. The semester will start with basic analytic solutions and image theory to aid in the development of more complex numeric models. Emphasis will then switch to numeric ground water flow models (MODFLOW) and the use of particle tracking models (GWPATH) to simulate the movement of solutes in ground water. The numeric modeling process will focus on forming the problem description, selecting boundary conditions, assigning the model parameters, calibrating the model, and preparing the model report. Course topics include: Analytic Methods, Numeric Methods, Conceptual Model and Grid design, Boundary Conditions, Sources, and Sinks, and Particle Tracking.

CIVE.5760 GIS Applications in Civil and Environmental Engineering (Formerly 14.576) - Credits: 3
This course is to introduce students to the basic concepts of Geographic Information Systems (GIS) and GIS applications in Civil and Environmental Engineering. Topics to be covered include GIS data and maps, queries, map digitization, data management, spatial analysis, network analysis, geocoding, coordination systems and map projections, editing. Examples related to transportation, environmental, geotechnical and structural engineering will be provided to help students better understand how to apply GIS in the real world and gain hands-on experience. This course will consist of lectures and computer work.

CIVE.5790 Green and Sustainable Civil Engineering (Formerly 14.579) - Credits: 3
This course focuses on various green and sustainable materials and technologies applicable to five areas of civil engineering: environmental engineering, water resources engineering, structural engineering, transportation engineering, and geotechnical engineering. This course also covers current green building laws and introduces fundamentals of entrepreneurship and patent/copyright laws.

CIVE.5800 Construction Law (Formerly 14.580) - Credits: 3
An introduction to contract, statutory and tort law governing the relationships between the multitude of parties involved in the construction process. The purpose of this course is to give students an understanding of how the law interacts with the construction industry. Course introduces students to the obligations, rights and risks of architects, engineers, general contractors, subcontractors, sureties and insurers throughout the construction process.

CIVE.5810 Engineering Systems Analysis (Formerly 14.581) - Credits: 3
The course presents advanced methods of operations research, management science and economic analysis that are used in the design, planning and management of engineering systems. Main topics covered, include: the systems analysis methodology, optimization concepts, mathematical programming techniques, Network analysis and design, project planning and scheduling, decision analysis, queuing systems, simulation methods, economic evaluation. The examples and problems presented in the course illustrate how the analysis methods are used in a variety of systems applications, such as: civil engineering, environmental systems, transportation systems, construction management, water resources, urban development, etc.
CIVE.5850 Transportation Safety (Formerly 14.585) - Credits: 3
Transportation Safety goes beyond the accepted standards for highway design. Providing a safe and efficient transportation system for all users is the primary objective of federal, state, and local transportation agencies throughout the nation. This class addresses fundamentals of highway design and operation, human factors, accident investigation, vehicle characteristics and highway safety analysis.

CIVE.5910 Capstone Practicum (Formerly 14.591) - Credits: 3
The course will include: directed study regarding the technical and also social, political and financial aspects of a project; and on-site project review and assessment and culminate with preparation of a professional project report and presentations. Not-for-profit domestic and international projects may be studied. Course will be open to those having completed preparatory work. Project availability will be by agreement of faculty advisor and project sponsors prior to enrollment. (Offered only upon availability of suitable projects and adequate outside financial support.)

CIVE.5950 Hazardous Waste Site Remediation (Formerly 14.595) - Credits: 3
This course focuses on the principles of hazardous waste site remediation (with an emphasis on organic contaminants) using physical, chemical or biological remediation technologies. Both established and emerging remediation technologies including: bioremediation, intrinsic remediation, soil vapor extraction (SVE), in situ air sparging (IAS), vacuum-enhanced recovery (VER), application of surfactants for enhanced in situ soil washing, hydraulic and pneumatic fracturing, electrokinetics, in situ reactive walls, phytoremediation, and in situ oxidation, will be addressed. A term paper and professional presentation in class regarding a relevant topic is required.

CIVE.5960 Grad Industrial Exposure (Formerly 14.596) - Credits: 0
CIVE.6510 Special Topics in Civil Engineering (Formerly 14.651) - Credits: 3
Course content and credits to be arranged with instructor who agrees to direct the student.

CIVE.6530 Special Topics (Formerly 14.653) - Credits: 3
CIVE.6930 Civil Engineering Individual Project (Formerly 14.693) - Credits: 3
CIVE.7050 Supervised Teaching in Civil Engineering (Formerly 14.705) - Credits: 0
CIVE.7330 Masters Project in Civil Engineering (Formerly 14.733) - Credits: 3
CIVE.7360 Masters Project in Civil Engineering (Formerly 14.736) - Credits: 6
CIVE.7410 Master's Thesis-Civil Engineering (Formerly 14.741) - Credits: 1
CIVE.7430 Master's Thesis - Civil Engineering (Formerly 14.743) - Credits: 3
CIVE.7460 Master's Thesis - Civil Engineering (Formerly 14.746) - Credits: 6
CIVE.7490 Master's Thesis - Civil Engineering (Formerly 14.749) - Credits: 9
CIVE.7510 Doctoral Dissertation (Formerly 14.751) - Credits: 1
CIVE.7520 Independent Study in Civil Engineering (Formerly 14.752) - Credits: 3
CIVE.7530 Doctoral Dissertation (Formerly 14.753) - Credits: 3
CIVE.7560 Doctoral Dissertation/Civil Engineering (Formerly 14.756) - Credits: 6
CIVE.7570 Doctoral Dissertation (Formerly 14.757) - Credits: 7
CIVE.7590 Doctoral Dissertation (Formerly 14.759) - Credits: 9
CIVE.7630 Continued Graduate Research (Formerly 14.763) - Credits: 3
CIVE.7660 Continued Graduate Research (Formerly 14.766) - Credits: 6
CIVE.7690 Continued Graduate Research (Formerly 14.769) - Credits: 9

CIVE.7520 Independent Study in Civil Engineering (Formerly 14.752) - Credits: 3
CIVE.7530 Doctoral Dissertation (Formerly 14.753) - Credits: 3
CIVE.7560 Doctoral Dissertation/Civil Engineering (Formerly 14.756) - Credits: 6
CIVE.7570 Doctoral Dissertation (Formerly 14.757) - Credits: 7
CIVE.7590 Doctoral Dissertation (Formerly 14.759) - Credits: 9
CIVE.7630 Continued Graduate Research (Formerly 14.763) - Credits: 3
CIVE.7660 Continued Graduate Research (Formerly 14.766) - Credits: 6
CIVE.7690 Continued Graduate Research (Formerly 14.769) - Credits: 9
ENGN.5010 Engineering for Teachers (Formerly 25.501) - Credits: 3

The course will focus on increasing teachers' understanding of the Engineering Design Process. The linkage between science, engineering, and technology will be discovered as teachers engage in a variety of home-based projects requiring them to apply design principles to the building, testing, and evaluating of prototypes. Teachers will also gain knowledge of the various fields of engineering. Through their participation in the course, teachers will discuss how they might integrate engineering-technology concepts with other areas of their curriculum.

ENGN.5500 Introduction to Nanotechnology (Formerly 25.550) - Credits: 3

This course is designed to provide you with a broad overview to the multi-disciplinary field of nanotechnology. The course is team-taught by researchers from science, engineering, health and environment, management, and humanities disciplines. The topics include an introduction to nanoscale phenomena; fundamental theoretical concepts and experimental techniques in nanotechnology; nanoscale manufacturing and processing; innovative nanomaterials for various applications; applications of the technology; and environmental and health impacts of nanotechnology.

ENGN.5700 Selected Issues in Nanomanufacturing (Formerly 25.570) - Credits: 0

A seminar course that examines the issues associated with high rate template-based nanomanufacturing, including: technologies for nanoscale templates, high rate assembly of nanoelements and polymer systems, registration at the nanoscale, interfacing with biological systems, measurement of nanoelements, and molecular modeling. Environmental, regulatory, and ethical issues associated with new technologies are also addressed. The course is co-taught by faculty from Northeastern University, the University of Massachusetts Lowell, and the University of New Hampshire. Meeting dates: January 27, February 10, February 24, March 10, March 24, and April 7. Time: 12:00 to 3:30, including lunch.

ENGN.5800 Thesis Review (Formerly 25.580) - Credits: 1
ENGN.5810 Project Review (Formerly 25.581) - Credits: 1
ENGN.5900 Graduate Industrial Cooperative Educational Experience I (Formerly 25.590) - Credits: 1

Industrial experience credit for co-op and internships with industry. Students must register with department co-op coordinator.

ENGN.5910 Graduate Industrial Cooperative Educational Experience II (Formerly 25.591) - Credits: 1

Industrial experience credit for co-op and internships with industry. Students must register with department co-op coordinator.

ENGN.5920 Graduate Industrial Cooperative Educational Experience III (Formerly 25.592) - Credits: 3

Industrial experience credit for co-op and internships with industry. Students must register with department co-op coordinator.

ENGN.5980 Seminar for Teaching Assistants in Engineering - Credits: 0

Prepare graduate students for their role as teaching assistants in labs and lectures. Topics include: (1) classroom management, (2) grading strategies, (3) how to prepare for lecture and lab, (4) understanding the cultural differences that come with the diverse campus population, (5) balancing teaching and research responsibilities, (6) how to do graduate-level research. This course is mandatory for all new teaching assistants in the College of Engineering.

ENGN.6010 Academic and Technical Writing for Research in Engineering - Credits: 0

This course addresses the complex nature of academic language and academic writing by focusing on sentence, paragraph and text structures, purposeful and appropriate word choices, and the writing process. Through attention to details and critical reading of various materials, students will enhance their writing skills by applying effective planning, drafting, rewriting and editing strategies. Students will further become adept at critically and creatively evaluating, analyzing, constructing and presenting their ideas and arguments. As a workshop class, the final product of the class will be one or more of (1) a journal paper that is ready for submission, (2) a conference paper, and (3) one or more chapters of a dissertation or thesis. Please
Note: Advanced English language proficiency required.
Department of Electrical & Computer Engineering

Graduate Degrees:

- Master’s of Science in Electrical Engineering (M.S.E.)
- Master’s of Science in Computer Engineering (M.S.E.)
- Doctor of Philosophy in Electrical Engineering (Ph.D.)
- Doctor of Philosophy in Computer Engineering (Ph.D.)
- Doctor of Engineering in Electrical Engineering (D.Eng.)
- Doctor of Engineering in Computer Engineering (D.Eng.)

Graduate Certificates:

- Electrical and Computer Engineering
- Communications Engineering
- Microwave and Wireless Engineering
- VLSI and Microelectronics

Interdisciplinary

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

Graduate Admissions Requirements

- Academic Requirements

Research

Research is conducted and courses offered in the following areas:

- Artificial/Machine Intelligence
- Bio-Engineering/Bio-Informatics/Bio-Sensors
- Computational Engineering
- Computer Architecture and Embedded Systems
- Computer/Telecommunications/Sensor Networks
- Control Systems
- Distributed Systems and Networks
- Electric Vehicles and Battery Technology
- Electromagnetics
- Metamaterials
- Microwave Engineering
- Mobile/Wireless Communications
- Optoelectronic and Semiconductor Devices
- Power Systems
- Printable Electronics
- Quantum/Nano Electronics
- Signal/Image Processing and Computer Vision
- Solar Energy and Photovoltaics
- Stochastic Processes
- Storage and I/O Systems
- VLSI Design and Fabrication

Graduate Certificates

Three 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.

Master’s Programs

- Master’s of Science in Engineering (M.S. Eng.) - Electrical Engineering (EE)
- Master’s of Science in Engineering (M.S. Eng.) - Computer Engineering (CP)

- Graduate Admissions Requirements
- Academic Requirements
Areas of Concentration in Electrical Engineering
- Information Systems (Telecommunications)
- Information Systems (Communications Engineering)
- Power and Energy Engineering
- Opto-Electronics
- Other

Areas of Concentration in Computer Engineering
- Computer Networking and Distributed Systems
- Computer Architecture and Embedded Systems
- Artificial and Machine Intelligence
- Multimedia Digital Signal and Image Processing and Applications

Graduate Admissions Requirements

1. General requirement for all applications:
All applicants must submit the application materials supplied by the Graduate Admissions Office as well as the official score report for the Graduate Record Examination (GRE) Aptitude Test.

2. 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 pre-requisites.

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
- 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

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
- 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
- EECE.4130 Linear Feedback Systems

Graduates who lack any of the above backgrounds and their pre-requisites are required to make up their deficiencies as conditions for acceptance.

3. With a BS in Technology:
Students who lack the BS Engineering in EE or CP but hold a bachelors 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.

4. Applicants applying for the Accelerated Bachelor’s to Master’s program:
The Bachelor’s to Master’s 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. With the approval of the Graduate Coordinator, students in the BS/MS program may use up to six credits of graduate courses with an earned grade of B or better for both graduate and undergraduate degrees.

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

<table>
<thead>
<tr>
<th>Non-Thesis Option</th>
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<tbody>
<tr>
<td>Core Requirements</td>
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<tr>
<td>Technical Electives</td>
</tr>
<tr>
<td>Advanced Project</td>
</tr>
<tr>
<td>Total credit hours</td>
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<table>
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<tr>
<th>Thesis Option</th>
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<tbody>
<tr>
<td>Core Requirements</td>
</tr>
<tr>
<td>Technical Electives</td>
</tr>
<tr>
<td>Thesis</td>
</tr>
<tr>
<td>Graduate Seminar (16.601/601)</td>
</tr>
<tr>
<td>Total credit hours</td>
</tr>
</tbody>
</table>

With the approval of the Graduate Coordinator, students in the BS/MS program may use up to six credits of graduate courses with an earned grade of B or better 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 students thesis advisor for thesis option.

The credits for Advanced Graduate Project (EECE.7330) cannot be counted toward the requirement for the thesis option. It can be replaced with a 3-credit technical elective for the non-thesis option.

2. Core Requirement

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**

(choose 3 courses)

- 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 Introduction to Communications Theory
- 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**

(choose 3 courses)

- 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

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 students 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.

4. Research for Thesis Option

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.

**Areas of Concentration**

In addition to the required three core courses (9 credits), three additional courses from a concentration are recommended depending upon whether a thesis is selected or not.

1. **Concentration courses in Electrical Engineering**

- Information Systems (Telecommunications) EECE.5100
Digital Signal ProcessingEECE.5110 Medical Imaging 
DiagnosisEECE.5460 Computer 
TelecommunicationsEECE.5480 Coding and Information 
TheoryEECE.5820 Wireless CommunicationsEECE.5860 
Stochastic Modeling in TelecommunicationsEECE.6170 
Modeling and Simulation Techniques for Communication 
NetworksEECE.6180 Performance of Wireless 
Communications NetworksEECE.6610 Local Area 
/Computer NetworkingEECE.6850 Statistical Theory of 
CommunicationsEECE.6870 Stochastic 
EstimationEECE.6880 Theoretical Acoustics 

• Information Systems (Communications Engineering) 
EECE.5330 Microwave EngineeringEECE.5460 Computer 
TelecommunicationsEECE.5480 Coding and Information 
TheoryEECE.5710 Radar SystemsEECE.5820 Wireless 
CommunicationsEECE.5860 Stochastic Modeling in 
TelecommunicationsEECE.6170 Modeling and Simulation 
Techniques for Communication NetworksEECE.6180 
Performance of Wireless Communications 
NetworksEECE.6610 Local Area/Computer 
NetworkingEECE.6840 Time Series Analysis EECE.6850 
Statistical Theory of CommunicationsEECE.6870 
Stochastic Estimation 

• Power and Energy Engineering EECE.5140 Power Systems 
TransmissionEECE.5150 Power ElectronicsEECE.5160 
Advanced Machine TheoryEECE.5250 Power Systems 
DistributionEECE.5280 Alternative Energy 
SourcesEECE.5290 Electric Vehicle TechnologyEECE.6150 
Solid State Drives SystemsEECE.6160 Computational 
Power Analysis 

• Opto-Electronics EECE.5080 Quantum Electronics for 
EngineersEECE.5180 Electromagnetic Materials for Optical 
EngineeringEECE.5190 Engineering of Submicron 
MachinesEECE.5230/4230 Introduction to Solid State 
ElectronicsEECE.5320 Computational 
ElectromagneticsEECE.5830 Wave Propagation in 
PlasmasEECE.5900 Fiber Optic 

CommunicationsEECE.5950 Solid State 
ElectronicsEECE.6070 Electromagnetics of Complex 
MediaEECE.6080 Scattering and Diffraction of EM 
WavesEECE.6100 Optics for Information 
ProcessingPHYS.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 16.568 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. 

2. Concentration courses in Computer Engineering 

• Computer Networking and Distributed Systems 
EECE.5580 World Wide Web programmingEECE.5830 
Network Design: Principles, Protocols and 
ApplicationsEECE.5900 Fiber Optic 
CommunicationsEECE.6570 High-Speed Integrated 
Networks: Design and EvaluationsEECE.6580 Computer 
Network SecurityEECE.6590 Distributed 
SystemsEECE.6600 Mobile IP NetworkingEECE.6610 
Local Area/Computer NetworkingEECE.6660 Storage 
Area Networks 

• Computing and Embedded Systems Hardware and 
Architecture EECE.5020 VLSI DesignEECE.5040 VLSI 
FabricationEECE.5170 MMIC Design and 
FabricationEECE.5500 Advanced Digital Systems 
DesignEECE.5520 Microprocessors II and Embedded 
SystemsEECE.5530 Software EngineeringEECE.5570 
Object Oriented DesignEECE.5720 Embedded Real-time 
SystemsEECE.5740 Advanced Logic DesignEECE.5750 
FPGA Logic Design TechniquesEECE.6500 Advanced 
Computing Systems Hardware ArchitectureEECE.6520 
Parallel and Multi-processor ArchitectureEECE.6560 Fault
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 primary difference between the two types of doctoral degrees is the requirement of 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 Ph.D. and D.Eng. in Electrical and Computer Engineering is to provide a research intensive program with the rigorous course work to strengthen the student's knowledge in the fundamentals of Electrical and Computer Engineering. A secondary goal for Doctor of Engineering Program is for them to develop an appreciation for the social and economic issues connected with the operation of a modern high technology enterprise. The programs include advanced graduate coursework in Electrical/Computer Engineering and allied subjects, a non-technical component (in the case of the Doctor of Engineering programs), and research culminating in a doctoral dissertation.

A complete description of the doctoral programs are 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) General Test scores. 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. Visit the ECE Graduate Website (http://www.uml.edu/ecegrad).

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 Engineering and a minimum of two and a half years to a maximum of four years after MS Engineering.

Transfer Credit

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

Candidacy Requirements

1. Qualifying Examination
The qualifying examination is a written exam will be held twice a year at the beginning of each semester. The exact dates will be announced on the website and in the ECE office. A doctoral student must take this examination no later than the first year of study at UML as an EE/CP doctoral student. So, if a student is accepted into the Doctoral Program in the Fall, the student must take the exam in the following Spring semester. If a student is accepted into the Doctoral Program in the Spring, the student must take the exam in the following Fall semester. The doctoral committee reserves the right to drop from the program those students who do no comply with the requirements of this clause. A doctoral student who fails at the first attempt will be allowed one more opportunity to retake this examination an this must be done the next time it is held. So, if the student fails the exam in the Fall, he/she must retake the exam in the Spring OR if the student fails the exam in the Spring, then he/she must retake the exam in the Fall.

2. Thesis Proposal and Oral Exam
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 will be submitted to the College Doctoral Committee and the Registrar's Office for acceptance as a candidate for the Doctor of Philosophy or Doctor of Engineering Degree. Admission to candidacy status does not guarantee the obtaining of the degree.

3. Final Defense of Dissertation
This is the final oral examination, conducted by the Doctoral Committee. The membership of the committee may be augmented by non-voting faculty. The candidate has to submit a written Dissertation based on the research during the period of the Ph.D. degree. After receiving the approval of the advisor and the Doctoral Committee, the final oral examination shall be conducted. In order to pass, the candidate may not receive more than one dissenting vote from the membership of the examination committee.

Academic Requirements

1. Credit Requirement

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

<table>
<thead>
<tr>
<th>Course Category</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECE and Allied Subjects</td>
<td>30</td>
</tr>
<tr>
<td>Thesis</td>
<td>21</td>
</tr>
<tr>
<td>Courses/Thesis *</td>
<td>12</td>
</tr>
<tr>
<td>Graduate Seminar **</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total credit hours</strong></td>
<td>63</td>
</tr>
</tbody>
</table>

* Graduate level engineering courses including associated science and math course OR Dissertation credits approved by faculty advisor and dissertation committee.

** All Doctoral students (Ph.D. and D.Eng.) who have been admitted Fall 2012 or later must take the Graduate Seminar course for a total of TWO semesters during their doctoral studies. This course is mandatory for doctoral students.

For more information, please go to this link: Graduate Seminar (http://www.uml.edu/docs/Graduate%20seminar_Dec2012_tcm18-87489.pdf)

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

<table>
<thead>
<tr>
<th>Course Category</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECE and Allied Subjects</td>
<td>33</td>
</tr>
<tr>
<td>Thesis</td>
<td>21</td>
</tr>
<tr>
<td>Non-Technical Component</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total credit hours</strong></td>
<td>63</td>
</tr>
</tbody>
</table>

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 Requirement

The core courses are beginning graduate courses. They emphasize the fundamentals, concepts, and analytical techniques relevant to Electrical/Computer Engineering. They also help the student prepare for the qualifying examination.

Required Core Courses for Ph.D. and D.Eng degrees in Electrical Engineering: (choose three courses)

- EECE.5070 Electromagnetic Materials and Waves
- 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 Introduction to Communications Theory
- EECE.5840 Probability and Random Processes
- EECE.5950 Solid State Electronics

Students in Electrical Engineering must take three courses of the above courses.

Required Core Courses for Ph.D. and D.Eng degrees 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

3. 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.

Graduate Certificates

Electrical and Computer Engineering Graduate Certificates:

- Communications Engineering?
- Field Programmable Gate Array

- Microwave and Wireless Engineering
- Stochastic Systems
- VLSI and Microelectronics

Interdisciplinary Graduate Certificates:

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

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. ECE certificates can be used as concentrations in the ECE Masters programs.

Credits earned from these graduate certificates may be used toward a graduate degree with the approval of the graduate program coordinator.

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

About Graduate Certificates

Most graduate certificates are comprised of four courses (12 graduate credits) designed to provide specific knowledge and expertise vital to today’s changing and complex needs in the work place. In most cases courses may be applied toward a degree program.

Requirements to Complete a Graduate Certificate

The four courses must be completed within a five year period with a minimum 3.0 grade point average, and with no more than 6 credits below B. Courses completed for one certificate may not be used for another certificate.

Certificate Application Process

Individuals must complete a simplified application, provide an official undergraduate transcript indicating that a baccalaureate degree has been awarded, and submit a nominal application fee. GRE’s are not required.

- Graduate Certificate Application Form
Communications Engineering Certificate

Electrical and Computer Engineering Department

Contact: Kavitha Chandra, Ph.D., 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.

This is a 12 credit certificate; all courses are 3 credits each.

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

Microwave and Wireless Engineering Certificate

Electrical and Computer Engineering Department

Contact: 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 microwave 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.

This is a 12 credit certificate; all courses are 3 credits each.

Required Courses:

- EECE.5430 Communications Theory
- EECE.5840 Probability and Random Processes

Field Programmable Gate Array

Electrical and Computer Engineering Department

Contact: Yan Luo, Ph.D., 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: (Choose one) 3-credit courses:

- 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
• EECE.5330 Microwave Engineering
• EECE.5820 Wireless Communications OR
• EECE.5430 Communications Theory

Elective Courses: (Choose two of the following)
• EECE.5060 Antenna Design
• EECE.5710 Radar System
• EECE.6180 Performance of Wireless Communication Networks
• EECE.5310 Radio Frequency (RF) Design

Stochastic Systems Certificate

Electrical and Computer Engineering Department

Contact: Oliver Ibe, 978-934-3118, Oliver_Ibe@uml.edu

This certificate provides a thorough grounding in the modeling of signals represented as random functions of time. A background in linear system theory, signal transforms and the theory of probability and random processes is given. The certificate is completed by choosing specialized courses in time series analysis, statistical communication theory or applied stochastic estimation. These courses deal with the estimation of signals and of noise using a variety of mathematical models such as likelihood and entropy based techniques, matched, adaptive and nonlinear filtering of signals. The holder of this certificate will have the analytical and practical competence to design for and evaluate probabilistic issues in communications, complex systems, and/or networks.

This is a 12 credit certificate; all courses are 3 credits each.

Required Courses:
• EECE.5840 Probability and Random Processes
• EECE.7110: Special Topics in ECE: Advanced Markov Methods

Elective Courses: (Choose two of the following)
• EECE.5090 Linear Systems Analysis
• EECE.5430 Theory of Communication
• EECE.6870 Applied Stochastic Estimation

VLSI &Microelectronics Certificate

Department of Electrical &Computer Engineering

Contact: 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.

This is a 12 credit certificate; all courses are 3 credits each.

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

The Electrical and Computer Engineering Department also participates in the following interdisciplinary certificate programs:

Biomedical Engineering Certificate

Electrical &Computer Engineering Department

Contact: Mufeed Mahd, 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. This is a 12 credit program comprised of two required three-credit courses, and two elective three-credit courses.

**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:** Ziyad Salameh, 978-934-3333, Ziyad_Salameh@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:** Xuejun Lu, Ph.D. (mailto:xuejunlu@uml.edu), 978-934-3359

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:
- Applied Physics
- Computer Engineering
- Computer Science
- Electrical Engineering
- Materials Engineering
- Mechanical Engineering

Within each cluster, there are a number of carefully selected courses ranging from introductory graduate level to more advanced, specialized electives.

Students must successfully complete four courses (12 credits), 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 MIMIC 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
The program will provide students with a fundamental knowledge of nanotechnology and is intended to respond to the increasing demand for trained professionals in nanoscience and technology. The certificate is designed for students with a background in chemistry, physics, biology, or any branch of engineering who want nanotechnology and nanomanufacturing workforce preparation. Students may focus on a concentration area based on their interests and background. Courses in each concentration 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
- xxx.xxxx Processing of Nanocomposites

Design and Devices

- EECE.7100 Special Topics in ECE: Nanoelectronics
- EECE.5020 VLSI 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: 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
- PHYS.5390 Electro-optics
- 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:** 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**
EECE.5040 VLSI Fabrication (Formerly 16.504) - Credits: 3

Fabrication of resistors, capacitors, p-n junction and Schottky Barrier diodes, BJTs 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.

EECE.5050 Microwave Electronics (Formerly 16.505) - Credits: 3

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.

EECE.5060 Antenna Theory and Design (Formerly 16.506) - Credits: 3


EECE.5070 Electromagnetic Materials and Waves (Formerly 16.507) - Credits: 3

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.

EECE.5080 Quantum Electronics for Engineers (Formerly 16.508) - Credits: 3

Introduction to the fundamental postulates of quantum theory: Planck’s quantization hypothesis; wave-particle duality; time-dependent &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.

EECE.5090 Linear Systems Analysis (Formerly 16.509) - Credits: 3


EECE.5100 Digital Signal Processing (Formerly 16.510) - Credits: 3


EECE.5110 Medical Diagnostic Imaging (Formerly 16.511 & IB.511) - Credits: 3

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.

EECE.5120 Mixed-Signal VLSI Design (Formerly 16.512) - Credits: 3

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, floorplanning 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 (Formerly 16.513) - Credits: 3

System representations, state variables, transfer functions, controllability and observability, phase variables, canonical variables, representation of nonlinear systems, Lagrange's equations, generalized co-ordinates, 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.

EECE.5140 Integrated Power Systems (Formerly 16.414/514) - Credits: 3

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.5170 MMIC Design and Fabrication (Formerly 16.517) - Credits: 3

The domain of microwave monolithic integrated circuits (MMIC) design and fabrication engineer stretches from realms of device physics and microwave circuit theory in the frequency range from 300MHz to 300 GHz. The main goal of the course is to embody most of the application of the spectrum that have been deployed during the past five decades due to advances of many microwave solid-state devices. The principles of semiconductors emphasizing 1) the properties which predominate at microwave frequencies, 2) the theories for circuit design techniques required to utilize them at microwave frequencies, and 3) practical engineering applications for controlling microwave signals in amplitude and phase using semiconductors, will be treated in great details. Special emphasis will be laid on correlation of S parameters with microwave device parameters and their usage in designing Low-noise amplifiers, High-power amplifiers and oscillators and their integration in MMIC design.

EECE.5190 Engineering of Submicron Machines (Formerly 16.519) - Credits: 3

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.

EECE.5200 Computer Aided Engineering Analysis (Formerly 16.520) - Credits: 3

An advanced programming course, which considers the digital computer as a tool for solving significant engineering problems. The course is based on a specific area in engineering which will be selected from such topics as digital and image processing, spectral estimation, optimization techniques, etc. Typical algorithms related to the specific topic will be studied. User oriented programs or subroutine packages will be developed in a project.

EECE.5210 Real Time Digital Signal Processing (Formerly 16.521 & IB.511) - Credits: 3

This course provides an introduction to real-time digital signal processing techniques using the TMS320C3x floating point and TMS320C5x fixed point processors. The architecture, instruction set and software development tools for these processors are studied via a series of C and assembly language computer projects where real time adaptive filters, modems, digital control systems and speech recognition systems are
implemented.

EECE.5230 Introduction to Solid State Electronics (Formerly 16.523) - Credits: 3

EECE.5240 Computational Methods for Power System Analysis (Formerly 16.424/524) - Credits: 3
The course explores some of the mathematical and simulation tools used for the design, analysis and operation of electric power systems. Computational methods based on linear and nonlinear optimization algorithms are used to solve load flow problems, to analyze and characterize system faults and contingencies, and to complete economic dispatch of electric power systems. Real case studies and theoretical projects are assigned to implement the techniques learned and to propose recommendations. Different software applications will be used concurrently including ATP, PowerWorld Simulator, Aspen, MatLab with Simulink and Power System Toolbox, PSCAD, etc.

EECE.5250 Power Distribution Systems (Formerly 16.525) - Credits: 3
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.

EECE.5260 Power Systems Stability and Control (Formerly 16.426/526) - Credits: 3

EECE.5270 Advanced VLSI Design Techniques (Formerly 16.427/527) - Credits: 3
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.

EECE.5280 Alternate Energy Sources (Formerly 16.528) - Credits: 3
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.

EECE.5290 Electric Vehicle Technology (Formerly 16.529) - Credits: 3
Electric vehicle VS internal combustion engine vehicle. Electric vehicle (EV) saves the environment. EV design, EV motors, 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.

EECE.5310 RF Design (Formerly 16.531) - Credits: 3
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.

EECE.5320 Computational Electromagnetics (Formerly 16.532) - Credits: 3

EECE.5330 Microwave Engineering (Formerly 16.533)
GRADUATE / COLLEGE OF ENGINEERING

WAN architectures including media access control (MAC) from data link protocols to transport protocols. LAN and stack and the ISO/OSI seven layer stacks are examined in depth. Software architectures are discussed including TCP/IP protocol multiplexing, switching, ATM, ISDN, SONET. Layered system that serves as backbone for moving data, including telephone modems. Architecture and functionality of telephone modulation and specific cases such as DSL, cable modems, are presented including modems, baseband encoding, wireless systems. Techniques for sending data over the media baseband and broadband coaxial cable, fiber optic systems and transport voice and data traffic including twisted pair, based telecommunications system. Discussion of media used to move data over long distances and their applications for pathology, pharmacogenetics, public health, food safety civil defense, and environmental monitoring. Optical, electrochemical and mechanical sensing techniques will be discussed.

**EECE.5410 Introduction to Biosensors (Formerly 16.441/541) - Credits: 3**

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.

**EECE.5430 Theory of Communication (Formerly 16.543) - Credits: 3**

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.

**EECE.5460 Communication Networks (Formerly 16.546) - Credits: 3**

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.

**EECE.5480 Coding and Information Theory (Formerly 16.548) - Credits: 3**

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.

**EECE.5500 Advanced Digital System Design (Formerly 16.550) - Credits: 3**

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.

**EECE.5510 Advanced Robotics Automation and Machine Intelligence (Formerly 16.551) - Credits: 3**

Covers advanced foundations and principles of robotic manipulation; includes the study of advanced robot motion planning, task level programming and architectures for building perception and systems for intelligent robots. Autonomous robot navigation and obstacle avoidance are addressed. Topics include computational models of objects and motion, the mechanics of robotic manipulators, the structure of manipulator control systems, planning and programming of robot actions. Components of mobile robots, perception, mechanism, planning, and architecture; detailed case studies of existing systems. Pre-Req: Permission of Instructor.

**EECE.5520 Microprocessor Systems II & Embedded Systems (Formerly 16.5521) - Credits: 3**

Continuation of 16.317. CPU architecture, memory interfaces and management, coprocessor interfaces, bus concepts, bus arbitration techniques, serial I/O devices, DMA, interrupt
control devices. Including Design, construction, and testing of dedicated microprocessor systems (static and real-time). Hardware limitations of the single-chip system. Includes microcontrollers, programming for small systems, interfacing, communications, validating hardware and software, microprogramming of controller chips, design methods and testing of embedded systems.

EECE.5530 Software Engineering (Formerly 16.553) - Credits: 3
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.

EECE.5560 Robotics (Formerly 16.556) - Credits: 3
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 & dynamics, motion and trajectory control and planning are also covered. Laboratories include design, analysis and simulation of real life industrial robots.

EECE.5590 Introduction to Nanoelectronics (Formerly 16.459/559) - Credits: 3
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 (Formerly 16.460/560) - Credits: 3
A survey of biomedical instrumentation that leads to the analysis of various medical system designs and the related factors involved in medical device innovation. In addition to the technical aspects of system integration of biosensors and physiological transducers there will be coverage of a biodesign innovation process that can translate clinical needs into designs. A significant course component will be project-based prototyping of mobile heath applications. The overall goals of the course are to provide the theoretical background as well as specific requirements for medical device development along with some practical project experience that would thereby enable students to design electrical and computer based medical systems.

EECE.5600 Biomedical Instrumentation (Formerly 16.560) - Credits: 3
A survey of biomedical instrumentation that leads to the analysis of various medical system designs and the related factors involved in medical device innovation. In addition to the technical aspects of system integration of biosensors and physiological transducers there will be coverage of a biodesign innovation process that can translate clinical needs into designs. A significant course component will be project-based prototyping of mobile health applications. The overall goals of the course are to provide the theoretical background as well as specific requirements for medical device development along with some practical project experience that would thereby enable students to design electrical and computer based medical systems.

EECE.5610 Computer Architecture and Design (Formerly 16.561) - Credits: 3

EECE.5620 VHDL/Verilog Synthesis & Design (Formerly 16.562) - Credits: 3
Circuit and system representations including behavioral, structural, and physical descriptions using HDL. Modeling of short and narrow MOS transistors for submission applications. Overview 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 microcontroller, 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. A project of industrial vigor for fabrication at
MOSIS is required.

EECE.5680 Electro Optic Systems (Formerly 16.568) - Credits: 3

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.

EECE.5710 Radar Systems (Formerly 16.571) - Credits: 3


EECE.5720 Embedded Real Time Systems (Formerly 16.572) - Credits: 3

Designing embedded real-time computer systems. Types of real-time systems, including foreground/background, non-preemptive multitasking, and priority-based pre-emptive multitasking systems. Soft vs. hard real time systems. Task scheduling algorithms and deterministic behavior. Ask synchronization: semaphores, mailboxes and message queues. Robust memory management schemes. Application and design of a real-time kernel. A project is required.

EECE.5730 Operating Systems (Formerly 16.573) - Credits: 3

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 real operating systems.

EECE.5740 Advanced Logic Design (Formerly 16.574) - Credits: 3


EECE.5750 Field Programmable Gate Arrays Logic Design Techniques (Formerly 16.575) - Credits: 3

Advanced logic design techniques using field programmable gate arrays (FPGAs), programmable logic devices, programmable array logic devices, and other forms of reconfigurable logic. Architectural descriptions and design flow will be covered as well as rapid prototyping techniques, ASIC conversions, in-system programmability, high level language design techniques, and case studies highlighting the tradeoffs involved in designing digital systems with programmable devices. This course is generally offered summers only.

EECE.5760 Principles of Solid State Devices (Formerly 16.576) - Credits: 3
EECE.5770 Verification of Digital Systems (Formerly 16.577) - Credits: 3
EECE.5780 Modeling and Implementation of Digital Systems using MATLAB - Credits: 3

The course covers the methodology and tools to design digital systems with MATLAB. Topics include algorithm design and analysis with MATLAB, MATLAB Simulink development, conversion from algorithm to VHDL implementation, synthesis to FPGA and performance evaluation. Labs are included to practice design methodology and tools with FPGA or other platforms.

EECE.5800 Robotics, Automation and Machine Intelligence (Formerly 16.580) - Credits: 3

Covers advanced foundations and principles of robotic manipulation; includes the study of advanced robot motion planning, task level programming and architectures for building perception and systems for intelligent robots. Autonomous robot navigation and obstacle avoidance are addressed. Topics include computational models of objects and motion, the mechanics of robotic manipulators, the structure of manipulator control systems, planning and programming of robot actions. Components of mobile robots, perception, mechanism, planning and architecture; detailed case studies of existing systems.

EECE.5810 Computer Vision and Digital Image Processing (Formerly 16.581) - Credits: 3
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.

EECE.5820 Wireless Communications (Formerly 16.582) - Credits: 3

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.

EECE.5830 Network Design: Principles, Protocols and Applications (Formerly 16.583) - Credits: 3

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.

EECE.5840 Probability and Random Processes (Formerly 16.584) - Credits: 3


EECE.5880 WWW Programming (Formerly 16.588) - Credits: 3
EECE.5900 Fiber Optic Communication (Formerly 16.590) - Credits: 3

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 (FDDI, SONET, ATM); coherent transmission; wavelength division multiplexing and CDMA; fiber amplifiers.

EECE.5930 Industrial Experience (Formerly 16.593) - Credits: 1

EECE.5950 Solid State Electronics (Formerly 16.595) - Credits: 3

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 eitters. Prerequisite: 16.323 or Permission of Instructor.

EECE.5980 Seminar for Teaching Assistants (Formerly 16.598) - Credits: 0

This course will meet once per week and attendance in mandatory for all TAs. The course will cover an overview of laboratories for the following week.

EECE.6010 Graduate Seminar (Formerly 16.601) - Credits: 0

There will be a series of seminars by distinguished researchers form academia and industry in addition to UML faculty. Moreover, there will be seminars dedicated to instructional sessions in library services, introduction to Department and Faculty research, and information on thesis requirements and professional ethics. Attendance is mandatory for doctoral and MS students with thesis option. The students are required to write short reports summarizing the talk after each seminar. This course is offered in the fall semester.

EECE.6020 Graduate Seminar (Formerly 16.602) -
Credits: 0

There will be a series of seminars by distinguished researchers from academia and industry, in addition to UML faculty. Moreover, there will be seminars dedicated to instructional sessions in library services, introduction to Department and Faculty research, and information of thesis requirements and professional ethics. Attendance is mandatory for doctoral and MS students with thesis option. The students are required to write short reports summarizing the talk after each seminar. This course is offered in the spring semester.

EECE.6120 Converged Voice and Data Network
(Formerly 16.612) - Credits: 3

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, access networks for converged services: xDSL and HFC networks, and IP TV service.

EECE.6160 Computational Power Systems Analysis
(Formerly 16.616) - Credits: 3

Power system matrices, power flow studies, fault studies, state estimation, optimal power dispatch, and stability studies.

EECE.6170 Modelling Of Communication Networks
(Formerly 16.617) - Credits: 3

Overview of general architectures for B-ISDN and Internet, network layering, signaling, performance requirements, traffic management strategies, usage parameter control, connection admission control, congestion control, stochastic processes, Markov chains and processes, stochastic models for voice, video and data traffic, Poisson processes, Markov-modulated processes, traffic analysis, queuing systems, M/M/1, M/M/m, M/G/1 queues, fluid buffer models, effective bandwidth approaches, simulation modeling, discrete event simulation of transport and multiplexing protocols using OPNET software, statistical techniques for validation and sensitivity analysis.

EECE.6500 Advanced Computing Systems Hardware Architecture (Formerly 16.650) - Credits: 3

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.

EECE.6510 Advanced Embedded System Design with FPGA - Credits: 3

This course covers the topics related to FPGA based embedded systems, including microprocessor architectures, embedded system architecture, firmware, bootloader, JTAG etc., bare metal processor vs embedded OS, and core and soft core IP’s, interconnects between processor and FPGA, buses and interfaces, and external devices such as sensors and cameras. Labs are included for practice the design of FPGA based embedded systems.

EECE.6520 Parallel & MP Architect (Formerly 16.652)
- Credits: 3
EECE.6530 AI and Machine Learning (Formerly 16.653) - Credits: 3
EECE.6540 Heterogeneous Computing - Credits: 3

This course introduces heterogeneous computing architecture and the design and optimization of applications that best utilize the resources on such platforms. The course topics include heterogeneous computer architecture, offloading architecture/API, operating systems for heterogeneous resources, GPU/FPGA acceleration, OpenCL programming framework, performance optimization, and software development. Labs are included to practice design methodology and tools.

EECE.6560 Fault Tolerant System Design (Formerly 16.656) - Credits: 3
EECE.6580 Computer Network Security (Formerly 16.658) - Credits: 3

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. Pre-Req: Permission of Instructor.
EECE.6590 Distributed Systems (Formerly 16.659) - Credits: 3
EECE.6600 Mobile Communication Networks (Formerly 16.660) - Credits: 3

The goal of this course is to enable students to understand communication systems that permit a user to be either continuously or intermittently connected to a communication network as he/she moves from one place to another. The key issue in these communications systems, which are referred to as mobile communication systems, is that there is provision for handling a device, service or user, over from on network to another. That is, mobility management is an essential aspect of mobile communication networks. The learning objectives of the course include enabling the student to understand mobile radio propagation, antenna and communications systems; the so-called 2G, 2.5G, 3G and 4G networks; mobile IP and mobile TCP; mobile ad hoc networks; WiMAX networks; and cognitive radio networks.

EECE.6660 Storage Area Networks (Formerly 16.666) - Credits: 3
EECE.6690 Opto Electronic Devices (Formerly 16.669) - Credits: 3
EECE.6870 Applied Stochastic Estimation (Formerly 16.687) - Credits: 3


EECE.6880 Theoretical Acoustics (Formerly 16.688) - Credits: 3
EECE.6920 Directed Studies/Electrical Engineering (Formerly 16.692) - Credits: 3

Provides opportunity for students to get a specialized or customized course in consultation with a faculty member.

EECE.7100 Selected Topics (Formerly 16.710) - Credits: 3

Topics of current interest in electrical Engineering. Subject matter to be announced in advance.

EECE.7110 Special Topics (Formerly 16.711) - Credits: 3

Topics of current interest in Electrical Engineering. Subject matter to be announced in advance.

EECE.7120 Special Topics in Electrical Engineering (Formerly 16.712) - Credits: 3

Topics of current interest in Electrical Engineering. Subject matter to be announced in advance.

EECE.7150 Special Topics (Formerly 16.715) - Credits: 3
EECE.7290 Selected Topics in Electrical Engineering (Formerly 16.729) - Credits: 3

Advanced topics in various areas of Electrical Engineering and related fields. Prerequisite: specified a the time of offering.

EECE.7300 Thesis - Electrical Engineering (Formerly 16.730) - Credits: 6
EECE.7320 Systems Engineering Thesis (Formerly 16.732) - Credits: 3
EECE.7330 Advance Graduate Project (Formerly 16.733) - Credits: 3

The Advanced Project is a substantial investigation of a research topic under the supervision of a faculty member. A written proposal must be on file in the Electrical &Engineering Graduate Office before enrollment. A written report is required upon completion of the project. This course can be taken only once, and may evolve into a master’s thesis. However, credit for this course will not be given if thesis credit is received.

EECE.7360 Graduate Project - Electrical Engineering (Formerly 16.736) - Credits: 6
EECE.7390 Graduate Project - Electrical Engineering (Formerly 16.739) - Credits: 9
EECE.7400 Advanced Project In Electrical Engineering (Formerly 16.740) - Credits: 3
EECE.7430 Master’s Thesis in Electrical Engineering (Formerly 16.743) - Credits: 1-3

Master’s Thesis Research

EECE.7460 Master’s Thesis in Electrical Engineering
(Formerly 16.746) - Credits: 6

Co-requisites: Minimum of 6 credit-hours of graduate courses at an acceptable level when registering for first three credits and 12 credit hours when registering for subsequent credits; matriculated status in the M.S. Eng. Program in Electrical, Computer or Systems Engineering; approval of a written proposal outlining the extent and nature of proposed research work. The report on the research work, performed under the supervision of a faculty member, must be published in an appropriate form and presented to a committee of three faculty members appointed at the time of acceptance of the thesis proposal. The student is required to give an oral defense of the thesis before the committee and other faculty members.

EECE.7490 Master's Thesis - Electrical Engineering
(Formerly 16.749) - Credits: 9

EECE.7510 Doctoral Thesis (Formerly 16.751) - Credits: 1

EECE.7520 PhD Thesis (Formerly 16.752) - Credits: 2

EECE.7530 Doctoral Dissertation/EE (Formerly 16.753) - Credits: 3

Doctoral Dissertation Research

EECE.7540 Doctoral Thesis - Electrical Engineering
(Formerly 16.754) - Credits: 4

EECE.7550 Doctoral Dissertation (Formerly 16.755) - Credits: 5

EECE.7560 Doctoral Dissertation/Electrical Engineering (Formerly 16.756) - Credits: 6

Doctoral Dissertation Research

EECE.7570 Doctoral Dissertation (Formerly 16.757) - Credits: 7

EECE.7590 Doctoral Dissertation/Electrical Engineering (Formerly 16.759) - Credits: 9

No more than 9 credits of doctoral dissertation research may be taken before passing the doctoral qualifying examination. No more than 13 credits of doctoral dissertation research may be taken before passing the defense of the thesis proposal examination.

EECE.7660 Continued Grad Research (Formerly 16.766) - Credits: 6

EECE.7710 Eng Sys Analysis I (Formerly 16.771) - Credits: 3

Study of the key areas in multiple engineering disciplines including Mechanical, Electrical, Software, Systems and Optical. Students are introduced to weekly topics and then work in multidiscipline teams to solve technical assignments. Topics covered include: Concept of Operations and Requirements development, integration, test and verification, vibration/shock analysis, thermal analysis, power supply design, digital electronics & FPGA, intro to optical engineering, SCRUM planning, continuous integration and UML/SW design. Content may vary year to year. This course is part of the Engineering Leadership Development Program (ELDP) and team taught by industry experts at BAE Systems.

EECE.7720 Eng Sys Analysis II (Formerly 16.772) - Credits: 3

Introduction and analysis of complex systems aligned with the key product lines of BAE Systems. Students are introduced to multiple types of systems and then work in multidiscipline teams to solve technical assignments. The systems covered include but are limited to: Electronic Warfare (EW), Communications Electronic Attack (Comms EA), Wide Area Airborne Surveillance (WAAS), Signal Intelligence (SIGINT), RADAR Navigation, Radio Communications, and Infrared Countermeasures (IRCM). Content may vary year to year. This course is part of the Engineering Leadership Development Program (ELDP) and team taught by industry experts at BAE Systems.

EECE.7730 Eng Sys Analysis III (Formerly 16.773) - Credits: 3

Study of project management concepts, product development methods, transition to operations and new business capture. Topics covered include but are not limited to risks and opportunities management, earned value management, lean product development, business strategy, design for manufacturability/maintainability (DFM^2), and request for information (RFI) response. Content may vary year to year. This course is part of the Engineering Leadership Development Program (ELDP) and team taught by industry experts at BAE Systems.
Energy Engineering

Energy Engineering Program

Graduate Programs offered:

- Doctor of Engineering (D.Eng.) Energy Engineering Option
- Doctor of Philosophy (Ph.D.) Energy Engineering Option
- Master of Science in Engineering (M.S.E.) Renewable (Solar) Engineering Option - administered through the Mechanical Engineering Department
- Nuclear Engineering Option - administered through the Chemical Engineering Department
- Bachelor’s-Master’s Program

Energy Engineering offers professional training at the doctoral and master’s degree levels designed to prepare the student to perform state-of-the-art research and design work on energy systems.

For additional information, contact the graduate coordinator for Renewable (Solar) Engineering (mailto:robert_parkin@uml.edu) or the graduate coordinator for Nuclear Engineering. (mailto:sukesh_aghara@uml.edu)

Master’s Program

Master of Science Degree Program in Energy Engineering

The UMass Lowell graduate program in Energy Engineering offers professional training at the master’s degree level designed to prepare the student to perform state-of-the-art work on energy systems. There are two options:

- Renewable (Solar) Engineering
- Nuclear Engineering

The programs are designed to achieve a balance between hands-on experience and theory. Energy engineering draws students from all branches of engineering, mathematics, physics and chemistry.

Thesis, Project, and Course-Only Requirements

There are three pathways to earning an MS degree in Energy Engineering:

- Thesis: 30 credits - 24 credits of courses (15 credits from core), plus 6 credits of thesis,
- Project: 30 credits - 27 credits of courses (15 from core), plus 3 credits of project, "(available to Nuclear option students only)"
- Course-Only: 30 credits - all from courses (15 from core, none from thesis or project credits)

A student’s thesis must be defended in an oral examination conducted by the student’s thesis committee.

Course Requirements

Students may choose to specialize in any area of interest in the college related to the energy field. Each student must take a series of core courses appropriate for the area of specialization. The exact makeup of the core curriculum will be guided and approved by the Graduate Committee of the Energy Engineering program. All students working toward the Master of Science Degree in Energy Engineering must take the following core courses:

Nuclear Option Required core courses:

- ENGY.5040 Energy Engineering Workshop
- ENGY.5050 Nuclear Reactor Physics
- ENGY.5070 Nuclear Reactor Engineering Analysis
- ENGY.5090 System Dynamics
- CHEN.5280 Advanced Transport Phenomena

Renewable (Solar) Option Required core courses

- MECH.5040 Energy Engineering Workshop
- MECH.5210 Fundamentals of Solar Utilization
- MECH.5260 Transfer Processes in Energy Systems
- MECH.5270 Solar Systems Engineering
- MECH.5200 Numerical Methods for Partial Differential Equations or MECH.5540 Dynamics Systems and Controls

The remainder of the course requirements are to be made up of elective courses which should be approved by the appropriate graduate coordinator.

The courses that are typically taken as elective courses include, but are not restricted to:

- CHEN.5060 Colloidal, Interfacial and Nanomaterials Science and Engineering
- CHEN.5080 Material Science and Engineering
- CHEN.5100 Advanced Separation Processes
- CHEN.5200 Advanced Thermodynamics
The objective of UMass Lowell’s doctoral program in energy engineering is to prepare engineers for leadership positions in industry, academia and government to provide society with sustainable energy systems. Presently there are two areas of concentration: renewable (solar) and nuclear. The renewable (solar) concentration is administered by the Mechanical Engineering Department and the nuclear engineering concentration is administered by the Chemical Engineering Department.

**Admission Requirements**

The applicant is required to have an M.S. degree in engineering or other suitable technical area, or its equivalent, or to have completed fifteen credit hours of graduate study, with a minimum grade point average of 3.25.

Students may be required to make up prerequisites which they lack in comparison to the equivalent Engineering curriculum at the University of Massachusetts Lowell. In cases where a student has an M.B.A. or has completed the Business Administration Minor for Engineering students, in addition to a B.S. in engineering or its equivalent, portions or all of the management/non-technical component of the Doctor of Engineering program may be waived upon review by the administering Department. Students may apply for transfer of up to a maximum of 24 credits in acceptable graduate engineering courses (with grade of B or better) towards the doctoral program, upon approval by the Program Doctoral Committee.

**Course Requirements**

A total of 63 credit hours of graduate level courses are required for both the Ph.D. and D.Eng. degrees. These credits are composed of the following components:

- **The Ph.D. degree** must involve a traditional research-based dissertation, plus: A minimum of 30 approved credit hours of graduate-level engineering including associated science and math courses. A minimum of 21 credit hours of doctoral dissertation. The balance of the remaining 12 credits can be a mix of graduate-level engineering including associated science and math course and dissertation credits at the discretion of the department, faculty advisor and dissertation committee.

- **The D.Eng. degree** must involve a dissertation, which can be either a traditional research-based dissertation or an industry-based project, plus: 33 approved credit hours of graduate-level engineering including associated science and math courses. 21 credit hours of doctoral dissertation. 9 credit hours of approved management-type courses.

- In addition to this 63 semester hours of approved graduate courses and dissertation: The student must have a minimum grade point average of 3.25 to graduate.
student is required to take and pass the doctoral qualifying examination.

Dissertations which are industrial in orientation should use the D.Eng. degree, based upon discussion with the supervising faculty advisor. Students may elect either degree designation with the consent of the faculty advisor, subject to the requirements of each degree.

Core Courses
The core requirements will consist of two courses in advanced mathematics, two courses in thermal/fluid processes, one course in materials, and one course in systems/controls. The specific courses follow:

Advanced Mathematics (select two of these or suitable alternatives with approval of the graduate coordinator):
- CHEN./ENGY.5090 Systems Dynamics
- CHEN./ENGY.5390 Mathematical Methods for Engineers
- MECH.5200 Numerical Methods for Engineers
- MATH.5300 Applied Math
- MATH.5840 Stochastic Process

Thermal/Fluid Processes (select two of these or suitable alternatives with approval of the graduate coordinator):
- CHEN.5100 Advanced Separation Processes
- CHEN.5200 Advanced Thermodynamics
- CHEN.5280 Advanced Transport Phenomena
- MECH.5260 Transfer Processes in Energy Engineering
- MECH.5810 Advanced Fluid Mechanics
- MECH.5890 Finite element in Thermo-Fluids
- MECH.5130 Finite Element Methods

Materials (select one of these or a suitable alternative with approval of the graduate coordinator):
- CHEN.5060 Interfacial Science and Engineering and Colloids
- CHEN.5080 Material Science and Engineering
- CHEN.5230 Nanodevices and Electronic Materials
- PLAS.5470 Materials for Renewable Energy and Sustainability
- CHEN.5350 Principles of Cell and Microbe Cultivation
- PHYS.5390 Electro_Optics

Systems/Controls (select one of these or a suitable alternative with approval of the graduate coordinator):
- EECE.5130 Control Systems
- EECE.5840 Probability and Random Processes
- MECH.5750 Industrial Design of Experiments
- MECH.5540 Dynamic Systems and Control

Concentration Courses
A total of 12 credits of concentration courses must be taken, either from the renewable area or from the nuclear area. The specific courses in those areas follow:

Renewable (select four of these or suitable alternatives with approval of the graduate coordinator):
- EECE.5150 Power Electronics
- EECE.5280 Alternative Energy Systems
- MECH.5040 Energy Systems Design Workshop
- MECH.5210 Solar Engineering Fundamentals
- MECH.5250 Grid-Connected Solar Electric Systems
- MECH.5270 Solar Systems Engineering
- MECH.5280 PV Manufacturing
- MECH.5340 Green Combustion and Bio-Fuels
- MECH.5580 Aero/Wind Engineering
- MECH.5740 Design for Reliability Engineering
- PHYS.5770 Solid State Electronic and Optoelectronic Devices

Nuclear (select five of these or suitable alternatives with approval of the graduate coordinator):
- ENGY.5040 Energy Engineering Workshop
- ENGY.5050 Nuclear Reactor Physics
- ENGY.5060 Special Topics in Nuclear Reactor Physics
- ENGY.5070 Nuclear Reactor Engineering and Safety Analysis
- ENGY.5080 Special Topics in Nuclear Reactor Engineering
- ENGY.5110 Advanced Reactor Concepts
- ENGY.5140 Hazardous and Nuclear Waste Management
- ENGY.5190 Nuclear Reactor Operator Training I
- ENGY.5200 Nuclear Reactor Operator Training II

For Nuclear Option Students

Qualifying Examination
Students are required to take the qualifying examination within their first year of residency in the program. The first part of the exam is intended to cover knowledge of undergraduate engineering and is satisfied by passing the Professional Engineering Fundamentals Exam. The second part is intended to cover topics in an area of energy engineering of the student’s interest, with the approval of the student’s thesis advisor. The written part of this examination is closed book and composed of two sections, each of three hours duration. The examination is set and evaluated by the program Graduate Examination Committee, which determines whether or not a student shall be eligible to take the oral portion. Students who pass the written part of the qualifying examination must take the oral part of the examination within 6 weeks of notification of results of the written exam. The student is permitted two attempts at passing the qualifying examination which is administered on a declared schedule. Students who fail the qualifying examination the first time must retake the exam at its next scheduled offering. Students failing the doctoral exam twice will be automatically dismissed from the doctoral program.

Dissertation

Students may register for no more than six credit hours of research in preparing a formal dissertation proposal. This proposal, and the student’s ability to perform the research, must be orally defended before the student’s doctoral committee and other interested parties. The written proposal and oral defense constitute the candidacy examination. Upon passing this examination and completing all course requirements, the student becomes a candidate for the D.Eng./Ph.D. degree and may register for additional research credit with the adviser’s approval.

The research work for the dissertation shall be conducted under the supervision of a program faculty advisor and a committee of two others, at least one of whom must be a faculty member in the university with the appropriate background for the thesis topic.

For Renewable Option Students:

Combined Qualifying Examination and Dissertation Proposal

The Doctoral Qualifying Exam will consist of a written dissertation proposal (a document of typically 20 to 50 pages with appendices) and associated oral presentation by the examinee to an audience of peers and a committee of faculty members (minimum of three) where one of whom must be the examinee’s dissertation adviser. The committee may have in addition one of more members from outside UMass Lowell.

At least one week prior to the date of the presentation of the dissertation proposal, an announcement document must be submitted to the department graduate coordinator and to the Associate Dean of Graduate Studies in the College of Engineering by the Associate Dean of Graduate Studies.

The dissertation proposal is open to the public. The proposal will outline the motivation for the research, give a summary of the related past work in the area and present the scope of the proposed dissertation research. The presentation should be approximately 30 minutes. The proposal should clearly articulate the proposed contribution of the student to the knowledge base and how it differs from the past work. The examinee will be expected to answer questions from the audience that demonstrate his/her understanding of the proposed research, as well as demonstration his/her proficiency in the general research field related to the dissertation proposal.

Other Requirements

- The student is required to be in full time residency at the university for at least one year.
- The student must have a minimum grade point average of 3.25 in order to graduate.
Mechanical Engineering

Department of Mechanical Engineering

The UMass Lowell Department of Mechanical Engineering offers the following graduate programs:

- **Doctor of Philosophy** (Ph.D.) Option in Mechanical Engineering
- **Doctor of Engineering** (D.Eng.) Option in Mechanical Engineering
- **Master of Science in Mechanical Engineering** (M.S. Eng.)
- **Master of Science in Energy Engineering - Renewable (Solar) Option**
- **Graduate Certificates**
- **Design Manufacturing Engineering**
- **Structural Dynamics and Acoustic Modeling Techniques**
- **Microelectromechanical Systems/Nanoelectromechanical Systems** (interdisciplinary)
- **Composites and Materials**
- **Renewable Engineering Systems**
- **Integrated Engineering Systems**
- **Nanotechnology (interdisciplinary)**
- **Bachelor’s/Master’s Program**

The admission requirements of the University are to be followed for all degree programs in Mechanical Engineering. The student is required to submit official transcripts for all prior college level studies, official score report for the Graduate Record Examination Aptitude Test, and three letters of recommendation. Applicants for Master or Doctor of Engineering Degrees in Mechanical Engineering must be in possession of a bachelor’s degree in engineering or equivalent. Mechanical Engineering graduates can also apply for the Ph.D. degree in Applied Physics.

**Masters Program**

**Master’s Program in Mechanical Engineering**

- **Degree Requirements**
- **Mechanical Engineering Concentrations** Mechanics &Materials Concentration Thermofluids Concentration Energy Concentration Vibrations/Dynamics/Controls Concentration Design and Manufacturing Concentration Out-of-Department Concentrations

- **Energy Engineering Option**
- **ME-Based Graduate Certificates**

The Department of Mechanical Engineering offers both Master of Science in Engineering (MSE) program and a combined BSE/MSE program. These programs offer a choice of either a thesis option or a non-thesis option. To receive the MSE degree requires a minimum of thirty (30) credit hours of acceptable graduate work, including nine (9) credit hours of research for the thesis option.

The entrance requirement for the MSE program is a BSE in Mechanical Engineering, or other engineering discipline, at an acceptable grade point average provided having strong performance in mathematics and science courses. Students with a non-ME bachelors degree can be required to take up to 5 undergraduate ME courses in order to ensure that the student has adequate background knowledge.

Students on the thesis option may register for thesis credits after submitting a thesis agreement signed by his/her thesis advisor to the graduate coordinator. Upon completing the thesis, the student is required to defend it orally before a committee of three faculty members including the advisor. The committee members must receive a completed version of the thesis manuscript at least 14 days before the thesis is defended.

**Degree Requirement**

All MSE degree candidates must satisfy each of the following five requirements. No course can count towards more than one requirement:

1. Three (3) credit hours of advanced mathematics from the following list: MECH.5200 Numerical Methods for Partial Differential Equations ENGY.5390 (CHEN.5390) Mathematical Methods for Engineers MATH.5450 Partial Differential Equations MATH.5300 Applied Math I
2. Three (3) credit hours of solid mechanics courses from the following list: MECH.5130 Finite Element Analysis IMECH.5620 Solid Mechanics I
3. Three (3) credit hours of thermofluid courses from the following list: MECH.5400 Heat Conduction MECH.5420 Convective Heat and Mass Transfer MECH.5590 Multi-
Scale Computational fluid Dynamics IMECH.5810
Advanced Fluids CHEN.5280 Advanced Transport Phenomena

4. Nine (9) credit hours of course work in a Mechanical Engineering Concentration.

5. Either 1. or 2. below: Thesis Option: Nine (9) credit hours of MS thesis, Plus, three (3) credit hours of course work approved by the thesis advisor. Non-Thesis Option: Twelve (12) credit hours of course work approved by the graduate coordinator. Nine (9) of these credits may be taken in an Out-of-Department Concentration. In their first year non-thesis students must submit a plan of study to the graduate coordinator and obtain his/her approval. Any change to the submitted plan requires the approval of the graduate coordinator.

**Mechanical Engineering Concentrations**

1. **Mechanics & Materials Concentration:**
   - MECH.5120 Applied Finite Elements
   - MECH.5130 Finite Element Analysis I
   - MECH.5140 Finite Element Analysis of Composites
   - MECH.5620 Solid Mechanics I
   - MECH.5630 Dynamic Behavior of Materials
   - MECH.5690 Fracture Mechanics
   - MECH.5700 Polymer Nanocomposites
   - MECH.5910 Mechanical Behavior of Materials
   - MECH.6140 Finite Element Analysis II
   - MECH.6010 Special Topics: Mechanics/Materials
   - MECH.5970 Processing of Composites
   - MECH.5960 Composite Materials

2. **Thermofluids Concentration:**
   - MECH.5400 Heat Conduction
   - MECH.5420 Convective Heat and Mass Transfer
   - MECH.5450 Advanced Industrial Heat and Mass Transfer
   - MECH.5490 Cooling of Electronic Equipment
   - MECH.5530 MEMS & Microsystems
   - MECH.5580 Aero/Wind Engineering
   - MECH.5590 Multi-Scale Computational Fluid Dynamics I

3. **Energy Concentration:**
   - MECH.5040 Energy Engineering Workshop
   - MECH.5210 Solar Fundamentals
   - MECH.5250 Grid-Connected Solar Electric Systems
   - MECH.5260 Transport Processes in Energy Systems
   - MECH.5270 Solar Energy Engineering
   - MECH.5280 Photovoltaics Manufacturing
   - MECH.5340 Green Combustion and Biofuels
   - CHEN.5280 Advanced Transport Phenomena
   - ENGY.5050 Reactor Physics
   - ENGY.5070 Reactor Engineering and Safety Analysis
   - ENGY.5090 Dynamics Systems

4. **Vibrations/Dynamics/Controls Concentration:**
   - MECH.5100 Dynamics and Diagnostics of Rotating Machinery
   - MECH.5130 Finite Element Analysis I
   - MECH.5150 Modal Analysis
   - MECH.5160 Experimental Modal Analysis
   - MECH.5180 Signal Processing Techniques
   - MECH.5240 Fundamentals of Acoustics
   - MECH.5300 Autonomous Robotic Systems
   - MECH.5500 Vibrations
   - MECH.5540 Dynamic Systems and Controls
   - MECH.5790 Robotics
   - MECH.6030 Special Topics: Vibration Dynamics
   - MECH.6110 Matrix Methods
   - EECE.5130 Control System
   - EECE.5840 Probability and Random Processes

5. **Design and Manufacturing Concentration:**
   - MECH.5120 Applied Finite Elements
   - MECH.5490 Cooling of Electronic Equipment
Out-of-Department Concentrations:

Non-thesis students can take nine (9) credit hours in an Out-of-Department concentration which will normally consist of nine (9) credit hours from one of the graduate certificates listed below. Students can suggest their own out-of-department concentration, but prior approval must be obtained from the graduate coordinator.

Courses from one of the following graduate certificates offered out of the ME department are acceptable:

- Applied Statistics
- Biomedical Engineering
- Biotechnology & Bioprocessing
- Communications Engineering
- Elastomeric Materials
- Energy Conversion
- Environmental Biotechnology
- Environmental Risk Assessment
- Foundations of Business
- Identification & Control of Ergonomic Hazards
- Integrated Engineering Systems
- Materials Sciences & Engineering
- Medical Plastics Design & Manufacturing
- Microwave and Wireless Engineering
- Modeling, Simulation, and Control of Systems and Processes
- Molecular & Cellular Biotechnology
- Nanotechnology
- New Venture Creation
- Plastics Design
- Plastics Materials
- Plastics Processing
- Stochastic Systems

- Sustainable Infrastructure for Developing Nations
- Telecommunications
- VLSI & Microelectronics

Energy Engineering Option

The University offers a Master of Science degree in Energy Engineering. This unique area of concentration represents a separate multidisciplinary program that is administered jointly by the Mechanical Engineering Department (Solar Option) and the Chemical and Nuclear Engineering Department (Nuclear Option). The Energy Engineering Program has two M.S. degree options: Renewable (Solar) Engineering and Nuclear Engineering. Students interested in either of these program options should refer to the catalog section focused specifically on the Energy Engineering Program.

ME-Based Certificate Programs

Non-degree candidates who have a BS in engineering or a physical science are encouraged to apply to take a graduate certificate in which the ME department participates. A paper certificate will be awarded upon successful completion.

- Bachelor's-Master's Program

Doctoral Program

Doctoral Programs in Mechanical Engineering

The UMass Lowell Department of Mechanical Engineering offers two doctoral degree tracks with two options each.

- Doctor of Philosophy (Ph.D.) Option in Mechanical Engineering
- Doctor of Engineering (D.Eng.) Option in Mechanical Engineering

Ph.D. Option in Mechanical Engineering

The intent of the Doctor of Philosophy program is to prepare engineers for leadership positions in industry, academia and government. The programs include advanced graduate course work in engineering and allied subjects and research, culminating in a doctoral dissertation. The Ph.D. degree is oriented toward academic research.

Admission Requirements

Applicants must have a minimum of a B.S. in Mechanical Engineering, or a closely related field with a minimum grade point average of 3.0 and an min GPA of 3.25 in science and engineering courses. Applicants with a M.S. in Mechanical Engineering, or a closely related field, must have a minimum...
graduate GPA of 3.25.

One of the letters of recommendation submitted as part of the graduate school application should be from a mechanical engineering department faculty member willing to act as thesis advisor.

**Transfer Credits**

1. A student with a master’s degree in Engineering or a closely related field may apply to have coursework for the master’s degree up to a total of 24 credits.
2. A student with graduate-level work completed at an accredited US or Canadian university may apply for transfer of up to 24 semester credits in acceptable graduate engineering courses (with grade of B or better) towards the doctoral program, upon approval by the Department Graduate Coordinator.
3. In cases where a student has an M.B.A., or has completed the Business Administration Minor for Engineering students, in addition to a B.S. in engineering or a closely related field, portions of the management component of the Doctor of Engineering program may be waived upon review by the administering department.

Note: Students may be required to make up prerequisites which they lack in comparison to the equivalent Engineering curriculum at the University of Massachusetts Lowell.

**Degree Requirements**

A total of 63 credit hours of graduate level courses are required for the Ph.D. degree. The Ph.D. degree must involve a traditional research-based dissertation, plus:

- A minimum of 30 approved credit hours of graduate-level engineering courses, including associated science and math courses.
- A minimum of 21 credit hours of doctoral dissertation.
- The balance of the remaining 12 credits can be a mix of graduate-level engineering including associated science and math course and dissertation credits at the discretion of the department, faculty advisor and dissertation committee.

In addition to these 63 semester hours of approved graduate courses and thesis:

- The student must have a minimum grade point average of 3.25 in order to graduate.
- The student is required to take and pass the doctoral qualifying examination.

Among the coursework, the Ph.D candidate must take:

- One Course in advanced mathematics: MECH.5200 Numerical Methods for Partial Differential Equations
ENGY.5390 (CHEN.5390) Mathematical Methods for Engineers
MATH.5300 Applied Math
IMATH.5450 Partial Differential Equations
Or another advanced mathematics approved by the graduate coordinator

- Four courses from the following five areas of concentration:

  1. **Mechanics & Materials Concentration:**
     - MECH.5200 Applied Finite Elements
     - MECH.5130 Finite Element Analysis I
     - MECH.6140 Finite Element Analysis II
     - MECH.6010 Special Topics: Mechanics/Materials
     - MECH.5970 Processing of Composites
     - MECH.5960 Composite Materials
     - MECH.5910 Mechanical Behavior of Materials
     - MECH.5690 Fracture Mechanics
     - MECH.5620 Solid Mechanics I
     - MECH.5630 Dynamic Behavior of Materials
     - MECH.5140 Finite Element Analysis of Composites

  2. **Thermofluids Concentration:**
     - MECH.5400 Heat Conduction
     - MECH.5420 Convective Heat and Mass Transfer
     - MECH.5450 Advanced Industrial Heat and Mass Transfer
     - MECH.5490 Cooling of Electronic Equipment
     - MECH.5530 MEMS & Microsystems
     - MECH.5580 Aero/Wing Engineering
     - MECH.5590 Multi-Scale Computational Fluid Dynamics I
     - MECH.5600 Multi-Scale Computational Fluid Dynamics II
     - MECH.5810 Advanced Fluid Mechanics
3. Energy Concentration:

- MECH.5040 Energy Engineering Workshop
- MECH.5210 Solar Fundamentals
- MECH.5250 Grid-Connected Solar Electric System
- MECH.5260 Transport Processes in Energy Systems
- MECH.5280 Photovoltaics Manufacturing
- CHEN.5280 Advanced Transport Phenomena
- ENGY.5050 Reactor Physics
- ENGY.5070 Reactor Engineering and Safety Analysis
- ENGY.5090 Dynamic Systems

4. Vibrations/Dynamics/Controls Concentration:

- MECH.5100 Dynamics and Diagnostics of Rotating Machinery
- MECH.5130 Finite Element Analysis I
- MECH.5150 Modal Analysis
- MECH.5160 Experimental Modal Analysis
- MECH.5180 Signal Processing Techniques
- MECH.5240 Fundamentals of Acoustics
- MECH.5300 Autonomous Robotic Systems
- MECH.5500 Vibrations
- MECH.5540 Dynamic Systems and Controls
- MECH.5790 Robotics
- MECH.6030 Special Topics: Vibration Dynamics
- MECH.6110 Matrix Methods
- EECE.5130 Control Systems
- EECE.5840 Probability and Random Processes

5. Manufacturing Concentration:

- MECH.5120 Applied Finite Elements
- MECH.5490 Cooling of Electronic Equipment
- MECH.5530 MEMS & Microsystems
- MECH.5710 Collaborative Engineering
- MECH.5720 Manufacturing Processes
- MECH.5740 Design for Reliability Engineering
- MECH.5750 Industrial Design of Experiments
- MECH.5760 Engineering Project Management
- MECH.5770 Event Driven Manufacturing
- MECH.5790 Robotics

Combined Qualifying Examination and Dissertation Proposal

The Doctoral Qualifying Exam will consist of a written dissertation proposal (a document of typically 20 to 50 pages without appendices) and associated oral presentation by the examinee to an audience of peers and a committee of faculty members (minimum of three) where one of whom must be the examinee’s dissertation advisor. The committee may have in addition one or more members from outside UML.

At least one week prior to the date of the presentation of the dissertation proposal, an announcement document must be submitted to the department graduate coordinator and to the Associate Dean of Graduate Studies in the College of Engineering by the Associate Dean of Graduate Studies.

The dissertation proposal is open to the public. The proposal will outline the motivation for the research, give a summary of the related past work in the area and present the scope of the proposed dissertation research. The presentation should be approximately 30 minutes. The proposal should clearly articulate the proposed contribution of the student to the knowledge base and how it differs from the past work. The examinee will be expected to answer questions from the audience that demonstrate his/her understanding of the proposed research, as well as demonstration his/her proficiency in the general research field related to the dissertation proposal.

D.Eng. Option in Mechanical Engineering

The intent of the Doctor of Engineering program is to prepare engineers for leadership positions in industry, academia and government. The programs includes advanced graduate course work in engineering and allied subjects and research, culminating in a doctoral dissertation. Compared to the Ph.D. degree, the D.Eng is oriented toward industry.

Admission Requirements

Applicants must have a minimum of a B.S. in Mechanical Engineering, or a closely related field with a minimum grade point average of 3.0 and an min GPA of 3.25 in science and engineering courses. Applicants with a M.S. in Mechanical Engineering, or a closely related field, must have a minimum graduate GPA of 3.25.

In the cases where a student has an M.B.A., or has completed the Business Administration Minor for Engineering student, in addition to a B.S. in engineering or its equivalent, portions of
the management component of the Doctor of Engineering program may be waived upon review by the administering department.

One of the letters of recommendation submitted as part of the graduate school application should be from a mechanical engineering department faculty member willing to act as thesis advisor.

Transfer Credits

1. A student with a master’s degree in Engineering or a closely related field may apply to have coursework for the master’s degree up to a total of 24 credits.
2. A student with graduate-level work completed at an accredited US or Canadian university may apply for transfer of up to 24 semester credits in acceptable graduate engineering courses (with grade of B or better) towards the doctoral program, upon approval by the Department Graduate Coordinator.
3. In cases where a student has an M.B.A., or has completed the Business Administration Minor for Engineering students, in addition to a B.S. in engineering or a closely related field, portions of the management component of the Doctor of Engineering program may be waived upon review by the administering department.

Note: Students may be required to make up prerequisites which they lack in comparison to the equivalent Engineering curriculum at the University of Massachusetts Lowell.

Degree Requirements

A total of 63 credit hours of graduate level courses are required for the D.Eng degree. These credits are composed of the following three components:

- 33 approved credit hours of graduate-level engineering courses, which must include doctoral core, described below.
- 9 credit hours of approved management-type courses.
- 21 credit hours of doctoral dissertation. The D.Eng. degree can involve a dissertation that involves an industry-based project.

In addition to these 63 semester hours of approved graduate courses and thesis:

- The student must have a minimum grade point average of 3.25 in order to graduate.
- Students are required to take and pass the doctoral qualifying examination.
- Students must take a doctoral candidacy (thesis defense) examination.

Doctoral Core Requirement

Students must satisfy the following doctoral core requirement:

- One Course in solid mechanics
- One Course in Thermal fluids (approved by grad coordinator)
- Two Courses in advanced mathematics (approved by grad coordinator)
- Four courses from the following five areas of concentration:
  1. Mechanics & Materials Concentration:
     - MECH.5120 Applied Finite Elements
     - MECH.5130 Finite Element Analysis I
     - MECH.5140 Finite Element Analysis of Composites
     - MECH.5620 Solid Mechanics I
     - MECH.5690 Fracture Mechanics
     - MECH.5910 Mechanical Behavior of Materials
     - MECH.5960 Composite Materials
     - MECH.5970 Processing of Composites
     - MECH.6010 Special Topics: Mechanics/Materials
     - MECH.6140 Finite Element Analysis II
  2. Thermofluids Concentration:
     - MECH.5400 Heat Conduction
     - MECH.5420 Convective Heat and Mass Transfer
     - MECH.5450 Advanced Industrial Heat and Mass Transfer
     - MECH.5490 Cooling of Electronic Equipment
     - MECH.5530 MEMS & Microsystems
     - MECH.5580 Aero/Wing Engineering
     - MECH.5590 Multi-Scale Computational Fluid Dynamics I
     - MECH.5600 Multi-Scale Computational Fluid Dynamics II
     - MECH.5810 Advanced Fluid Mechanics
3. Energy Concentration:
- MECH.5040 Energy Engineering Workshop
- MECH.5210 Solar Fundamentals
- MECH.5250 Grid-Connected Solar Electric Systems
- MECH.5260 Transport Processes in Energy Systems
- MECH.5270 Solar Energy Engineering
- MECH.5280 Photovoltaics Manufacturing
- MECH.5340 Green Combustion and Biofuels
- CHEN.5280 Advanced Transport Phenomena
- ENGY.5050 Reactor Physics
- ENGY.5070 Reactor Engineering and Safety Analysis
- ENGY.5090 Dynamic Systems

4. Vibrations/Dynamics/Controls Concentration:
- MECH.5100 Dynamics and Diagnostics of Rotating Machinery
- MECH.5130 Finite Element Analysis I
- MECH.5150 Modal Analysis
- MECH.5160 Experimental Modal Analysis
- MECH.5180 Signal Processing Techniques
- MECH.5240 Fundamentals of Acoustics
- MECH.5300 Autonomous Robotic Systems
- MECH.5500 Vibrations
- MECH.5540 Dynamic Systems and Controls
- MECH.5790 Robotics
- MECH.6030 Special Topics: Vibration Dynamics
- MECH.6110 Matrix Methods
- EEEC.5130 Control Systems
- EEEC.5840 Probability and Random Processes

5. Manufacturing Concentration:
- MECH.5120 Applied Finite Elements
- MECH.5490 Cooling of Electronic Equipment
- MECH.5530 MEMS & Microsystems
- MECH.5710 Collaborative Engineering
- MECH.5720 Manufacturing Processes
- MECH.5740 Design for Reliability Engineering
- MECH.5750 Industrial Design of Experiments
- MECH.5760 Engineering Project Management
- MECH.5770 Event Driven Manufacturing
- MECH.5790 Robotics

Management Courses for the Doctor of Engineering Degree

D.Eng. students are required to take 9 credits of graduate management courses from the following list:
- MECH.5760 Engineering Project Management (3 credits)
- PLAS.5070 Plastics Industry Organization (3 credits)
- PLAS.5140 Statistics for Six Sigma (3 credits)
- PLAS.5150 Lean Plastics Manufacturing (3 credits)
- PLAS.5370 Business Law for Engineers (3 credits)
- PLAS.5400 Commercial Development of Polymeric Systems (3 credits)
- PLAS.5900 Survey of Intellectual Property (3 credits)
- ACCT.5010 Financial Accounting (2 credits)
- FINA.5010 Business Finance (2 credits)
- MKTG.5010 Marketing Fundamentals (2 credits)
- POMS.5010 Operations Fundamentals (2 credits)
- MGMT.5010 Organizational Behavior (2 credits)
- MGMT.5110 Global Enterprise & Competition (2 credits)
- MGMT.5120 New Venture Creation (3 credits)

Qualifying Examination

Students must take the doctoral qualifying examination at the end of their first year of study. This examination tests basic competency at the undergraduate level. The student is permitted two attempts at passing the qualifying examination. Students who fail the qualifying examination the first time must retake the exam at its next scheduled offering. Students failing the doctoral exam twice will automatically be dismissed from the doctoral program. Those who do not take the examination at the prescribed time may lose all their financial support, if any, and may be dismissed from the doctoral program.

Candidacy Examination and Dissertation Proposal

The research work for the dissertation shall be conducted under the supervision of a departmental faculty advisor and a committee of two others. Students are required to submit and defend a dissertation proposal before a Department Doctoral
Committee. Students may register for no more than six credit hours of research in preparing a formal dissertation proposal. This proposal, and the students ability to perform the research, must be orally defended before the students doctoral committee and other interested parties. This constitutes the candidacy examination.

Upon passing this examination, and completing all course requirements, the student becomes a candidate for the D.Eng degree and may register for additional research credit with the advisors approval.

Graduate Certificates in Mechanical Engineering

The following graduate certificates are offered in Mechanical Engineering:

- Design and Manufacturing Engineering
- Structural Dynamics and Acoustic Modeling Techniques
- Microelectromechanical Systems/Nanoelectromechanical Systems (interdisciplinary)
- Composites and Materials
- Renewable Energy Engineering
- Integrated Engineering Systems (interdisciplinary)
- Nanotechnology (interdisciplinary)

Apply for a graduate certificate.

Design & Manufacturing Engineering

Contact:
Sammy Shina, Ph.D.
978-934-2950
Sammy_Shina@uml.edu

Required Course (one 3-credit course):

- MECH.5750 Industrial Design of Experiments
- MECH.5760 Engineering Project Management

Choose Three of the Following Courses (three 3-credit courses):

- MECH.5710 Collaborative Engineering and Quality
- MECH.5740 Design for Reliability Engineering
- MECH.5750 Industrial Design of Experiments

Structural Dynamic Modeling Techniques

Contact persons:
Peter Avitabile
978-934-3176
Peter_Avitabile@uml.edu

Christopher Niezrecki
978-934-2963
Christopher_Niezrecki@uml.edu

This certificate is aimed at educating engineers in very critically needed techniques for modeling structural dynamic applications. In all undergraduate curriculums accredited by the Engineering Accreditation Commission of ABET, the materials presented bring the student to a firm comprehension and understanding of static design configurations but does not go beyond this point to address the practical reality of structural dynamic response for meaningful design configurations. Therefore, many new or practicing engineers are not prepared to address these types of problems. These suite of courses in this certificate provides materials that has strong, practical relevance and provides tools and techniques to address these structural dynamic applications. Both hands-on and product oriented practice will be emphasized.

A total of four courses (12 credits) are required for the certificate with one required course (which must be either MECH.550 Advanced Vibrations or MECH.515 Structural Dynamic Modeling Techniques).

The courses in this certificate are:

- MECH.5100 Dynamics and Diagnostics of Rotating Machinery
- MECH.5130 Finite Element Analysis I
- MECH.5150 Structural Dynamic Modeling Techniques
- MECH.5160 Experimental Modal Analysis
- MECH.5170 Structural Dynamics
- MECH.5180 Signal Processing
- MECH.5240 Fundamentals of Acoustics
- MECH.5760 Engineering Project Management
- MECH.5790 Robotics
- CHEN.5230 Electronic Material Processes
- CHEN.5240 Self Assembly and Nanotechnology
- PLAS.5180 Plastics Product Design
- PLAS.5530 Medical Device Design I
MEMS/NEMS (Microelectromechanical Systems/Nanoelectromechanical Systems)

Contact:
Hongwei Sun
978-934-4391
Hongwei_Sun@uml.edu (mailto:hongwei_sun@uml.edu)

This 12-credit certificate program provides an interdisciplinary education and training for engineers who will work in the fast growing MEMS/NEMS industry with microsystems design methods, advanced microfabrication, packaging and assembly techniques, VLSI circuits design and fabrication, nanoelectronics, nano-assembly and integration, material processing. Both hands-on and product oriented practice are emphasized.

Choose four courses with at least one course from Group 1 and at least one course from Group 2.

Group 1

- MECH.5570 Microsystem Design
- MECH.5530 MEMS & Microsystems

Group 2

- EECE.7100 Special Topics in Nanoelectronics
- CHEN.5240 Self Assembly and Nanotechnology

Group 3

- CHEN.5230 Electronic Material Process
- EECE.5020 VLSI Design
- EECE.5040 VLSI Fabrication

Composites and Materials

Contact persons:
Alireza Amirkhizi
978-934-5968
Alireza_Amirkhizi@uml.edu
(mailto:alireza_amirkhizi@uml.edu)

Christopher Hansen

Renewable Energy Engineering

Contact:
This 12 credit certificate provides engineers and scientists with a rigorous but practical grounding in the fundamentals of renewable energy systems for design, research, development and manufacture. The certificate is part of a long-standing interdisciplinary graduate degree program in renewable energy engineering with experienced faculty. The courses address topics ranging from green building technologies (basic insulation and efficiency, passive solar heating and cooling, daylighting, solar hot water) to photovoltaic and wind systems, solar electrolyzers and fuel cells to stochastic process modeling of irradiation.

Choose any four classes from the following list with at least one of the four being MECH.5210 Solar Fundamentals or MECH.5270 Solar Energy Engineering. Other suitable courses may used for the certificate with the permission of the coordinator.

- ECE.5280 Alternative Energy Systems
- MECH.5040 Energy Systems Design Workshop
- MECH.5090 Dynamic Systems Analysis
- MECH.5210 Fundamentals of Solar Engineering
- MECH.5250 Grid-Connected Solar Electric Systems
- MECH.5260 Transfer Processes in Energy Systems
- MECH.5270 Solar Energy Engineering
- MECH.5280 Photovoltaic Manufacturing
- MECH.5340 Green Combustion and Bio-Fuels
- PLAS.5470 Materials for Renewable Energy and Sustainability
- PHYS.5770 Solid State Electronic and Optoelectronic Devices

Other suitable courses may be used as electives for the certificate with prior permission of the coordinator.

Integrated Engineering Systems

Applied Physics, Computer Engineering, Computer Science, Electrical Engineering, Materials Engineering, Mechanical Engineering, Plastics Engineering departments

Contact person:
Craig Armiento
978-934-3395
Craig_Armiento@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
6. Mechanical Engineering

Within each cluster, there are a number of carefully selected courses ranging from introductory graduate level to more advanced, specialized electives.

Students must successfully complete four courses (12 credits), 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 Network Design: Principles, Protocols, and Applications
• EECE.5730 Operating Systems and Kernel Design for Computer Engineers
• 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
• COMP.5230 Software Engineering I
• COMP.5240 Software Engineering II

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.5120 Electronic Materials
• EECE.5190 Engineering of Submicron Machines
• EECE.5900 Fiber Optic Communications and Networks
• EECE.5430 Introduction to Communication Theory
• 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
• CHEN.5070 Material Science and Engineering
• PLAS.5030 Mechanical Behavior of Polymers
• CHEN.5230 Nanodevices and Electronic Materials
• CHEN.5270 Nanomaterials Science and Engineering
• 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.5730 Manufacturing Systems Engineering
• MECH.5910 Mechanical Behavior of Materials
• MECH.5150 Modal Analysis- Theoretical Methods
• MECH.5790 Robotics
• MECH.5620 Solid Mechanics
• MECH.5270 Solar Systems Engineering
Nanotechnology

Civil & Environmental, Mechanical, Plastics Engineering departments

Contact: 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 nanoscience and technology. The certificate is designed for students with a background in chemistry, physics, biology, or any branch of engineering who want nanotechnology and nanomanufacturing workforce preparation. Students may focus on a concentration area based on their interests and background. Courses in each concentration area are carefully designed to provide both analytical and practical competence. Students may take any combination from the electives list.

Core Course: (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.5060/5270 Interfacial Science and Engineering and Colloids
- MECH.5780 Advanced Materials
- PLAS.5130 New Plastics Materials
- PLAS.5980 Smart Polymers

Manufacturing
- CHEN.5230 Electronic Materials Processing
- CHEN.5240 Self-assembly and Nanotechnology
- CHEN.5350 Cell & Microbe Cultivation
- CHEN.5450 Isolation & Purification of Biotech Products

Design and Devices

- EECE.5040 VLSI Fabrication
- ENGN.5510 Nanomanufacturing I
- ENGN.5260 Nanoscale Plastics Processing
- PLAS.5020 New Plastics Processing Techniques

Health and Environmental Impacts

- PUBH.5030 Toxicology and Health
- PUBH.5140 Aerosol Science
- PUBH.5250 Industrial Hygiene and Ergonomics 19.557
- PUBH.6100 Exposure Assessment
- PUBH.6170 Measurements of Airborne Contaminants

EECE.5020 VLSI Design
EECE.5120 Electronic Materials
EECE.5080 Quantum Electronics for Engineers
MECH.5010 Graduate Research Seminar - Credits: 0-1

Research seminar for students to listen to and engage with engineering-relevant researchers. Invited speakers will present recent research advances in fields relevant to mechanical engineering, and engage with the audience through a question and answer session.

MECH.5040 Energy Engineering Workshop (Formerly 22.504) - Credits: 3

A group design of an innovative energy system. Integration of many aspects of the student's engineering background, including design concepts, technical analyses, economic and safety considerations. Ideally the whole design cycle of design, build, test. A formal report and oral presentation.

MECH.5050 Directed Studies - ME (Formerly 22.505) - Credits: 3
MECH.5100 Dynamics and Diagnostics of Rotating Machinery (Formerly 22.510) - Credits: 3

Course provides the theoretical and practical background in the fundamentals of dynamics and diagnostics of rotating machinery. The course starts with an overview of rotating machinery components and systems with emphasis on their designs, and then builds and in-depth understanding of the dynamics of rotating systems by analyzing the design and dynamics of their component. Diagnostics, health monitoring, and associated signal processing theories regarding rotating machinery are emphasized, with applied examples such as aircraft engines, gas turbines, rotocrafts, wind turbines, and automotive drivetrains, along with other turbomachines.

MECH.5110 FEA of Textiles and Composites - Credits: 3

This course covers applications of finite element analysis to the mechanical behavior of textiles and composites, including topics such as mechanics of orthotropic materials, elasticity and strength of laminates, computational micromechanics, meso-scale finite element modeling, material testing, modeling techniques. These topics will be studied using software packages such as Abaqus and Matlab.

MECH.5120 Applied Finite Element Analysis (Formerly 22.512) - Credits: 3

An introduction to finite element methods using popular commercial packages. The features common to different programs as well as special features of particular programs are presented. Primary focus is on hands-on familiarity with the software with a limited discussion of the underlying finite element theory. ALGOR, ADINA, ABAQUS, LS-DYNA, HyperMesh, and FEMAP are among the pre/post-processing and analysis packages used in the class. This is a WWW based course and access to a PC, the Internet, and a frames-capable browser is required.

MECH.5130 Theory of Finite Element Analysis (Formerly 22.513) - Credits: 3

Matrix algebra and the Rayleigh-Ritz technique are applied to the development of the finite element method. The minimum potential energy theorem, calculus of variations, Galerkin's and the direct-stiffness method are used. Restraint and constraint conditions are covered. C0 and C1 continuous shape functions are developed for bar, beam, and two and three dimensional solid elements. Recovery methods, convergence and modeling techniques are studied. Applications to problems in static stress analysis and heat conduction.

MECH.5140 Finite Element Analysis of Composites (Formerly 22.514) - Credits: 3
MECH.5150 Structural Dynamic Modeling Techniques (Formerly 22.515) - Credits: 3


MECH.5160 Experimental Modal Analysis (Formerly 22.516) - Credits: 3

Prerequisite: 22.4xx/5xx Experimental Modal Analysis I (or permission of instructor) Review of system transfer and FRF matrices for development of a modal model. Review of DSP techniques for experimental modal analysis. Excitation techniques for the development of the system FRF matrix; SISO and MIMO techniques. Modal parameter estimation using time and frequency domain techniques. Advanced data manipulation for dynamic analysis. Introduction to structural dynamic modification and system modeling concepts. Models developed using MATLAB and commercially available software.

MECH.5170 Structural Dynamics (Formerly 22.517) - Credits: 3

Prerequisite: MECH.5150 Development of system equations of motion for mdof systems. Proportional and non-proportional
differential equations. The focus will be (a) iterative solution methods for linear and non-linear equations, (b) spatial discretization and meshing (c) finite difference methods (FDM), (d) finite volume methods (FVM), (e) finite element methods (FEM) and (f) boundary element methods (BEM). The theory behind each of these methods will be developed and discussed. Computer programming applications involving the solution of linear and non-linear PDEs in multiple dimensions will play a key role in this course. Unique computer programming assignments will be selected from different engineering/science fields (possibilities include: fluid flow, heat transfer, electrostatics, electromagnetism, structural analysis, medical, ocean engineering etc.) to illustrate the broad applicability of numerical methods. Students will be expected to complete programming assignments -- while most class examples will deal with pseudo code and/or matlab, a working knowledge of one of the following programming languages is recommended: Matlab, Octave, C, C++, fortran, Java, BASIC, or Python.

MECH.5180 Signal Proc Techniques (Formerly 22.518) - Credits: 3

The course covers analytical/numerical modeling and analysis of signals and systems. The course topics include: Fourier Series, Linear Systems and Transfer Functions, Laplace Transforms, Analog filters, Fourier Transforms, Analog to Digital Conversion (A/D & D/A), Quantization, Sampling and Nyquist Theorem, Aliasing, Discrete Fourier Transform (DFT), Windowing & Leakage, FFT & STFT, Spectrograms, Spectral Analysis and Estimation, Convolution, ARMA processes, Correlation, Coherence, Kurtosis, Multi-rate filters and the Wavelet Transform, FIR & IIR Filters, Adaptive Filters, Signal Processing Hardware and Implementation.

MECH.5190 Engineering Spectral Analysis (Formerly 22.519) - Credits: 3

Analytical and experimental background for the fundamental understanding of time and frequency domain signals, required for digital signal processing, vibration, and acoustic signal analysis. Introductory theory is based on simplified concepts form different mechanical signatures in the time domain. The spectral conversion from time domain to frequency domain is illustrated from a phenomenological perspective using examples and dynamic signal analyzer illustrations. The concepts of vibration and acoustic measurement methods are studied through practical projects and LabVIEW exercises. Students will be prepared for more advanced topics on dynamic systems, controls, vibrations, advanced signal processing, acoustics, and experimental structural dynamics. Familiarity with Matlab required.

MECH.5200 Numerical Methods for Partial Differential Equations (Formerly 22.520) - Credits: 3

Mathematical approaches for numerically solving partial differential equations. The focus will be (a) iterative solution methods for linear and non-linear equations, (b) spatial discretization and meshing (c) finite difference methods (FDM), (d) finite volume methods (FVM), (e) finite element methods (FEM) and (f) boundary element methods (BEM). The theory behind each of these methods will be developed and discussed. Computer programming applications involving the solution of linear and non-linear PDEs in multiple dimensions will play a key role in this course. Unique computer programming assignments will be selected from different engineering/science fields (possibilities include: fluid flow, heat transfer, electrostatics, electromagnetism, structural analysis, medical, ocean engineering etc.) to illustrate the broad

MECH.5210 Solar Fundamentals (Formerly 22.521) - Credits: 3

Utilization Terrestrial irradiation on tilted surfaces; radiation, conduction, convection in collectors; absorptance, emittance, reflection, transmittance of solar irradiation; energy flow in flat plate and concentrator collectors; storage; design tools; small project; web-based.

MECH.5230 Structural Health Monitoring (Formerly 22.523) - Credits: 3

Detail the entire process of structural health monitoring applications, including operational evaluation, data acquisition, normalization and cleansing, feature extraction and data compression, and statistical model development and pattern recognition. Aiming at detecting, localizing, and evaluating the damage severeness, topics that will be covered in this course include: sensors and sensor networks, signal processing and detection theory, nondestructive evaluation techniques, time and frequency modeling, damage prognosis, unsupervised/supervised learning, probability and statistics in feature evaluation. Case study of SHM activities will be conducted throughout the entire course, including mechanical, aerospace and civil structures.

MECH.5240 Fund of Acoustics (Formerly 22.524) - Credits: 3

Fundamentals of acoustics are introduced. Topics include: Motivation for studying acoustics, oscillatory motion, harmonic waves, the wave equation, sound pressure levels, decibel scale, frequency analysis, sound power, intensity, acoustic sources, directivity, sound radiation, sound power measurement, sound in enclosures, acoustic mode shapes, reverberation time, sound absorbing material, impedance, transmission loss, cavity resonators, reactive and dissipative mufflers, and applications to noise control.

MECH.5250 Grid-Connected Solar Electric Systems (Formerly 22.525) - Credits: 3

Students will study the concepts and design considerations of grid-connected, solar-powered, electrical generation systems, from residential through utility scale. Emphasis will be on practical applications that help make the student *work ready* at graduation. Grading consists of two tests during semester;
one individual project (residential scale PV system); and one group project (commercial-scale system). This course fulfills an elective requirement for renewable energy students.

MECH.5260 Transport Processes in Energy Systems (Formerly 22.526) - Credits: 3

Course focuses on the development of a fundamental understanding of transport processes from a multi-scale and multi-physics perspective, and the application of such understanding to the analysis of energy engineering systems. Derivations of the equations describing the mechanisms for mass, momentum, and energy transport are presented, together with approaches for the evaluation of material properties and constitutive relations. Emphasis is placed on a holistic view of transport processes as combinations of transient, advective, diffusive, and reactive phenomena.

MECH.5270 Solar Energy Engineering (Formerly 22.527) - Credits: 3

Systems engineering, stochastic modeling, design, and life-cycle cost analysis of several solar systems: photovoltaics, passive heating, solar cooling, and daylighting; Web Based.

MECH.5280 Photovoltaics Manufacturing (Formerly 22.528) - Credits: 3

Overview of the manufacturing processes used to make a typical crystalline solar cell. Detailed study of selected processes and manufacturing problems, such as solar cell testing, characterization, reliability issues, factors affecting yields, automated material handling, affect of impurities in crystal growth.

MECH.5290 Fuel Cell Fundamentals (Formerly 22.529) - Credits: 3

The primary objective of this course is to understand the fundamental science and engineering of fuel cells and redox flow batteries (i.e., reversible fuel cells). The fundamental principles of electrochemistry, thermodynamics, and kinetics of electrochemical reaction processes, as well as mass transport in electrochemical energy systems will be considered. Emphasis will be placed on operating principles and the design and diagnostics of the proton exchange membrane fuel cell as a portable energy conversion system, and the vanadium redox flow battery as a large-scale energy storage system. Cell components and their influence on the overall performance of these systems will be discussed in detail. An introduction to the cost analysis of electrochemical energy storage will be presented.

MECH.5300 Autonomous Robotic Systems (Formerly 22.530) - Credits: 3

This course covers concepts related to autonomous robotic systems, emphasizing the synthesis and design of control algorithms for autonomous robotic vehicles. Topics that will be covered in the course include: Linear and nonlinear systems analysis, stability in the sense of Lyapunov, linearization of nonlinear dynamic equations, rigid body equations of motion in three dimensions, dynamic model derivation of aerial, space, marine and ground vehicles, fundamentals of flight dynamics, feedback control design for autonomous robotic vehicles, guidance and navigation, description of components typically encountered to autonomous robotic vehicles, guidance and navigation, description of components typically encountered to autonomous robotic vehicles, cooperative control of multi-robot teams and state estimation.

MECH.5310 Math Methods In Mechanical Engineering (Formerly 22.531) - Credits: 3

MECH.5320 Off-Grid Solar Electric System (Formerly 22.532) - Credits: 3

This course examines the technical, financial and societal aspects of photovoltaic (PV) systems that are not connected to the electrical grid. Topics include: reasons for going off the grid, the components of an off-grid PV system, how to size a PV system to meet the required load, site impacts on performance, determining the loss of load probability (LOLP) for a system, hybrid systems, e.g. solar plus a generator, energy storage solutions, regulatory issues, and cost. Systems sized to meet the annual load requirements of a remote communication system, a net-zero home, and a small village will be examined. HOMERMicrogrid, PVWatts, and other software will be used to design these systems.

MECH.5340 Green Combustion and Biofuels (Formerly 22.534) - Credits: 3

Fundamentals of combustion and pollutant formations in application to internal combustion engines, turbines, and fire safety. Concepts include flame structure, flame speed, flammability, ignition, reaction kinetics, nonequilibrium processes, diffusion flames, and boundary layer combustion. Additional specific emphasis on combustion modeling, green approaches to energy production, and biofuels.

MECH.5420 Convective Heat/Mass Transfer (Formerly 22.542) - Credits: 3

MECH.5450 Advanced Industrial Heat and Mass Transfer (Formerly 22.545) - Credits: 3

This course specializes in obtaining practical solutions for applied and industrial heat transfer problems related to device development and production processes. Topics include review of heat transfer modes (i.e. conduction, convection and radiation), transport phenomena in material processing and manufacturing, analytical models and numerical simulations. Representative problems include curing of polymers, thermal conditioning of human body, food packaging and long-term food preservation, thermal management of electrical and electronic equipment, control of water vapor and pollutant transfer, material processing, and heat and mass exchangers.

MECH.5490 Cooling of Electronic Equipment (Formerly 22.549) - Credits: 3

This course focuses on teaching the primary techniques for cooling electronics, and methods for modeling their performance. Heat-transfer fundamentals: conduction, convection, radiation, phase change, and heat transfer across solid interfaces. Heat-generating electronic equipment: ICs, power converters, circuit cards and electrical connectors. Thermal management equipment: heat sinks, interface materials, heat spreaders including liquid loops, and air movers. System design: system packaging architectures, facilities, system analysis. Advanced Topics: spray cooling, refrigeration

MECH.5500 Vibrations (Formerly 22.550) - Credits: 3

This course provides the analytical background for the fundamental understanding of vibration analysis, modeling and testing of mechanical systems. The course starts with an overview of the concepts in vibrations and later builds an in-depth understanding of the vibrations of single degree of freedom and multi degree of freedom systems. Both free and forced vibrations of these systems under steady-state and transient mechanical excitations will be investigated. The important concepts of modal analysis and vibration measurement methods will be studied. The continuous system modeling, nonlinear and random vibrations will also be touched upon.

MECH.5530 MEMS & Microsystems (Formerly 22.553) - Credits: 3

The purpose of this course is to give a broad introduction to Micro-electro-mechanical Systems (MEMS) technology, and will provide graduate students in mechanical, electrical, manufacturing and related engineering disciplines with necessary fundamental knowledge and experience in the design, manufacture, and packaging of microsystems. The topics include basic sensing and actuating principles, modeling of electromechanical components, material properties, fabrication technologies, process integration, system design, and packaging of MEMS and microsystems. The course will also cover current literature, MEMS markets and applications. The course will be a combination of lectures, case studies and homework assignments. The students are expected to possess prerequisite knowledge in college mathematics, physics, and chemistry, as well as in engineering subjects such as fundamental materials science, electronics, thermal-fluid, and machine design.

MECH.5540 Dynamic Systems and Controls (Formerly 22.554) - Credits: 3

Matrix-based classical and modern techniques are applied to the dynamics of control systems. Design of controllers, and full and reduced-order observers. Introduction to optimal control and Kalman filters.

MECH.5570 Microsystem Design (Formerly 22.557) - Credits: 3

Design aspects of Microsystems (MEMS). Topics covered include working principles of various microsystems, analytical and numerical modelling, and case studies. Course incorporates lectures, computer laboratories and term project presentations.

MECH.5580 Aero/Wind Eng (Formerly 22.558) - Credits: 3

This course will introduce and examine classical and modern theoretical and computational two and three dimensional aerodynamics and aeroelastic modeling with applications in wind and subsonic aero/hydrodynamics applications. In addition, wind and meteorological science as well as simple FEM structural modeling and coupling concepts will be examined. The class will comprise scheduled lectures and discussions. Students will be expected to perform presentations and directed projects which involve computer programming.

MECH.5590 Multi-Scale Computational Fluid Dynamics I (Formerly 22.559) - Credits: 3

Derivation of governing equations; Scale analysis; Role of relative dimensionless parameters; Discretization of the governing equations; Finite-Difference, Finite-Volume, and/or Finite Element Techniques; Solutions of several problems in micro/meso/macro scale applications.

MECH.5600 Multi-Scale Computational Fluid Dynamics II (Formerly 22.560) - Credits: 3

Applications of CFD methods to the solution of multi-phase
problems such as: heat pipes, fuel cells, nanofluidics, material processing and manufacturing, etc.

MECH.5620 Solid Mechanics I (Formerly 22.562) - Credits: 3

Topics covered include the theory of stress, kinematics of strain, Hooke’s Law, work and energy, equations of stress equilibrium, Navier’s equations, strain compatibility, and the Beltrami-Michell equations. Problems for uniformly varying 3-D states of stress, torsion, and plane deformation are studied. Axisymmetric deformation is considered. Green’s function solutions for plane and axisymmetric problems are studied.

MECH.5630 Dynamic Behavior on Materials - Credits: 3

The time-dependent material behavior and stress-wave propagation in solids. Topics will be selected from applied mechanics and materials science, e.g. mathematical and physical description of one dimensional and three dimensional waves in solids, strain rate-dependent behavior of materials, viscoelasticity of materials and its time-and frequency-domain descriptions including relaxation and creep, introduction to shock waves, introduction to experimental techniques for material characterization in dynamic environment such as ultrasonic testing, split Hopkinson bar technique, dynamic mechanical analysis, and drop tower and impact experiments.

MECH.5690 Fracture Mechanics (Formerly 22.569) - Credits: 3

The application of fracture mechanics and approaches for exploring the impact of cracks on engineering structures. Topics will be chosen from a range of mathematical techniques, applied mechanics, and materials science, e.g. theoretical strength, stress concentration, linear and nonlinear fracture mechanics, stress singularity, fracture modes, energy methods, stable and unstable crack growth thermal cracks, crack tip plastic zone, Dugdale and Irwin models, the R-curve, power-law materials, and the J-integral. Students should have a good understanding of the principles of strengths of materials and be able to apply these principles to the solution of problems in solid mechanics. The associated knowledge in complex variables and partial differential equations will be reviewed as needed.

MECH.5710 Quality Engineering (Formerly 22.571) - Credits: 3

Focuses on methodologies used by world class companies to guide the design and development of high quality, low cost products in the most timely manner through the use of analytical tools in case studies: Topics include: new product creation strategy and process, organizational aspects of multidisciplinary design teams, concurrent project management, and structural methodologies for identifying customer requirements and manufacturing process design, control and selection. In particular, focus is on the interrelationship of CE, manufacturing and Quality tools and methodologies and how they contribute in determining the appropriate level of product/process quality and design efficiency.

MECH.5740 Design For Reliability Engineering (Formerly 22.574) - Credits: 3

(3-0)3 Design for Reliability Engineering provides a systematic approach to the design process that is focused on reliability and the physics of failure. It provides the requirements on how, why, and when to use the wide variety of reliability engineering tools available in order to achieve the reliability goals of the total design cycle. Topics include the product design cycle and customer requirements, analytical physics, reliability statistics, accelerated testing, accelerated reliability growth, industry standard predictive models, design reliability assessment, reliability FMEA, product risk evaluation and thermodynamic reliability.

MECH.5750 Industrial Design of Experiment (Formerly 22.575) - Credits: 3

Concepts of Robust Design and statistical Design Of Experiments (DOE) as applied to the design and manufacturing of new high technology products. Classical and current methodologies of DOE including Full Factorial, Fractional Factorial, Taguchi, Central Composite and Yates Algorithms. The course will also provide for different methods for experimental design and analysis, including average and variability analysis. Commercial software packages and case studies using industrial experiments will be used to illustrate the material.

MECH.5760 Engineering Project Management (Formerly 22.576) - Credits: 3

Skills are developed enabling engineers to be effective decision makers and technical leaders in an environment where technology management, business operations and strategies for contract compliance are critical to achieving competitive advantage. Elements of the Project Planning and Control System are presented along with analytical methods important for maintaining Projects on schedule and within budget.

MECH.5790 Robotics (Formerly 22.579) - Credits: 3

Common robotics joints and robotics classification. Planes of motion and fold lines. Robotics capability. Forward and inverse kinematics and the RobSim software package. Trajectory planning and elementary obstacle avoidance.
Robotics dynamics and feasible trajectory evaluation. Design of the control system for the non-linear robotics problem. Classroom studies are followed by hands-on applications in the Automated Manufacturing Assembly and Robotics Laboratory.

MECH.5800 Adv Grad Res Dev Proj (Formerly 22.580) - Credits: 3

MECH.5810 Advanced Fluid Mechanics (Formerly 22.581) - Credits: 3

Fundamental equations of fluid motion, kinematics, vorticity, circulation, Crocco’s theorem, Kelvin’s theorem, Helmholtz’s velocity laws, secondary flows. Stream function, velocity potential, potential flows. Unsteady Bernoulli equation, gravity water waves.

MECH.5830 Advanced Aerodynamics (Formerly 22.583) - Credits: 3


MECH.5840 Ocean Engineering (Formerly 22.584) - Credits: 3

Physical Properties of the Ocean Environment, ocean wave mechanics, computer solutions of wave interactions, physical modeling of marine vehicles and coastal environments (modeling and scaling laws), resistance and propulsion of surface ships and submarines, and forces on floating and submerged objects such as buoys, pipelines, piers, and breakwaters. Research report required summarizing some aspect of ocean engineering.

MECH.5890 Finite Element in Thermofluids (Formerly 22.589) - Credits: 3

The Galerkin finite element technique is first applied to a simple one-dimensional steady state convection/conduction equation. The element equations are derived and the assembly process is described. These concepts are then extended to two-dimensional transient problems. A finite element package is used to solve a variety of fluid flow problems. All course materials are available on the WWW.

MECH.5910 Mechanical Behavior of Materials (Formerly 22.591) - Credits: 3

Quantification of structure-property relationships requires application of solid mechanics concepts to materials microstructure. Using micromechanics approach, the course focuses on the deformation and fracture behavior of metals, ceramics, composites and polymeric. Topics include: elastic behavior, dislocations, crystal plasticity, strengthening mechanisms, composite materials, glassy materials, creep and creep fracture, tensile fracture, and fatigue.

MECH.5930 Graduate Co-op Education (Formerly 22.593) - Credits: 0

The prediction, analysis, and prevention of failure in mechanical design is covered. Failure mechanisms such as creep, plastic deformation, crack propagation, cyclic fatigue, thermal fatigue, fretting and galling are considered. Theories of failure such as Colomb-Mohr, Beltrami, and Huber-Von Mises are used to predict failure. Cumulative damage theories such as those of Gatts, Corten and Dolan, Marin, and Manson will be studied. Statistical methods of analysis and test data interpretation are studied. Materials such as steels, aluminum alloys, solders, plastics, and composites will be considered.

MECH.5950 Graduate Co-op II (Formerly 22.595) - Credits: 0

MECH.5960 Mechanics of Composite Materials (Formerly 22.596) - Credits: 3

Analysis of anisotropic lamina and laminated composites. Methods of fabrication and testing of composites. Other topics include environmental effects, joining and machining.

MECH.5970 Processing of Composites (Formerly 22.597) - Credits: 3

Methods of fabrication. Analysis of forming, fiber orientation, permeability, polymer rheology, flow through porous media, consolidation, cure kinetics, combined flow and cure models. Effect of manufacturing defects

MECH.6020 Special Topic: Thermo-Fluids (Formerly 22.602) - Credits: 3

Study of advanced topics in thermo-fluid energy systems and processes not covered in the regular curriculum. Contents may vary from year to year.

MECH.6030 Special Topic: Vibration Dynamics (Formerly 22.603) - Credits: 3
Study of advanced topics in vibrations/dynamics not covered in the regular curriculum. Contents may vary from year to year.

MECH.6110 Matrix Methods for Structural Dynamics  
(Formerly 22.611) - Credits: 3

3-0-3 Prerequisite: 22.515 Matrix linear algebra. Solution of algebraic equations using Gaussian elimination and decomposition variants. Eigenanalysis using various direct similarity techniques and simultaneous vector iteration methods. Algorithm development of solution techniques. Solution techniques for structural mechanics, dynamic systems and stability. Models developed using MATLAB.

MECH.6140 Advanced Finite Element Methods  
(Formerly 22.614) - Credits: 3

Nonlinear finite element methods as applied to large deformation and nonlinear material behavior are the focus of this course. Various classical and contemporary constitutive models and their implementation in the finite element method are considered. Procedures for determining material parameters from a matrix of material test results are investigated.

MECH.6220 Family Violence (Formerly 22.622) - Credits: 3
MECH.6500 Nano. Transport Phen. for Manufacturing Nanodevice (Formerly 22.650) - Credits: 3

This course on nanoscale transport phenomena constitutes a bridge between existing fluid and heat transfer courses in multiple disciplines and emerging nanoscale science and engineering concepts to reflect the forefront of nanomanufacturing. The course is designed to incorporate recent advances in manufacturing polymer-based nanodevices. Key issues of the implementation and maintenance costs for fabrication will be addressed. Hands-on laboratory experiments will be performed to complement the lectures with the ultimate goal of designing and building a complete nanodevice at the end of the course. The course will prepare graduates for employment focused on designing and manufacturing nano/microfluidic systems, lab-on-a-chip devices, electronics devices, medical devices, and other emerging.

MECH.7410 Master's Thesis - Mechanical Engineering (Formerly 22.741) - Credits: 1
MECH.7420 Master's Thesis - Mechanical Engineering (Formerly 22.742) - Credits: 2
MECH.7430 Master's Thesis - ME (Formerly 22.743) - Credits: 3

MECH.7460 Master's Thesis - ME (Formerly 22.746) - Credits: 6

MECH.7490 Master's Thesis - Mechanical Engineering (Formerly 22.749) - Credits: 9

MECH.7510 Adv Projects In Mechanical Engineering (Formerly 22.751) - Credits: 1-3
MECH.7530 Doctoral Dissertation/Mechanical Engineering (Formerly 22.753) - Credits: 1-3

MECH.7560 Doctoral Dissertation/Mechanical Engineering (Formerly 22.756) - Credits: 6

MECH.7590 Doctoral Dissertation/Mechanical Engineering (Formerly 22.759) - Credits: 9

A masters and doctoral students who have attained the required number of thesis credits may enroll in:

MECH.7610 Continued Grad Research (Formerly 22.761) - Credits: 1

Continued Grad Research

MECH.7630 Continued Graduate Research (Formerly 22.763) - Credits: 3

Continuing Graduate Research

MECH.7660 Continued Graduate Research (Formerly 22.766) - Credits: 6

Continuing Graduate Research

MECH.7690 Continued Graduate Research (Formerly 22.769) - Credits: 9
Continuing Graduate Research

MECH.7710 Systems Analysis I (Formerly 22.771) -
Credits: 3
Study of the key areas in multiple engineering disciplines including Mechanical, Electrical, Software, Systems and Optical. Students are introduced to weekly topics and then work in multidiscipline teams to solve technical assignments. Topics covered include: Concept of Operations and Requirements development, integration, test and verification, vibration/shock analysis, thermal analysis, power supply design, digital electronics & FPGA, intro to optical engineering, SCRUM planning, continuous integration and UML/SW design. Content may vary year to year. This course is part of the Engineering Leadership Development Program (ELDP) and team taught by industry experts at BAE Systems.

MECH.7720 Systems Analysis II (Formerly 22.772) -
Credits: 3
Introduction and analysis of complex systems aligned with the key product lines of BAE Systems. Students are introduced to multiple types of systems and then work in multidiscipline teams to solve technical assignments. The systems covered include but are limited to: Electronic Warfare (EW), Communications Electronic Attack (Comms EA), Wide Area Airborne Surveillance (WAAS), Signal Intelligence (SIGINT), RADAR Navigation, Radio Communications, and Infrared Countermeasures (IRCM). Content may vary year to year. This course is part of the Engineering Leadership Development Program (ELDP) and team taught by industry experts at BAE Systems.

MECH.7730 Systems Analysis III (Formerly 22.773) -
Credits: 3
Study of project management concepts, product development methods, transition to operations and new business capture. Topics covered include but are not limited to risks and opportunities management, earned value management, lean product development, business strategy, design for manufacturability/maintainability (DFM^2), and request for information (RFI) response. Content may vary year to year. This course is part of the Engineering Leadership Development Program (ELDP) and team taught by industry experts at BAE Systems.
Plastics Engineering

Department of Plastics Engineering

The UMass Lowell Department of Plastics Engineering offers the following Graduate Programs:

- **Doctor of Philosophy (Ph.D.)**
  Plastics Engineering Option

- **Doctor Engineering (D.Eng.)**
  Plastics Engineering Option

- **Polymer Science/Plastics Engineering Option**
  (http://www.uml.edu/Catalog/Graduate/Sciences/Chemistry/Doctoral-Program.aspx) (This joint program is offered through the Chemistry Department. It is a good fit for students interested in polymer synthesis and polymer characterization.)

- **Master of Science in Engineering (M.S.E.)**

- **Graduate Certificates:**
  Commercial Development for Plastics Engineers
  Elastomeric Materials
  Integrated Engineering Systems [Interdisciplinary]
  Medical Plastics Design and Manufacturing
  Nanotechnology [Interdisciplinary]
  Plastics Design
  Plastics Engineering Fundamentals
  Plastics Materials
  Plastics Processing

- **Bachelor’s-Master’s (BS/MS) Program**
  (https://www.uml.edu/catalog-AY16/pdf/Undergraduate.pdf)

**About the Plastics Engineering Department**

The Plastics Engineering Department at UMass Lowell is an internationally recognized leader in plastics engineering research and education. Founded in 1954 as the first of its kind, it continues to offer the only accredited Plastics Engineering program in the U.S. Over 3,000 graduates are working in leadership positions in the plastics industry worldwide. The department offers a number of degree programs in Plastics Engineering, ranging from a Bachelor of Science (B.S.) to a Doctor of Philosophy (Ph.D.), as well as a number of other options, in order to fit a wide variety of career goals.

The department is staffed by 20 full-time faculty who conduct research in areas as diverse as nanomanufacturing and green polymeric materials. Close faculty connections to industry ensure that students develop an understanding of current issues in the field, while working relationships with other departments emphasize the increasingly interdisciplinary nature of modern scientific research. The Plastics Engineering Department at UMass Lowell maintains 20,000 square feet of dedicated laboratory space where students have an opportunity to work with and conduct research using the latest manufacturing, design, materials formulation and testing technologies.

The Plastics Engineering Department at UMass Lowell - over 50 years of academic and research excellence!

**Master's Program - Thesis and Non-thesis Options**

**Master of Science in Engineering Degree Programs (MS Eng)**

The Department of Plastics Engineering has recently restructured its MSE Degree Program. Plastics Engineering MSE graduate students accepted into the program beginning in the Fall of 2005 must follow either the "Thesis Option" Curriculum or the "Non-thesis Option" Curriculum described in the following sections.

Graduate students enrolled in the Thesis Option MSE Program prior to the Fall of 2005 may elect to follow either the new "thesis" or "non-thesis" program requirements described below, or those in effect at the time they were accepted into the degree program. Most MSE Plastics Engineering students opt for the 30 credit hour thesis option MSE degree program. The 33 credit hour non-thesis MSE degree program is intended for part time graduate students working full time jobs as practicing engineers.

**Thesis Option**

- Admission Requirements and Prerequisites
- Graduate Student Advising

**Non-thesis Option**

- Admission Requirements and Prerequisites
- Graduate Student Advising

**Thesis Option**

This graduate program offers professional training at the master’s level designed to provide the opportunity for the study of more advanced theory and practice in plastics materials, design and processing. The department also offers graduate training in the areas of rubber and elastomer technology and medical plastics. The graduate programs are also designed to broaden the background of experienced members of the profession to help them keep up with the latest fundamental developments in these fields.

The Department of Plastics Engineering offers a Master of Science in Engineering (M.S.E.) in Plastics Engineering. More
than 800 graduate students have received Plastics Engineering degrees since the graduate program was established in 1968. Most M.S.E. Plastics Engineering students opt to enroll in the 30 credit hour research oriented thesis option M.S.E. program. A smaller percentage elect to enroll in the 33 credit hour non-thesis M.S.E option. Students who have enrolled in the thesis option Plastics Engineering M.S.E. program must complete at least 24 course credits and 6 thesis credits as outlined in the program requirements section below. Students may transfer as many as 12 science or engineering graduate course credits from other universities or from courses completed when in non-degree status at UMass Lowell provided they are approved by the Plastics Engineering Department’s M.S.E. program coordinators. (For University regulations regarding transfer credit and other regulations, see Graduate Policies in the on-line catalog.) The thesis option M.S.E. degree will be awarded upon the satisfactory completion of 30 credit hours of study as outlined below.

Graduate students enrolled in the Thesis Option M.S.E. Program prior to the Fall of 2005 may elect to follow the either the new program requirements (thesis or non-thesis program) described below, or those in effect at the time they were accepted into the degree program. The new thesis option M.S.E. program requirements are:

Requirement 1 Complete the cluster of "core course" requirements as described in the detailed program description that follows.

The following courses (9 credit hours) are required for all students:

- PLAS.5440 Advanced Plastics Materials 3 credits
- PLAS.5780 Advanced Plastics Processing 3 credits
- PLAS.xxxx Current Topics Plastics Seminars (1) 1 credit
- PLAS.5740 Physical Properties Laboratory 1 credit
- PLAS.5720 Plastics Processing Laboratory 1 credit

Total 9 credits

Special notes for students having a Plastics Engineering B.S. Degree:

Students who have a B.S. Degree in Plastics Engineering from UMass Lowell are not required to take the Physical Properties Lab (PLAS.5740) and Plastics Processing Lab (PLAS.5720). However, these students must still meet the 24 course credit hour program requirement by substituting other Plastics Engineering Graduate Courses.

Requirement 2 Complete the course requirements for one or more of the department’s graduate “Certificates” as an "area of specialization." Some of the certificate course requirements may also be core requirements. The course requirements for each graduate certificate are also outlined below.

[Note: The Graduate Certificate in Plastics Engineering Fundamentals does not satisfy Requirement 2 for the thesis option M.S.E. Plastics Engineering Program.]

(a.) Graduate Certificate in "Plastics Design"

Required Courses:

- PLAS.5030 Mechanical Behavior of Polymers
- PLAS.5180 Plastics Product Design

Elective Courses (any two of the following):

- PLAS.5060 Polymer Structure, Properties, and Applications
- PLAS.5230 Screw Design Principles
- PLAS.5410 Computer Applications in Plastics
- PLAS.5490 Design with Elastomers
- PLAS.5510 Computer Aided Extrusion Die Design
- PLAS.5520 Design of Polymer Processing Machinery
- PLAS.5760 Advanced Mold Design
- PLAS.5850 Computer Aided Engineering and Design I
- PLAS.5860 Computer Aided Engineering and Design II

(b.) Graduate Certificate in "Plastics Materials"

Required Courses:

- PLAS.5440 Advanced Plastics Materials
- PLAS.5060 Polymer Structure, Properties, and Applications

Elective Courses (any two of the following):

- PLAS.5050 Polymer Structure II
- PLAS.5110 Polymer Blends and Multiphase Systems
- PLAS.5120 Porous Polymers
- PLAS.5130 New Plastics Materials
- PLAS.5400 Commercial Development of Polymeric Systems
- PLAS.5530 Polymers in Medicine I
PLAS.5590 Elements of Packaging
PLAS.5650 Engineering Thermosetting Resins
PLAS.5660 Polymeric Material Systems Selection
PLAS.5800 Polymer Science I
PLAS.5960 Plastics, Elastomers and Additives from Renewable Resources

(c.) Graduate Certificate in "Plastics Processing"

Required Courses:
- PLAS.5780 Advanced Plastics Process Engineering
- PLAS.5090 Plastics Processing Theory I

Elective Courses (any two of the following):
- PLAS.5060 Polymer Structure, Properties, and Applications
- PLAS.5100 Plastics Processing Theory II
- PLAS.5180 Plastics Product Design
- PLAS.5210 Lean Plastics Manufacturing
- PLAS.5230 Screw Design Principles
- PLAS.5240 Process Analysis, Instrumentation, and Control
- PLAS.5260 Nanoscale Plastics Processing
- PLAS.5500 Processing with Elastomers
- PLAS.5510 Computer Aided Extrusion Die Design
- PLAS.5520 Design of Polymer Processing Machinery
- PLAS.5850 Computer Aided Engineering and Design I
- PLAS.5880 Injection Molding

(d.) Graduate Certificate in "Medical Plastics Design and Manufacturing"

Required Courses:
- PLAS.5530 Polymers in Medicine I
- PLAS.5750 Biomaterials

Elective Courses (any two of the following):
- PLAS.5540 Polymers in Medicine II
- PLAS.5790 Problems in Biomaterials - Directed Study
- PLAS.6750 Biomaterials II
- CHEN.5550 Biopharmaceutical GMP and Licensing

* Offered by the Chemical Engineering Department
- BMBT.5000 Introduction to Biomedical Engineering
- Biotechnology **
** Offered by the Biomedical Engineering Department

(e.) Graduate Certificate in "Elastomeric Materials"

Required Courses:
- PLAS.5350 Rubber Technology
- PLAS.5950 Thermoplastic Elastomers

Elective Courses (any two of the following):
- PLAS.5490 Design with Elastomers
- PLAS.5500 Processing with Elastomers
- PLAS.5060 Polymer Structure, Properties, and Applications
- PLAS.5960 Plastics, Elastomers and Additives from Renewable Resources

Requirement 3 Complete the requirements for an additional number of Elective Plastics Engineering Graduate Courses such that the "total" course credit hours is at least 24 credit hours (not counting thesis credits).

Core Courses + Non-Core Certificate Courses + Electives Courses = 24 Credits.

Up to two elective courses from other engineering departments may be substituted for Plastics Engineering courses if approved by the graduate coordinator.

Requirement 4 Complete the mandatory 6 Credit Hour Thesis requirement. The thesis research is conducted under the supervision of a three member advisory committee (see "Thesis Committee" below). Upon completion of the thesis research work, the student must prepare the written thesis manuscript and defend the work in an oral presentation such that all three committee members approve of the work.

Thesis Committee

As soon as a student has chosen an area of research, a Thesis Committee is selected by the student and his or her research advisor in accordance with the policy of the department. The Thesis Committee shall consist of at least three members, at least two of whom shall be from the student’s major department. One member of the committee shall be the student’s thesis advisor. An outside expert, such as the supervisor of a research project conducted at an industrial setting or a faculty member from another institution, may be a member of the committee, but that individual must possess
academic credentials which would qualify him or her to serve as a member of the University of Massachusetts Lowell faculty.

24 Course Credit Hours + 6 Thesis Credits = 30 Credit Hours Total

(Requirements 1, 2, 3) (Requirement 4)

The M.S.E. degree, and the appropriate Graduate Certificate (the area of specialization), will be awarded upon satisfactory completion of 30 credit hours of study as outlined. More detailed descriptions of the "Thesis Option" requirements are given below.

Admission Requirements and Prerequisites:

Admission to the program is open to candidates with a B.S. in Plastics Engineering or a related engineering or science field. The pre-requisite math requirements include Calculus II and Differential Equations. Applicants must also take the Graduate Record Examination (GRE), provide three Letters of Reference, an Official Transcript, and a Statement of Purpose as per the UMass Lowell Graduate Admissions Policy. You can apply online at www.uml.edu/grad. (https://www.uml.edu/Grad/default.aspx)

The foundation "Plastics" courses required in previous years are no longer required. Students who have taken these foundation graduate courses in the past can receive some graduate course credit for these courses as outlined above.

The Plastics Engineering Department makes every attempt to offer as many of these courses as possible during the evening so that students having full time jobs can complete the degree program. A listing of evening graduate courses for the next few semesters is given on http://plastics.uml.edu. (https://www.uml.edu/Engineering/Plastics/default.aspx)

Non-matriculated students (with an appropriate B.S. Degree) may begin taking courses without application to the M.S.E. Plastics Engineering Program. However, some students, especially those students working full time days elect to enroll in the non-thesis M.S.E. option. This option was established in the Fall of 2004. Students enrolled in the non-thesis M.S. Plastics Engineering option must complete a total of 33 course credits as outlined in the course requirements section below. Students may transfer as many as 12 science or engineering graduate course credits from other universities or from courses completed when in non-degree status at UMass Lowell provided they are approved by the Plastics Engineering Department’s M.S.E. program coordinators. (For University regulations regarding transfer credit and other regulations, see the Graduate Policies in the online catalog.)

Non-thesis Option

This graduate program offers professional training at the master's level designed to provide the opportunity for the study of more advanced theory and practice in plastics materials, design and processing. The department also offers graduate training in the areas of rubber and elastomer technology and medical plastics. The graduate programs are also designed to broaden the background of experienced members of the profession to help them keep up with the latest fundamental developments in these fields.

The Department of Plastics Engineering offers a Master of Science in Engineering (M.S.E.) in Plastics Engineering. Most M.S.E. Plastics Engineering students enroll in the thesis option program. However, some students, especially those students working full time days elect to enroll in the non-thesis M.S.E. option. This option was established in the Fall of 2004. Students enrolled in the non-thesis M.S. Plastics Engineering option must complete a total of 33 course credits as outlined in the course requirements section below. Students may transfer as many as 12 science or engineering graduate course credits from other universities or from courses completed when in non-degree status at UMass Lowell provided they are approved by the Plastics Engineering Department’s M.S.E. program coordinators. (For University regulations regarding transfer credit and other regulations, see the Graduate Policies in the online catalog.)

Requirement 1 Complete the "core course" requirements listed below.

The following courses (18 credit hours) are required for all students.

- PLAS.5030 - Mechanical Behavior of Polymers 3 credits
- PLAS.5440 - Advanced Plastics Materials 3 credits
- PLAS.5780 - Advanced Plastics Processing 3 credits
- PLAS.5060 - Polymer Structure Properties and Applications 3 credits
- PLAS.5180 - Plastics Product Design 3 credits
- PLAS.xxxx - Current Topics Plastics Seminars (Materials, Design, etc.) 1 credit

The completion of the thesis requirement. Once an advisor is selected, the student and advisor should complete the Departmental Advising Form, indicating the thesis topic. Both the student and advisor must sign this form before the student can register for thesis credits. This form is available in the Plastics Engineering Department Office (B204) and should be submitted to the graduate program coordinator.

Graduate Student Advising:

One of the graduate coordinators will be the academic advisor for students enrolled in the non-thesis M.S.E. Plastics Engineering Degree Program. The advisor will help the student remedy deficiencies in prerequisites, select electives of most value, and plan the overall study program efficiently. The thesis advisor will be the chairperson of the thesis advisory committee that will guide the student in the thesis research and supervise
The M.S.E. degree, and the appropriate Graduate Certificate (the area of specialization), will be awarded upon satisfactory completion of 33 credit hours of study as specified above. This non-thesis M.S.E. degree is an alternative to the more traditional 30 credit thesis option M.S.E degree.

**Admission Requirements and Prerequisites:**

Admission to the program is open to candidates with a B.S. in Plastics Engineering or a related engineering or science field. The pre-requisite math requirements include Calculus II and Differential Equations. Applicants must also take the Graduate Record Examination (GRE), provide three Letters of Reference, an Official Transcript, and a Statement of Purpose as per the UMass Lowell Graduate Admissions Policy. The GRE Requirement is waived for any student who has completed any one of the Plastics Engineering Graduate Certificates and have maintained a 3.5 GPA for this certificate. You can apply online at www.uml.edu/grad. (https://www.uml.edu/Grad/default.aspx)

The foundation "Plastics" courses required in previous years are no longer required. Students who have taken these foundation graduate courses in the past can receive some graduate course credit for these courses as outlined above.

The Plastics Engineering Department makes every attempt to offer as many of these courses as possible during the evening so that students having full time jobs can complete the degree program. Return to the home page for a listing of evening graduate courses for the next few semesters.

Non-matriculated students (with an appropriate B.S. Degree) may begin taking courses without application to the M.S.E. Plastics Engineering Program. However, it is recommended that students apply to the M.S.E. Program as soon as possible (i.e. prior to taking too many course credits) since there is no guarantee of acceptance into the M.S.E. Program. In addition, no more than 12 credit hours taken as a non-matriculated student can be transferred into the M.S.E. Program upon acceptance.

**Graduate Student Advising:**

One of the graduate coordinators will be the academic advisor for students enrolled in the non-thesis M.S.E. Plastics Engineering Degree Program. The advisor will help the student remedy deficiencies in prerequisites, select electives of most value, and plan the overall study program efficiently.

**Full Time vs. Part Time Status**

Both the Thesis and Non-thesis Option M.S.E. Plastics Engineering Programs are open to full time and part time students. Many of the courses required for these programs are offered at night so that engineers working at local companies can take advantage of the programs. Students taking fewer than 9 credits in a semester are considered part time, while those taking 9 or more credits are considered full time students. Graduate students must maintain full time student status in order to be eligible for teaching assistant (T.A.) or research assistant positions (R.A.).
Funding Policy - Plastics Engineering Graduate Students

Teaching Assistant Positions:

The Department of Plastics Engineering has a limited number of "Teaching Assistant Positions" (T.A.) and "Research Assistant" Positions (R.A.) available for full-time Masters and Doctoral Plastics Engineering Graduate Students. Only those students who have applied and have been accepted into the respective programs will be considered for such a position.

Most of the T.A. positions awarded by the department are "half" T.A. positions which provide a 9 credit tuition waiver and 9 credit fee waiver for in-state students, along with a stipend. Out-of-state students receive the 9 credit tuition waiver, a fee reduction and a stipend. A departmental committee selects the T.A.'s during the spring semester for the following September. It is recommended that interested candidates should visit the campus and meet with a Graduate Coordinator prior to June 1. T.A. applications are available in Ball 204 or at http://plastics.uml.edu. (https://www.uml.edu/Engineering/Plastics/default.aspx)

Research Assistant Positions:

Unlike T.A. positions that are awarded by the Plastics Engineering Department, R.A. positions, either "full time" or "half time", are awarded by individual faculty who conduct funded research. Accepted students must correspond with the individual faculty to inquire about R.A. positions. Faculty research interests are listed in the Faculty section of the department web site. It is recommended that applicants interested in obtaining R.A. funding should send a letter and resume to those faculty having similar research interests.

Many of the full time graduate students enrolled in the Department of Plastics Engineering do not receive T.A. or R.A. funding, especially during their first year of study. Many students are able to arrange funding during their second year after completing much of their coursework and after having time to interact with the various faculty members; however, there is no guarantee of funding.

- Bachelor’s-Master’s Program
  (https://www.uml.edu/catalog-AY16/pdf/Undergraduate.pdf)

Doctoral Programs

Doctoral Programs in Plastics Engineering

The UMass Lowell Department of Plastics Engineering offers two doctoral degree options:

- Doctor of Engineering (D.Eng.) Plastics Engineering

Option

- Doctor of Philosophy (Ph.D.) Plastics Engineering Option

In addition the Plastics Engineering Department has a joint program with the Chemistry Department. It offers a joint Polymer Science/Plastics Engineering Ph.D. degree. The degree is awarded by the Chemistry Department, not the Department of Plastics Engineering. This degree option is a good fit for students interested in polymer synthesis and polymer characterization.

Plastics Engineering Doctoral Programs

The two Doctoral Plastics Engineering programs have equivalent admission requirements and differ primarily in their course requirements.

Ph.D. in Engineering, Plastics Engineering Option

The Ph.D. degree program is designed to produce qualified professionals for technical and research positions in the plastics industry, for technical positions in government, and for teaching careers in colleges and universities. This degree is awarded by the College of Engineering. The goal of the Ph.D. program is to develop decision-making engineers with sound theoretical and technical research knowledge in the areas of plastics materials, design, and processing research and development.

The Doctor of Engineering in Plastics Engineering

The D.Eng. Plastics Engineering degree program is designed to produce qualified professionals for technical and management positions in the plastics industry, as well as for technical or administrative positions in government and for teaching careers in colleges and universities. The goal of the Doctor of Engineering program is to develop decision-making engineers with sound theoretical and technical research knowledge who are design and development oriented and who also have a firm background in engineering management. This degree has a management component that is not required for the Ph.D., with fewer technical courses. This interdisciplinary program encompasses study in materials, design, processing, mathematics, computer science, and management.

Admission Requirements

Graduates with a B.S. in Engineering (e.g. Plastics, Mechanical, Chemical, Materials,…) and high academic standing may apply for admission to either of the doctoral programs. Technical graduates who do not have a B.S. in “Engineering” but have a science degree may request admission to the program with the understanding that they will also be required to take and pass the “Fundamentals of Engineering Exam” given by the National Council of Examiners for Engineering and Surveying. Admission to the program will be based on review by the Graduate Admissions Office and by the Admissions Committee of the Plastics Engineering Department.
Plan of the Doctoral Programs

Each student entering the program must develop a plan of study in consultation with his or her advisory committee. After taking at least one year of graduate courses, the student will take a qualifying examination covering all the basic elements of plastics engineering. A student who performs well on this examination will be reviewed by the Admissions Committee of the Plastics Engineering Department and admitted to degree candidacy. He or she will then complete the remaining course work, seminars and labs, do a research proposal, conduct research and prepare a written dissertation, and present an oral defense of the research before the dissertation committee.

Qualifying Examination

The qualifying examination for both doctoral programs will be administered in September (and in January if there is sufficient demand for a second exam). It will be administered as two (2) four hour long examinations, covering the following topics: plastics processing, plastics design, plastics properties, and plastics materials with a total of four questions in each subject area for a total of 16 questions. One of the two exams is open book and one is closed book. In order to pass the exams, students must pass at least two of the four questions in each subject area, and pass at least eleven questions. Any changes to the format will be indicated by the doctoral coordinator when the specific examination date is announced. The student will receive an overall exam grade of pass or fail based on the stated criteria. A student who fails the exam on a marginal basis may make a second attempt the next time the exam is administered. All decisions of the Plastics Engineering Department regarding passing of the qualifying exam are final.

Dissertation Proposal

Once the student has passed the qualifying exam, he or she will submit a dissertation proposal and defend the proposal before the Doctoral Committee. Upon approval, the student’s name will be submitted to the College Doctoral Committee and the Registrar’s Office as a candidate for the Doctor of Engineering or the Doctor of Philosophy degree.

Transfer Credit

Up to 24 credits in graduate engineering courses are transferable to either the Doctor of Engineering or Doctor of Philosophy programs upon approval by the department’s Doctoral Committee.

Course Requirements for the D.Eng. Plastics Engineering Degree

The following courses are required for the D.Eng. degree:

- PLAS.5440 Advanced Plastics Materials (3 credits)
- PLAS.5780 Advanced Plastics Processing (3 credits)
- PLAS.5740 Physical Properties Laboratory (1 credit)
- PLAS.5720 Plastics Processing Laboratory (1 credit)
- PLAS.5030 Mechanical Behavior of Polymers (3 credits)
- PLAS.5060 Polymer Structure, Properties and Applications (3 credits)
- PLAS.5090 Plastics Processing Theory I (3 credits)
- PLAS.5180 Plastics Product Design (3 credits)
- PLAS.5480 Numerical and Analytical Methods (3 credits)
- PLAS.5850 Computer Aided Engineering and Design (3 credits)
- PLAS.XXXX Current Topics Plastics Seminar (1 credit)
- PLAS.XXXX Engineering Elective (3 credits)
- PLAS.XXXX Engineering Elective (3 credits)
- Engineering Management Courses (9 credits)
- Doctoral Research Dissertation (21 credits)

TOTAL: 63 credits

Engineering Management Courses for the D.Eng. Program

Doctor of Engineering students are required to take 9 credits of graduate engineering management courses from the College of Management or from the list of courses immediately below offered within the College of Engineering.

- PLAS.5070 Plastics Industry Organization (3 credits)
- PLAS.5160 Six Sigma (3 credits)
- PLAS.5210 Lean Plastics Manufacturing (3 credits)
- PLAS.5370 Business Law for Engineers (3 credits)
- PLAS.5400 Commercial Development of Polymeric Systems (3 credits)
- PLAS.5900 Survey of Intellectual Property (3 credits)
- MECH.5760 Engineering Project Management (3 credits)
- ACCT.5010 Financial Accounting (2 credits)
- FINA.5010 Business Finance (2 credits)
- MKTG.5010 Marketing Fundamentals (2 credits)
- POMS.5010 Operations Fundamentals (2 credits)
- MGMT.5010 Organizational Behavior (2 credits)
- MGMT.5110 Global Enterprise & Competition (2 credits)
Course Requirements for the Ph.D. in Engineering, Plastics Engineering Option

(A) Students with a B.S. Plastics Engineering, Plastics Engineering degree from UMass Lowell will be required to take a placement test on the following subjects:

- PLAS.5440 Advanced Plastics Materials
- PLAS.5780 Advanced Plastics Processing

If they failed in the test or do not take the test, they will be required to take these courses and can be counted as electives. Students with UMass Lowell undergraduate GPA higher than 3.0 can waive the above two courses.

In addition, the following courses are required for the Ph.D. degree:

- PLAS.6420 Characterization of polymers and plastics (3 credits)
- PLAS.6820 Physical Polymer Science (3 credits)
- PLAS.6780 New Development in Polymer Manufacturing (3 credits)
- PLAS.6180 Structure Product Design (3 credits)
- PLAS.5090 Plastics Processing Theory I (3 credits)
- PLAS.5480 Numerical and Analytical Methods (3 credits)
- PLAS.5850/PLAS.5760 Computer Aided Engineering or Advanced Mold Design (3 credits)
- PLAS.xxxx Engineering Elective and transfer credits from M.S. program (9 - 21 credits)
- Doctoral Research Dissertation (21 - 33 credits)

TOTAL: 63 Credits

(B) The following courses are required for a Ph.D. degree for students with a M.S. Plastics Engineering Degree from UMass Lowell:

- PLAS.6420 Characterization of polymers and plastics (3 credits)
- PLAS.6820 Physical Polymer Science (3 credits)
- PLAS.6780 New Development in Polymer Manufacturing (3 credits)
- PLAS.6180 Structure Product Design (3 credits)
- PLAS.5090 Plastics Processing Theory I (3 credits)
- PLAS.5480 Numerical and Analytical Methods (3 credits)
- PLAS.5850/PLAS.5760 Computer Aided Engineering or Advanced Mold Design (3 credits)
- PLAS.5720 Plastics Processing Laboratory (1 credit)
- PLAS.5740 Physical Property Laboratory (1 credit)
- PLAS.xxxx Current Topics Plastics Seminar (1 credit)
- PLAS.xxxx Engineering Elective (9 - 18 credits)
- Doctoral Research Dissertation (21 - 33 credits)

TOTAL: 63 credits

(C) Students with B.S. degree in engineering or other disciplines from UML or other schools will be required to take a placement test on the following subjects:

- PLAS.5030 Mechanical Behavior of Polymers
- PLAS.5060 Polymer Structure, Properties and Applications
- PLAS.5180 Plastics Product Design
- PLAS.5780 Advanced Plastics Processing
- PLAS.5440 Advanced Plastics Materials

If the failed in the test or do not take the test, they will be required to take these courses and can be counted as electives.

In addition, the following courses are required for the Ph.D. degree:

- PLAS.6420 Characterization of polymers and plastics (3 credits)
- PLAS.6820 Physical Polymer Science (3 credits)
- PLAS.6780 New Development in Polymer Manufacturing (3 credits)
- PLAS.6180 Structure Product Design (3 credits)
- PLAS.5090 Plastics Processing Theory I (3 credits)
- PLAS.5480 Numerical and Analytical Methods (3 credits)
- PLAS.5850/PLAS.5760 Computer Aided Engineering or Advanced Mold Design (3 credits)
- PLAS.xxxx Current Topics Plastics Seminar (1 credit)
- PLAS.xxxx Engineering Elective (9 - 18 credits)
- Doctoral Research Dissertation (21 - 33 credits)

TOTAL: 63 credits
Ph.D. Polymer Science/Plastics Engineering Option

A doctoral program in Chemistry with an option in Polymer Science/Plastics Engineering is offered jointly with the Polymer Science group in the Department of Chemistry. This program is designed to provide the student with a background in advanced course work and laboratory techniques which will prepare him or her to carry out, under the guidance of experienced scientists, an original, independent investigation leading to an acceptable contribution to the body of contemporary knowledge. Further details of the program are described in the Chemistry section of this catalog.

Certificate Programs

Graduate Certificates in Plastics Engineering

The UMass Lowell Department of Plastics Engineering offers eight graduate certificates in a wide variety of topics.

- Commercial Development for Plastics Engineers
- Elastomeric Materials
- Medical Plastics Design and Manufacturing
- Plastics Design
- Plastics Engineering Fundamentals
- Plastics Materials
- Plastics Processing
- Sustainable Polymeric Materials and Additives

About Graduate Certificates

All Plastics Engineering graduate certificates are comprised of four courses (12 graduate credits) designed to provide specific knowledge and expertise vital to today’s changing and complex needs in the workplace. In all cases courses may be applied toward a degree program provided they meet transfer credit requirements.

Note: Courses used as credit towards one Plastics Engineering Certificate may not count towards another Plastics Engineering Certificate.

Requirements to Complete a Graduate Certificate

The four courses must be completed within a five year period with a minimum 3.0 grade point average, and with no more than 3 credits below a B. Courses completed for one certificate may not be used for another certificate, but can be used for the graduate degrees.

Certificate Application Process

Individuals must complete a simplified application, provide an official undergraduate transcript indicating that a baccalaureate degree has been awarded, and submit a nominal application fee. GRE’s are not required.


For more information visit the Plastics Engineering Department website (https://www.uml.edu/Engineering/Plastics/default.aspx).

Commercial Development for Plastics Engineers

Department of Plastics Engineering

Contact:
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Admission to this 12 credit program is open to candidates with a B.S. in Engineering or a related field.

Courses previously used for another Plastics Engineering Certificate may not be used for a second Plastics Engineering certificate. Students who wish to continue with their education may apply all of these courses to any one of the Plastics Engineering Graduate M.S. Degree Programs or our D.Eng. Degree Program.

Required Courses (Six credits):

- PLAS.5140 Statistics for Six Sigma
- PLAS.5370 Business Law for Engineers

Elective Courses (any two of the following courses - total of six credits):

- PLAS.5150 Lean Plastics Manufacturing
- PLAS.5400 Commercial Development of Polymeric Systems
- PLAS.5900 Survey of Intellectual Property
- PLAS.6070 Supply Chain Management
- MECH.5760 Engineering Project Management
- MGMT.5160 New Product Development Processes
- MGMT.6150 Foundations of New Venture Creation

Elastomeric Materials
Plastics Engineering Department

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This 12 credit certificate program is designed for students who have attained a bachelor's degree and need additional knowledge in elastomeric materials. Admission to the program is open to candidates with a B.S. in Engineering or a related field.

Courses previously used for another Plastics Certificate may not be used for a second Plastics Certificate. The Plastics Engineering Department makes every attempt to offer many of these courses during the evening to accommodate the schedules of working adults.

Required Courses (Six credits):
- PLAS.5350 Rubber Technology
- PLAS.5950 Thermoplastic Elastomers

Elective Courses (choose two - total of six credits):
- PLAS.5490 Design with Elastomers
- PLAS.5500 Processing with Elastomers
- PLAS.5960 Plastics, Elastomers and Additives from Renewable Resources
- PLAS.5060 Polymer Structure, Properties, and Applications

Medical Plastics Design and Manufacturing

Department of Plastics Engineering

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The use of plastics in medical products and medical devices is rapidly increasing. The Plastics Engineering Department at UMass Lowell is continuing its leadership role in Plastics Engineering Education by responding to industry’s need for Medical Plastics training. This 12 credit program will provide knowledge needed for the development of new "engineering intensive" medical products which combine complex material compositions, designs, and manufacturing processes. The certificate program is intended for medical professionals, engineers and technologists working in the medical products industry.

Required Courses (Six credits):
- PLAS.5530 Medical Device Design I
- PLAS.5750 Biomaterials

Elective Courses (choose two - total of six credits):
- PLAS.5540 Medical Device Design II
- PLAS.5790 Problems in Biomaterials (Directed Study)
- PLAS.6750 Biomaterials II
- CHEN.5550 Biopharmaceutical GMP and Licensing (Offered by the Chemical Engineering Department)
- BMBT.5000 Introduction to Biomedical Engineering & Biotechnology (Offered by the Biomedical Engineering program)
- PLAS.5030 Mechanical Behavior of Polymers
- PLAS.5180 Plastics Product Design

Plastics Design

Plastics Engineering Department

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The certificate program is designed for students who have attained a bachelors degree and need more plastics design background. The Plastics Engineering Department makes every attempt to offer many of these courses during the evening to accommodate the schedules of working professionals. Graduates who have already completed these course requirements can receive a retroactive certificate.

Required Courses (Six credits):
- PLAS.5030 Mechanical Behavior of Polymers
- PLAS.5180 Plastics Product Design

Elective Courses (choose two - total of six credits):
- PLAS.5060 Polymer Structure, Properties, and Applications
- PLAS.5410 Computer Applications in Plastics
- PLAS.5490 Design with Elastomers
This 12-credit certificate program is designed for students who have attained a Bachelor's degree and want more plastics materials, processing and design background. Admission to the program is open to candidates with a B.S. in Engineering or a related field. There is no application fee and the graduate record exam (GRE) is not required for admission. Courses previously used for another Plastics Certificate may not be used for a second Plastics Certificate. However, certificate courses may be applied to appropriate graduate degrees if students want to continue their education. The Plastics Engineering Department makes every attempt to offer many of these courses during the evening so that students having full time jobs can complete the certificate program. Many of these courses are also available on-line.

**Required Courses** (Six credits):

- PLAS.5440 Advanced Plastics Materials
- PLAS.5780 Advanced Plastics Processing

**Elective Courses** (choose two - total of six credits):

- PLAS.5030 Mechanical Behavior of Polymers
- PLAS.5060 Polymer Structure, Properties, and Application
- PLAS.5120 Polymer Blends and Multiphase Systems
- PLAS.5320 Adhesives and Adhesion
- PLAS.5330 Coatings Science and Technology
- PLAS.5400 Commercial Development of Polymeric Systems
- PLAS.5350 Rubber Technology
- PLAS.5420 Colloidal Nanoscience and Nanoscale Engineering
- PLAS.5470 Materials for Renewable Energy and Sustainability
- PLAS.5650 Engineering Thermosetting Resins
- PLAS.5660 Polymeric Material Systems Selection
- PLAS.5890 Polymer Nanocomposites
- PLAS.5960 Plastics, Elastomers and Additives from Renewable Resources
- PLAS.6100 Plastics Industry Development
- PLAS.6820 Physical Polymer Science
This 12-credit certificate program is designed for students who have attained a bachelor’s degree and need more plastics processing background. The Plastics Engineering Department makes every attempt to offer many of these courses during the evening to accommodate the schedules of working professionals. Graduates who have already completed these course requirements can receive a retroactive certificate.

**Required Courses** (Six credits):

- PLAS.5780 Advanced Plastics Process Engineering
- PLAS.5180 Plastics Product Design

**Elective Courses** (choose two - total of six credits):

- PLAS.5060 Polymer Structure, Properties, and Applications
- PLAS.5090 Plastics Processing Theory I
- PLAS.5150 Lean Plastics Manufacturing
- PLAS.5230 Screw Design Principles
- PLAS.5240 Process Analysis, Instrumentation, and Control
- PLAS.5260 Nanoscale Plastics Processing
- PLAS.5500 Processing with Elastomers
- PLAS.5510 Computer Aided Extrusion Die Design
- PLAS.5520 Design of Polymer Processing Machinery
- PLAS.5850 Computer Aided Engineering and Design I
- PLAS.5880 Injection Molding
- PLAS.6780 New Developments in Polymer Manufacturing.

**Sustainable Polymeric Materials and Additives**

**Plastics Engineering Department**

**Contact:**
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The Department of Plastics Engineering offers this program as a stand alone, four course graduate certificate in “Sustainable Polymeric Materials and Additives. This certificate program is designed for students who have attained a Bachelor’s degree in science or engineering and want to enhance their knowledge of renewable materials and additives, but are not ready to commit to completion of a Plastics Engineering Master’s degree. Admission to the program is open to candidates with a B.S in Engineering or a related field. The Graduate Record Exam (GRE) is not required for admission. Courses previously used for another Plastics Engineering Certificate may not be used for a second Plastics Engineering certificate. However, these certificate courses may be applied to appropriate graduate degrees with the permission of the appropriate academic department if students want to continue their education.

**Required Courses** (6 credits):

- PLAS.5960 Plastics, Elastomers and additives from Renewable Resources
- PLAS.5330 Coatings Science and Technology

**Elective Courses** (any two of the following 3 credit courses - total of 6 credits):

- PLAS.5470 Materials for Renewable Energy and Sustainability
- PLAS.5750 Biomaterials
- CHEN.5350 Cell and Microbe Cultivation
- CHEM.5630 The Chemistry of Natural Products
PLAS.5000 Advanced Project In Plastics I (Formerly 26.500) - Credits: 1
A laboratory course for advanced projects in the areas of plastics materials, design, processing, elastomers, coatings, adhesives, or medical plastics.

PLAS.5010 Advanced Project In Plastics II (Formerly 26.501) - Credits: 3
Continuation of 26.500.

PLAS.5060 Polymer Structure Properties & Applications (Formerly 26.506) - Credits: 3
Relationships between polymer structure (chemical composition, molecular weight and flexibility, intermolecular order and bonding, supramolecular structure) and practical properties (processability, mechanical, acoustic, thermal, electrical, optical, and chemical) and applications.

PLAS.5090 Plastics Processing Theory I (Formerly 26.509) - Credits: 3
Principles of Rheology and continuum mechanics involved in the processing of plastics, and their applications in plastics process engineering including flows in standard geometries and extrusion applications.

PLAS.5100 Plastics Processing Theory II (Formerly 26.510) - Credits: 3
A continuation of Theory I using the transport phenomena approach to analyze and describe plastics conversion processes, including roll processing blown film extrusion, injection molding, and mixing.

PLAS.5110 Polymer Blends (Formerly 26.511) - Credits: 3
Physical, mechanical, and thermal properties, preparation, and testing of polymer blends, alloys, and multiphase systems. Thermodynamic theories and experimental determination of miscibility of polymer blends. Structure property relationships for multiphase systems and interpenetrating networks.

PLAS.5120 Porous Polymers (Formerly 26.512) - Credits: 3
Preparation, structure, and properties of porous polymers. Includes both practical systems in development and production and novel techniques of more fundamental interest and/or aimed at more specialized applications. Exising and potential applications for these materials will also be discussed, and related back to their structure and properties.

PLAS.5130 New Plastics Materials (Formerly 26.513) - Credits: 3
Critical examination of the new plastics appearing in the research literature and being field-tested for commercialization in the plastics industry.

PLAS.5140 Statistics for Six Sigma (Formerly 26.514) - Credits: 3
A review of statistical techniques for Six Sigma with applications specifically designed for the plastics processing industry. Those completing the course should be at the Six Sigma green belt level or better.

PLAS.5150 Lean Plastics Manufacturing (Formerly 26.515) - Credits: 3
Methods of analysis and operation of plastics manufacturing facilities. Topics include: performance measurement, inventory control, forecasting, production planning, scheduling, resource management, supply chains, various technologies for improved productivity.

PLAS.5180 Plastics Product Design (Formerly 26.518) - Credits: 3
This course reviews the theoretical principles and the engineering practice associated with the development of new plastic products. The course focuses on design practices for products that will be produced by conventional and advanced injection molding processes. Topics include design methodology, plastic materials selection, design for manufacturing, computer aided engineering, mechanical behavior of plastics, structural design of plastic parts, prototyping techniques, experimental stress analysis, and assembly techniques for plastic parts.

PLAS.5220 Advanced Project in Plastics IV (Formerly 26.522) - Credits: 3
PLAS.5240 Process Analysis Instrument and Control (Formerly 26.524) - Credits: 3
PLAS.5280 Plastics Information Data Bases  
(Formerly 26.528) - Credits: 1  
Review of procedures for literature searching, databases, etc.

PLAS.5300 Selected Topics  
(Formerly 26.530) - Credits: 1-3  
Topics in various fields of Plastics Engineering. Content may vary from year to year so that students may, by repeated enrollment, acquire a broad knowledge of contemporary Plastics Engineering.

PLAS.5320 Adhesives and Adhesion  
(Formerly 26.532) - Credits: 3  
Adhesive joining of engineering materials. Surface chemistry, theories of adhesion and cohesion, joint design, surface preparation, commercial adhesives, Rheology, equipment, testing, service life, and reliability.

PLAS.5330 Coatings Science and Technology I  
(Formerly 26.533) - Credits: 3  
This course reviews the basic principles of design and formulation of waterborne, high-solids, powder resins used for the development of solvent-less green coatings and the use of bio-derived resins, mostly based on soybean oil and other renewable raw materials. The mechanisms and methods of curing and of polymerization for polymers used as coatings will also be covered.

PLAS.5340 Coatings Science and Technology II  
(Formerly 26.534) - Credits: 3  
A continuation of 26.533. This graduate course reviews the basic principles of design and formulation of waterborne, high-solids, powder resins that meet current manufacturing regulations. Rheology of polymer and pigment dispersion, and their application to coatings, inks and adhesives will be included here.

PLAS.5350 Rubber Technology  
(Formerly 26.535) - Credits: 3  
Polymerization and compounding of the commercial elastomers. Properties and test methods. Leading applications and methods of processing.

PLAS.5370 Business Law for Engineers  
(Formerly 26.537) - Credits: 3  
Business legal issues engineers encounter in practice, including contractual, products liability, and intellectual property issues. Business torts relating to product design, manufacturing and inadequate warning defects. Unreasonably dangerous products and strict liability.

PLAS.5400 Commercial Development of Plastics  
(Formerly 26.540) - Credits: 3  
The concepts of industrial marketing will be reviewed for research, pricing strategies, and product planning for market segmentation, place (distribution)-promotional activities. Topics will include creating a demand, selling, and servicing base resins and additives.

PLAS.5410 Computer Applications in Plastics  
(Formerly 26.541) - Credits: 3  
Problem solving in plastics engineering has been dramatically influenced by the computer and innovative software packages. This graduate course will focus on the application and development of software packages for engineering analyses of plastics processes. Specially, the course will cover the basic CAD programs, Pro/ENGINEER, SOLIDWORKS, followed by basic Pre- and-Post processor software, FEMAP, meshing program HYPERMESH, FEMLAB multiphysics, and MATHEMATICA.

PLAS.5420 Colloidal Nanoscience and Nanoscale Engineering  
(Formerly 10.542/26.542) - Credits: 3  
This course will cover the fundamentals of nanoscale colloidal processes, intermolecular forces and electrostatic phenomena at interfaces, boundary tensions and films at interfaces, electrostatic and London forces in disperse systems, interactions and self-assembly of polymer colloids, nanoparticles, surfactants and biomolecules. Applications include microfluidics; lab-on-a-chip; nano-biocolloids, vesicles, colloidosomes, polymersomes and polymer hydrogel microcapsules for drug delivery and nanostructured materials and devices.

PLAS.5440 Advanced Plastics Materials  
(Formerly 26.544) - Credits: 3  
This course reviews the historical developments of polymeric material systems, commodity, engineering, biodegradable, and high performance thermoplastics. Topics include their synthesis, structure, properties, and applications and there is also an overview of typical additives that are used to modify the properties of plastics. Knowledge of general and/or organic chemistry is recommended as a prerequisite for this course.

PLAS.5450 Additives for Polymer Materials
Additives incorporated into polymers to modify processing and end-use properties: reinforcements, plasticizers, stabilizers, flame retardants, colorants, biostats, blowing agents, anti-stats, impact modifiers, and processing aids.

PLAS.5470 Materials for Renewable Energy and Sustainability (Formerly 26.547) - Credits: 3

This course reviews the selection and design of materials for use in energy generation and conservation applications. Both traditional and renewable technologies for energy generation are reviewed, and the differences in materials needs for generation, storage and transmission highlighted. Particular emphasis is placed on organic and polymeric materials technological challenges in solar, wind and hydro/geothermal energy and future transportation fuel production. The concept of life cycle assessment is introduced for the optimization of systems from a materials science perspective. The impacts of global economics, ethics and efficiency are also addressed. The course approaches sustainability as an open-ended, complex engineering problem and introduces students to the broad range of career opportunities for materials engineers in renewable energy.

PLAS.5480 Analytical and Numerical Methods in Plastics Processing (Formerly 26.548) - Credits: 3

This course covers the use of analytical and numerical methods related to engineering. Topics include ordinary differential equations, linear second order differential equations, matrices, vectors, linear systems of equations, partial differential equations. Use of numerical methods to differential equations, linear algebra, regression, interpolation, data analysis, and partial differential equations.

PLAS.5490 Product Design for Elastomers (Formerly 26.549) - Credits: 3

This course covers the basics of thermoset and thermoplastic elastomer product design. Topics include mechanical behavior, large deformation structural analysis, design for manufacturability, performance limitations, and end use applications for elastomers and assembly considerations.

PLAS.5500 Processing with Elastomers (Formerly 26.550) - Credits: 3

This course covers the basics of elastomer processing. Topics include mixing, Rheology, extrusion, injection molding, compressing molding, and curing as it applies to elastomers.

PLAS.5510 Extrusion Die Design (Formerly 26.551) - Credits: 3

This is a project-oriented course which utilizes current CAE programs to design extruder dies. This course will study the basic principles of extrusion die design and apply these principles in designing extrusion dies. A review of the extrusion process and the flow behavior of various polymers will be studied.

PLAS.5520 Machine Design (Formerly 26.552) - Credits: 3

Hydraulics, machine logic, drives, pumps, motors, heaters, barrel and screw combinations, mechanical design. Hydraulic and electrical control circuits development. A semester project is required.

PLAS.5530 Medical Device Design I (Formerly 26.553) - Credits: 3

A systematic approach to inventing new medical devices. The class details the process of validating medical needs including market assessment and the evaluation of existing technologies; basics of regulatory (FDA) and reimbursement planning; brainstorming and early prototyping for concept creation. Course format includes expert guest lecturers and interactive practical discussions with faculty. Students will prepare a medical device proposal and presentation.

PLAS.5540 Medical Device Design II (Formerly 26.554) - Credits: 3

This course focuses on how to take a medical device invention forward from early concept to technology translation and implementation planning. Topics include technology research &development; patent strategies; techniques for analyzing intellectual property; advanced planning for reimbursement and FDA approval; choosing translation strategies (licensing vs. start-up); ethical issues including conflict of interest; fundraising approaches and cash requirements; essentials of writing a business or research plan; strategies for assembling a development team. Students will prepare a final medical device proposal and presentation.

PLAS.5630 Current Topics in Plastics Materials I (Formerly 26.563) - Credits: 1

Individual research and presentation in the field of plastics materials.

PLAS.5640 Current Topics in Plastics Materials II (Formerly 26.564) - Credits: 1
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Individual research and presentation in the field of plastics materials.

**PLAS.5650 Thermosets** (formerly 26.565) - Credits: 3

Provides an in-depth review of the major families of engineering thermosetting resins: phenolics, aminos, polyesters, epoxies, silicones, and various polyurethanes systems. Emphasis is on the basic chemistry, inherent physical properties and processability, and the effect of polymer modifiers (additives) on the functional properties of molding compounds. Typical market sectors served and related processing/fabrication technologies used in reinforced plastics/composites are reviewed.

**PLAS.5660 Polymer Materials Systems Solution** (formerly 26.566) - Credits: 3

This course investigates the selection processes to be followed in screening material candidates, and specifying a material of record. Emphasis is placed on prioritizing performance requirements, contrasting potential candidates, reviewing processing demands, and post-fabrication schemes. The course will be based on actual case studies.

**PLAS.5680 Dynamic Mechanical Properties II** (formerly 26.568) - Credits: 3

Practical review of theoretical concepts of rheological measurements with practical applications of experimental techniques. Emphasis will be on the viscoelastic properties of polymer solutions, melts, and solids with correlation with theoretical dynamic mechanical behavior.

**PLAS.5690 Current Topics in Plastics Design I** (formerly 26.569) - Credits: 1

Individual research and presentation in the field of plastics design.

**PLAS.5700 Current Topics in Plastics Processing I** (formerly 26.570) - Credits: 1

Individual research and presentation in the field of plastics processing.

**PLAS.5710 Plastics Processing Engineering Laboratory I** (formerly 26.571) - Credits: 1

Laboratory study of the interaction between process variables and materials in extrusion, injection molding, blow molding, thermoforming, compounding and mixing.

**PLAS.5720 Advanced Plastics Processing Engineering Laboratory** (formerly 26.572) - Credits: 1

Measurement of mechanical properties in tension, compression, shear, and flexure; dielectric constant and dissipation factor; thermal behavior under stress; melt rheology.

**PLAS.5740 Advance Physical Properties Lab** (formerly 26.574) - Credits: 1

Measurement of mechanical properties in tension, compression, shear, and flexure; dielectric constant and dissipation factor; thermal behavior under stress; melt rheology.

**PLAS.5750 Biomaterials I** (formerly 26.575) - Credits: 3

A comprehensive study of the history, current and future rents within biomedical devices and their applications. Students will be introduced to research techniques used to analyze the different classes of biomaterials. An overview of typical host reactions such as inflammatory response and their evaluation will be touched upon.

**PLAS.5760 Advanced Mold Design** (formerly 26.576) - Credits: 3

This course provides an integrated approach to mold engineering which includes the interrelationships of polymeric materials, engineering principles, processing, and plastics product design. Major topics include cost estimation, mold layout and feed system design, cooling systems, structural design considerations, and ejector system design. Analytical treatment of the subject matter is given based on the relevant rheology, thermodynamics, heat transfer, fluid flow and strength of materials.

**PLAS.5770 Plastics Process Engineering I** (formerly 26.377/577) - Credits: 3

The first course in a two semester sequence to study the fundamental principles of polymer processing, i.e., the conversion of the polymeric materials into useful articles. The course will first study the properties of polymers (bulk and rheological and thermal properties) and why they are important to understanding polymer processing. This course will emphasize the fundamental principles of the extrusion process and examine the correlation between elements of the extruder, polymer properties, and processing variables and why they all must be considered when studying and understanding a plastics processing technique.

**PLAS.5780 Advanced Plastics Processing** (formerly 26.578) - Credits: 3

This course reviews the common plastics manufacturing processes, including extrusion, injection molding, blow
molding, thermoforming, and rotational molding. After the review, the course focus shifts to the impacts of screw design and processing parameters on the conveyance, melting, devolatilization, and mixing with single screws and compounding with twin screw extruders. This course also includes an overview of die designs, multi-shot and gas assist injection molding, film stretching and methods for heating and cooling in plastics processing.

PLAS.5790 Problems In Biomaterials/Directed Study (Formerly 26.579) - Credits: 3
Selection of a current biomaterial problem of interest by the individual student, examination of pertinent literature to determine present knowledge in the area, formulation of an approach to resolve or clarify the issues involved, and (time permitting) work towards the solution of the selected problem.

PLAS.5820 Current Topics in Plastics Design II (Formerly 26.582) - Credits: 1
Individual research and presentation in the field of plastics product or tooling design.

PLAS.5830 Advanced Research Methodology (Formerly 26.583) - Credits: 3
A systematic evaluation of the techniques used in efficient research and development. Experimental data are analyzed and plotted using a mathematical approach. Creative thinking, problem solving, and student presentation of data are stressed. Extensive reading of research papers, analysis of such, and defense of the analysis required.

PLAS.5850 Computer Aided Engineering I (Formerly 26.585) - Credits: 3
This course provides a fundamental approach to computer-aided engineering for plastics processing. Emphasis is upon the theory and techniques of computer aided engineering as applied to plastics processing problems, allowing students to understand the various assumptions and methods used to create the programs.

PLAS.5890 Polymer Nanocomposites (Formerly 22.570/26.589) - Credits: 3
This course deals with the preparation, characterization, behavior and properties of polymer nanocomposites, with an emphasis on the most commercially relevant systems to date, as well as new developments in the field. The major preparation routes to these materials are discussed, with an emphasis on the importance not only of dispersion but of true thermodynamic compatibility in these systems. From there, the focus shifts to describe the consequences of nanocomposite structure in terms of both molecular behavior and macroscopic properties, as informed by the most up-to-date research literature available. Case studies of specific systems will serve as opportunities to gain deeper understanding, and the safety issues surrounding nanoparticle handling will also be presented. Finally, current research by invited lecturers working in the field will be presented as time permits.

PLAS.5900 Survey of Intellectual Property (Formerly 26.590) - Credits: 3
A review of patents, trademarks, copyrights and their application for protection of technology in the plastics industry. Other topics to be considered will be employee rights/non-competition agreements, foreign protection, and technology licensing. (in the Plastics Industry)

PLAS.5910 Industrial Thesis Development I (Formerly 26.591) - Credits: 1-9
Enables graduate students to work part-time to compliment academic studies with practical industrial experience and acquire/enhance expertise in their research as well as thesis investigation.

PLAS.5930 Cooperative Education (Formerly 26.593) - Credits: 1
Enables graduate students to work full time to gain practical industrial experience for one semester while on reduced course load.

PLAS.5950 Thermoplastic Elastomers (Formerly 26.595) - Credits: 3
A comprehensive review of thermoplastic elastomer (TPE) technology. Physical and chemical nature of the various classes of TPE’s will be considered with emphasis on mechanical and rheological properties relevant to engineering applications.

PLAS.5960 Plastics, Elastomers and Additives from Renewable Resources (Formerly 26.596) - Credits: 3
This course will provide an introduction to plastics, elastomers and additives obtained from renewable resources. Processes that involve conversion (chemically/enzymatically) of naturally occurring precursors (monomers) obtained from renewable resources to plastics and elastomers will be reviewed. Brief discussion of processing, degradation and recycling of these materials will also be included.

PLAS.6010 Graduate Industrial Coop Education I
Graduate students interested in developing a practical industrial experience component to complement their academic training may register for this course with advisor’s approval. This credit is not applicable to the mandated degree credit hours.

PLAS.6020 Medical Device Development Regulation
(Formerly 26.602) - Credits: 3

Comprehensive and in-depth analysis of US medical device diagnostics development and approval requirements. Detailed analysis of quality assurance issues and regulatory reforms implemented under the Food and Drug Administration. Provides a step-by-step guide through the Center for Devices and Radiological Health (CDRH) investigational device exemptions, premarket approval, 510 (k) application process, and product development protocol and review processes.

PLAS.6060 Plastics Manufacturing Systems Engineering (Formerly 26.606) - Credits: 3

The course provides guidance about plastics manufacturing as an integrated system with broadly applicable analysis in three areas: 1) machinery, 2) controls, and 3) operations. The machinery topics include heating/cooling, hydraulics/pneumatics, electric drives, and sensors. The controls topics include signal conditioning, data acquisition, machine controllers, and related control laws. The operations topics include process characterization, process optimization, quality control, and automation. The course is developed to support plastics processing engineers and others involved with plastics manufacturing who are performing process development, research, and machine design.

PLAS.6070 Supply Chain Management for Engineers
(Formerly 26.607) - Credits: 3

This course focuses on design, development, and planning supply chain networks while examining the product’s life cycle with an emphasis of the manufacturing processes. Throughout the course, global supply chain management, supply chain drivers, distribution networks, network design under uncertainty, supply-demand cycle, demand forecasting, inventory management, supply chain performance, end-of-life, cradle-grave and cradle-cradle products, along with supply chain decision-making topics will be covered. These topics will be demonstrated with the implementation of examples, and case studies.

PLAS.6100 Plastics Industry Development (Formerly 26.610) - Credits: 3

The goals of this course are numerous. In the large sense, the primary focus of this course will be to review many of the major technological developments and discoveries that have helped make the plastics industry what it is today. Having a thorough understanding of how these developments were implemented commercially can help us implement modern day technologies in a more efficient and productive manner.

PLAS.6110 Coloration of Engineering Thermoplastics - Credits: 3

A comprehensive approach to all elements of Color Technology focused on needs for future plastics engineers. The course includes theory of color vision, instrumental color measurement and tolerancing, chemistry and processes of commercial dyes and pigments, their testing in polymers, failure modes and elements of industrial color matching. Special attention will be given to weatherability of color formulations.

PLAS.6180 Structural Product Design (Formerly 26.618) - Credits: 3

Design of plastic and composite products to meet structural requirements including strength, stiffness, impact, fatigue, and creep while remaining low weight, low cost, and easy to manufacture. The course will include an overview of structural properties of polymeric materials as well as application of finite element analysis to homework and project assignments.

PLAS.6420 Characterization of Polymers and Plastics
(Formerly 26.642) - Credits: 3

This course provides an in-depth review of the various means by which important properties of polymers and plastics are determined. Lectures will cover analysis of composition and structure (including deformation techniques) as well as measurements of common physical, mechanical, thermal, barrier, fire and optical properties. Coverage will include both the fundamental basis for the techniques and their practical applications, strengths and weaknesses. Time and resources allowing, selected techniques will be demonstrated in the lab as well.

PLAS.6500 Nanoscale Transport Phenomena for Manufacturing Nanodevices (Formerly 26.650) - Credits: 3

An interdisciplinary course taught by faculty from the Chemical, Mechanical and Plastics Engineering Department, who have special knowledge in nanoscale fluid mechanics and heat transfer. The course on nanoscale transport phenomena constitutes a bridge between existing fluid and heat transfer courses in multiple disciplines and emerging nanoscale science
and engineering concepts to reflect the forefront of nanomanufacturing. The course is designed to incorporate recent advances in manufacturing polymer based nanodevices. Key issues of the implementation and maintenance cost for fabrication will be addressed. Hands-on laboratory experiments will be performed to complement the lectures with the ultimate goal of designing and building a complete nanodevice at the end of the course. The course will prepare graduates for employment focused on designing and manufacturing nano/microfluidic systems, lab on ship devices, electronic devices, medical devices and other emerging technologies.

PLAS.6750 Biomaterials II (Formerly 26.675) - Credits: 3

The degradation of biomaterials in the biological environment for applications such as sutures, orthopedic implants, dental implants, etc. will be reviewed. Students will analyze issues unique to the field of implants, devices and biomaterials. While reviewing new products and standards, the prospective and possibilities of biomaterials will be studied.

PLAS.6780 New Developments in Polymer Manufacturing - Credits: 3

This course explores advanced concepts and new developments in polymer manufacturing. It is designed for students with prior courses and/or experience in polymer processing.

PLAS.6820 Physical Polymer Science - Credits: 3

Comprehensive course covering physical polymer science and engineering. The role of molecular conformation and configuration in determining the physical behavior of polymers. The amorphous and crystalline states of polymers; polymer/polymer phase diagrams; glass-rubber transition and polymer viscoelastic behavior.

PLAS.7410 Master’s Thesis - Plastics Engineering (Formerly 26.741) - Credits: 1
PLAS.7430 Masters Thesis Plastics Engineering (Formerly 26.743) - Credits: 3

Individual research projects in plastics.

PLAS.7460 Master’s Thesis - Plastics Engineering (Formerly 26.746) - Credits: 6

Individual research projects in plastics.

PLAS.7490 M S Grad Res Plastics (Formerly 26.749) - Credits: 9

Individual research projects in plastics.

PLAS.7510 Doctoral Thesis Research (Formerly 26.751) - Credits: 1
PLAS.7520 Doctoral Thesis Research (Formerly 26.752) - Credits: 2
PLAS.7530 Doctoral Dissertation/Plastics Engineering (Formerly 26.753) - Credits: 3

Individual research projects in plastics.

PLAS.7560 Doctoral Dissertation/Plastics Engineering (Formerly 26.756) - Credits: 6

Individual research projects in plastics.

PLAS.7590 Doctoral Dissertation/Plastics Engineering (Formerly 26.759) - Credits: 9

Individual research projects in plastics.

PLAS.7630 Continued Graduate Research (Formerly 26.763) - Credits: 3

Individual research projects in plastics.

PLAS.7660 Continued Graduate Research (Formerly 26.766) - Credits: 6

Individual research projects in plastics.

PLAS.7690 Continued Graduate Research (Formerly 26.769) - Credits: 9

Individual research projects in plastics.