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Application Procedure

Institutional 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/), 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. Certain graduate programs require graduate entrance examinations. The applicant must have obtained a satisfactory score on the appropriate entrance examination if 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.

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.

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.

Application Procedure for Graduate Admission

Applicants can apply using the online application.

- Master’s & Doctoral Application
- Application Deadline
- Types of Admission
- Graduate Certificate Application Procedure
- Non Degree Status
- Graduate Readmission/Deferral Policy

Master’s & Doctoral Application Information

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. Letters of recommendation written by individuals qualified to judge the ability of the applicant to carry on graduate work and research as requested by the department. Refer to the department page to learn about the number of required recommendations.
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 an institutionally approved language test for students from countries where English is not the national language. The thresholds for English tests are set by the department. Institutionally approved English tests: TOEFL, IELTS, Duolingo. 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.

Graduate Certificate Candidate Application Information

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, submit the appropriate application fee, and submit an official transcript indicating the conferral of a bachelor’s degree. The graduate record exam (GRE) and letters of recommendation are 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.

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 Philosophy in Engineering (Ph.D.)

- Chemical Engineering

Doctor of Nursing Practice (DNP)

- Nursing

Doctor of Philosophy (Ph.D.)

- Applied Psychology and Preventative Science
- Applied Biology
- Biomedical Science;
  Developmental & Evolutionary Biology;
  Quantitative Biology & Biophysics; and
  Cellular & Molecular Biology
- Biomedical Engineering & Biotechnology
- Business Administration
- Business Accounting
- Leadership Finance
- Management
- Information Systems
- Chemistry
Doctor of Physical Therapy (DPT)

- Physical Therapy

Doctor of Science


Master's Programs Offered

Listed by Degree Earned

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

Master of Arts (MA)

- Criminal Justice (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- History (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

Master of Business Administration (MBA)

- General Business
- Accounting
- Business Analytics
- Entrepreneurship
- Finance (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- Healthcare
- Information Technology (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- International Business
- Managerial Leadership
- Marketing

Master of Education (M.Ed.)

&Instruction: Initial Certification
Curriculum & Instruction: Science Education, beyond initial
Math Education, beyond initial

- Educational Administration
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- Reading & Language (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
  Teacher of Reading
  Non-licensure

Master of Music (MM)

  Community Music
- Sound Recording Technology
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

Master of Public Administration (MPA)

Public Administration (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
  - Human Service Management
  - Public Humanities and the Arts
  - Justice Administration

Master of Public Health (MPH)

Public Health (https://www.uml.edu/Health-Sciences/Public-Health/Programs-of-Study/masters/MPH.aspx)
  - Dietetics
  - Epidemiology
  - Healthcare Management
  - Nutrition
  - Social and Behavioral Sciences

Master of Science (MS)

- Accounting
- Biological Sciences (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
  Bioinformatics
  Biotechnology
  Education
- Biomedical Engineering & Biotechnology
  Biomedical & Biotechnology (PSM)
- Business Analytics
- Chemistry
  Chemistry & Polymer Science
  Pharmaceutical Biochemistry (PSM)
- Clinical Laboratory Sciences
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
  Clinical Lab Science (PSM)
- Computer Science
  Bio/Chemical Informatics
  Software Engineering - Not Accepting new applications
- Co-op Option in Engineering
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- Engineering Management
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- Entrepreneurship
- Environmental Studies
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
  Atmospheric Sciences
  Environmental Engineering Sciences
  Environmental Geoscience (PSM)
- Finance
- Health Information Management
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
  Health Informatics
  Health Management
- Information Technology
- Marine Sciences & Technology
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
  Coast & Ocean Admin. Science/Technology (PSM)
- Mathematics
  Applied & Computational Mathematics
  Industrial Mathematics (PSM)
  Mathematics for Teachers
  Probability & Statistics
- Nursing
  Adult / Gerontological Nursing
  Family Health
  Non-licensure
Nursing

- Pharmaceutical Science
- Physics
- Public Health
- Radiological Science & Protection
- Security Studies
- 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
Doctor of Philosophy in Engineering, Biomedical Engineering

Program Description

Admission Requirements
Applicants to the BME doctoral option are required to have a degree at the level of Bachelor or Master’s in engineering or basic/applied/health sciences with a strong emphasis on mathematics (Calculus I and II), chemistry (Organic Chemistry), and the physical sciences (Physics I, and Physics II), with some exposure to the life sciences (physiology, cell biology, or molecular biology). Students who do not meet all requirements may be admitted into the program pending the successful completion of requisite courses.

Applicants must submit official transcripts of all undergraduate and graduate records. Three letters of recommendation written by individuals qualified to judge the ability of the applicant to conduct graduate work and research are required. GRE and TOEFL (if applicable) are required.

Financial Support
Doctoral students will be supported from a variety of sources. It is expected that the bulk of the funding will be from externally funded research grants. As is current practice in the College of Engineering, these will be combined Teaching Assistant/Research Assistant positions for the first two years. In general, continued support after the first two years will be as a Research Assistant. It is anticipated that a number of doctoral students will be supported by fellowships or traineeships in the future.

Course Requirements
As with other options in the Ph.D. in Engineering, the Biomedical Engineering doctoral option will require the satisfactory completion of a total of 63 credit hours, with a minimum of 30 course credits and 21 research credits. The remaining 12 credits can be a mix of research and course credits. Students will have to maintain a minimum GPA of 3.25 to graduate.

1. Biomedical Core Courses (15 credits) - To fulfill this requirement, all students must complete the following four courses: Bioinstrumentation (3), Fundamentals of Biomaterials (3), Biomechanics (3), and Quantitative Physiology (3). In addition, an Advanced Mathematics (3) course will be required. This math core course will be chosen in conjunction with the dissertation research advisor. All students must demonstrate proficiency by passing with a minimum CGPA of 3.25 in the core courses.

2. Track Courses (12 credits) - The purpose of the track courses is to provide depth of knowledge in a specific area of Biomedical Engineering and to pose a solid foundation for students to excel in their specific research topic. It is recommended that students first identify a field of interest in collaboration with their research advisor, and then select track courses that align with the research topic of choice. Initial tracks for the program will mimic the tracks in the undergrad BME program (Medical Devices, Biomechanics, or Cellular &Tissue Engineering). Additional track courses can be chosen in collaboration with the research advisor.

3. Elective Courses (3 credits minimum) - The remaining three required course credits can be selected in conjunction with the research advisor to add breadth to the program. This course can be an appropriate engineering, math, or science course.

4. Graduate Seminar Course (0 credit) - A key component of the Ph.D. option will be to provide comprehensive professional skills training from start to finish. This training will be accomplished through courses as well as other requirements of the program. Importantly, the program will be designed to ensure that student progress is actively monitored such that students will move through the program in a timely manner (3 to 5 years). This rate of progress will be accomplished by including a Graduate Seminar Course (0 credit) in each year of their program. One of the requirements of this seminar will be a work-in-progress presentation of their research to date. As the student progresses through the program, this presentation may include a review of the literature, methods development for their proposal, and preliminary findings of their research.

5. Dissertation Research (21 credits) - A minimum of 21 credit hours of Dissertation Research will be required.

6. Additional Credits (12 credits) - An additional 12 credits that can be a mix of research and course credits to bring the total for the degree up to 63 credits.

- Doctor of Philosophy in Biomedical Engineering Degree Pathway (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

Qualifying Exam
The Dissertation Research Proposal will also serve as the qualifying exam. Each Ph.D. student is required to present their research proposal to their Graduate Committee and to describe initial results obtained to date together with plans to complete the research. A full-time student will have to write and orally defend their Dissertation Research Proposal by the end of their second year. Core knowledge and ability to think critically and in an interdisciplinary fashion will be evaluated during the defense of the Dissertation Research Proposal. Students who fail to pass this examination on the first attempt will be given one opportunity to re-take the exam. Students who fail the exam a second time will be recommended to complete an appropriate master’s degree and exit the doctoral program.

Optional Industrial Internship
As an optional component to the program, select students will
have the opportunity to apply for an Industrial Internship with an industrial partner after passing their Dissertation Research Proposal. These internships will expose students to non-academic environments and will also help foster the development of new University-Corporate collaborations.

Dissertation Defense
A thesis for the doctoral degree must represent distinct scholarship and must be an original contribution to knowledge. It must show familiarity with the state-of-the-art of the field and must demonstrate the ability to plan and carry out the proposed research, to organize results, and to defend the approach and conclusions in a scholarly manner.

BME Graduate Committee
The proposed doctoral option will be overseen by a standing BME Graduate Committee comprised of faculty members from the Biomedical Engineering Department. This committee will be chaired by the Associate Chair for Biomedical Engineering. The committee will:

1. evaluate program curriculum and policies,
2. monitor the dissertation research proposal exam,
3. approve thesis defense committees, and
4. assist in mediating issues that may arise between students and faculty.

Master's Program in Biomedical Engineering &Biotechnology
The Boston, Dartmouth, and Lowell campuses of the University of Massachusetts offer joint Master of Science in Biomedical Engineering and Biotechnology.

- Co-op Option in Engineering
- Admission Requirements
- Transfer of Credits
- Academic Program
- General Program Requirements
- Core Course Requirements - Requirement 1 (minimum 19 credits)
- Elective Specialization Course Requirements - Requirement 2 (minimum 12 credits)
- Earning the Master of Science Degree
- Combined Bachelor’s and Master’s Degree Program

Co-op Option in Engineering

The Department of Biomedical Engineering &Biotechnology Program participates in the Graduate Master’s Co-op Option in Engineering. For detailed information about the Co-op Program and curriculum requirements, please see the Graduate Catalog Engineering Co-op page (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf).

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 academic ability, 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 must submit the following and are expected to meet the standards indicated:

1. Generally students with an overall undergraduate or graduate 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.

2. Applicants accepted into the program should present a minimum Graduate Record Exam (GRE) combined verbal (142) and quantitative (152) score of 294. 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.

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

4. International applicants should present a minimum Test of English as a Foreign Language (TOEFL) score of 79.
Two letters of recommendation, from individuals familiar with the applicants academic ability will be required.

Applicants will also be required to submit a Statement of Purpose (personal essay) that 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 program.

Applicants shall 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 will guide them in course selection.

**Transfer of Credits**

For students who have previously completed graduate course work, the admission committee may approve the transfer of up to 12 credits of graduate credits for courses from an accredited United States or Canadian 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 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 credits will be accepted for transfer from institutions within 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 the master’s degree (minimum of 31 credits), but would not have to take the waived course.

**Academic Program**

The curriculum is organized around common experiences, including common core courses, elective/specialization courses and an optional research project. The program makes some use of distance learning/on-line/faculty exchange for delivery of courses. The program encourages a multidisciplinary team approach during a variety of courses.

**General Program Requirements**

The program of courses includes a core requirement (Requirement 1) and elective / specialization course requirements (Requirement 2).

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, maximum 6 credits, that they can apply toward their program. 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 - Requirement 1 (minimum 19 credits)**

The core courses provide a common foundation for all students, either from life science or physical science/engineering backgrounds. Core requirements consist of three compulsory courses and four additional courses selected from four categories of approved courses. All course selections must be approved by the advisor.

**Students shall complete the following three core courses:**

- BMBT.5000 [Introduction to Biomedical Engineering and Biotechnology (3 cr)](https://www.uml.edu/catalog/courses/BMBT/5000)
- BMBT.5200 [Bioethics (1 cr)](https://www.uml.edu/catalog/courses/BMBT/5200)
- Elective Specialization Course from the list below (3 cr) or Research Project (3 cr)

For the Research Project, students should conduct research in a faculty lab or in industry and register for an Independent Study/Advanced Project under the Research Advisor’s department. If the Research Advisor can’t set up a number in their department, the student should register for BMBT.7200 [Independent Study with a section established for the Research](https://www.uml.edu/catalog/courses/BMBT/7200).
Advisor.

Students shall take one course from each of the following four core categories. Students should consult the advisor for the most appropriate selection from the approved courses in each of the categories. With adequate justification, students may submit an Academic Petition to substitute a course for one of the courses listed below in these respective categories.

**MATH (3 cr.)***
- BMEN.5380 (https://www.uml.edu/catalog/courses/BMEN/5380) Computational Biomechanics
- CHEN.5390 (https://www.uml.edu/catalog/courses/CHEN/5390) Math Methods for Engineers
- CHEN.5480 (https://www.uml.edu/catalog/courses/CHEN/5480) Engineering Process Analytics
- MATH.5300 (https://www.uml.edu/catalog/courses/MATH/5300) Applied Math I
- MATH.5760 (https://www.uml.edu/catalog/courses/MATH/5760) Statistical Programming Using SAS
- PUBH.5750 (https://www.uml.edu/catalog/courses/PUBH/5750) Epidemiology and Biostatistics
- PUBH.5770 (https://www.uml.edu/catalog/courses/PUBH/5770) Biostatistics for Health Data
- RADI.5820 (https://www.uml.edu/catalog/courses/RADI/5820) Numerical Methods in Radiological Sciences
- RADI.6060 (https://www.uml.edu/catalog/courses/RADI/6060) Monte Carlo Simulation of Radiation Transport

**PHYSIOLOGY (3-4 cr.)***
- BIOL.5490L (https://www.uml.edu/catalog/courses/BIOL/5490L) Biology Of Muscle Lab (1 cr)
- BIOL.5620 (https://www.uml.edu/catalog/courses/BIOL/5620) Cardiovascular Physiology Lecture (3 cr)
- BIOL.5630 (https://www.uml.edu/catalog/courses/BIOL/5630) Cardiovascular Physiology Lab (1 cr)
- BIOL.5800 (https://www.uml.edu/catalog/courses/BIOL/5800) Development Biology (3 cr)
- BIOL.5810L (https://www.uml.edu/catalog/courses/BIOL/5810L) Development Biology Lab (1 cr)
- BIOL.5900 (https://www.uml.edu/catalog/courses/BIOL/5900) Human Neurobiology (3 cr)
- HSCI.5510 (https://www.uml.edu/catalog/courses/HSCI/5510) Clinical Pathophysiology (3 cr)

**LABORATORY (3-5 cr.)***
- BIOL.5190/5210L (https://www.uml.edu/catalog/courses/BIOL) Biochemistry Techniques (5 cr)
- BIOL.5290 (https://www.uml.edu/catalog/courses/BIOL/5290) Recombinant Protein Production Techniques (4 cr)
- BIOL.5320/5340L (https://www.uml.edu/catalog/courses/BIOL) Genomics and Lab (4 cr)
- BIOL.5760 (https://www.uml.edu/catalog/courses/BIOL/5760) Cell Culture (4 cr)
- BIOL.5950 (https://www.uml.edu/catalog/courses/BIOL/5950) Immunology Lecture and Lab (2 cr)
- CHEN.5860 (https://www.uml.edu/catalog/courses/CHEN/5860) Biotech Processing Projects Lab (3 cr)
- EECE.5600 (https://www.uml.edu/catalog/courses/EECE/5600) Biomedical Instrumentation (3 cr)
- MLSC.6100/6101L (https://www.uml.edu/catalog/courses/MLSC) Clinical Toxicology and Lab (4 cr)
- NUTR.5650 (https://www.uml.edu/catalog/courses/NUTR/5650) Lab Methods in Nutrition Assessment (3 cr)
- PHRM.6400/6420 (https://www.uml.edu/catalog/courses/PHRM) Pharmaceutical Analysis and Lab (4 cr)
- RADI.5060 (https://www.uml.edu/catalog/courses/RADI/5060) Nuclear Instrumentation with Lab (3 cr)

**ADVANCED CELL AND MOLECULAR BIOLOGY (3 cr.)***
- BIOL.5420 (https://www.uml.edu/catalog/courses/BIOL/5420) Advanced Cell Biology (3 cr)
- BIOL.5670 (https://www.uml.edu/catalog/courses/BIOL/5670) Molecular Biology (3 cr)
- BIOL.5820 (https://www.uml.edu/catalog/courses/BIOL/5820) Cancer Biology (3 cr)
- BIOL.6660 (https://www.uml.edu/catalog/courses/BIOL/6660) Selected Topics in Molecular and Cellular Biology (3 cr)
- NUTR.5720 (https://www.uml.edu/catalog/courses/NUTR/5720) Nutrigenetics (3 cr)
- RADI.5620 (https://www.uml.edu/catalog/courses/RADI/5620) Radiation Biology (3 cr)

*Students may take additional courses from the Core categories as Elective courses.
** Students who take this course, which included a co-requisite lab, to satisfy the Physiology Core requirement, may take a course from the Elective list below in place of the LAB core
Elective Specialization Course Requirements - Requirement 2
(minimum 12 credits)

All students shall complete a minimum of 12 credits of elective specialization courses. Students may take courses from one specialization area, across specialization areas and/or from the list of additional course offerings as noted below. Specialization courses will help the student attain depth in focused areas.

Elective Specialization Courses:

a. Courses in MEDICAL IMAGING AND INSTRUMENTATION
EECE.5100 (https://www.uml.edu/catalog/courses/EECE/5100) Digital Signal Processing
EECE.5110 (https://www.uml.edu/catalog/courses/EECE/5110) Medical Diagnostic Imaging
EECE.5410 (https://www.uml.edu/catalog/courses/EECE/5410) Introduction to Biosensors
EECE.5520 (https://www.uml.edu/catalog/courses/EECE/5520) Microprocessor Systems II & Embedded Systems
EECE.6150 (https://www.uml.edu/catalog/courses/EECE/6150) Medical Image Reconstruction
EECE.7100 (https://www.uml.edu/catalog/courses/EECE/7100) Selected Topics: Biomedical Imaging and Data Science

b. Courses in BIOTECHNOLOGY AND BIOPROCESSING
CHEN.5340 (https://www.uml.edu/catalog/courses/CHEN/5340) Industrial Bioprocessing
CHEN.5350 (https://www.uml.edu/catalog/courses/CHEN/5350) Cell and Microbe Cultivation
CHEN.5380 (https://www.uml.edu/catalog/courses/CHEN/5380) Advanced Separations in Biotechnology
CHEN.5450 (https://www.uml.edu/catalog/courses/CHEN/5450) Isolation and Purification of Biotech Products
CHEN.5460 (https://www.uml.edu/catalog/courses/CHEN/5460) Biomaterial Science
CHEN.5500 (https://www.uml.edu/catalog/courses/CHEN/5500) Biomedical Applications of Nanotechnology
CHEN.5550 (https://www.uml.edu/catalog/courses/CHEN/5550) Biopharmaceutical Regulatory Compliance

c. Courses in CLINICAL PATHOLOGY
MLSC.5120 (https://www.uml.edu/catalog/courses/MLSC/5120) Medical Bacteriology
MLSC.5500 (https://www.uml.edu/catalog/courses/MLSC/5500) Foundations in Biomedical Research
MLSC.5530 (https://www.uml.edu/catalog/courses/MLSC/5530) Emerging Topics in Clinical Chemistry
MLSC.5800 (https://www.uml.edu/catalog/courses/MLSC/5800) Clinical Applications of Molecular Genetics
MLSC.6130 (https://www.uml.edu/catalog/courses/MLSC/6130) Infections Disease
MLSC.6150 (https://www.uml.edu/catalog/courses/MLSC/6150) Medical Mycology and Parasitology
NUTR.5720 (https://www.uml.edu/catalog/courses/NUTR/5720) Nutrigenetics

d. Course in MEDICAL PLASTICS DESIGN AND MANUFACTURING
CHEN.5550 (https://www.uml.edu/catalog/courses/CHEN/5550) Biopharmaceutical Regulatory Compliance
PLAS.5030 (https://www.uml.edu/catalog/courses/PLAS/5030) Mechanical Behavior of Polymers
PLAS.5180 (https://www.uml.edu/catalog/courses/PLAS/5180) Plastics Product Design
PLAS.5530 (https://www.uml.edu/catalog/courses/PLAS/5530) Medical Device Design I
PLAS.5540 (https://www.uml.edu/catalog/courses/PLAS/5540) Medical Device Design II
PLAS.5750 (https://www.uml.edu/catalog/courses/PLAS/5750) Biomaterials I
PLAS.5790 (https://www.uml.edu/catalog/courses/PLAS/5790) Problems in Biomaterials
PLAS.6020 (https://www.uml.edu/catalog/courses/PLAS/6020) Medical Device Development Regulation
PLAS.6750 (https://www.uml.edu/catalog/courses/PLAS/6750) Biomaterials II

e. Courses in MOLECULAR & CELLULAR BIOTECHNOLOGY
BIOL.5410 (https://www.uml.edu/catalog/courses/BIOL/5410) Topics in Cell Biology
BIOL.5600 (https://www.uml.edu/catalog/courses/BIOL/5600) Stem Cell Biology
BIOL.5690L (https://www.uml.edu/catalog/courses/BIOL/5690L) Molecular Techniques
CHEN.5350 (https://www.uml.edu/catalog/courses/CHEN/5350) Cell and Microbe Cultivation
CHEN.5450 (https://www.uml.edu/catalog/courses/CHEN/5450) Isolation and Purification
f. Courses in PHARMACEUTICAL SCIENCES
   PHRM.6100 (https://www.uml.edu/catalog/courses/PHRM/6100) Principles of Pharmaceutical Sciences
   PHRM.6410 (https://www.uml.edu/catalog/courses/PHRM/6410) Drug Delivery
   PHRM.6600 (https://www.uml.edu/catalog/courses/PHRM/6600) Pharmacokinetics and Drug Metabolism

   g. Courses in ERGONOMICS AND BIOMECHANICS
   BMEN.5300 (https://www.uml.edu/catalog/courses/BMEN/5300) Ergonomics and Work
   BMEN.5380 (https://www.uml.edu/catalog/courses/BMEN/5380) Computational Biomechanics
   BMEN.5310 (https://www.uml.edu/catalog/courses/BMEN/5310) Occupational Biomechanics
   BMEN.5400 (https://www.uml.edu/catalog/courses/BMEN/5400) Occupational Safety Engineering
   BMEN.6380 (https://www.uml.edu/catalog/courses/BMEN/6380) Methods in Work Analysis
   PUBH.5061 (https://www.uml.edu/catalog/courses/PUBH/5061) Environmental Health

   h. Additional Course Offerings

   Biological Sciences:
   BIOL.5050L (https://www.uml.edu/catalog/courses/BIOL/5050) Bioinformatics
   BIOL.5090 (https://www.uml.edu/catalog/courses/BIOL/5090) Photobiology
   BIOL.5720 (https://www.uml.edu/catalog/courses/BIOL/5720) Virology
   BIOL.5840 (https://www.uml.edu/catalog/courses/BIOL/5840) Comparative Vertebrate Embryology
   BIOL.5930 (https://www.uml.edu/catalog/courses/BIOL/5930) Immunology
   BIOL.5940 (https://www.uml.edu/catalog/courses/BIOL/5940) Advanced Topics in Immunology
   BIOL.5 (https://www.uml.edu/catalog/courses/BIOL/5950) Bioinformatic Tolls in Sequence Analysis

   Biomedical Engineering:
   BMEN.5020 (https://www.uml.edu/catalog/courses/BMEN/5020) Biomedical Devices
   BMEN.5030 (https://www.uml.edu/catalog/courses/BMEN/5030) Medical Device Design
   BMEN.5035 (https://www.uml.edu/catalog/courses/BMEN/5035) Advanced Medical Device Development
   BMEN.5040 (https://www.uml.edu/catalog/courses/BMEN/5040) Medical Device Development Regulation
   BMEN.5110 (https://www.uml.edu/catalog/courses/BMEN/5110) Tissue Engineering
   BMEN.5115 (https://www.uml.edu/catalog/courses/BMEN/5115) Advanced Tissue Engineering
   BMEN.5130 (https://www.uml.edu/catalog/courses/BMEN/5130) Neural Engineering
   BMEN.5305 (https://www.uml.edu/catalog/courses/BMEN/5305) Biomechanics
   BMEN.5325 (https://www.uml.edu/catalog/courses/BMEN/5325) Biofluid Mechanics
   BMEN.5350 (https://www.uml.edu/catalog/courses/BMEN/5350) Respiratory Dynamics Devices
   BMEN.5380 (https://www.uml.edu/catalog/courses/BMEN/5380) Computational Biomechanics
   BMEN.5390 (https://www.uml.edu/catalog/courses/BMEN/5390) Computer Aided Engineering Design and Analysis
   BMEN>5410 Biomedical Optics
   BMEN.5610 (https://www.uml.edu/catalog/courses/BMEN/5610) Drug Delivery

   Chemistry:
   CHEM.5130 (https://www.uml.edu/catalog/courses/CHEM/5130) Spectroscopy
   CHEM.5500 (https://www.uml.edu/catalog/courses/CHEM/5500) Biochemistry I
   CHEM.5510 (https://www.uml.edu/catalog/courses/CHEM/5510) Biochemistry II
   CHEM.5550L (https://www.uml.edu/catalog/courses/CHEM/5550) Lab in Modern Biochemistry and Biophysics
   CHEM.5600 (https://www.uml.edu/catalog/courses/CHEM/5600) Advanced Physical Biochemistry
   CHEM.5620 (https://www.uml.edu/catalog/courses/CHEM/5620) Biopharmaceutical Development
   CHEM.5700
Protein Chemistry
CHEM.6310
(https://www.uml.edu/catalog/courses/CHEM/6310)
Principles of Medicinal Chemistry I

Chemical Engineering:
CHEN.5370
(https://www.uml.edu/catalog/courses/CHEN/5370)
Nanomaterials Characterization I
CHEN.5410
(https://www.uml.edu/catalog/courses/CHEN/5410)
Nanomaterials Characterization II

Electrical and Computer Engineering:
EECE.5160
(https://www.uml.edu/catalog/courses/EECE/5160)
Biomedical Imaging and Data Science
EECE.5440
(https://www.uml.edu/catalog/courses/EECE/5440)
Computational Data-Driven Modeling I
EECE.5470
(https://www.uml.edu/catalog/courses/EECE/5470)
Computational Data-Driven Modeling II
EECE.5560
(https://www.uml.edu/catalog/courses/EECE/5560)
Robotics
EECE.5590
(https://www.uml.edu/catalog/courses/EECE/5590)
Intro to Nanoelectronics
EECE.5680
(https://www.uml.edu/catalog/courses/EECE/5680)
ElectroOptic Systems
EECE.5810
(https://www.uml.edu/catalog/courses/EECE/5810)
Computational Vision & Digital Image Processing
EECE.5950
(https://www.uml.edu/catalog/courses/EECE/5950)
Solid State Electronics
EECE.6690
(https://www.uml.edu/catalog/courses/EECE/6690)
Optoelectronic Devices

Mechanical Engineering:
MECH.5710
(https://www.uml.edu/catalog/courses/MECH/5710)
Quality Engineering
MECH.5750
(https://www.uml.edu/catalog/courses/MECH/5750)
Industrial Design of Experiments
MECH.5760
(https://www.uml.edu/catalog/courses/MECH/5760)
Engineering Project Management
MECH.5960
(https://www.uml.edu/catalog/courses/MECH/5960)
Mechanics of Composite Materials

Medical Lab Science:
MLSC.5310
(https://www.uml.edu/catalog/courses/MLSC/5310)
Clinical Immunohematology
MLSC.6000
(https://www.uml.edu/catalog/courses/MLSC/6000)
Biomarker Discovery & Application
MLSC.6001
(https://www.uml.edu/catalog/courses/MLSC/6001)
Biomarker Discovery & Application Lab

Nutritional Science:
NUTR.5630
(https://www.uml.edu/catalog/courses/NUTR/5630)
Vitamins & Minerals
NUTR.6010
(https://www.uml.edu/catalog/courses/NUTR/6010)
Nutrition Assessment
NUTR.6040
(https://www.uml.edu/catalog/courses/NUTR/6040)
Nutrition Epidemiology

Pharmaceutical Science:
PHRM.6120
(https://www.uml.edu/catalog/courses/PHRM/6120)
Principles of Pharm Sciences Lab
PHRM.6501
(https://www.uml.edu/catalog/courses/PHRM/6501)
Drug Discovery

Plastics Engineering:
PLAS.5320
(https://www.uml.edu/catalog/courses/PLAS/5320)
Adhesives and Adhesion
PLAS.5970
(https://www.uml.edu/catalog/courses/PLAS/5970)
Plastics and the Environment
PLAS.6420
(https://www.uml.edu/catalog/courses/PLAS/6420)
Characterization of Polymers and Plastics

Radiological Science/Medical Physics:
RADI.5010L
(https://www.uml.edu/catalog/courses/RADI/5010)
Radiation Safety and Control I
RADI.5020L
(https://www.uml.edu/catalog/courses/RADI/5020)
Radiation Safety and Control II
RADI.5240
(https://www.uml.edu/catalog/courses/RADI/5240)
Environmental Health Physics
RADI.5330
(https://www.uml.edu/catalog/courses/RADI/5330)
External Radiation Dosimetry and Shielding
RADI.5340
(https://www.uml.edu/catalog/courses/RADI/5340)
Internal Radiation Dosimetry and Bioassay
RADI.5410
(https://www.uml.edu/catalog/courses/RADI/5410)
Radiochemistry
RADI.5650
(https://www.uml.edu/catalog/courses/RADI/5650)
Introduction to Radiation Therapy Physics
RADI.5820
Numerical Methods in Radiological Science

RADI.5980
Introduction to Medical Imaging

RADI.6050
Radiation Interactions and Transport

RADI.6060
Monte Carlo Simulation of Radiation Transport

RADI.6650
Advanced Radiation Therapy Physics

RADI.6980
Advanced Medical Imaging

Other:
XXXX.XXXX Other elective as approved by BMEBT Graduate Coordinator

Earning the Master of Science Degree
Following successful completion of coursework with a minimum of 31 credits completed or transferred in that satisfy the core and elective specialization courses, the student will be awarded the Master of Science degree. Students must have at least a cumulative B average to receive the Master of Science degree.

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).

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
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 academic ability and research potential, and commitment to an interdisciplinary, team-work approach.

Applications will be accepted from individuals holding appropriate bachelors 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 should have had undergraduate coursework in statistics/experimental design and life science/biomedical science, and meet the minimum requirements as stated below.

Applicants are encouraged to contact participating faculty to discuss potential research opportunities and to describe those discussions 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.

An application can be completed and submitted on-line. Applicants must submit the following and are expected to meet the standards indicated:

- Admission Requirements
- Academic and Research Advisors
- Transfer of Credits/Advanced Standing
- Academic Program
- General Program Requirements
- Core Course Requirements (Requirement 1)
- Elective Specialization Course Requirement (Requirement 2)
- Earning the En-Route MS Degree
- Doctoral Dissertation Proposal
- Selection of the Doctoral Dissertation Committee
- Qualifying Examination
- Doctoral Credit Requirements
- Dissertation Defense
- Appendix - Elective Specialization Courses
undergraduate and graduate transcripts from all schools attended.

- For acceptance into the program, applicants should present a minimum Graduate Record Exam (GRE) score of 142 in verbal and 152 in quantitative tests (294 combined). The date of the GRE exam should not precede the date of application by more than three years. The AACC will also pay particular attention to the applicants score on the GRE analytical writing section. Only official GRE scores from the Educational Testing Service will be considered acceptable.

- Applicants must have a minimum of two semesters or three quarters (equivalent of one academic year) of calculus, strong quantitative skills, and undergraduate coursework in statistics/experimental design and life science/biomedical science, as evidenced by their transcripts.

- International applicants, whose native language is not English, 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. Students who have completed at least two academic semesters of full time college/university in the United States may request a waiver of this requirement. For further details please see the information on international graduate admissions.

- 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:
  - Indication of an applicants qualifications and motivation for the program. Applicants should briefly describe 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 and career plans as they relate to the multidisciplinary nature of the BMEBT doctorate, and discuss their research experience (academic, industrial) and include any publications and grants or patents;
  - Indication of how an applicant will fit into the program. Applicants should describe 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.

Admissibility will be determined by the AACC. The AACC may take into consideration individual circumstance. Extraordinary qualifications in some areas can be used to outweigh weaknesses in others. Admissibility to the Program does not guarantee funding. Final acceptance into the program depends on the applicant securing the support of a research advisor in the form of a Research Assistant (RA), or a department that has an available Teaching Assistant (TA) position relevant to the student’s background, or a combination of these two. Other sources of funding, such as scholarships and self-support, are also possible. Applicants may be offered admission contingent upon the successful completion of remedial courses to fill gaps in preparation or knowledge.

Academic and Research Advisors

It is the responsibility of the applicant to identify a faculty research advisor with the assistance of the Program. The research advisor will serve as the chair of the student’s dissertation committee. Academic advising is initially the responsibility of the AACC, and it pertains to the completion of the core courses (Requirement 1). The research advisor will also hold the responsibility of serving as academic advisor with respect to the selection of specialization courses (Requirement 2) that may be applicable to the student’s research.

Transfer of Credits/Advanced Standing

For students who have previously completed graduate course work, the AACC may approve the transfer of graduate credits for courses from an accredited college or university in the United States or Canada that received a grade of B (3.0 on a 4.0 scale) or better if those courses were not required by another earned degree. The graduate school at each campus
The AACC may also approve to waive courses without transfer of course credit. Students would still be responsible for the full 31 credits required for the MS and 63 credits required for the Ph.D., but would not have to take the waived course.

To earn the en-route MS degree, a student must complete or transfer in credit to meet the core requirements (19 credits) and specialization requirements (12 credits) for Requirement 1 and Requirement 2, respectively. Transfer credits are not to exceed 24 in total.

Students who join the doctoral program with an earned masters degree may receive "Advanced Standing". For these students, the number of credits required to complete the Ph.D. will be determined by the AACC, but at a minimum 12 course credits (core or specialization), doctoral seminar (taken twice, 1 credit each) and 30 dissertation research credits will be required. Students with Advanced Standing will be required to submit a Doctoral Dissertation Proposal and pass the Doctoral Qualifying Examination before progressing to the dissertation stage. As part of its academic advising roles, Advanced Standing is initiated by the AACC, but the formal request is filed by the student via completing an Academic Petition with attached supporting documentation, such as transcripts and course syllabi. The AACC can request information from the student pertaining to courses taken at the previous institution(s) and other relevant material prior to making a final decision on what courses the student will be required to take at UMass Lowell. The AACC will prepare an Advanced Standing Letter, summarizing the academic requirements, including courses the student will have to take.

Academic Program

The curriculum is organized around common experiences, including common core courses, elective courses and specialization options, and a research project. 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 a variety of courses, including the research project, and in the selection of the dissertation committee. In addition, each student then completes a focused research project leading to a doctoral dissertation. Industry representation may occur in the research project, doctoral seminar series, and via participation in the Doctoral Dissertation Committee.

General Program Requirements

The program of courses is based on the MS curriculum and it includes a core requirement, including a research project (Requirement 1), elective specialization requirement (Requirement 2), and two credits of doctoral seminar. As students advance, they will have to pass a qualifying examination, which is combined with the defense of the dissertation proposal, complete a dissertation project with a minimum of 30 credits of research, and pass the dissertation defense.

The Ph.D. degree 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 academic requirements of their “home campus” for such matters as grade point averages, documentation of completion of requirements, registration for program continuation if needed, and submitting the final dissertation to the library along with other documents required for graduation. No course receiving a grade below C (2.0 on a 4.0 scale) can receive credit to satisfy the minimum credit requirement. 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 registration 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 academic advisor. The interdisciplinary nature of this program makes close contact between each student and his or her advisor important. Academic petitions pertaining to approval of core of elective specialization courses that are not listed in the approved course list should be routed through the academic and/or research advisors before being submitted to the AACC for review.

Core Course Requirements (Requirement 1)

The core courses follow the MS curriculum. They provide a common foundation for all students, either from life science or physical science/engineering backgrounds. A detailed list of courses in the MS curriculum is provided in the Appendix. Briefly, core requirements consist of three compulsory courses and four additional courses selected from four categories of approved courses.

Students shall complete the following three core courses:

BMBT.5000
(https://www.uml.edu/catalog/courses/BMBT/5000) Introduction to Biomedical Engineering and Biotechnology (3 cr)
BMBT.5200
(https://www.uml.edu/catalog/courses/BMBT/5200) Bioethics (1 cr)
Research Project (3 cr) - Independent Study/Advanced Project / BMBT.7200
For the Research Project, students should register for an Independent Study or Advanced Project taken from the research Advisor’s department. If the Research Advisor can’t set up a number in their department, the student should register for the BMBT.7200 Independent Study with a section established for the Research Advisor. The Research Project course should be taken toward the end of the MS course requirements to help students prepare for Qualifier Exam/Proposal Defense.

Students shall take one course from each of the following four core categories. Students are encouraged to consult their research and/or academic advisors for the most appropriate selection from the approved courses in each of these categories. Upon recommendation by their advisors, and with adequate justification expressed on the academic petition, approved courses may be substituted by other courses that substantively relate to these respective categories.

**Mathematics (3 cr)**
- BMEN.5 (Computational Biomechanics)
- CHEN.5390 (Math Methods for Engineers)
- CHEN.5480 (Engineering Process Analytics)
- MATH.5300 (Applied Math I)
- MATH.5 (Statistical Programming Using SAS)
- PHYS.5630 (Computational Methods in Physics)
- PLAS.5480 (Analytical and Numerical Methods in Plastics Processing)
- PUBH.5750 (Epidemiology and Biostatistics)

**Physiology (3-4 cr)**
- BIOL.5490L (Biological of Muscle and Lab (4 cr))
- BIOL.5620/5630L (Cardiovascular Physiology Lecture and Lab (4 cr))
- BIOL.5800/5810L (Developmental Biology and Lab (4 cr))
- BIOL.5900 (Human Neurobiology (3 cr))
- HSCI.5510 (Clinical Pathophysiology (3 cr))

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**Laboratory (3-5 cr)**
- BIOL.5190/5210L (Biochemistry Techniques (5 cr))
- BIOL.5290 (Recombinant Protein Production Techniques (4 cr))
- BIOL.5320/5340L (Genomics and Lab (4 cr))
- BIOL.5760 (Cell Culture (4 cr))
- BIOL.5950 (Immunology Lecture and Lab (2 cr))
- CHEN.5860 (Biotech Processing Projects Lab (3 cr))
- EECE.5600 (Biomedical Instrumentation (3 cr))
- MLSC.6100/6101L (Clinical Toxicology and Lab (4 cr))
- NUTR.5650 (Lab Methods in Nutrition Assessment (3 cr))
- PHRM.6400/6420L (Pharmaceutical Analysis and Lab (4 cr))
- RADI.5060 (Nuclear Instrumentation with Lab (3 cr))

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**Advanced Cell and Molecular Biology (3 cr)**
- BIOL.5420 (Advanced Cell Biology (3 cr))
- BIOL.5670 (Molecular Biology (3 cr))
- BIOL.5820 (Cancer Biology (3 cr))
- BIOL.6660 (Selected Topics in Molecular and Cellular Biology (3 cr))

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**Other math course approved by the AACC**

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**Other physiology course approved by the AACC**

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**Other lab course approved by the AACC**
The Doctoral Qualifying Examination must be taken within one year after completion of the MS Biomedical Engineering and Biotechnology requirements or within two years for students with advanced standing. It will consist of an oral presentation of the written dissertation proposal to an audience of peers and the Doctoral Dissertation Committee, followed by examination by the Committee.

At least two weeks prior to the date of the presentation of the dissertation proposal, an announcement must be submitted to the program graduate coordinator to be posted on UML Announcements. At the same time, the written copy of the proposal must be provided to the Dissertation Committee members.

The dissertation proposals presentation is open to the public. The presentation 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 no longer than 45 minutes. The presentation should clearly articulate the proposed contribution of the student to the knowledge base and how it differs from or complements past work. The examinee will be expected to answer questions from the audience to demonstrate his/her understanding of the proposed research, as well as his/her proficiency in the general research field related to the dissertation proposal.

Following the presentation, the Dissertation Committees examination will primarily focus on the subject of the proposal, but it may also include areas that may come up during the discussion, as appropriate.
After successfully defending the dissertation proposal and passing the concomitant examination, the student attains the designation doctoral candidate. If the student fails any part of the Doctoral Qualifier Examination, the Doctoral Dissertation Committee may recommend retaking it within one or two semesters, depending on the circumstances. Failure to pass the second Doctoral Qualifier Examination results in dismissal from the Ph.D. program.

**Doctoral Credit Requirements**

1. **Doctoral Seminar** - 2 credits minimum (credits for a seminar depends on host department)
   
   Doctoral students should present research in progress in an appropriately selected doctoral seminar. The selection of the most appropriate seminar will be based on the suggestion of the students research advisor. The seminar will emphasize not only research, but also communication and writing. Students will write summaries of each presentation and submit it to the AACC/graduate coordinator as a progress report. Course is graded pass-fail or satisfactory-unsatisfactory (depending on grading system in use for each department).

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/qualifying examination, carrying out their dissertation research and preparation and defense of the doctoral dissertation.

**Appendix: Elective Specialization Courses**

*a. Courses in MEDICAL IMAGING AND INSTRUMENTATION*

- EECE.5100 [Digital Signal Processing](https://www.uml.edu/catalog/courses/EECE/5100)
- EECE.5110 [Medical Diagnostic Imaging](https://www.uml.edu/catalog/courses/EECE/5110)
- EECE.5410 [Introduction to Biosensors](https://www.uml.edu/catalog/courses/EECE/5410)
- EECE.5520 [Microprocessor Systems II & Embedded Systems](https://www.uml.edu/catalog/courses/EECE/5520)
- EECE.6150 [Medical Image Reconstruction](https://www.uml.edu/catalog/courses/EECE/6150)
- EECE.7100 [Selected Topics: Biomedical Imaging and Data Science](https://www.uml.edu/catalog/courses/EECE/7100)

*b. Courses in BIOTECHNOLOGY AND BIOPROCESSING*

- CHEN.5340 [Industrial Bioprocessing](https://www.uml.edu/catalog/courses/CHEN/5340)
- CHEN.5350 [Cell and Microbe Cultivation](https://www.uml.edu/catalog/courses/CHEN/5350)
- CHEN.5380 [Advanced Separations in Biotechnology](https://www.uml.edu/catalog/courses/CHEN/5380)
- CHEN.5450 [Isolation and Purification of Biotech Products](https://www.uml.edu/catalog/courses/CHEN/5450)
- CHEN.5460 [Biomaterial Science](https://www.uml.edu/catalog/courses/CHEN/5460)
- CHEN.5500 [Biomedical Applications of Nanotechnology](https://www.uml.edu/catalog/courses/CHEN/5500)
- CHEN.5550 [Biopharmaceutical Regulatory Compliance](https://www.uml.edu/catalog/courses/CHEN/5550)

*c. Courses in CLINICAL PATHOLOGY*

- MLSC.5120 [Medical Bacteriology](https://www.uml.edu/catalog/courses/MLSC/5120)
- MLSC.5500 [Foundations in Biomedical Research](https://www.uml.edu/catalog/courses/MLSC/5500)
- MLSC.5530 [Emerging Topics in Clinical Chemistry](https://www.uml.edu/catalog/courses/MLSC/5530)
MLSC.5800
(https://www.uml.edu/catalog/courses/MLSC/5800) Clinical Applications of Molecular Genetics
MLSC.6130
(https://www.uml.edu/catalog/courses/MLSC/6130) Infectious Disease
MLSC.6150
(https://www.uml.edu/catalog/courses/MLSC/6150) Medical Mycology and Parasitology

d. Courses in MEDICAL PLASTICS DESIGN AND MANUFACTURING
CHEN.5530
(https://www.uml.edu/catalog/courses/CHEN/5530) Biopharmaceutical Regulatory Compliance
PLAS.5030
(https://www.uml.edu/catalog/courses/PLAS/5030) Mechanical Behavior of Polymers
PLAS.5180
(https://www.uml.edu/catalog/courses/PLAS/5180) Plastics Product Design
PLAS.5530
(https://www.uml.edu/catalog/courses/PLAS/5530) Medical Device Design I
PLAS.5540
(https://www.uml.edu/catalog/courses/PLAS/5540) Medical Device Design II
PLAS.5750
(https://www.uml.edu/catalog/courses/PLAS/5750) Biologics I
PLAS.5790
(https://www.uml.edu/catalog/courses/PLAS/5790) Problems in Biologics
PLAS.6020
(https://www.uml.edu/catalog/courses/PLAS/6020) Medical Device Development Regulation
PLAS.6750
(https://www.uml.edu/catalog/courses/PLAS/6750) Biologics II

e. Courses in MOLECULAR & CELLULAR BIOTECHNOLOGY
BIOL.5410
(https://www.uml.edu/catalog/courses/BIOL/5410) Topics in Cell Biology
BIOL.5600
(https://www.uml.edu/catalog/courses/BIOL/5600) Stem Cell Biology
BIOL.5690L
(https://www.uml.edu/catalog/courses/BIOL/5690L) Molecular Techniques
CHEN.5350
(https://www.uml.edu/catalog/courses/CHEN/5350) Cell and Microbe Cultivation
CHEN.5450
(https://www.uml.edu/catalog/courses/CHEN/5450) Isolation and Purification

f. Courses in PHARMACEUTICAL SCIENCES
PHRM.6100
(https://www.uml.edu/catalog/courses/PHRM/6100) Principles of Pharmaceutical Sciences
PHRM.6410
(https://www.uml.edu/catalog/courses/PHRM/6410) Drug Delivery
PHRM.6600
(https://www.uml.edu/catalog/courses/PHRM/6600) Pharmacokinetics and Drug Metabolism

g. Courses in ERGONOMICS AND BIOMECHANICS
BMEN.5300
(https://www.uml.edu/catalog/courses/BMEN/5300) Ergonomics and Work
BMEN.5310
(https://www.uml.edu/catalog/courses/BMEN/5310) Occupational Biomechanics
BMEN.5380
(https://www.uml.edu/catalog/courses/BMEN/5380) Computational Biomechanics
BMEN.5400
(https://www.uml.edu/catalog/courses/BMEN/5400) Occupational Safety Engineering
BMEN.6380
(https://www.uml.edu/catalog/courses/BMEN/6380) Methods in Work Analysis
PUBH.5061
(https://www.uml.edu/catalog/courses/PUBH/5061) Environmental Health
PUBH.5510

h. Additional Course Offerings

Biological Sciences:
BIOL.5050L
(https://www.uml.edu/catalog/courses/BIOL/5050) Bioinformatics
BIOL.5090
(https://www.uml.edu/catalog/courses/BIOL/5090) Photobiology
BIOL.5720
(https://www.uml.edu/catalog/courses/BIOL/5720) Virology
BIOL.5840
(https://www.uml.edu/catalog/courses/BIOL/5840) Comparative Vertebrate Embryology
BIOL.5930
(https://www.uml.edu/catalog/courses/BIOL/5930) Immunology
BIOL.5940
(https://www.uml.edu/catalog/courses/BIOL/5940) Advanced Topics in Immunology

Biomedical Engineering:
BMEN.5020
(https://www.uml.edu/catalog/courses/BMEN/5020) Biomaterials
BMEN.5030
(https://www.uml.edu/catalog/courses/BMEN/5030) Medical Device Design
BMEN.5035
(https://www.uml.edu/catalog/courses/BMEN/5035) Advanced Medical Device Development
BMEN.5040
(https://www.uml.edu/catalog/courses/BMEN/5040) Medical Device Development
BMEN.5110
(https://www.uml.edu/catalog/courses/BMEN/5110) Tissue
Engineering
BMEN.5115
(https://www.uml.edu/catalog/courses/BMEN/5115) Advanced
Tissue Engineering
BMEN.5130
(https://www.uml.edu/catalog/courses/BMEN/5130) Neural
Engineering
BMEN.5305
(https://www.uml.edu/catalog/courses/BMEN/5305)
Biomechanics
BMEN.5325
(https://www.uml.edu/catalog/courses/BMEN/5325) Biofluid
Mechanics
BMEN.5350
(https://www.uml.edu/catalog/courses/BMEN/5350)
Respiratory Dynamics Devices
BMEN.5380
(https://www.uml.edu/catalog/courses/BMEN/5380)
Computational Biomechanics
BMEN.5390
(https://www.uml.edu/catalog/courses/BMEN/5390)
Computer
Aided Engineering Design and Analysis
BMEN.5410
(https://www.uml.edu/catalog/courses/BMEN/5410)
Biomedical Optics
BMEN.5610
(https://www.uml.edu/catalog/courses/BMEN/5610) Drug
Delivery

Chemical Engineering:
CHEN.5370
(https://www.uml.edu/catalog/courses/CHEN/5370)
Nanomaterials Characterization I
CHEN.5410
(https://www.uml.edu/catalog/courses/CHEN/5410)
Nanomaterials Characterization II

Chemistry:
CHEM.5130
(https://www.uml.edu/catalog/courses/CHEM/5130)
Spectroscopy
CHEM.5500
(https://www.uml.edu/catalog/courses/CHEM/5500)
Biochemistry I
CHEM.5510
(https://www.uml.edu/catalog/courses/CHEM/5510)
Biochemistry II
CHEM.5530L
(https://www.uml.edu/catalog/courses/CHEM/5530L) Lab in
Modern Biochemistry and Biophysics
CHEM.5600
(https://www.uml.edu/catalog/courses/CHEM/5600) Advanced
Physical Biochemistry
CHEM.5620
(https://www.uml.edu/catalog/courses/CHEM/5620)
Biopharmaceutical Development
CHEM.5700
(https://www.uml.edu/catalog/courses/CHEM/5700) Protein
Chemistry
CHEM.6310
(https://www.uml.edu/catalog/courses/CHEM/6310) Principles
of Medicinal Chemistry I

Electrical and Computer Engineering:
EECE.5160
(https://www.uml.edu/catalog/courses/EECE/5160) Biomedical Imaging and Data Sci
EECE.5440
(https://www.uml.edu/catalog/courses/EECE/5440) Comp. Data-Driven Modeling I
EECE.5470
(https://www.uml.edu/catalog/courses/EECE/5470) Comp. Data-Driven Modeling II
EECE.5560
(https://www.uml.edu/catalog/courses/EECE/5560) Robotics
EECE.5590
(https://www.uml.edu/catalog/courses/EECE/5590) Intro to Nanoelectronics
EECE.5680
(https://www.uml.edu/catalog/courses/EECE/5680) Electro Optic Systems
EECE.5810
(https://www.uml.edu/catalog/courses/EECE/5810) Comp Vision &Dig Image Proc
EECE.5950
(https://www.uml.edu/catalog/courses/EECE/5950) Solid State Electronics
EECE.6690
(https://www.uml.edu/catalog/courses/EECE/6690) Opto Electronic Devices

Mechanical Engineering:
MECH.5710
(https://www.uml.edu/catalog/courses/MECH/5710) Quality
Engineering
MECH.5750
(https://www.uml.edu/catalog/courses/MECH/5750) Industrial
Design of Experiments
MECH.5760
(https://www.uml.edu/catalog/courses/MECH/5760) Engineering Project Management
MECH.5960
(https://www.uml.edu/catalog/courses/MECH/5960) Mechanics
of Composite Materials

Medical Lab Science:
MLSC.5310
(https://www.uml.edu/catalog/courses/MLSC/5310) Clinical
Immunohematology
MLSC.6000
(https://www.uml.edu/catalog/courses/MLSC/6000) Biomarker
Discovery & App
MLSC.6001
(https://www.uml.edu/catalog/courses/MLSC/6001) Biomarker
Discovery & App Lab

Nutritional Science:
NUTR.5630
(https://www.uml.edu/catalog/courses/NUTR/5630) Vitamins
& Minerals
NUTR.6010
(https://www.uml.edu/catalog/courses/NUTR/6010) Nutrition
Assessment
NUTR.6040
Nutrition Epidemiology

**Pharmaceutical Science:**
PHRM.6120 (https://www.uml.edu/catalog/courses/PHRM/6120) Principles of Pharm Sciences Lab
PHRM.6501 (https://www.uml.edu/catalog/courses/PHRM/6501) Drug Discovery

**Plastics Engineering:**
PLAS.5320 (https://www.uml.edu/catalog/courses/PLAS/5320) Adhesives and Adhesion
PLAS.5970 (https://www.uml.edu/catalog/courses/PLAS/5970) Plastics and the Environment
PLAS.6420 (https://www.uml.edu/catalog/courses/PLAS/6420) Characterization of Polymers and Plastics

**Radiological Science/Medical Physics:**
RADI.5010L (https://www.uml.edu/catalog/courses/RADI/5010) Radiation Safety and Control I
RADI.5020L (https://www.uml.edu/catalog/courses/RADI/5020) Radiation Safety and Control II
RADI.5240 (https://www.uml.edu/catalog/courses/RADI/5240) Environmental Health Physics
RADI.5330 (https://www.uml.edu/catalog/courses/RADI/5330) External Radiation Dosimetry and Shielding
RADI.5340 (https://www.uml.edu/catalog/courses/RADI/5340) Internal Radiation Dosimetry and Bioassay
RADI.5410 (https://www.uml.edu/catalog/courses/RADI/5410) Radiochemistry
RADI.5650 (https://www.uml.edu/catalog/courses/RADI/5650) Introduction to Radiation Therapy Physics
RADI.5820 (https://www.uml.edu/catalog/courses/RADI/5820) Numerical Methods in Radiological Science
RADI.5980 (https://www.uml.edu/catalog/courses/RADI/5980) Introduction to Medical Imaging
RADI.6050 (https://www.uml.edu/catalog/courses/RADI/6050) Radiation Interactions and Transport
RADI.6650 (https://www.uml.edu/catalog/courses/RADI/6650) Advanced Radiation Therapy Physics
RADI.6980 (https://www.uml.edu/catalog/courses/RADI/6980) Advanced Medical Imaging

**Other:**
XXXX.XXXX Other elective as approved by BMEBT

Graduate Coordinator
BMBT.5000 Introduction to Biomedical Engineering & Biotechnology (Formerly IB 500) - Credits: 3

This introductory course envelopes a breadth of different topics and fundamental concepts in biomedical engineering and biotechnology (BMEBT) that will allow students to explore and identify areas that may be of interest to them. Topics covered in the course may include, but are not limited to, the following: engineering and ethics, anatomy and physiology, biomechanics, biomaterials, tissue engineering, bioinstrumentation, biomedical sensors, biosignal processing, radiation treatment and medical imaging. Speakers from industry may also be invited to present topics of contemporary importance.

BMBT.5120 Medical Image Processing (Formerly IB 512) - Credits: 3

This course will focus on post-acquisition manipulation and analysis used clinically and in research. Techniques for processing N-dimensional images acquired using several different medical image modalities will be studied including basic image visualization, filtering, segmentation and registration. The emphasis will be on engineering methods & techniques rather than a rigorous mathematical investigation of algorithms and theory. Programming will not be required, but homework and projects will require use of an open-source software tool, ImageJ, to perform image processing tasks. [NOTE: Many students in prior semesters have expressed a preference for using MATLAB from Mathworks for image processing. All assignments can be completed using either ImageJ OR MATLAB].

BMBT.5130 Biomedical Analytics & Informatics (Formerly IB 513) - Credits: 3

The focus of this course will be on the analysis of large biomedical data sets using the R Programming Language, an open-source programming language with several development platforms freely available for Windows, Mac, and Linux. The central topics will cover basic data analytics methods applying the widely used data analysis tool, R. This course will not focus on any specific biotechnology area. Many of the analytical skills obtained can be applied across a number of biomedical applications. The syllabus also covers an overview of major biomedical "Big Data" areas. Students may implement their final course project using a dataset in any biomedical application area of their choosing, i.e. genomics, medical imaging, health policy informatics, and personal health monitoring. There is no programming pre-requisite for this course. Students must have the willingness and capacity to learn how to apply R Programming.

BMBT.5160 Basic Principles of Nuclear Magnetic Resonance Imaging (Formerly IB 516) - Credits: 3

The goal of this course is to provide the student with a general understanding of the physical principles of magnetic resonance imaging (MRI) and the instrumentation used to create a magnetic resonance image. This goal will be sought without deep exploration of any particular physical science or mathematical discipline. Background knowledge in freshman-level science and mathematics courses is assumed. The topics to be covered in this course include: 1) theoretical and experimental aspects of MRI and their application to problems in medicine and biology, 2) physical principles underlying the generation and detection of the nuclear magnetic resonance signal, 3) MRI instrumentation, and 4) Nuclear magnetic resonance relaxation parameters and how they affect contrast in a magnetic resonance image.

BMBT.5170 Embedded System Design in Medical Systems (Formerly IB 517) - Credits: 3

This course covers the design principles of embedded systems including both the hardware and software aspects. We will introduce the design methodology and cost effectiveness of embedded systems. We will discuss the microprocessor, memory and storage subsystems. The interfacing between the computer system and medical instruments will be reviewed. Firmware, operating systems, programming tools will be considered. The course will have a lab component that includes hands-on exercises of embedded Linux (or RTEMS) in an online virtual laboratory environment.

BMBT.5200 Ethical Iss. Biomedical (Formerly IB 520) - Credits: 1

The purpose of this course is to illustrate the ethical implications of engineering, and how to reason through these implications and make the best decisions possible. This course addresses ethical issues that arise in the discipline of biomedical engineering. Unlike most bioethics courses, this course draws from the literature in biomedical ethics and from engineering ethics, to cover important emerging issues that face biomedical engineers. Topics may include, but are not limited to, ethics related to general research, public health, robotic surgery, medical device validation, gene editing, artificial organs, longevity research, prosthetics, artificial intelligence, and brain-computer interfaces.

BMBT.5250 Introduction to Translational Science (Formerly IB 525) - Credits: 3

Introduction to Translational Science will introduce students to the elements of translational research and is targeted toward individuals who have no prior experience with clinical or translational research. This course will focus on the principles and practices of translational medicine as they apply to the
development of a new drug (small molecules and/or biologics), device, or diagnostic. The course will cover the following topics: Defining translational research, pre-clinical development of novel targets and leads, clinical development, the regulatory process, the design of the first-in-human clinical trial, protecting human subjects and managing clinical data.

BMBT.5500 BMBT Laboratory Experience (Formerly IB 550) - 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.6000 Capstone Project (Formerly IB 600) - Credits: 3

Design or research project, either on campus or in industry, that synthesizes the knowledge accumulated in the BMEBT core curriculum. The course includes a brief project proposal, final report and presentation to be overseen by a UMass Lowell faculty member, as well as industry sponsor if conducting the research in industry. All research must be publishable (i.e. projects with strict IP are not allowed). Students should register in their final semester of MS required coursework.

BMBT.6010 Sem: Biomedical Engineering & Biotechnology (Formerly IB 601) - Credits: 3

The goal of the seminar is to have students develop effective writing and speaking skills required for preparation of research papers and professional presentations. The course emphasizes the importance of clear, concise writing style and delivery of presentations to both scientists and the lay public. Outside readings are designed to critically evaluate contemporary issues related to: disclosure and conflict of interest, publishing ethics, the balance of research, security, and publishing censorship, electronic science collaborations, and the social implications of science. Preparation of research grant proposals, the curriculum vitae, and poster presentations, and the submission of manuscripts for publication are also reviewed.

BMBT.6050 1-Credit Continued Capstone Project (Formerly IB 605) - Credits: 1

1-Credit Continued Capstone Project course is for students who need an extra semester to complete their capstone. Part of reduced course load program for international students.

BMBT.7100 Directed Study (Formerly BMBT 710) - Credits: 1-3

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.7560 Doctoral Dissertation (Formerly IB 756) - Credits: 6

BMBT.7590 Dissertation Research (Formerly IB 759) - Credits: 1-9

BMBT.7610 Continued Graduate Research - Credits: 1

BMBT.7700 CPT - Co-op Training (Formerly IB 770) - Credits: 1

Course required to perform CPT.

BMBT.7710 CPT-Co-op Training (Formerly IB 771) - Credits: 0-1

Course required to perform CPT. "Variable credit course, student chooses appropriate amount of credits when registering."

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

Thesis Review

BMEN.5020 Fundamentals of Biomaterials - Credits: 3

This course will provide an introduction to materials used in biomedical applications. It will provide students with an understanding of the fundamental principles and language associated with current biomaterials research and to understand the issues associated with medical applications of these materials. The goal is to enable students in the course to read the biomaterials literature with critical understanding. The course will introduce principles of materials science and cell biology underlying the design of medical implants, artificial organs, and matrices for tissue engineering and covers surface
chemistry and physics of selected biomaterials, surface characterization methodology, acute and chronic response to implanted biomaterials, and molecular and cellular interactions.

**BMEN.5035 Advanced Medical Device Development**  
- Credits: 3

This course focuses on the events that occur after the “solution concept freeze” in the medical device development process, including device designs, clinical evaluation, quality systems, manufacturing processes, regulatory and legal compliance.

**BMEN.5040 Medical Device Development Regulation**  
- Credits: 3

A 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 though the Center for Devices and Radiological Health (CDRH) investigation device exemptions, premarket approval, 510(k) application process and product development protocol and review process.

**BMEN.5110 Tissue Engineering**  
- Credits: 3

Tissue engineering utilizes engineering materials, cells, and other biochemical factors to develop and manipulate cells, tissues, or organs which can replace and/or support biological functions. In this course, we will explore the principles underlying tissue structure-function relationships; how to rationally alter, restore, or improve cellular environments; and clinical implementations.

**BMEN.5115 Advanced Tissue Engineering**  
- Credits: 3

Tissue engineering research continues to attract the interest of researchers and the general public. Popular media outlets like the New York Times, Time, and Wired continue to engage a wide audience and foster excitement for the field as regenerative medicine inches toward becoming a clinical reality. This course will cover enabling technologies, and current applications of the tissue engineering field. The enabling technologies section will focus upon those strategies typically incorporated into tissue-engineered devices or utilized in their development, including advanced scaffolding techniques, bioreactors, and micro physiological systems. Finally, the applications section presents engineered tissues and organs that are currently under development for generative medicine applications.

**BMEN.5130 Neural Engineering**  
- Credits: 3

Neural Engineering represents the intersection between neuroscience and the technologies designed to measure and modulate the nervous system. This course will review the fundamental principles of cellular and systems neuroscience in the peripheral and central nervous systems, followed by surveys of cutting edge optical/electrical neural interfaces, in vivo/vitro synthetic model systems, prostheses, as well as ethical considerations in neuroscience/neural engineering.

**BMEN.5200 Bioinstrumentation**  
- Credits: 3

This course builds upon students' undergraduate knowledge/experience in circuit analysis and biological signal quantification/processing. Using analog and digital filtering/processing techniques, students will analyze real data sets related to cell/tissue imaging, biomedical imaging, force transduction, and electrophysiological recordings (EMG, EKG, and MEA). As a final project, students will be required to design and propose a set of experiments using bioinstrumentation techniques covered in class, with an emphasis on failure modes and effects analysis (hardware) as well as signal processing and proposed statistical analysis.

**BMEN.5300 Ergonomics and Work (Formerly BMBT.5300)**  
- Credits: 3

An overview of the scientific basis for design of the workplace to optimize physical and mental interaction of workers with machines, tools, and work methods. Topics include work measurement, anthropometry, biomechanics, work physiology, cumulative trauma disorder and information presentation and processing.

**BMEN.5305 Biomechanics**  
- Credits: 3

The course provides an overview of musculoskeletal anatomy, the mechanical properties and structural behavior of biological tissues, and biodynamics. Specific course topics will include structure and function relationships in tissues and organs; application of stress and strain analysis to biological tissues; analysis of forces in human function and movement; energy and power in human activity; introduction to modeling viscoelasticity of tissues.

**BMEN.5315 Biomechanics II**  
- Credits: 3

This course prepares students with the mathematical preliminaries and theoretical framework to analyze the mechanics of biological materials and human movement. The course will focus on methods to model biological tissues as non-linear, elastic, homogeneous, anisotropic, incompressible materials, and analyze human movement, including the impulse-momentum and work-energy principles, as well as gait analysis.

**BMEN.5320 Occupational Biomechanics Laboratory**
(Formerly BMBT.5320) - Credits: 3
A laboratory presentation of the biomechanical basis for understanding and predicting human motor capabilities using bioinstrumentation. Computerized data acquisition, electromyography and load cells for strength measurement are examples of the equipment used in this lab. Particular emphasis is placed on the evaluation of occupational activities.

BMEN.5325 Biofluid Mechanics - Credits: 3
This course will introduce fundamental principles and mathematical/physical models for air and blood flow in the physiological systems. Their practical applications will be discussed, with an emphasis on modeling and the potential of flow studies for clinical research applications.

BMEN.5350 Respiratory Dynamics and Devices - Credits: 3
An aerosol is an assembly of particles suspended in a gaseous medium. They are omnipresent in our workplaces and outdoor environments. They include a wide range of phenomena such as dust, fume, smoke, mist, fog, haze, clouds and smog. Certain aerosols pose significant health threats, while others improve the quality of our lives. It is necessary to understand how airborne particles behave to control against their undesirable effects and to harness their beneficial potential. This course will explore the mechanics of aerosol behavior, including their generation, transformation, and fate occupational and environmental settings.

BMEN.5380 Computational Biomechanics - Credits: 3
Computational biomechanics is a powerful engineering method to model fluid-structure interaction in biological systems. While its traditional roots are in the realm of engineering, the techniques have found wide use in the biomedical engineering domain to simulate the biomechanical response and hemodynamics of the human body and medical devices. This course will prepare students with hands-on and practical skills using computational packages and software to solve biomechanical problems.

BMEN.5390 Computer Aided Design for Biomedical Engineering - Credits: 3
This course introduces the student to the use of CAD for construction of basic shapes and multi-vie drawings. It is a project-oriented course introducing the student to graphic design using SolidWorks. Design, analysis and visualization of engineering components and systems using interactive computer programs with an emphasis on computer simulation.

(Formerly BMBT.5400) - Credits: 3
The purpose of this course is to introduce students to the principles of safety hazards in the work environment. This course is primarily designed to emphasized the safety aspects to the hazards at work. It begins with the historical development of occupational safety and health and progressively examines the fundamentals of recognition, measurement, evaluation, and control of occupational safety hazards.

BMEN.5410 Biomedical Optics - Credits: 3
This course will introduce fundamental principles of the interactions between light and biological tissue, including their applications in biology and medicine for detection, imaging, and treatment.

BMEN.5610 Drug Delivery - Credits: 3
This class describes the engineering of pharmaceutical delivery systems emphasizing design and application of materials and novel techniques to overcome challenges or barrier to effective drug delivery. Topics will include drug delivery fundamentals and transport mechanisms, drug formation for delivery, and applications.

BMEN.5810 Data Analytics & Biostatistics for BME - Credits: 3
Data analysis is a major skill that is required to solve problems as well as to design and develop biotechnology solutions and medical devices. A bioengineer must not only apply the long standard general statistical methods in order to analyze data but also master some of the unique aspects involved in the analysis of biomedical datasets. This course will require the student to become proficient in MATLAB and the Statistics and Machine Learning Toolbox in order to achieve course learning objectives. The student will also be required to demonstrate their bioanalytical proficiency through the implementation of an individual project.

BMEN.6090 Research Methods in Medical Device Design - Credits: 3
Research Methods will provide biomedical engineering graduate students with a mentored experience to learn and master a hands-on research methodology. Appropriate research methodologies are those within Medical Device Design that provide the student with critical hands-on skillsets to further support their graduate studies. Student will work approximately 3 hours a week per credit on a designated research project. Regular meetings with the research mentor will also occur. Students are required to submit final project report and final presentation to their mentor.
BMEN.6190 Research Methods in Cellular & Tissue Engineering - Credits: 3

Research Methods will provide biomedical engineering graduate students with a mentored experience to learn and master a hands-on research methodology. Appropriate research methodologies are those within Cellular and Tissue Engineering that provide the student with critical hands-on skillsets to further support their graduate studies. Student will work approximately 3 hours a week per credit on a designated research project. Regular meetings with the research mentor will also occur. Students are required to submit final project report and final presentation to their mentor.

BMEN.6320 Advanced Biomechanics (Formerly BMBT.6320) - Credits: 3

A course in advanced biomechanical modeling methods, covering three dimensional static models, optimization methods and dynamic models. Special emphasis will be placed on biomechanical models of the hand. Time will also be dedicated to reviewing current developments in the scientific literature.

BMEN.6380 Methods of Work Analysis (Formerly BMBT.6380) - Credits: 3

Criteria for selection of an approach to ergonomic job analysis depend on the combination of exposures (Micro- and Macro-level ergonomic stressors) observed to be present as well as the analytical goal. Many ergonomic analysis techniques are based on traditional industrial engineering approaches (time-motion study and work sampling), applied to the identification and evaluation of potential risks to workers' health. A variety of methods, both observational and instrumentational, will be discussed; laboratory sessions will permit hands-on application of several of these for critical evaluation.

BMEN.6390 Research Models in Biomechanics - Credits: 3

Research Models will provide biomedical engineering graduate students with a mentored experience to learn and master modeling framework in biomechanics. Appropriate research models will provide the student with critical hands-on skillsets to further support their graduate studies. Student will work approximately 3 hours a week per credit on a designated research project. Regular meetings with the research mentor will also occur. Students are required to submit final project report and final presentation to their mentor.
Biomedical Engineering

Department of Biomedical Engineering

The Department of Biomedical Engineering at UMass Lowell offers a:

- Doctor of Philosophy in Biomedical Engineering

The Boston, Dartmouth, and Lowell campuses of the University of Massachusetts offer a joint:

- Master of Science in Biomedical Engineering and Biotechnology
- Doctor of Philosophy in Biomedical Engineering and Biotechnology
- Graduate Certificate in Biomedical Engineering and Biotechnology (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

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

Biotechnology and Bioprocessing

Biological Sciences Department & Chemical and Nuclear Engineering Department

Contact:
Carl Lawton, Ph.D.
978-934-3158
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 (https://www.uml.edu/catalog/courses/BIOL/5350) -or- CHEN.5350 (https://www.uml.edu/catalog/courses/CHEN/5350)
  Principles of Cell and Microbe Cultivation
- BIOL.5450 (https://www.uml.edu/catalog/courses/BIOL/5450) -or- CHEN.5450 (https://www.uml.edu/catalog/courses/CHEN/5450)
  Isolation and Purification of Biotech Products
- BIOL.5550 (https://www.uml.edu/catalog/courses/BIOL/5550) -or- CHEN.5550 (https://www.uml.edu/catalog/courses/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

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 (https://www.uml.edu/catalog/courses/CHEN/5080)
  Introduction to Materials Sciences (3 credits)

Elective Courses (choose three):

- CHEN.5060 (https://www.uml.edu/catalog/courses/CHEN/5060)
  Colloidal, Interfacial & Nanomaterials Science & Engineering (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

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:

- CHEN.5230 (https://www.uml.edu/catalog/courses/CHEN/5230) Nanodevices and Electronic Materials (3 credits)
- CHEN.5240 (https://www.uml.edu/catalog/courses/CHEN/5240) Self Assembly & Nanotechnology (3 credits)
- CHEN.5290 (https://www.uml.edu/catalog/courses/CHEN/5290) Recent Advances in Nanotechnology and Green Chemistry (3 credits)
- CHEN.5330 (https://www.uml.edu/catalog/courses/CHEN/5330) Macromolecular Colloidal Science and Engineering (3 credits)
- ENGY.5370 (https://www.uml.edu/catalog/courses/ENGY/5370) Nanomaterials Characterization I (3 credits)
- ENGY.5410 (https://www.uml.edu/catalog/courses/ENGY/5410) Nanomaterials Characterization II (3 credits)
- System Dynamics (3 credits)
- CHEN.5280 (https://www.uml.edu/catalog/courses/CHEN/5280) Advanced Transport Phenomena (3 credits)
- CHEN.5300 (https://www.uml.edu/catalog/courses/CHEN/5300) Advanced Control Strategies (3 credits)
- CHEN.5390 (https://www.uml.edu/catalog/courses/CHEN/5390) Math Methods for Engineers (3 credits)
- CHEN.5480 (https://www.uml.edu/catalog/courses/CHEN/5480) Engineering Process Analytics
- A Technical Elective with the Approval of the Coordinator (3 credits)

Apply (https://www.uml.edu/Grad/Process/certificate-app.aspx)

Degree Pathways for Biomedical Engineering

The Department of Biomedical Engineering at UMass Lowell offers a Doctor of Philosophy in Biomedical Engineering.

- Degree pathway (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
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.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.5250 Sustainable Chemistry and Engineering - Credits: 3
This course will provide an overview of the principles of sustainable or green chemistry and engineering. The first half of the course will review the fundamental chemical engineering principles (including chemical reactions, kinetics, catalysis, thermodynamics, separations, and equilibrium) that can be used to advance the field of green chemistry and engineering. The second half of the course will introduce several emerging green engineering topics, including waste treatment, alternative energy, and renewable materials and chemicals.

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 nanothehnology 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.5340 Industrial Bioprocessing - Credits: 3

Students will learn principles and concepts of industrial bioprocessing. The course covers key concepts and practices of upstream, downstream and analytical bioprocessing technologies. In addition, recent FDA initiatives of Process Analytical Technology (PAT), Quality by Design, and Emerging Technologies will be covered. The course consists of 14 modules. Each module will cover subject matter provided by industry experts.

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 hydroxypatite 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.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.5460 Biomaterials Science and Engineering -

Credits: 3

The goal of this course is to provide an understanding for design, synthesis, fabrication, and characterization of biomaterials for medical applications. The course will also cover biomimetic engineering strategies to generate materials that can be used for improving human health such as drug delivery, tissue engineering, and regenerative medicine. Example topics include biocompatibility, protein adsorption, degradation, swelling, mechanical properties, biomaterial-tissue interactions, vaccines, micro/nano technologies, instructive biomaterials for stem cells, medical devices and implants, performance of implants, and modulation of cell behavior and function through biomaterial strategies.

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 examining 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.7CPT Curricular Practical Training for GRADUATE / COLLEGE OF ENGINEERING**
Engineering Doctoral Candidates - Credits: 1

Curricular Practical Training (CPT) is a training program for doctoral students in Engineering. Participation in CPT acknowledges that this an integral part of an established curriculum and directly related to the major area of study or thesis.

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.5180 Energy Technology, Economics and Policy - Credits: 3

Survey course where students integrate the knowledge form previous undergraduate courses to explore and interpret energy technologies, economics and policies. This course is an elective course for engineering students and requires a good basic understanding of technical concepts related to the measurement and calculation of energy conversion and engineering economics.

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.6010 Graduate Research Seminar (Formerly 24.601) - Credits: 0
ENGY.6510 Selected Topics in Energy Engineering (Formerly 24.651) - Credits: 3
ENGY.7050 Supervised Tchg - Nuclear Engineering (Formerly 24.705) - Credits: 0
ENGY.7330 Graduate Project - Energy Engineering (Formerly 24.733) - Credits: 3
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: 1-3
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

ENGY.7CPT Curricular Practical Training for Engineering Doctoral Candidates - Credits: 1

Curricular Practical Training (CPT) is a training program for doctoral students in Engineering. Participation in CPT acknowledges that this an integral part of an established curriculum and directly related to the major area of study or thesis.
Masters Program

Civil Engineering Master’s Programs

The UMass Lowell Department of Civil & Environmental Engineering offers master’s degree programs in Civil Engineering and in Environmental Studies. Options within the Master of Science in Civil 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 Engineering
  - Environmental Engineering Option
  - Geotechnical Engineering Option
  - Geoenvironmental Option
  - Structural Engineering Option
  - Transportation Engineering Option

- Master of Science in Environmental Studies
  - Atmospheric Sciences Concentration
  - Environmental Engineering Sciences Concentration

- Co-op Option in Engineering

The Department of Civil & Environmental Engineering participates in the Graduate Master’s Co-op Option in Engineering. For detailed information about the Co-op Program and curriculum requirements, please see the Graduate Catalog Engineering Co-op page.

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

Master of Science in Civil Engineering (Environmental Engineering Option)

The program offers an opportunity to pursue a broad range of interests in the field of environmental 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, groundwater remediation, solid waste management, environmental chemistry, hydrology, hydraulics, air pollution control 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 five 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
The 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**
  ([https://www.uml.edu/catalog/courses/CHEM/1210](https://www.uml.edu/catalog/courses/CHEM/1210)) Chemistry I
- **CHEM.1230L**
  ([https://www.uml.edu/catalog/courses/CHEM/1230L](https://www.uml.edu/catalog/courses/CHEM/1230L)) Chemistry I Lab
- **CHEM.1220**
  ([https://www.uml.edu/catalog/courses/CHEM/1220](https://www.uml.edu/catalog/courses/CHEM/1220)) Chemistry II
- **CHEM.1240L**
  ([https://www.uml.edu/catalog/courses/CHEM/1240L](https://www.uml.edu/catalog/courses/CHEM/1240L)) Chemistry II Lab
- **MATH.1310**
  ([https://www.uml.edu/catalog/courses/MATH/1310](https://www.uml.edu/catalog/courses/MATH/1310)) Calculus I
- **MATH.1320**
  ([https://www.uml.edu/catalog/courses/MATH/1320](https://www.uml.edu/catalog/courses/MATH/1320)) Calculus II
- **MATH.2310**
  ([https://www.uml.edu/catalog/courses/MATH/2310](https://www.uml.edu/catalog/courses/MATH/2310)) Calculus III
- **MATH.2340**
  ([https://stage.uml.edu/catalog/courses/MATH/2340](https://stage.uml.edu/catalog/courses/MATH/2340)) Differential Equations
- **PHYS.1410**
  ([https://www.uml.edu/catalog/courses/PHYS/1410](https://www.uml.edu/catalog/courses/PHYS/1410)) Physics I
- **PHYS.1410L**
  ([https://www.uml.edu/catalog/courses/PHYS/1410L](https://www.uml.edu/catalog/courses/PHYS/1410L)) Physics I Lab
- **CIVE.2030**
  ([https://www.uml.edu/catalog/courses/CIVE/2030](https://www.uml.edu/catalog/courses/CIVE/2030)) Statics
- **CIVE.2050**
  ([https://www.uml.edu/catalog/courses/CIVE/2050](https://www.uml.edu/catalog/courses/CIVE/2050)) Dynamics
- **CIVE.3010**
  ([https://www.uml.edu/catalog/courses/CIVE/3010](https://www.uml.edu/catalog/courses/CIVE/3010)) Fluid Mechanics
- **CIVE.3620**
  ([https://www.uml.edu/catalog/courses/CIVE/3620](https://www.uml.edu/catalog/courses/CIVE/3620)) Environmental Engineering

**Core Courses (5 total)**

- **CIVE.5610**
  ([https://www.uml.edu/catalog/courses/CIVE/5610](https://www.uml.edu/catalog/courses/CIVE/5610)) Physical and Chemical Treatment Processes
- **CIVE.5620**
  ([https://www.uml.edu/catalog/courses/CIVE/5620](https://www.uml.edu/catalog/courses/CIVE/5620)) Physical and Chemical Hydrogeology
- **CIVE.5670**
  ([https://www.uml.edu/catalog/courses/CIVE/5670](https://www.uml.edu/catalog/courses/CIVE/5670)) Environmental Aquatic Chemistry
- **CIVE.5680**
  ([https://www.uml.edu/catalog/courses/CIVE/5680](https://www.uml.edu/catalog/courses/CIVE/5680)) Environmental Fate and Transport
- **CIVE.5780**
  ([https://www.uml.edu/catalog/courses/CIVE/5780](https://www.uml.edu/catalog/courses/CIVE/5780)) Biological Wastewater Treatment

**Elective Courses (select 5)**

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

- **CIVE.5270**
  ([https://www.uml.edu/catalog/courses/CIVE/5270](https://www.uml.edu/catalog/courses/CIVE/5270)) Geotechnical and Environmental Site Characterization
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 soilstructure 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 one required course: CIVE.5310 [Advanced Soil Mechanics](https://www.uml.edu/catalog/courses/CIVE/5310), five courses from a list of core geotechnical electives and four other elective courses, selected with the consent of a students faculty advisor. Additional advanced structural, geoenvironmental and geology courses may be taken as electives after consultation with a faculty advisor and approval from the Department. Program and course details are included in the graduate course list and the graduate catalog.

**Core Courses**

- CIVE.5310 [Advanced Soil Mechanics](https://www.uml.edu/catalog/courses/CIVE/5310)
- ENVS.5010 [Wetlands Ecology](https://stage.uml.edu/catalog/courses/ENVS/5010)
- ENVS.5020 [Freshwater Ecology](https://stage.uml.edu/catalog/courses/ENVS/5020)
- ENVS.5810 [Understanding the Massachusetts Contingency Plan](https://www.uml.edu/catalog/courses/ENVS/5810)
- GEOL.5100 [Geology of New England](https://www.uml.edu/catalog/courses/GEOL/5100)

Additional advanced courses may be taken as electives after consultation with a faculty advisor and approval from the department.
Advanced Soil Mechanics

**Elective Core course (Select 5; courses not taken may be used as electives)**

- CIVE.5270
  (https://www.uml.edu/catalog/courses/CIVE/5270)
  Geotechnical and Environmental Site Characterization
- CIVE.5280
  (https://www.uml.edu/catalog/courses/CIVE/5280)
  Drilled Deep Foundations
- CIVE.5290
  (https://www.uml.edu/catalog/courses/CIVE/5290)
  Engineering with Geosynthetics
- CIVE.5300
  (https://www.uml.edu/catalog/courses/CIVE/5300)
  Driven Deep Foundations
- CIVE.5320
  (https://www.uml.edu/catalog/courses/CIVE/5320)
  Theoretical and Numerical Soil Mechanics
- CIVE.5330
  (https://www.uml.edu/catalog/courses/CIVE/5330)
  Advanced Foundation Engineering
- CIVE.5340
  (https://www.uml.edu/catalog/courses/CIVE/5340)
  Soil Dynamics and Earthquake Engineering
- CIVE.5360
  (https://www.uml.edu/catalog/courses/CIVE/5360)
  Soil Engineering
- CIVE.5370
  (https://www.uml.edu/catalog/courses/CIVE/5370)
  Experimental Soil Mechanics
- CIVE.5380
  (https://www.uml.edu/catalog/courses/CIVE/5380)
  Soil Behavior
- CIVE.5390
  (https://www.uml.edu/catalog/courses/CIVE/5390)
  Ground Improvement

**Elective Courses (4 total)**

- CIVE.5040
  (https://www.uml.edu/catalog/courses/CIVE/5040)
  Advanced Strength of Materials
- CIVE.5110
  (https://www.uml.edu/catalog/courses/CIVE/5110)
  Inspection and Monitoring of Civil Infrastructure
- CIVE.5210
  (https://www.uml.edu/catalog/courses/CIVE/5210)
  Reliability Analysis in Engineering
- CIVE.5460
  (https://www.uml.edu/catalog/courses/CIVE/5460)
  Pavement Design
- CIVE.5500
  (https://www.uml.edu/catalog/courses/CIVE/5500)
  Behavior of Structures
- CIVE.5560
  (https://www.uml.edu/catalog/courses/CIVE/5560)
  Finite Element Analysis
- CIVE.5620
  (https://www.uml.edu/catalog/courses/CIVE/5620)
  Physical and Chemical Hydrogeology
- CIVE.5720
  (https://www.uml.edu/catalog/courses/CIVE/5720)
  Marine and Coastal Processes
- CIVE.5750
  (https://www.uml.edu/catalog/courses/CIVE/5750)
  Groundwater Modeling
- CIVE.5760
  (https://www.uml.edu/catalog/courses/CIVE/5760)
  GIS Applications in Civil &Environmental Engineering
- CIVE.5810
  (https://www.uml.edu/catalog/courses/CIVE/5810)
  Engineering Systems Analysis
- GEOL.5560
  (https://www.uml.edu/catalog/courses/GEOL/5560)
  Applied Geophysics

**Master of Science 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 (2 total)

- CIVE.5310  
  (https://www.uml.edu/catalog/courses/CIVE/5310)  
  Advanced Soil Mechanics
- CIVE.5620  
  (https://stage.uml.edu/catalog/courses/CIVE/5620)  
  Physical and Chemical Hydrogeology

Geotechnical Core Course (Select 1; courses not taken may be used as electives):

- CIVE.5270  
  (https://www.uml.edu/catalog/courses/CIVE/5270)  
  Geotechnical Environmental Site Characterization
- CIVE.5290  
  (https://www.uml.edu/catalog/courses/CIVE/5290)  
  Engineering with Geosynthetics
- CIVE.5360  
  (https://www.uml.edu/catalog/courses/CIVE/5360)  
  Soil Engineering
- CIVE.5380  
  (https://stage.uml.edu/catalog/courses/CIVE/5380)  
  Soil Behavior

Environmental Core Course (Select 1; courses not taken may be used as electives):

- CIVE.5670  
  (https://www.uml.edu/catalog/courses/CIVE/5670)  
  Environmental Aquatic Chemistry
- CIVE.5950  
  (https://www.uml.edu/catalog/courses/CIVE/5950)  
  Hazardous Waste Site Remediation

Elective Courses (6 total)

- CIVE.5210  
  (https://www.uml.edu/catalog/courses/CIVE/5210)  
  Reliability Analysis in Engineering
- CIVE.5280  
  (https://www.uml.edu/catalog/courses/CIVE/5280)  
  Drilled Deep Foundations
- CIVE.5300  
  (https://www.uml.edu/catalog/courses/CIVE/5300)  
  Driven Deep Foundations
- CIVE.5320  
  (https://www.uml.edu/catalog/courses/CIVE/5320)  
  Theoretical and Numerical Methods in Soil Mechanics
- CIVE.5330  
  (https://www.uml.edu/catalog/courses/CIVE/5330)  
  Advanced Foundation Engineering
- CIVE.5340  
  (https://www.uml.edu/catalog/courses/CIVE/5340)  
  Soil Dynamics and Earthquake Engineering
- CIVE.5370  
  (https://www.uml.edu/catalog/courses/CIVE/5370)  
  Experimental Soil Mechanics
- CIVE.5390  
  (https://www.uml.edu/catalog/courses/CIVE/5390)  
  Ground Improvement
- CIVE.5610  
  (https://www.uml.edu/catalog/courses/CIVE/5610)  
  Physical and Chemical Treatment Process
- CIVE.5640  
  (https://www.uml.edu/catalog/courses/CIVE/5640)  
  Hydraulics and Hydrology
- CIVE.5660  
  (https://www.uml.edu/catalog/courses/CIVE/5660)  
  Environmental Applications & Implications of Nanomaterials
- CIVE.5680  
  (https://www.uml.edu/catalog/courses/CIVE/5680)  
  Environmental Fate and Transport
Additional advanced courses may be taken as electives after consultation with a faculty advisor and approval from the Department.

**Master of Science in Civil Engineering (Structural Engineering Option)?**

The structural option within Civil Engineering offers instruction and research in advanced concepts and techniques to develop innovative solutions for critical and challenging problems in Structural Engineering. A student seeking an MS Engineering in Structural Engineering must have at least one core course from each group (A, B, and C) to meet the core course requirements. Student study programs in structural engineering are developed with a faculty advisor to meet the needs of the individual. Students should also meet the prerequisite requirement in each graduate-level course by receiving an approval from the instructor.

**Core Course Requirement (3 total)**

**Group A (Design; select 1; courses not taken may be used as elective):**

- [CIVE.5510](https://www.uml.edu/catalog/courses/CIVE/5510) Advanced Steel Design
- [CIVE.5520](https://www.uml.edu/catalog/courses/CIVE/5520) Design of Concrete Structures

**Group B (Analysis; select 1; courses not taken may be used as elective):**

- [CIVE.5030](https://www.uml.edu/catalog/courses/CIVE/5030) Computer-Based Analysis of Structures
- [CIVE.5040](https://www.uml.edu/catalog/courses/CIVE/5040) Advanced Strength of Materials
- [CIVE.5500](https://www.uml.edu/catalog/courses/CIVE/5500) Behavior of Structures
- [CIVE.5560](https://www.uml.edu/catalog/courses/CIVE/5560) Finite Element of Analysis (or equivalent)

**Group C (Dynamics, Stability, and Materials; select 1; courses not taken may be used as elective):**

- [CIVE.5050](https://www.uml.edu/catalog/courses/CIVE/5120) Concrete Materials
- [CIVE.5120](https://www.uml.edu/catalog/courses/CIVE/5120) Structural Stability
- [CIVE.5150](https://www.uml.edu/catalog/courses/CIVE/5150) Cementitious Materials for Sustainable Concrete
- [CIVE.5570](https://www.uml.edu/catalog/courses/CIVE/5570) Structural Dynamics

**Elective Courses (7 total)**

- [CIVE.5080](https://www.uml.edu/catalog/courses/CIVE/5080) Practice of Structural Engineering
- [CIVE.5110](https://www.uml.edu/catalog/courses/CIVE/5110)
Inspection and Monitoring of Civil Infrastructure

- CIVE.5210
- CIVE.5280
- CIVE.5300
- CIVE.5310
- CIVE.5330
- CIVE.5340
- CIVE.5360
- CIVE.5390
- CIVE.5410
- CIVE.5460
- CIVE.5530
- CIVE.5540
- CIVE.5590

Reliability Analysis in Engineering

- CIVE.5210

Drilled Deep Foundations

- CIVE.5280

Drive n Deep Foundations

- CIVE.5300

Advanced Soil Mechanics

- CIVE.5310

Advanced Foundation Engineering

- CIVE.5330

Soil Dynamics and Earthquake Engineering

- CIVE.5340

Soil Engineering

- CIVE.5360

Ground Improvement

- CIVE.5390

Traffic Engineering

- CIVE.5410

Pavement Design

- CIVE.5460

Wood Structures

- CIVE.5530

Pre-stressed Concrete Design

- CIVE.5540

Masonry Design

- CIVE.5760

GIS Application in Civil and Environmental Engineering

- CIVE.5810

Engineering Systems Analysis

- CIVE.5830

Stochastic Concepts for Engineering

Notes:

1. Additional geotechnical and geoenvironmental courses and appropriate advanced courses from the Departments of Mathematics and Mechanical Engineering may be taken as electives after consultation with a faculty advisor and with the approval of the Department.

2. With the approval of the Department, a student may substitute one of the core requirements with another advanced Mathematics or Engineering course.

Master of Science in Civil Engineering (Transportation Engineering Option)?

The program in Transportation Engineering offers courses in planning, design and operation of multimodal 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:

The undergraduate prerequisite courses are as follows:

- MATH.1310
- MATH.1320
Calculus II
- MATH.2310
  (https://www.uml.edu/catalog/courses/MATH/2310)
  Calculus III
- MATH.2340
  (https://www.uml.edu/catalog/courses/MATH/2340)
  Differential Equations
- CIVE.2860
  (https://www.uml.edu/catalog/courses/CIVE/2860)
  Prob. & Stat. for Engineers
- PHYS.1410
  (https://www.uml.edu/catalog/courses/PHYS/1410)
  Physics I
- PHYS.1410L
  (https://www.uml.edu/catalog/courses/PHYS/1410L)
  Physics I Lab
- CIVE.3400
  (https://www.uml.edu/catalog/courses/CIVE/3400)
  Transportation Engineering
- CIVE.3720
  (https://www.uml.edu/catalog/courses/CIVE/3720)
  Civil Engineering Systems

Core Courses Requirements (Select 3; courses not taken may be used as elective)
- CIVE.5400
  (https://www.uml.edu/catalog/courses/CIVE/5400)
  Urban Transportation Planning
- CIVE.5410
  (https://www.uml.edu/catalog/courses/CIVE/5410)
  Traffic Engineering
- CIVE.5420
  (https://www.uml.edu/catalog/courses/CIVE/5420)
  Transportation Network Analysis
- CIVE.5480
  (https://www.uml.edu/catalog/courses/CIVE/5480)
  Traffic Management and Control
- CIVE.5490
  (https://www.uml.edu/catalog/courses/CIVE/5490)
  Traffic Flow and Emerging Transportation Technologies

Elective Courses (7 total)
- CIVE.5405
  (https://www.uml.edu/catalog/courses/CIVE/5405)
  Advanced Highway Geometric Design
- CIVE.5415
  (https://www.uml.edu/catalog/courses/CIVE/5415)
  Hazardous Materials Transportation
- CIVE.5430
  (https://www.uml.edu/catalog/courses/CIVE/5430)
  Traffic Principles for Intelligent Transportation Systems
- CIVE.5440
  (https://www.uml.edu/catalog/courses/CIVE/5440)
  Transportation Economics and Project Evaluation
- CIVE.5450
  (https://www.uml.edu/catalog/courses/CIVE/5450)
  Public Transit Planning and Design
- CIVE.5460
  (https://www.uml.edu/catalog/courses/CIVE/5460)
  Pavement Design
- CIVE.5470
  (https://www.uml.edu/catalog/courses/CIVE/5470)
  Airport Planning and Design
- CIVE.5760
  (https://www.uml.edu/catalog/courses/CIVE/5760)
  GIS Applications in Civil and Environmental Engineering
- CIVE.5810
  (https://www.uml.edu/catalog/courses/CIVE/5810)
  Engineering Systems Analysis
- CIVE.5830
  (https://www.uml.edu/catalog/courses/CIVE/5830)
  Stochastic Processes for Engineering
- CIVE.5850
  (https://www.uml.edu/catalog/courses/CIVE/5850)
  Transportation Safety
- CRIM.5660
Transportation Systems Safety and Security

Other than the above listed elective courses, students may take courses from other appropriate disciplines such as engineering, management, computer science, and mathematics as electives after consultation with a faculty advisor and with the approval of the Department. A few examples are:

- **Engineering**: CIVE.5210 (Reliability Analysis in Engineering; MECH.5760 (Engineering Project Management; CHEN.5390 (Mathematical Methods for Engineers

- **Management**: MIST.6030 (Database Management; MIST.6170 (Advanced Machine Learning; MIST.7060 (Data Analytics; MIST.6160 (Advanced Data Mining; MIST.6060 (Business Intelligence and Data Mining; POMS.4050 (Predictive Data Analytics; POMS.6220 (Decision Analytics

- **Math and Science**: COMP.5730 (Data Base I; COMP.5450 (Machine Learning; MATH.5910 (Linear Statistics Modeling and Regression; MATH.5750 (Applied Statistics with R; MATH.5500 (Mathematical Modeling; COMP.4200 (Artificial Intelligence; COMP.6040 (Network Optimization; MATH.5720 (Optimization

- **Other**: PUBH.6890 (Advanced Regression Modeling; BIOL.5071 (Data Science for Biologists in Python

### 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](https://www.uml.edu/catalog/courses/CHEM/1210)

- CHEM.1230L
  [Chemistry I Lab](https://www.uml.edu/catalog/courses/CHEM/1230L)

- CHEM.1220
  [Chemistry II](https://www.uml.edu/catalog/courses/CHEM/1220)

- CHEM.1240L
  [Chemistry II Lab](https://www.uml.edu/catalog/courses/CHEM/1240L)

- MATH.1310
  [Calculus I](https://www.uml.edu/catalog/courses/MATH/1310)

- MATH.1320
  [Calculus II](https://www.uml.edu/catalog/courses/MATH/1320)

- PHYS.1410
  [Physics I](https://www.uml.edu/catalog/courses/PHYS/1410)

- PHYS.1410L
  [Physics I Lab](https://www.uml.edu/catalog/courses/PHYS/1410L)

**Core Courses**

- CIVE.5670
  [Environmental Aquatic Chemistry](https://www.uml.edu/catalog/courses/CIVE/5670)

- CIVE.5730
  [Solid Waste Engineering](https://www.uml.edu/catalog/courses/CIVE/5730)

- ATMO.5230
  [Air Pollution Control or ATMO.5710](https://stage.uml.edu/catalog/courses/ATMO/5230 or https://stage.uml.edu/catalog/courses/ATMO/5710)

**Elective Courses**

- CIVE.5610
  [Physical and Chemical Treatment Processes](https://www.uml.edu/catalog/courses/CIVE/5610)

- CIVE.5620
  [Physical and Chemical Hydrogeology](https://www.uml.edu/catalog/courses/CIVE/5620)

- CIVE.5640
  [Hydraulics and Hydrology](https://www.uml.edu/catalog/courses/CIVE/5640)

- CIVE.5660
  [Environmental Application & Implications of Nanomaterials](https://www.uml.edu/catalog/courses/CIVE/5660)

- CIVE.5680
  [Environmental Fate and Transport](https://www.uml.edu/catalog/courses/CIVE/5680)

- CIVE.5690
  [Micropollutants in the Environment](https://www.uml.edu/catalog/courses/CIVE/5690)

- CIVE.5720
  [Marine and Coastal Processes](https://www.uml.edu/catalog/courses/CIVE/5720)

- CIVE.5750
  [Groundwater Modeling](https://www.uml.edu/catalog/courses/CIVE/5750)
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 (Environmental Law and Policy)
- PUBH.527 (Environmental Law and Policy)

Elective Courses

- ECON.615 (Environmental and Natural Resources Economics)
- 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
  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
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, acoustic/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.5150 Cementitious Materials for Sustainable Concrete - Credits: 3
This course is designed for introducing advanced topics in cement hydration chemistry, materials characterization and concrete sustainability. Advanced topics in chemistry of commonly used cementitious materials, micro-structure, mechanical properties, durability and sustainability will be offered. Students will learn and practice to characterize and analyze the roles of chemical admixtures and supplementary cementitious materials in concrete property improvement. Chemical issues involved in the engineering behavior of concrete will be offered. A service-learning project about sustainable concrete will be provided. Emerging topics such as self-healing concrete, self-consolidating concrete, mart concrete, 3D concrete printing and ultra-high performance concrete will also be covered.

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 engineering. The course begins with introduction to site investigation planning and various geophysical methods including: seismic measurements, ground penetrating radar, electrical resistivity, electromagnetic conductivity, time domain reflectometry. Drilling methods for soil, gas and ground water sampling; decontamination procedures; and long term monitoring methods are studied. Emphasis in this course is placed on conventional and state-of-the-art in situ methods for geotechnical and environmental site characterization: standard penetration test, vane shear test, dilatometer test, pressuremeter test and cone penetration tests. Modern advances in cone penetrometer technology, instrumented with various sensors (capable of monitoring a wide range of physical and environmental parameters: load, pressure, sound, electrical resistivity, temperature, PH, oxidation reduction potential, chemical contaminants) are playing a major role in site characterization. Principles underlying these methods along with the interpretation of test data will be covered in detail. The course will also look into emerging technologies in the area of site characterization. (3-0)3

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.5405 Advanced Highway Geometric Design - Credits: 3

Development of the principals of modern roadway design while addressing context specific design requirements and constraints. Topics will include guidelines for highway design, design and review of complex geometry, geometric design to address safety and operational concerns, multi-modal design for signalized and un-signalized intersections, complete streets design concepts, and superelevation. Course-work will also include principals to present transportation designs to the public, transportation advocates, and private clients.

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.5415 Hazardous Materials Transportation - Credits: 3

Hazmat transportation, safety and security are a convergence of operations, policies and regulation, and planning and design. This course will address the multimodal operations, vessels, technologies, packaging and placarding involved in the safe and secure transportation of hazmat. Safety and security rules, regulations, emergency preparedness and response, industry initiatives and programs, and U.S. government agencies governing hazmat transportation will be included, as well as international impacts on hazmat transportation safety and security.

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 and Emerging Transportation Technologies (Formerly 14.549) - Credits: 3

Traffic flow theories seek to describe through precise mathematical models (a) the interactions between vehicles and the roadway system and (b) the interactions among vehicles. This course covers both conventional human-driven vehicles and the emerging connected and automated vehicles. Such theories form the basis of the models and procedures used in design and operational analysis of streets and highways. In particular, the course examines the fundamental traffic flow characteristics and the flow-speed-density relationship, as well as time and space headway, string stability, traffic flow stability, popular analytical techniques for traffic stream modeling at both microscopic and macroscopic levels, shock wave 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 Design of Concrete Structures (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.5660 Environmental Applications and Implications of Nanomaterials - Credits: 3

This course will cover (I) novel properties, synthesis, and characterization of nanomaterials; (II) environmental engineering applications of nanomaterials, with an emphasis on nano-enabled water and wastewater treatment technologies such as membrane processes, adsorption, photo-catalysis, and
### 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.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.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.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: 9
Credits: 7
CIVE.7590 Doctoral Dissertation (Formerly 14.759) - Credits: 9
CIVE.7610 Continued Graduate Research - Credits: 1
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.7CPT Curricular Practical Training for Engineering Doctoral Candidates - Credits: 1

Curricular Practical Training (CPT) is a training program for doctoral students in Engineering. Participation in CPT acknowledges that this an integral part of an established curriculum and directly related to the major area of study or thesis.
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.5030 American Culture, Ethics and Communications in Engineering - Credits: 1

Overview of American culture and how it has been shaped by immigrants from the colonial era to the present and cultural influences from immigrants and their role in contributing to accomplishments in engineering, technology, science and the arts will be explored. Students will learn about the history of Lowell, MA in the context of key events. The concepts and practice of engineering ethics and the ethical principles and responsibilities that students should exercise in academia and professional careers will be introduced. The impact of engineering on society and the environment will be discussed through case studies. The course will promote communication skills through reading, listening and viewing assignments and responding with written reports and presentations to the class.

ENGN.5200 Aerospace Systems Design and Integration - Credits: 3

This introductory course discusses the basics of Aerospace Systems design and integration as they apply to modern advanced aircraft platforms (both military and civilian). Detailed analyses of individual aircraft engine systems- and sub-systems will be studied as well as their intended interaction with other aircraft-based systems (e.g., hydraulic, lubrication, fuel, pneumatic, electronic, electrical, etc.). Emphasis will be given on modern advanced controls through study of EEC (Electronic Engine Controls) and FADEC (Full-Authority Digital Engine Controls), and their performance as part of the overall aircraft avionics systems. A brief review of appropriate requirements and protocols for systems- and sub-systems design, testing, validation & verification, performance is examined.

ENGN.5300 Gas Turbine Engine Theory and Design - Credits: 3

This introductory course discusses the basics of open Brayton cycles for Gas Turbine Engines (GTEs) followed by a comprehensive review of the various GTE architectures (e.g., turbojet, turbofan, turboshaft, turboprop, ramjets, etc.) for applications in both civil and military platforms. Detailed analyses of individual engine components (fan, LP/IP/HP compressors combustors, HP/IP/LP turbines, nozzles, etc.) as well as overall engine system interaction and integration. GTE design conceptualization, testing, validation & verification, performance, emissions, and other parameters are examined with respect to overall design goal and intended operability and durability. Concluded by a broad review of popular airframe-engine models and their brief history of conceptualization and development.

ENGN.5400 Designing Sustainable Products - Credits: 3

The course introduces students to the sustainability aspects of product design. Sustainable products are designed to conserve materials and energy, select low-impact materials, eliminate toxic substances, extend product life, re-use materials, and reduce the generation of wastes. The entire product life cycle will be considered including: material extraction, material processing, manufacturing, transportation, product use, and disposal. Students will learn the impact of design solutions in a global, economic, environmental, and societal context. The students will learn strategies to identify the sustainability impacts throughout the product life cycle, as well as the application of sustainable product design principles and strategies to address these impacts.

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
ENGN.5920 Graduate Industrial Cooperative Educational Experience III (Formerly 25.592) - Credits: 1
ENGN.5930 Graduate Industrial Cooperative Educational Experience (Formerly 25.593) - Credits: 3
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.

ENGN.6020 Graduate Professional Development for Engineers - Credits: 1

This course is designed to provide master's students with the requisite preparation in understanding the expectations of the workplace and tools needed to engage in an effective job search process. The course will facilitate the transition and preparation to meet the increased expectations of a graduate student while on a graduate cooperative experience. The course will be comprised of a series of workshops and offer resources intended to provide students a good understanding of the US work environment, work culture and expectations. Topics include: workplace culture and expectations, professional communication skills, job search strategies, resume writing, mock interviews, technical writing.

ENGN.6030 Graduate Cooperative Experience - Credits: 0-1

This one-credit course is for co-op internship experience. There will be one credit whether the co-op experience is for three or six months. Learning objectives a s mutually agreed upon by the student and co-op supervisor will be required to be submitted at the beginning of the experience. A final evaluation by supervisor will be due before final grading. Full-time co-op is typically expected to be at a minimum of 30 hours per week. "Variable credit course, student chooses appropriate amount of credits when registering.”

ENGN.6040 Workforce Development - Credits: 1

Optional seminar series which will be comprised of weekly speakers from industry, government, academia and non-profit sectors with a focus on workforce development talks.
EECE.5040 VLSI Fabrication (Formerly 16.504) - Credits: 3

Fabrication of resistors, capacitors, p-n junction and Schottky Barrier diodes, BJT’s and MOS devices and Integrated circuits. Topics include: silicon structure, wafer preparation, sequential techniques in micro-electronic processing, testing and packaging, yield and clean room environments. MOS structures, crystal defects, Fick’s laws of diffusion; oxidation of silicon, photolithography including photoresist, development and stripping. Metallization for conductors, Ion implantation for depletion mode and CMOS transistors for better yield speed, low power dissipation and reliability. Students will fabricate circuits using the DSIP 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 Schrödinger’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...
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.5160 Biomedical Imaging and Data Science - Credits: 3


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 detail. 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.5180 Wireless Communications (Formerly 16.582/EECE.5820) - 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.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 16.5200) - 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 Semiconductor Physics for Solid-State Electronics (Formerly 16.523) - Credits: 3

The course covers fundamental solid-state and semiconductor physics relevant for understanding electronic devices. Topics include quantum mechanics of electrons in solids, crystalline structures, band theory of semiconductors, electron statistics and dynamics in energy bands, lattice dynamics and phonons, carrier transport, and optical processes in semiconductors.

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 Alternative 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
This course will consist of five three-hour labs, each requiring measurements of gain and patterns in an anechoic chamber. Differences. Students will also perform basic antenna measurements of microwave transmission lines, waveguides and cavities. Simple scattering problems. Finite difference methods. Finite element method.

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) - Credits: 3
An introductory course in the analysis and design of passive microwave circuits beginning with review of time-varying electromagnetic field concepts and transmission lines. Smith Chart problems; single and double stub matching; impedance transformer design; maximally flat and Chebyshev transformers; microstrip transmission lines, slot lines, coplanar lines; rectangular and circular waveguides; waveguide windows and their use in impedance matching; design of directional couplers; features of weak and strong couplings; microwave filter design; characteristics of low-pass, high-pass, band-pass, band-stop filter designs; two-port network representation of junctions; Z and Y parameters, ABCD parameters, scattering matrix; microwave measurements; measurement of VSWR, complex impedance, dielectric constant, attenuation, and power. A design project constitutes a major part of the course.

EECE.5340 Microwave Engineering Lab - Credits: 1
This lab course is offered as a practical supplement to the material taught in EECE.5330 Microwave Engineering. The students will develop skills in EM modeling (Ansys HFSS) and measurement of microwave transmission lines, waveguides and passive structures such as combiners and filters. Students will design basic microwave structures utilizing EM modeling tools, measure the resulting performance and provide justification of differences. Students will also perform basic antenna measurements of gain and patterns in an anechoic chamber. This course will consist of five three-hour labs, each requiring a detailed report of the results.

EECE.5350 Microwave Metrology - Credits: 3
Laboratory measurement techniques that are typical of those used to characterize wireless devices and systems, including network analyzer calibration, measurements of noise in amplifiers, mixers and oscillators; measurements of distortion in amplifiers and mixers; and characterizing the dynamic range of a receiver.

EECE.5360 Microwave Metrology Lab - Credits: 1
This lab course is offered as a practical supplement to the material taught in EECE.5350 Microwave Metrology. Students will calibrate test equipment and perform measurements of the following parameters: phase noise, noise figure, intermodulation distortion, translated frequency, gain compression, and high-power characterization. Students will also perform probe measurements and demonstrate de-embedding techniques. This course will consist of five three-hour labs, each requiring a detailed report of the results.

EECE.5370 Microwave Systems Engineering - Credits: 3
This course will explore concepts related to the design, analysis, and construction of systems and will examine the fundamental tradeoffs governing microwave system design: the hardware components and technologies that comprise working systems, the models used for characterizing the transmission and reception of signals, the physics of wave propagation and interaction, and estimation theory which seeks to separate signals from sources of error and guide algorithms for extracting information from received signals.

EECE.5380 Microwave Systems Engineering Lab - Credits: 1
This lab course is offered as a practical supplement to the material taught in EECE.5370 Microwave Systems Engineering. The students will perform cascade analyses using measured data to compare with analysis computed from nominal values given in component specifications. Monte Carlo analyses will also be performed to predict performance variation. Students will configure test setups to illustrate signal generation, up/down conversion and signal detection. Additionally, the students will configure a radiated test setup in an anechoic chamber to measure and validate link budget calculations based on the Friis transmission equation. This course will consist of five three-hour labs, each requiring a detailed report of the results.

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 & demodulation technique.

EECE.5440 Computational Data-Driven Modeling I - Credits: 3

Computational Data-Driven Modeling (CDM) I is the first in a sequence of two courses designed to introduce the student to basics skills in exploratory data analysis and data-driven computational modeling using foundational concepts drawn from linear algebra, probability, statistics, random processes, time-series analysis and dynamical systems. In CDM-1 students will learn to apply regression and classification algorithms on multivariate data and assess performance of these models. An interactive project-driven approach is taken using the Python programming platform and its associated open-source libraries for statistical modeling, data analysis and machine-learning. A review of the tools and techniques from probability and statistics will be undertaken.

EECE.5450 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.5470 Computational Data-Driven Modeling II - Credits: 3

Computational Data-Driven Modeling (CDM) II is the second in a sequence of two courses designed to introduce the student to skills in exploratory data analysis and data-driven computational modeling. CDM-II extends the students' knowledge on application of regression and classification algorithms in CDM-1 to more complex structures such as Bayesian networks and Hidden-Markov models. The focus will be on time-varying data using time-series and state-space models such as Kalman filters, Markov Processes and Particle filters for prediction and forecasting. The application of neural networks and deep-learning will be discussed. Students will undertake case-studies in data analytics with collaboration from professionals in industry.

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.5490 Optimization Models and Decision Analysis - Credits: 3

This course addresses the prototypical theme of how a system or organization can improve its decision-making and develops approaches for both prescriptive and predictive analytics. Whether it is a service or manufacturing entity, a firm should promulgate a mission statement with three evolving parts: strategy, tactics, and operations. For example, a strategic focus is to maximize profit, a tactical plan minimizes cost, and an operations manifesto establishes feasibility. Towards this objective, this course will present introductory and applied concepts on decision-making, optimization and simulation modeling under uncertainty. Case studies will supplement the theoretical concepts and enforce student learning. Background in engineering mathematics and/or permission of instructor. Undergraduate introduction to Probability and Statistics.

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
The material in this course is a combination of essential topics, techniques, algorithms, and tools that will be used in future robotics courses. Fundamental topics relevant to robots (linear algebra, numerical methods, programming) will be reinforced throughout the course using introductions to other robotics topics that are each worthy of a full semester of study (dynamics, Kinematics, controls, planning, sensing). Students will program real robots to further refine their skills and experience the material fully.

**EECE.5520 Microprocessor Systems II & Embedded Systems (Formerly 16.552) - Credits: 3**

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.5540 Data Intensive Computing - Credits: 3**

This course deals with various topics in data-intensive computing to address challenges in managing large-scale data and methods for extracting values from big data. Specifically, we explore state-of-the-art techniques to build parallel systems and applications for scalable data analysis on a massive and complex dataset, those from scientific and engineering problems. Topics include: 1) Storage requirements of big data; 2) parallel and distributed computing systems in both high-performance computing (HPC) and commercial domains; 3) Data-parallel frameworks such as MapReduce/Hadoop/Spark; 4) parallel file systems such as HDFS/Lustre; 5) NoSQL data models such as Dynamo/BigTable/Lustre; and 6) time-series data models such as InfluxDB/Prometheus.

**EECE.5560 Fundamentals of Robotics (Formerly 16.556) - Credits: 3**

The material in this course is a combination of essential topics, 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.
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.5625L VHDL/Verilog Synthesis & Design Lab - Credits: 1

This lab course is offered to provide the student practical applications of advanced FPGA topics. The lab will focus on advanced language constructs and effective coding for synthesis. Timing closure techniques and synthesis optimization for speed vs power will be explored. Features of synthesis tools including partial reconfiguration, tool reports and clock domain crossing will be evaluated. This course will consist of seven 2-hour labs, each requiring either completion of a worksheet or a detailed report of the results.

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.5700 Radar Systems Lab - Credits: 1

This lab course is offered as a practical supplement to the material taught in EECE.5710 Radar Systems. Students will build functional radar using a COTS-based radio system to demonstrate the detection of canonical targets (plates, spheres, corner reflectors) of known radar cross sections. This course will consist of five three-hour labs, each requiring a detailed report of the results.

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.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.5755 FPGA Logic Design Techniques Lab - Credits: 1

This lab course is offered to provide the student with the practical skills required to design and implement an FPGA. The student will design commonly used FPGA structures such as state machines and data processing elements and learn how to include library components such as FIFOs, memory interfaces and computer/debug interfaces. The student will work through all phases of development: coding, simulation, building and testing the FPGA on hardware. This course will consist of seven 2-hour labs, each requiring either completion of a worksheet or a detailed report of the results.

EECE.5760 Principles of Solid State Devices (Formerly 16.576) - Credits: 3

This course introduces the operating principles of Solid State Devices. Basic semiconductor science is covered including crystalline properties, quantum mechanics principles, energy
bands and the behavior of atoms and electrons in solids. The transport of electrons and holes (drift and diffusion) and the concepts of carrier lifetime and mobility are covered. The course describes the physics of operation of several semiconductor devices including p-n junction diodes (forward/reverse bias, avalanche breakdown), MOSFETs (including the calculation of MOSFET threshold voltages), bipolar transistor operation, and optoelectronic devices (LEDs, lasers, photodiodes).

EECE.5770 Verification of Digital Systems (Formerly 16.577) - Credits: 3

The increasing complexity of digital designs coupled with the requirement for first pass success creates a need for an engineered approach to verification. This course defines the goals for verification, presents techniques and applications, and develops a framework for managing the verification process from concept to reality.

EECE.5775L Verification of Digital Systems Lab - Credits: 1

This lab course is offered to provide the student with the practical skills to verify an FPGA design in simulation environment. The student will build various components of a test environment beginning with a basic testbench using manual verification and progressing to a more robust self-checking test environment. This includes generating constrained random stimulus and predicting, monitoring, and checking responses. The students will also create a regression test suite and evaluate coverage. This course will consist of seven 2-hour labs, each requiring either completion of a worksheet or a detailed report of the results.

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.5780 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.5811 Operating Systems (Formerly 16.573/EECE.5730) - 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 a real operating system.

EECE.5821 Computer Architecture and Design (Formerly 16.561/EECE.5610) - Credits: 3


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.5841 Computer Vision and Digital Image Processing (Formerly 16.581/EECE.5810) - 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.5850 Computer Network Security (Formerly 16.658 and EECE.6580) - 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 reviews unique challenges and the security &privacy solutions for the emerging data/communication/information/computing networks (e.g., Ad Hoc &sensor network, IoT, cloud and edge computing, big data, social networks, cyber-physical systems, critical infrastructures such as smart grids and smart transportation systems, etc.).

EECE.5900 Thesis Review - Credits: 1

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 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 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 architerture, IETF VoIP architecture, VoIP over WLAN,m access networks for converged services: xDSL and HFC networks, and IP TV service.

EECE.6150 Medical Image Reconstruction - Credits: 3

This course will deliver the students both traditional and state-of-the-art algorithms in a unified way, which can make the students qualify for a medical image reconstruction engineer. The topics includes central slice theorem, 2D parallel-beam, 2D fan-beam and 3D cone-beam reconstruction algorithms in terms of analytic and iterative methods. It will cover the state-of-the-art Katsevich algorithm, interior tomography, compressive sensing, and spectral CT.

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 hand-width approaches, simulation modeling, discrete event simulation of transport and multiplexing protocols using OPNET software, statistical techniques for validation and sensitivity analysis.

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, ard 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.6515L Advanced Embedded System Design with FPGA Lab - Credits: 1

This lab course is offered to provide the student with the practical skills required to use embedded processors in FPGAs. The student will design, implement, test, debug, and configure embedded systems in FPGAs using both soft and hard cores. Students will connect various memories, bus interfaces and external devices to build a system in an FPGA. Basic programming of the embedded processor will also be performed. This course will consist of seven 2-hour labs, each requiring either completion of a worksheet or a detailed report of the results.

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.6550 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.6570 High Speed Integrated Network (Last Term 2004 Fall) (Formerly 16.657) - 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 one 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 at 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 appropriate form and presented to a committee of three faculty members.
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 15 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: 1-6
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.

EECE.7CPT Curricular Practical Training for Engineering Doctoral Candidates - Credits: 1

Curricular Practical Training (CPT) is a training program for doctoral students in Engineering. Participation in CPT acknowledges that this an integral part of an established curriculum and directly related to the major area of study or thesis.
Master of Science in Engineering - Industrial Engineering

Industrial Engineering

- Degree Requirements
- Industrial Engineering Concentrations
  - Analytics and Operation Concentration
  - Ergonomics and Safety Concentration
  - Healthcare System Engineering Concentration
  - Manufacturing and Automation Concentration

The Department of Mechanical Engineering offers Master of Science in Industrial Engineering (MSIE) program. The program offers a choice of either a thesis track or a non-thesis track. To receive the MSE degree requires a minimum of thirty (30) credit hours of acceptable graduate work with at least 21 from Engineering. The thesis option including nine (9) credit hours of research for the thesis track.

The entrance requirement for the MSE program is a BSE in Industrial Engineering, or other engineering discipline, at an acceptable grade point average providing strong performance in mathematics and science courses. Students with a non-IE bachelors degree can be required to take up to 5 undergraduate IE courses in order to ensure that the student has adequate background knowledge.

Students on the thesis track 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 at least 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. The thesis defense is open to the public.

Co-op Option in Engineering

The Department of Mechanical Engineering participates in the Graduate Master’s Co-op Option in Engineering. For detailed information about the Co-op Program and curriculum requirements, please see the Graduate Catalog Engineering Co-op page (https://www.uml.edu/Catalog/Graduate/Engineering/co-opoption.aspx).

Degree Requirement

All MSIE degree candidates must satisfy the following requirements:

1. Core courses (four three-credit courses):
   - IENG.5010 (https://www.uml.edu/catalog/courses/IENG/5010)
     Advanced Deterministic Modeling & Analysis
   - IENG.5020 (https://www.uml.edu/catalog/courses/IENG/5020)
     Advanced Stochastic Modeling & Analysis
   - IENG.5050 (https://www.uml.edu/catalog/courses/IENG/5050)
     Industrial Automation
   - BMEN.5310 (https://www.uml.edu/catalog/courses/BMEN/5310)
     Occupational Biomechanics

In addition to the core, each student must complete either a thesis or non-thesis track.

1. Thesis Track:
   Nine (9) credit hours of thesis research, nine (9) credit hours of coursework approved by the thesis advisor, and at least one semester of the 0 credit research seminar (MECH.5010 (https://www.uml.edu/catalog/courses/MECH/5010)).
   M.S. students on the thesis track will design a student-specific curriculum sequence of twelve credit hours of coursework (in consultation with the thesis advisor and approved in writing by the student and their thesis advisor) within the first semester of graduate study. The contract will be sent to the graduate coordinator and to the Registrar’s office.

2. Non-Thesis Track:
   Six (6) credit hours of course work in an Industrial Engineering Concentration and twelve (12) credit hours of course work approved by the graduate coordinator.
   In their first year students must submit on a non-thesis track 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.
Industrial Engineering Concentrations

1. Analytics and Operations
   - Degree pathway (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

2. Ergonomics and Safety
   - Degree pathway (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

3. Health System Engineering
   - Degree pathway (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

4. Manufacturing and Automation
   - Degree pathway (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

Doctoral Program

Doctoral Program in Mechanical Engineering

The UMass Lowell Department of Mechanical Engineering offers a Doctor of Philosophy (Ph.D.) 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 program includes 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 a 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.
- Applicants must take the GRE
- Applicants from abroad whose native language is not English, must take The TOEFL exam (other UMass Lowell graduate admission approved exam)
- Applicants must fully completed application per the graduate admissions office.

Transfer Credits

- A student with an earned master’s degree in Engineering or a closely related field may transfer the entire degree (coursework and thesis) up to total number of credits granted by UMass Lowell with approval of the Department Graduate Coordinator.
- 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.

Note: Students may be required to make up prerequisites which they lack in comparison to the equivalent Engineering curriculum at the UMass 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 courses including associated science and math coursework and dissertation credits at the discretion of the department, faculty advisor and dissertation committee.
- At least two semesters of the 0 credit research seminar MECH.5010 (https://www.uml.edu/catalog/courses/MECH/5010)

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 proposal defense, complete and pass the dissertation defense, and submit fully approved dissertation per university requirements.

Concerning graduate-level STEM courses, the Ph.D. candidate must take the following:

- One Course in advanced mathematics: MECH.5200 (https://www.uml.edu/catalog/courses/MECH/5200)
- Mathematical Methods for Engineers: MATH.5300 (https://www.uml.edu/catalog/courses/MATH/5300)
- Applied Math I: MATH.5450 (https://www.uml.edu/catalog/courses/MATH/5450)
- Partial Differential Equations
- Or another advanced mathematics approved by the doctoral dissertation advisor

Dissertation Proposal

The Dissertation Proposal stage 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 should have in addition one or more members from outside UMass Lowell (or outside the UMass Lowell Mechanical Engineering department).

At least two weeks (14 days) 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 template for posting these and the dissertation announcement can be found at:Thesis/Dissertation Submission (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

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 to demonstrate his/her understanding of the proposed research, as well as his/her proficiency in the general research field related to the dissertation proposal.

Doctoral of Philosophy in Industrial Engineering

Doctoral Program in Industrial Engineering (Anticipated Start Fall 2022)

The UMass Lowell Department of Mechanical Engineering offers a Doctor of Philosophy (Ph.D.), Option in Industrial Engineering.

Ph.D. Option in Industrial Engineering

The intent of the Doctor of Philosophy program is to prepare engineers for leadership positions in industry, academia, and government. The program includes advanced graduate course work in engineering and allied subjects and research, culminating in a doctoral dissertation.

Admission Requirements

Applicants must have a minimum of a B.S. in Industrial Engineering, or a closely related field with a minimum grade point average of 3.0 and a min GPA of 3.25 in science and engineering courses.

Applicants with a M.S. in Industrial Engineering, or a closely related field, must have a minimum graduate GPA of 3.25.

Transfer Credits

1. A student with an earned master’s degree in Engineering or a closely related field may apply to transfer 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 to transfer up to 24 course credits in acceptable graduate engineering courses (with an earned grade of B or better) towards the doctoral program, upon approval by the Department Graduate Coordinator.

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 Master of Science in Engineering core 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 and science, including associated physic (PHYS), chemistry (CHEMS), production & operation management (POMS), public health (PUBH) and math (MATH) course and dissertation credits at the discretion of the department, faculty advisor and dissertation committee.
- At least two semesters of the 0 credit research seminar MECH.5010.

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.
- take and pass the doctoral qualifying examination/dissertation proposal.
- Successfully defend and complete a dissertation.
- Meet all other University requirements for the degree.

**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 the dissertation committee composed 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.

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 to demonstrate his/her understanding of the proposed research, as well as his/her proficiency in the general research field related to the dissertation proposal.

**Doctoral Core Requirement**

Students must satisfy the following doctoral core requirement:

- Four core courses
  1. IENG.5010 (https://www.uml.edu/catalog/courses/IENG/5010) Advanced Deterministic Modeling & Analysis
  2. IENG.5020 (https://www.uml.edu/catalog/courses/IENG/5020) Advanced Stochastic Modeling & Analysis
  3. IENG.5050 (https://www.uml.edu/catalog/courses/IENG/5050) Industrial Automation
  4. BMEN.5310 (https://www.uml.edu/catalog/courses/BMEN/5310) Occupational Biomechanics

- Six courses from one the following four areas of concentration

**Industrial Engineering Concentration**

1. **Analytics and Operations**
   - Degree pathway (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

2. **Ergonomics and Safety**
   - Degree pathway (https://www.uml.edu/catalog/pdf-
3. Health System Engineering
   - Degree pathway (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

4. Manufacturing and Automation
   - Degree pathway (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
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. “Variable credit course, student chooses appropriate amount of credits when registering.”

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: 1-3

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, rotorcrafts, 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

MECH.5180 Signal Proc Techniques (Formerly 22.518) - Credits: 3

The course covers analytical/numerical modeling and analysis of signal processing. 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.5195 Principles and Applications of Sensors for Engineering - Credits: 3

The course focuses on defining concepts and operational principles of various sensing technologies and their applications for assessing the conditions of aerospace, civil, and mechanical engineering systems and materials. Analytical and experimental background of commonly used wire-based and wireless transducers, their data acquisition protocols, and signal processing techniques in time and frequency domains are discussed. A strong emphasis is provided to non-contact and optical techniques, including mono/stereo computer-vision and thermal infrared for nondestructive evaluation and subsurface inspection. The concepts discussed in the lectures are analyzed in deep and applied through practical projects, demonstrations, and hands-on experiments on laboratory scale structures.

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 of 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.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.5220 Wind Energy Fundamentals - Credits: 3

An overview of all aspects of wind energy power generation: The nature of and statistics of wind, turbine siting requirements, aerodynamics of the rotor system, mechanical power transmission, generators, blade construction, structural analysis of turbine components, electrical power distribution.

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.5255 Hydropower - Credits: 3**

The fundamentals of hydropower engineering and the related parameters for the design of hydropower plants, including, hydraulic, hydromechanics and hydroelectric components, are presented in this course. References are also made to dams and water conduit systems, in multi-purpose hydro development projects, as well as small hydroelectric plants. The hydrological, environmental and economical aspects of hydro projects are also briefly addressed. At the end of the course, students should be able to calculate the basic parameters of hydropower projects, at a preliminary level, such as powerhouse capacity, turbine and generator technical parameters and dimensions, water conduit and hydro mechanical equipment types and sizes, and perform a cost-benefit evaluation.

**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.5285 Energy Policy and Energy Codes - Credits: 3**

Explore and codify the status of the world’s energy infrastructure and discuss energy-related policies. Identify areas of energy inefficiency and examine pathways to a future dominated by renewable and sustainable resources.

**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.5305 Introduction to Legged Locomotion - Credits: 3

Introduction to the modeling, analysis, planning, and control of legged robotic locomotion systems. Topics covered include: basic components of robotic systems, selection of coordinate frames, homogeneous transformations, solutions to kinematic equations, velocity and force/torque relations, legged Locomotion dynamics in Lagrange’s formulation and Newton-Euler formulation, digital simulation of kinematic and dynamic models, kinematics of legged robots, zero-moment-point (ZMP) stability, hybrid-zero-dynamics (HZD) methods, and motion planning and locomotion control.

MECH.5310 Math Methods In Mechanical Engineering (Formerly 22.531) - Credits: 3

MECH.5315 Modern Control Systems - Credits: 3

Introduction to the analysis and design of feedback controllers for linear systems using the state-space formulation. Topics covered include: linear algebra, vector spaces, state-space representation, realization theory, stability in the sense of Lyapunov, controllability and observability, Kalman decomposition, pole placement via state-feedback, observer design, linear quadratic regulators and introduction to nonlinear systems.

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.5330 Nanomaterials for Energy - Credits: 3

Introduction of fundamental materials development and principles in addressing issues associated with affordable and sustainable energy. The course starts with basic concepts in materials science and engineering, with special attention paid to the origin of size effects in controlling the properties of nanomaterials. Then a range of materials issues related to development of renewable energy resources and sustainable energy technologies will be discussed. Topics to be covered include: photovoltaic materials and solar energy conversion; thermoelectric materials; materials for electrical energy storage and generation; materials for hydrogen production; piezoelectric energy harvesting; and materials for other emerging energy processes.

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, reaction kinetics, nonequilibrium processes, diffusion flames, and boundary layer combustion. Additional specific emphasis on combustion modeling, green approaches to energy production, and biofuels.

MECH.5350 Fundamentals of Sustainable Energy - Credits: 3

Introduction to scientific principles associated with sustainable energy technologies. Topics include: thermodynamic laws and engineering fundamentals in energy processes, thermodynamic energy conversion, wind and geothermal energy, photovoltaics, ocean thermal energy conversion, electrochemical energy, biomass, and selected emerging energy technologies.

MECH.5410 Advanced Heat Transfer - Credits: 3

Advanced Heat Transfer is one of the core courses for graduate students to build the foundation and knowledge for the subsequent studies of specialized subjects. This course mainly comprises two parts: thermal conduction and convection. The thermal conduction part covers conduction formulations, analytical methods, and numerical technique to solve the multidimensional steady-state and transient conduction problems. The convection part covers the fundamental concepts of convection, governing equations, boundary layers and analytical solutions for external and internal flows, natural convection, boiling and condensation heat transfer.

MECH.5420 Convective Heat/Mass Transfer (Formerly 22.542) - Credits: 3

Conservation equations. Heat transfer in laminar and turbulent
boundary layer and duct flow. Free convection. Convective mass transfer.

**MECH.5440 Combustion Modeling - Credits: 3**

This course is focused on combustion modeling and computational combustion. It will introduce methods for modeling laminar and turbulent premixed and non-premixed flames, as well as particulate combustion. Specific emphasis will be placed on the theory and derivation of the methods, their implementation, and the use of existing computational tools. Models will include combustion kinetics, convective and diffusive transport, equilibrium, simple reactors, canonical premixed and non-premixed flames, and methods for treating turbulent flows. Practical applications include internal combustion engines and gas turbines.

**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.5491 Advanced Thermodynamics - Credits: 3**

The primary objective of this course is to prepare upper-level engineering students to effectively solve problems directly related to the fundamental science and engineering of thermodynamic systems. The course expands upon the first and second laws of thermodynamics. A significant emphasis is placed on the concepts of entropy generation and its transport mechanisms with respect to single-phase, multi-phase, chemically reacting and non-reacting systems. The methods of entropy generation minimization for commonly studied thermodynamic systems are discussed.

**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.5520 Probabilistic Methods and Analysis - Credits: 3**

The course will review the fundamentals of probability and statistics, and introduce the methodologies that are commonly adopted in mechanical engineering domain. The concepts of uncertainty, confidence and risk of engineering decision-making will be emphasized. Specific topic areas will include: random vibration and analysis, random data processing, probability evolution, uncertainty quantification in system modeling, model validation and verification, data fusion and model updating, Bayesian inference and statistical learning. Course assignments will be primarily deployed in Matlab environment.

**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.5550 Networked Multi-Agent Systems -
Credits: 3
Our world is increasingly becoming more connected, with multiple natural and engineered entities operating in a common space, and possessing the capability to sense, react to, and manipulate the physical world around us. Many modern world systems such as the traffic networks, multi-robot systems, stock exchanges, and even human societies, exist as multi-agent systems (or system-of-systems). In this course, we will discuss approaches to model, quantify, and influence (or control) the global behaviors of these multi-agent systems. The course will provide introductory dynamic modeling techniques for multi-agent systems. The course will provide introductory dynamic modeling techniques for multi-agent systems, discuss information-theoretic measures for quantifying the behaviors of these systems, and provide techniques to design stat-of-the-art controllers for these systems.

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 of 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.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 multi-disciplinary 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.5720 Manufacturing Processes - Credits: 3
Ferrous and non-ferrous, plastic and ceramic material behavior and properties. Electronic manufacturing processes, including printed circuit board fabrication, population and soldering. Castings, materials forming and shaping. Surface preparations and heat treatment. Additive manufacturing and fabrication of composites.

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


Classroom studies are followed by hands-on applications in the Automated Manufacturing Assembly and Robotics Laboratory.

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.5980 Experimental Characterization of Composites - Credits: 3

MECH.5CO-OP Curricula Practical Training (Formerly 22.5CO-OP) - Credits: 0-1
Curricula Practical Training. "Variable credit course, student chooses appropriate amount of credits when registering."

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.6040 Special Topic: Finite Element Methods - Credits: 3
Study of advanced topics in finite element methods 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.6150 Micromechanics of Composites and Metamaterials - Credits: 3
Overall behavior of composite materials and metamaterials. The fundamentals of homogenization for elastic composites, variational principles and energy-based bounds, and dynamic homogenization concepts and techniques are introduced. Voigt and Reuss mixture rules are discussed and expanded to dilute distribution, self-consistent, Mori-Tanaka, and periodic approaches with examples from particulate, whisker, platelet, and fiber-reinforced composites. The effects of damage and cracks and the concept of metamaterial are discussed and
examples are presented. The use of finite element calculations for static, nonlinear, and dynamic homogenization will be discussed and the application to non-mechanical and coupled problems are explored.

**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.6690 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.7410 Master's Thesis - Mechanical Engineering (Formerly 22.746)** - Credits: 6

MS Thesis Research

**MECH.7490 Master's Thesis - Mechanical Engineering (Formerly 22.749)** - Credits: 9

MS Thesis Research

**MECH.7510 Adv Projects In Mechanical Engineering (Formerly 22.751)** - Credits: 1-3

Doctoral Dissertation Research

**MECH.7530 Doctoral Dissertation/Mechanical Engineering (Formerly 22.753)** - Credits: 1-3

Doctoral Dissertation Research

**MECH.7560 Doctoral Dissertation/Mechanical Engineering (Formerly 22.756)** - Credits: 6

Doctoral Dissertation Research

**MECH.7590 Doctoral Dissertation/Mechanical Engineering (Formerly 22.759)** - Credits: 9

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.

MECH.7CPT Curricular Practical Training for Engineering Doctoral Candidates - Credits: 1

Curricular Practical Training (CPT) is a training program for doctoral students in Engineering. Participation in CPT acknowledges that this an integral part of an established curriculum and directly related to the major area of study or thesis.
**Master’s Program - Thesis and Non-thesis Options**

**Master of Science in Engineering Degree Programs (M.S.E.)**

In 2005, the Department of Plastics Engineering restructured its MSE Degree Program. Plastics Engineering MSE graduate students accepted into the program must follow either the "Thesis Option" Curriculum or the "Non-thesis Option" Curriculum described in the following sections. For the 30-credit hour thesis option, the student performs supervised research, prepare a written thesis manuscript, and defend the work during an oral presentation. The 33-credit hour non-thesis M.S.E. is designed 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

**Co-op Option in Engineering**

The Department of Plastics Engineering participates in the Graduate Master’s Co-op Option in Engineering. For detailed information about the Co-op Program and curriculum requirements, please see the Graduate Catalog Engineering Co-op page (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf).

**Thesis 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. Graduate students enrolled in the Thesis Option M.S.E. Program prior to the Fall of 2005 may elect to follow the either new program requirements (thesis or non-thesis program described below, or those in effect at the time they were accepted into the degree program.

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 (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf) and other regulations, see Graduate Polices (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf) 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.

**Requirement 1** Complete the cluster of "core course" requirements (9 credit hours):

- **PLAS.5440**
  Advanced Plastics Materials (3 credits)
- **PLAS.5780**
  Advanced Plastics Processing (3 credits)
- **PLAS.5730**
  Graduate Polymer Laboratory (3 credit)

Special notes for students having a B.S. Plastics Engineering from UMass Lowell:

- Students who have a B or higher in Polymer Materials I (PLAS.2010) and Polymer Materials II (PLAS.2020) are not required to take Advanced Plastics Materials (PLAS.5440). These students, however, must still meet the 24 course credit hour program requirement by substituting other Plastics Engineering Graduate Courses
- Students who received a grade of B or higher in Plastics Process Engineering I (PLAS.3770) and Plastics Process Engineering II
(PLAS.3780) are not required to take Advanced Plastic Materials (PLAS.5780). These students, however, must still meet the 24-course credit hour program requirement by substituting other Plastics Engineering Graduate Courses.

Special notes for students who have a B.S. Degree in Plastics Engineering from UMass Lowell or equivalent program may elect to test out of Advanced Plastics Materials (PLAS.5440) and Advanced Plastics Processing (PLAS.5780). These students, however, 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**
  (https://www.uml.edu/catalog/courses/PLAS/5030) Mechanical Behavior of Polymers
- **PLAS.5180**
  (https://www.uml.edu/catalog/courses/PLAS/5180) Plastics Product Design

**Elective Courses (any two of the following):**

- **PLAS.5060**
  (https://www.uml.edu/catalog/courses/PLAS/5060) Polymer Structure, Properties, and Applications
- **PLAS.5230**
  (https://www.uml.edu/catalog/courses/PLAS/5230) Screw Design Principles
- **PLAS.5410**
  (https://www.uml.edu/catalog/courses/PLAS/5410) Computer Applications in Plastics
- **PLAS.5490**
  (https://www.uml.edu/catalog/courses/PLAS/5490) Design with Elastomers
- **PLAS.5510**
  (https://www.uml.edu/catalog/courses/PLAS/5510) Computer Aided Extrusion Die Design
- **PLAS.5520**
  (https://www.uml.edu/catalog/courses/PLAS/5520) Design of Polymer Processing Machinery
- **PLAS.5530**
  (https://www.uml.edu/catalog/courses/PLAS/5530) Medical Device Design I
- **PLAS.5540**
  (https://www.uml.edu/catalog/courses/PLAS/5540) Medical Device Design II
- **PLAS.5760**
  (https://www.uml.edu/catalog/courses/PLAS/5760) Advanced Mold Design
- **PLAS.5850**
  (https://www.uml.edu/catalog/courses/PLAS/5850) Computer Aided Engineering and Design I
- **PLAS.5990**
  (https://www.uml.edu/catalog/courses/PLAS/5990) Rapid Prototyping
- **PLAS.6020**
  (https://www.uml.edu/catalog/courses/PLAS/6020) Medical Device Development Regulation

(b.) **Graduate Certificate in "Plastics Materials"**
Required Courses:

- PLAS.5440 (https://www.uml.edu/catalog/courses/PLAS/5440) Advanced Plastics Materials
- PLAS.5060 (https://www.uml.edu/catalog/courses/PLAS/5060) Polymer Structure, Properties, and Applications

Elective Courses (any two of the following):

- PLAS.5050 (https://www.uml.edu/catalog/courses/PLAS/5050) Polymer Structure II
- PLAS.5120 (https://www.uml.edu/catalog/courses/PLAS/5120) Porous Polymers
- PLAS.5320 (https://www.uml.edu/catalog/courses/PLAS/5320) Adhesives and Adhesion
- PLAS.5330 (https://www.uml.edu/catalog/courses/PLAS/5330) Coatings Science and Technology
- PLAS.5350 (https://www.uml.edu/catalog/courses/PLAS/5350) Rubber Technology
- PLAS.5400 (https://www.uml.edu/catalog/courses/PLAS/5400) Commercial Development of Polymeric Systems
- PLAS.5590 (https://www.uml.edu/catalog/courses/PLAS/5590) Elements of Packaging
- PLAS.5650 (https://www.uml.edu/catalog/courses/PLAS/5650) Engineering Thermosetting Resins
- PLAS.5800 (https://www.uml.edu/catalog/courses/PLAS/5800) Polymer Science I
- PLAS.5890 (https://www.uml.edu/catalog/courses/PLAS/5890) Polymer Nanocomposites
- PLAS.5960 (https://www.uml.edu/catalog/courses/PLAS/5960) Plastics, Elastomers and Additives from Renewable Resources
- PLAS.5970 (https://www.uml.edu/catalog/courses/PLAS/5970) Plastics and the Environment
- PLAS.6820 (https://www.uml.edu/catalog/courses/PLAS/6820) Physical Polymer Science

(c.) Graduate Certificate in "Plastics Processing"

Required Courses:

- PLAS.5180 (https://www.uml.edu/catalog/courses/PLAS/5180) Plastics Product Design

Elective Courses (any two of the following):
• **PLAS.5060**
  (https://www.uml.edu/catalog/courses/PLAS/5060)
  Polymer Structure, Properties, and Applications

• **PLAS.5090**
  (https://www.uml.edu/catalog/courses/PLAS/5090)
  Plastics Product Design

• **PLAS.5150**
  (https://www.uml.edu/catalog/courses/PLAS/5150)
  Lean Plastics Manufacturing

• **PLAS.5230**
  (https://www.uml.edu/catalog/courses/PLAS/5230)
  Screw Design Principles

• **PLAS.5240**
  (https://www.uml.edu/catalog/courses/PLAS/5240)
  Process Analysis, Instrumentation, and Control

• **PLAS.5250**
  (https://www.uml.edu/catalog/courses/PLAS/5250)
  Synthetic Fibers: Processing, Structure, and Properties

• **PLAS.5260**
  (https://www.uml.edu/catalog/courses/PLAS/5260)
  Nanoscale Plastics Processing

• **PLAS.5300**
  (https://www.uml.edu/catalog/courses/PLAS/5300)
  Processing with Elastomers

• **PLAS.5510**
  (https://www.uml.edu/catalog/courses/PLAS/5510)
  Computer Aided Extrusion Die Design

• **PLAS.5520**
  (https://www.uml.edu/catalog/courses/PLAS/5520)
  Design of Polymer Processing Machinery

• **PLAS.5850**
  (https://www.uml.edu/catalog/courses/PLAS/5850)
  Computer Aided Engineering and Design I

• **PLAS.5880**
  (https://www.uml.edu/catalog/courses/PLAS/5880)
  Injection Molding

• **PLAS.6780**
  (https://www.uml.edu/catalog/courses/PLAS/6780)
  New Developments in Polymer Manufacturing

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(d.) Graduate Certificate in "Medical Plastics Design and Manufacturing"

**Required Courses:**

• **PLAS.5530**
  (https://www.uml.edu/catalog/courses/PLAS/5530)
  Medical Device Design I

• **PLAS.5750**
  (https://www.uml.edu/catalog/courses/PLAS/5750)
  Biomaterials

**Elective Courses (any two of the following):**

• **PLAS.5540**
  (https://www.uml.edu/catalog/courses/PLAS/5540)
  Medical Device Design II

• **PLAS.5790**
  (https://www.uml.edu/catalog/courses/PLAS/5790)
  Problems in Biomaterials - (directed study)

• **PLAS.6020**
  (https://www.uml.edu/catalog/courses/PLAS/6020)
  Medical Device Development Regulation

• **PLAS.6750**
  (https://www.uml.edu/catalog/courses/PLAS/6750)
  Biomaterials II

• **CHEN.5550**
  (https://www.uml.edu/catalog/courses/CHEN/5550)
  Biopharmaceutical GMP and Licensing *

  * (offered by the Chemical Engineering Department)

• **BMBT.5000**
  (https://www.uml.edu/catalog/courses/BMBT/5000)
  Introduction to Biomedical Engineering & Biotechnology **

  ** (offered by the Biomedical Engineering program)

• **PLAS.5030**
  (https://www.uml.edu/catalog/courses/PLAS/5030)
  Mechanical Behavior of Polymers

• **PLAS.5180**
  (https://www.uml.edu/catalog/courses/PLAS/5180)
  Plastics Product Design

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(e.) Graduate Certificate in "Elastomeric Materials"
Required Courses:

- PLAS.5350
  (https://www.uml.edu/catalog/courses/PLAS/5350)
  Rubber Technology
- PLAS.5950
  (https://www.uml.edu/catalog/courses/PLAS/5950)
  Thermoplastic Elastomers

Elective Courses (any two of the following):

- PLAS.5490
  (https://www.uml.edu/catalog/courses/PLAS/5490)
  Design with Elastomers
- PLAS.5500
  (https://www.uml.edu/catalog/courses/PLAS/5500)
  Processing with Elastomers
- PLAS.5060
  (https://www.uml.edu/catalog/courses/PLAS/5060)
  Polymer Structure, Properties, and Applications
- PLAS.5960
  (https://www.uml.edu/catalog/courses/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 six-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 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.

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)

Non-matriculated students (with an appropriate B.S. Degree) may begin taking courses without application to the M.S.E. Plastics Engineering Program. It is recommended, however, 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.

Students may transfer as many as 12 science or engineering graduate course credits from other universities provided they are approved by the Plastics Engineering Department’s M.S.E. program coordinator. (For University regulations regarding transfer credit (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf) and other regulations, see the Graduate Policies (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf) in the on-line catalog.)

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 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.

Non-thesis Option

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.

Requirement 1 Complete the "core course" requirements (18 credits)

- PLAS.5030 (https://www.uml.edu/catalog/courses/PLAS/5030) - Mechanical Behavior of Polymers (3 credits)
- PLAS.5440 (https://www.uml.edu/catalog/courses/PLAS/5440) - Advanced Plastics Materials (3 credits)
- PLAS.5780 (https://www.uml.edu/catalog/courses/PLAS/5780) - Advanced Plastics Processing (3 credits)
- PLAS.5060 (https://www.uml.edu/catalog/courses/PLAS/5060) - Polymer Structure Properties and Applications (3 credits)
- PLAS.5180 (https://www.uml.edu/catalog/courses/PLAS/5180) - Plastics Product Design (3 credits)
- PLAS.5730 (https://stage.uml.edu/catalog/courses/PLAS/5720) Graduate Polymer Laboratory (3 credit)

Special notes for students having a Plastics Engineering B.S. Degree:

Students who have a B.S. Degree in Plastics Engineering from UMass Lowell or an equivalent program may elect to test out of Advanced Plastics Materials (PLAS.5440 (https://www.uml.edu/catalog/courses/PLAS/5440)) and Advanced Plastics Processing (PLAS.5780 (https://www.uml.edu/catalog/courses/PLAS/5780)). However, these students must still meet the 33 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".

- Plastics Design
- Plastics Materials
- Plastics Processing
- Medical Plastics Design and Manufacturing

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.

Requirement 3 Complete the requirements for an additional number of elective plastics graduate courses such that the "total" credit hours (core courses + certificate + electives) is 33 credits. Up to two elective courses from other engineering departments may be substituted if approved by the graduate coordinator.

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:

The M.S.E. Coordinator will be the academic advisor for students enrolled in the non-thesis M.S.E. Plastics Engineering Degree Program. The coordinator 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 nine credits in a semester are considered part time, while those taking nine or more credits are considered full time students. Graduate students must maintain full-time student status in order to be eligible for research assistant positions (R.A.).

Funding Policy - Plastics Engineering Graduate Students

Research Assistant Positions (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.

Doctoral Program

Doctoral Program in Plastics Engineering

The UMass Lowell Department of Plastics Engineering offers a 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.

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.

Admission Requirements

Graduates with a B.S. in Engineering (e.g. Plastics, Mechanical, Chemical, Materials...) and high academic standing may apply for admission to the Ph.D. 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 Program

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 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 Philosophy programs upon approval by the department's Doctoral Committee.

**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](https://www.uml.edu/catalog/courses/PLAS/5440)
- PLAS.5780 [Advanced Plastics Processing](https://www.uml.edu/catalog/courses/PLAS/5780)

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. Student whose UMass Lowell undergraduate GPA is 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](https://www.uml.edu/catalog/courses/PLAS/6420) (3 credits)
- PLAS.6820 [Physical Polymer Science](https://www.uml.edu/catalog/courses/PLAS/6820) (3 credits)
- PLAS.6780 [New Development in Polymer Manufacturing](https://www.uml.edu/catalog/courses/PLAS/6780) (3 credits)
- PLAS.6180 [Structure Product Design](https://www.uml.edu/catalog/courses/PLAS/6180) (3 credits)
- PLAS.5090 [Plastics Processing Theory I](https://www.uml.edu/catalog/courses/PLAS/5090) (3 credits)
- PLAS.5480 [Numerical and Analytical Methods](https://www.uml.edu/catalog/courses/PLAS/5480) (3 credits)
- PLAS.5850 [Computer Aided Engineering and Design](https://www.uml.edu/catalog/courses/PLAS/5850) (3 credits)
- PLAS.5760 [Computer Aided Engineering and Design](https://www.uml.edu/catalog/courses/PLAS/5760) (3 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](https://www.uml.edu/catalog/courses/PLAS/6420) (3 credits)
- PLAS.6820 [Physical Polymer Science](https://www.uml.edu/catalog/courses/PLAS/6820) (3 credits)
- PLAS.6780 [New Development in Polymer Manufacturing](https://www.uml.edu/catalog/courses/PLAS/6780) (3 credits)
- PLAS.6180 [Structure Product Design](https://www.uml.edu/catalog/courses/PLAS/6180) (3 credits)
- PLAS.5090 [Plastics Processing Theory I](https://www.uml.edu/catalog/courses/PLAS/5090) (3 credits)
- PLAS.5180 [Plastics Product Design](https://www.uml.edu/catalog/courses/PLAS/5180) (3 credits)
- PLAS.5480 [Numerical and Analytical Methods](https://www.uml.edu/catalog/courses/PLAS/5480) (3 credits)
Numerical and Analytical Methods (3 credits)

- PLAS.5850
  Computer Aided Engineering or Advanced Mold Design (3 credits)
- PLA.

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

(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
  Computer Aided Engineering or Advanced Mold Design (3 credits)
- PLAS.5730
  Graduate Polymer Laboratory (3 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.
PLAS.5000 Advanced Project In Plastics I  (Formerly 26.500) - Credits: 0-1
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.5020 Medical Device Development Regulation (Formerly 26.602 and PLAS.6020) - 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 (CRDH) investigational device exemptions, premarket approval, 510 (k) application process, and product development protocol and review processes.

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.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 Foams (Formerly 26.512) - Credits: 3
This course covers the fundamentals of polymer foaming, processing methods, recent technologies, foam characteristics, and applications. Fundamentals cover the cell nucleation and growth mechanisms in foaming and the role of thermodynamics and kinetics. Batch foaming, extrusion foaming, foam injection molding, and bead foaming are discussed as the common processing methods. The characteristics and performance of polymeric foams, process-structure-property relationships, and the relevant applications in various industries also are presented.

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.5230 Screw Design Principles (Last Term 2007 Spring) (Formerly 26.523) - Credits: 3
Energy balances, energy efficiency for extrusion and injection molding, application of energy equation (conduction, convection, viscous dissipation), equations of state, melt
conveying in simple and compound screws, screw scale up, plastication.

PLAS.5240 Process Analysis Instrument and Control (Formerly 26.524) - Credits: 3


PLAS.5250 Synthetic Fibers: Processing-Structure-Properties (Formerly 26.525) - Credits: 3

An introduction to processing-structure-properties of fibers and its significance to modern advanced materials. This course covers both traditional and emerging fiber spinning methods (ex. solution spinning, melt extrusion, gel-spinning, and electrosprining), post-processing techniques (ex. yarns, weaving), and the resulting multi-scale structures and properties. The unique physical and chemical properties of fibers and its application as past and emerging advanced materials will be discussed.

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 Green Coatings Science and Technology I (Formerly 26.533) - Credits: 3

This course reviews the basic principles of design and formulation of water-borne, high-solids and 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. The basic principles of formulation of coatings will be introduced. Permission of instructor for Plastics Engineering Undergraduates seeking to take course as technical elective.

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.5360 Rheology of Polymers (Formerly 26.536) - Credits: 3

Rheology of polymer melts, solutions, latexes, and pigment dispersions, and their application to coatings and adhesives.

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 (Formerly 26.545) - Credits: 3
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.5550 Medical Device Processing - Credits: 3
Critical analysis of current methods of medical device manufacturing, focusing on processing and performance considerations. Includes discussion of different production methods, material selection considerations, biocompatibility, leachables and extractables, device sterilization, and sterile packaging.

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
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, silicons, 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.

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
PLAS.5730 Graduate Polymer Laboratory - Credits: 3
This course provides in-coming graduate students hands-on experience with plastics processing and characterization techniques. Students formed parts of products using multiple extrusion processes, injection molding, blow molding, and thermoforming. These products then are characterized for their mechanical, thermal, and other characteristics using standard test methods. A heavy emphasis also is placed on reporting the

Typical market sectors served and related processing/fabrication technologies used in reinforced plastics/composites are reviewed.
results in a professional manner.

**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 in Medical Applications**  
(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.5880 Injection Molding**  
(Last Term 2008 Spring)(Formerly 26.588) - Credits: 3

An individual research project, term paper and presentation are required.

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.5940 Additive Manufacturing Engineering Fundamentals - Credits: 3

Critical analysis of current methods of additive manufacturing. Materials selection, processing-structure-property relationships, testing, relationship to transport phenomena and/or reaction kinetics.

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 and 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.5970 Plastics & Environment (Formerly 26.597) - Credits: 3

This course investigates the waste management solutions for different types of plastics. Both traditional and emerging recycling methods will be highlighted. Accumulation of plastic waste in the natural environment and the toxicoogy of plastics as well as their additives will be discussed. Further, analysis methods and instrumentation to characterize recycled plastics, and the differences in virgin polymers and recycled polymers will be introduced. Potential degradable, biodegradable or biobased alternatives will be reviewed along with the concepts of life cycle assessment and Green Chemistry for designing the most sustainable plastic materials.

PLAS.5990 Rapid Prototyping - Credits: 3

Survey of the rapidly expanding technology field of rapid prototyping. Technologies to be considered include stereolithography, laminated object manufacturing, selective laser sintering, fused deposition modeling, and solid ground curing.

PLAS.6010 Graduate Industrial Coop Education I (Formerly 26.601) - Credits: 1-3

Graduate students interested in developing a practical industrial experience component to compliment their academic training may register for this course with advisor's approval. This credit is not applicable to the mandated degree credit hours.

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-to-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 chip 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  
Individual research projects in plastics.

**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.

**PLAS.7CPT Curricular Practical Training for Engineering Doctoral Candidates - Credits: 1**

Curricular Practical Training (CPT) is a training program for doctoral students in Engineering. Participation in CPT acknowledges that this an integral part of an established curriculum and directly related to the major area of study or thesis.
Master’s Program

This program is no longer accepting students.

Master of Arts in Economic and Social Development of Regions

The Master of Arts in Economic and Social Development of Regions is designed to serve students from a variety of backgrounds. It attracts recent undergraduates from liberal arts fields such as social sciences (Economics, Sociology, Psychology, Political Science) and History, and also from practice-oriented fields such as Management, Education, and Engineering.

For those already working in public or private sector fields related to economic and social development, it can enhance skills and provide opportunities for career advancement. It is specifically designed to speak to the interests of international students as well as domestic ones.

Graduates of the program will be prepared to assume professional roles in local, state, and national government agencies (in the United States and abroad); in research, consulting, and planning aspects of business; and in non-profit organizations working on economic or social development. Students who choose to do so will also be prepared to go on to doctoral programs in social sciences, history, public policy, planning, and management.

In the Masters program, courses can be selected to address the student’s particular interests in one of six Focus Areas (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf):

1. Policy at the National, State, and Local level
2. Global Development and International Policy
3. Community Development, Social Policy, and Non-Profit Management
4. Innovation, Technology, and Policy
5. Environment and Sustainability
6. Research Methods

Admissions Requirements

The Economic and Social Development of Regions Master’s program at the University of Massachusetts at Lowell is designed not only for recent college graduates, but also for older, non-traditional, and mid-career students with experience in a variety of work and community settings. The requirements for admission include:

1. Bachelor’s degree from an accredited institution college or university.
2. An undergraduate grade point average of 3.0 or better. Applicants must submit an official transcript from their undergraduate institution.
3. Acceptable scores on the Graduate Record Examination Aptitude Test. (Use of GMAT scores may be approved by the graduate coordinator.) Students for whom English is not a national language must also submit a score for the Test of English as a Foreign Language (TOEFL).
4. Three letters of reference from individuals familiar with the educational and/or professional performance of the applicant.
5. A personal letter including a statement about the applicant’s professional interests, educational and work qualifications, and future goals.
6. A curriculum vitae summarizing education and work experience.
7. An interview may be requested by the Graduate Admissions Committee.

Students may be admitted in one of two categories:

1. Matriculated student. A fully accepted degree candidate who meets all criteria.
2. Matriculated with conditions. From time to time, a student may be accepted conditionally into the program. To become a fully matriculated student, the student must receive at least a 3.0 grade point average in nine credit hours of Economic and Social Development of Regions graduate level courses, while also completing any conditions established by the Graduate Admissions Committee. Conditional matriculation requires that students meet conditions 1 and 2 above.

Part-Time and Full-Time Study

MA students may attend either full-time or part-time. Most courses will be scheduled in the evening. Courses will be offered in fall and spring terms, and some courses may be available during the summer. Students taking a full-time load of 12 credits per semester can finish the program in three semesters. Students taking 9 or more credits in a semester will
be considered full-time students.

Transfer Credit

Matriculated students in Economic and Social Development of Regions may transfer up to 12 credits of course work completed at other accredited universities, provided that such courses are within the content area of Regional Economic and Social Development, and do not involve credit for field experience or professional work. Such transfer credit is subject to the approval of the Department Graduate Curriculum Committee and the Registrar’s Office, and all University policies governing graduate transfer credit.

Degree Requirements

A total of 30 (for project) or 33 (for thesis) academic credits, at least 18 of which must be taken at the University of Massachusetts at Lowell with a grade average of B or better, is required for completion of the degree.

The course of study includes two compulsory core courses (six credits):

- 57.506 Research Methods in Economic and Social Development
- 57.513 Foundations of Comparative Regional Development

The course of study must also include three of the following six courses (9 credits):

- 57.503 Work, Technology, and Training
- 57.511 Dynamics of Power and Authority, Diversity, and Inequality
- 57.537 Developing Economies
- 57.592 Qualitative Research Methods
- 57.593 Advanced Quantitative Methods
- 57.598 Organizational Dynamics in Regional Development

Students are also required to complete an additional 12 credits of course credits, and either six credits of thesis or three credits of project. The 12 credits of additional course requirements can be satisfied in a wide variety of ways. Students are encouraged to take advantage of six focus areas (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf) that specify additional course work in particular areas. However, students are also encouraged to tailor their program to achieve their own learning and career goals, by combining courses, independent study, and practica as appropriate. Non-core course selections must be approved in advance by the student’s graduate advisor.

Thesis or Project

The capstone to the degree program is a thesis or project demonstrating the student’s mastery of the field. Typically, the thesis (6 credits) involves a substantial piece of research in economic and social development, whereas the project (3 credits) involves carrying out and documenting a professional problem-solving activity. In some cases, more in-depth problem-solving activities may qualify for thesis status. Thesis or project work is supervised on an ongoing basis by the student’s thesis/project supervisor.

Graduate Advisor

Each newly matriculated student in the program will be assigned to an academic advisor from among the faculty of the graduate program. The student will meet with his/her academic advisor on a regular basis throughout the course of study to discuss course selections, planning for practica, and the development of the thesis or project. In particular, all non-core course selections require prior approval from the academic advisor. Each student will, in addition, select a faculty member to supervise his/her thesis or project. The student will retain his/her academic advisor to provide guidance on selection of remaining courses.

BA/MA and BS/MA Options (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

Undergraduate majors in related fields at the University of Massachusetts at Lowell may enroll in a BA/MA or BS/MA program that allows eligible students to complete both degrees in five years. Application for this program typically occurs in the junior year and applicants must meet all eligibility requirements, including a minimum 3.0 cumulative GPA. Additional information is available from the Graduate Coordinator.

Graduate Certificate Program

No Longer Excepting New Students for This Program! Economic & Social Development of Regions Contact:
Philip Moss (mailto:Philip_Moss@uml.edu)
978-935-2787
Robert Forrant (mailto:Robert_Forrant@uml.edu)
978-934-2904

The 12 credit certificate offers graduate level instruction to students interested in understanding, analyzing, and intervening to enhance the economic and social development of regions. It provides students with a strong grounding in the conceptual tools and the information needed to participate effectively in the development of neighborhoods, states, or nations.
Required Courses (all students):

- 57.513 Foundations of Comparative Regional Development (3 credits)

Plus two of the following seven core courses (Total of six credits):

- 57.503 Work, Technology, and Training (3 credits)
- 57.506 Research Methods in Economic and Social Development (3 credits)
- 57.511 Dynamics of Power and Authority, Diversity, and Inequality (3 credits)
- 57.537 Developing Economies
- 57.592 Qualitative Research Methods
- 57.593 Advanced Quantitative Methods
- 57.598 Organizational Dynamics in Regional Development

AND One Approved Elective (3 credits)

About Graduate Certificates (https://www.uml.edu/Grad/programs/about-certificates.aspx)
ECON.5130 Foundations Of Comparative Regional Development (Formerly 57.513)(Formerly POLI.5130) - Credits: 3

This course offers an initial grounding in economic, historical, political, and sociological methodologies and introduces discipline-based and interdisciplinary approaches to regional development. It introduces students to: identifying and assessing structural factors influencing regional development, defining regional development challenges, and generating problem-solving strategies and public policies. The course highlights the relationship between theory and application, and looks at development at the community, national, and international levels. It makes extensive use of case materials on regional development, including a unit on the development of the Massachusetts economy. Students will learn how to find, prepare and analyze data on regional economies and will learn several basic quantitative tools for regional analysis.

ECON.5140 Researching Industries and Companies in the Global Economy - Credits: 3

The Internet revolution gives us access to vast amounts of information on economics, industries, and companies. This course provides students with a framework, rooted in Prof. Lazonick’s "theory of innovative enterprise," for the integration of facts and logic in conducting research. Students learn where to find and how to make use of relevant information available as e-resources. Through the study of Lazonick’s research, the course enables students to take a deep dive into the theoretical approaches and sources of information that he has used to analyze economies, industries, and companies in global perspective. During the course, students work in teams to produce e-resource-based research reports on innovation, competition, and globalization in selected industrial sectors.

ECON.5150 Politics and Economics of Public Policy (Formerly 57.515)(Formerly POLI.5150) - Credits: 3

The course will provide students with both a set of analytical frameworks to understand how and why specific public policies develop, and a set of normative perspectives to assess what makes for good public policy. Our treatment will be interdisciplinary drawing from areas of economics and political science. Following some grounding in the political economy of the role of government and policy making in a market based economy such as the United States, we will do case studies to understand and to evaluate policies from a variety of current areas of interest to the students and professors. Students will be introduced to basic ideas of cost benefit analysis, program evaluation, and implementation analysis.

ECON.7300 Microeconomic/Organization Theory (Formerly 49.730) - Credits: 3

This course is an introduction to microeconomic theory. The focus is on the behavior of individual consumers and firms in competitive settings. Topics will include consumer preferences and utility, consumer choice, market demand, production theory and market structure.

ECON.7310 Statistics (Formerly 49.731) - Credits: 3

This course covers descriptive statistics, random variables and expected value, discrete and continuous probability distributions, joint distribution functions, sampling distributions, point and interval estimation, and hypothesis testing, and non-parametric statistics. This course will also provide a brief introduction to linear regression and analysis of variance (ANOVA).

ECON.7330 Econometrics I (Formerly 49.733) - Credits: 3

After a brief review of the required mathematics for the course, the primary focus will be on the multivariate linear model. Topics include: consistency and asymptotic normality of the parameter estimates, sampling distributions, hypothesis testing, parameter restrictions, and specification test and corrections for violation of model assumptions. This course will also include working with various statistical packages.

ECON.7340 Econometrics II (Formerly 49.734) - Credits: 3

This course is a continuation of Econometrics II; the focus will be on the more advanced techniques used in estimation and inference problems in social science research. Possible topics include nonlinear models, the generalized method of moments, limited dependent variable and sample selection problems, multi-equations models, time-series models, and panel data analysis. Statistical packages will be utilized for a hands-on approach to the techniques.
ENGL.5060 Writing in the Community (Formerly 42.506) - Credits: 3

Students learn advanced writing techniques in the classroom and apply them to real writing tasks in the community. Assignments include a writing project designed to meet the needs of a local organization, along with research and reflective pieces.

ENGL.5200 Experiencing Poetry: Sound and Sense (Formerly 42.520) - Credits: 3

The class offers seminar-style discussions on specific aspects of poetry, considering a range of excellent poems from various eras. Through hands-on writing exercises, we will examine the art from the vantage point of the practitioner, using imitation and exploration of technique as a kind of close reading. Assignments include analytical essays as well as creative work.

ENGL.5400 Modernist Literature (Formerly 42.540) - Credits: 3

Much of the influential literature produced during the modernist period, roughly 1900-1950, was considered radical in its time. This course will focus on the experimental, avant-garde impulse that manifests itself in the themes and techniques of key modernist texts, relating that impulse to questions about the nature of identity, the role of gender and class in constituting the modernist subject, and the sociocultural functions of literature itself. Readings will primarily texts such as Virginia Woolf’s Mrs. Dalloway, Zora Neale Hurston’s Their Eyes were Watching God, T.S. Eliot’s poetry, and James Joyce’s Portrait of the Artist as a Young Man, as well as theoretical texts. We will explore this period by examining these exemplary texts, historical and social events, and films.
GLST.7010 Global Studies I (Formerly GLS.701) - Credits: 3
The focus of this course is the intersection of theory and practice in Global Studies. Students will be acquainted with the three fields of study that structure the Ph.D. Global Studies curriculum: Comparative Cultures, Security and Human Rights, and Socio-Economic Development and the interdependence of these fields.

GLST.7011 Interdisciplinary Education and Research - Credits: 3
The recent growth of interdisciplinary programs has created new challenges and opportunities in higher education and research. This course is aimed at providing Global Studies PhD students with the skills and knowledge they need to overcome these challenges and make the most of these opportunities. In order to teach interdisciplinary research design and methods, students will also critique interdisciplinary research and learn how to identify research questions that are best approached using the perspectives of multiple disciplines. Additionally, students will become familiar with journals and conferences that publish and promote interdisciplinary work.

GLST.7012 Conflict, Cooperation, Security and Human Rights - Credits: 3
This is an interdisciplinary course for the Global Studies PhD Program. Drawing from political science, this course investigates the major global threats to human security, including poverty, public health crises, environmental deterioration, terrorism, mass killings and war. These threats to human security can also be framed as violations of human rights. Drawing from economics, the class will explore the interactions that lead to these violations and security threats with a game theoretic approach. Employing game theory, the study of interdependent decision-making, will enable students to analyze and gain an understanding of the strategies that lead to violations of human rights, with the aim of developing policies to mediate these threats to human security.

GLST.7017 International Political Economy, Trade and Development - Credits: 3
Since the end of the cold war it seems that analysts of international relations have changed their focus from the politics of preserving the peace to the politics of the international economy. Reading any international newspaper one is now less likely to see a story on the arms reduction talks between states on the front page than seeing an article on the trade relations between states. The economic crisis of 2007-8, the European debt crisis and the rise of China has brought more attention to the relationship between global politics and economics. This course is intended to give an introduction to international political economy (IPE) and global economic relations. Students will study the theoretical perspectives that are used by analysts, the history of IPE, and some important issues currently confronting the economic and trade relations of states in an era of globalization.

GLST.7020 Global Studies II (Formerly GLS.702) - Credits: 3
This course elaborates on the topics introduced in GLS 701 Global Studies I. It familiarizes students with specific knowledge competencies in the three fields of study that structure the Ph.D. Global Studies curriculum: Comparative Cultures, Security and Human Rights, and Socio-Economic Development and the interdependence of these fields. Emphasis includes geography, history, economics, and cultural studies.

GLST.7030 Global Research and Data Analysis (Formerly GLS.703) - Credits: 3
This course is designed to cultivate and further develop students’ understanding and skills in research methods and data analysis as they become practitioners of qualitative and quantitative research addressing a range of global studies issues and problems. Through the use of applied analysis projects students will explore multiple methods of data analysis, critique and evaluate existing research studies and reports, and develop skills in critical thinking.

GLST.7031 Quantitative Approaches to Global Studies - Credits: 3
This course introduces students to topics related to research design and quantitative analysis in global studies. This course can be broken up into three parts. During the first part students will build on what they have learned about constructing theories and Hypotheses, how to quantify concepts, and how to evaluate the academic work of others. In the second part students will begin to learn how to test theories and explore relationships using descriptive analysis and hypothesis testing. In the third and final part students will more thoroughly develop and evaluate their theories and hypotheses using correlation and regression analysis. The course will focus on data, units of analysis and techniques most appropriate for global studies.

GLST.7120 Global Media Freedom, Human Rights, and Democratization (Formerly GLS.712) - Credits: 3
Media freedom is widely seen as critical to promoting democracy, development and human rights. Each year United States and European Union donors contribute to media assistance programs in the developing world. The idea is that
independent media will deep government in line and make life better for citizens. Yet, little is known about weather free media are up to the task. This course addresses important questions in political communication, human rights, media studies and international relations and requires students to engage in systematic comparative analysis of the effects of media freedom on human rights, democratization and development.

GLST.7130 Special Topics in Security and Human Rights - Credits: 3

Strategy is a crucial concept and practice in the field of international security. We will examine the foundational works in the area of strategy as well as contemporary work before exploring strategy as deployed in a range of issue areas, including military conflict, climate change, and arms control. The class will emphasize student participation and the application of concepts we learn in class. Students are asked to write a series of short policy memos and final paper exploring the application of strategy to international security broadly defined.

GLST.7170 Developing Economies (Formerly GLS.717) - Credits: 3

The emphasis of this course is an examination of globalization and whether it can be made a human-centered process, to historically examine the interrelatedness of the world economy to determine how policies shaped by industrialized countries impact developing countries, and to define key terms including poverty, sustainable development, market, informal economy, and civil society.

GLST.7210 Curricular Practical Training - Credits: 1

An internship, practicum or other type of employment that is either required by the student’s academic program or an experience for which a student receives academic credit. To be eligible the student must be in legal F-1 status and have been enrolled full-time for one academic year. CPT work experience must be in the student’s field of study and contain a curricular component. Contact the Global Studies Program Director for additional details.

GLST.7220 Civil Wars - Credits: 3

This course aims to examine the traditional and recent developments in the civil war literature. Some topics that will be covered in this course include the causes and termination of civil wars; the organization of rebel groups and its effect on the dynamics of civil conflicts; constructing peace in the aftermath of civil war as well as the role of the international actors in establishing lasting peace. The course will introduce three sets of empirical methods. The first set examines the traditional studies that test extant theories on large-N TSCS datasets. The second set focuses extensively on "micro-level" studies that use village-level or other spatially disaggregated unit of analysis. The third set examines recent methodological developments, particularly survey and field experiments.

GLST.7530 Doctoral Dissertation/Global Studies (Formerly GLS 753) - Credits: 3

Doctoral Dissertation Research.

GLST.7560 Doctoral Dissertation/Global Studies (Formerly GLS 756) - Credits: 6

Doctoral Dissertation Research.

GLST.7590 Doctoral Dissertation/Global Studies (Formerly GLS 759) - Credits: 9

Doctoral Dissertation Research.

GLST.7610 Dissertation Review/Global Studies (Formerly GLS 761) - Credits: 1

Dissertation Review.

GLST.7910 Global Studies Directed Studies (Formerly GLS.791) - Credits: 3

Global Studies Directed Studies
HIST.5010 The Practice of History (Formerly 43.501) - Credits: 3

This course surveys the range of methodology and philosophy associated with various approaches to historical study. It includes a general introduction to the discipline as well as topical sections dealing with Historical Materialism, the Annales School, Postmodernism, Gender History, Post-Colonial Studies, and Public History, wrapping up with a focused reflection on the material as a whole.

HIST.5020 Introduction to Archives (Formerly 43.502) - Credits: 3

How should we remember and document the past? This course introduces students to the goals and operation of archives, which play a crucial role in the preservation of historical sources. The course considers archival administration, funding, management, record-keeping (both paper and digital), and security. Field trips to university, municipal, and national archives are expected, as well as occasional guest speakers from the world of archives. Students will complete a variety of different writing assignments as well as brief oral presentations.

HIST.5100 Modern Revolutions in a Global Context (Formerly 43.510) - Credits: 3

Course is an introduction to the historical study of revolutions and revolutionary movements. We will define revolution and examine competing theories about its causes, outcomes, and processes through the study of several revolutions, upheavals, coups, and rebellions from around the world. We will read about and discuss the origins of the modern idea of revolution and a few leading theorists and theories along with our historical analyses. Over the course of the semester, we will identify the elements of a revolution and the specific historical, social, and political contexts that create them.

HIST.5110 History of College, 1100-1900 (Formerly 43.511) - Credits: 3

The foundation of universities in late medieval Europe also ushered in the earliest colleges, intended primarily to house students but also to provide tutoring, social support, and financial assistance. The earliest colleges arose in Paris but soon spread to Bologna, Oxford, and other university towns. This course traces the history of colleges from late medieval Europe to nineteenth-century America. It considers the various models of colleges that developed in northern and southern Europe, and how those models were transferred across the Atlantic. Some colleges remained primarily residences, while others expanded to offer a full graduate and undergraduate curriculum. We will also consider topics like student life, financial arrangements, admissions, alumni, and academic requirements.

HIST.5120 Athenian Democracy and Political Culture (Formerly 43.512) - Credits: 3

The Athenian democracy serves as a key reference point in the history of democratic governance and is one of the best documented periods and institutions in ancient Greek history. We will undertake a detailed examination of the ways in which the workings of the Athenian democracy and state evolved throughout antiquity and the ways in which the workings of the Athenian democracy and state evolved throughout antiquity and the ways in which this form of radical democracy was viewed and critiqued during the period itself. The course will provide both an overview of Athenian institutional and social histories as well as a methodological survey of the variety of source material used by historians of ancient Athens. We will also look at broader issues including the connection between democracy and empire in the fifth century, social class, and the critique of democracy.

HIST.5130 World History: Theory and Practice (Formerly 43.513) - Credits: 3

In an increasingly globalized and diverse age, world history has become a growing teaching field at the secondary and the college level in the United States. The overarching purpose of this class is to prepare students as teachers and practitioners of world history. This course will introduce the field and concepts of world history. It will familiarize students with available materials such as textbooks, readers, primary documents, academic books and articles, websites, and podcasts. This course also exposes students to key global processes that have shaped our world since roughly the year 1400. Taking a global comparative perspective, this course will help students develop a topical, chronological, and geographical understanding of global history and cultures.

HIST.5150 Contemporary Global Issues in Historical Perspective - Credits: 3

In a period of intensifying globalization a basic understanding of our world is increasingly important. By looking at various contemporary issues, such as the revolutions in the Muslim world, atrocious war, gender, corruption, religion vs. secularism, immigration, and global economic issues, this course will provide historically grounded perspectives of contemporary issues around the world.

HIST.5170 Post-Colonial Europe, 1945 to the Present - Credits: 3

This course considers recent European history through a postcolonial optic, with particular focus on ongoing European
dilemmas of immigration, assimilation and multiculturalism. Its approach will be interdisciplinary, beginning a critical reflection upon salient examples of postcolonial theory, and then moving through three different thematic units. The first will be immigration and immigration politics, as those came to the very fore of European concern from the 1960s forward. The final unit adopts a cultural approach, using film, fiction, memoir, music and other sources to explore the textures of individual and community life among those of immigrant decent within contemporary Europe.

**HIST.5350 Immigration History (Formerly 43.535) - Credits: 3**

The course focuses on the experiences of women, men, and children who came to the U.S. from the colonial era through the 21st century. Their emigrations will be examined in a global context. Irish migration, the mass European migrations during the did late 19th / early 20th centuries, and post-Second World War immigration particularly from Asian and African countries are discussed. The Lawrence, Lowell, and Boston immigration stories are extensively considered. Students will acquire an understanding of U.S. Immigration History - Both the experiences of immigrants and reactions to that immigration over time, including the frequent passage of federal legislation to block or impede immigration. Students will utilize area immigration archives to produce original research on the topic.

**HIST.5360 Readings on the Great Depression and the New Deal (Formerly 43.536) - Credits: 3**

This course examines a turbulent period in American history: the era of the great economic boom and cultural revolution of the 1920s, the Great Depression and the New Deal, and World War II. This course critically examines the growth of a consumer economy in the 1920s, the cause of the Depression, and how the New Deal response affected the lives of ordinary Americans. We take a close look at the Great Migration of African Americans out of the South and how it affected race relations and the impact of the Great Depression and the New Deal on women. Finally, we consider how the country shook off its isolationism and emerged at the end of the Second World War as the world’s hegemonic superpower. Throughout, we consider the period’s larger lessons for other disjunctures in history.

**HIST.5370 Alcohol in American History - Credits: 3**

This course uses the production, distribution, consumption, and prohibition of alcoholic drinks as a lens for studying cultural, political, and economic change in American life from the colonial era to the present. Students will develop a related original project involving immersive use of archival materials to write an article-length research paper.

**HIST.5400 Law, Politics and Society in Early America (Formerly 43.540) - Credits: 3**

This class closely examines the colonies of Virginia, Maryland, Massachusetts, Maine, New Netherland/New York, Rhode Island and the Carolinas from the early seventeenth century through the mid-eighteenth century. The class focuses particularly on the wide range of legal, political and social systems present in British North America which made it possible for certain colonies to survive and thrive, while other colonies foundered and failed. Students will master a wide range of primary and secondary sources during the semester and will finish by conducting their own research on one of these seven colonies.

**HIST.5410 The American Revolution in the World - Credits: 3**

The American Revolution began as a North American conflict between the newly formed United States and Great Britain over the question of whether the thirteen colonies could become an independent nation. The entrance of France, the Netherlands and Spain into the war in the late 1770s made the Revolution a conflict which could be fought anywhere these five countries shared borders, whether in North America, Europe or Asia. The class will also examine the experiences of both Native Americans and African Americans in the Atlantic World as they experienced the war in far ranging ways. The class will use both primary and secondary sources and culminate in a research paper of topics chosen by individual students.

**HIST.5430 The North During the Civil War - Credits: 3**

Many classes about the Civil War era (1848-1877) focus on the changes brought about in southern society, especially the overthrow of slavery and the transformation of race relations. This course will analyze the dramatic changes that northern society experienced during this period. The North saw important transformations in its economy, government, and society. This course will explore changes in the North’s economy, work cultures, politics, gender system, and race relations, as well as how those developments both brought about the war and were accelerated by the Civil War. By the end of the semester, we will have a fuller understanding of the inter-relationships between the Industrial Revolution, capitalism, and U.S. victory in 1865.

**HIST.5450 Native Peoples of the Northern Eastern Woodlands (Formerly 43.545) - Credits: 3**

Students will analyze and research the history of the Native peoples of the northern Eastern Woodlands - an area encompassing the northeastern U. S., southeastern Canada, and
the North American Great Lakes region. The course provides coverage from pre-contact to the present. It emphasizes contributions of the first peoples to the broader course of the history of the northern Eastern Woodland region. The course offers a framework for understanding indigenous Americans and their historical experiences by exploring the forces of continuity and change that have shaped Native Americans’ lives through time and space. This view will stress the ongoing presence of American Indian peoples and their efforts to preserve the integrity and viability of their dynamic and self-directed societies.

HIST.5460 Topics in African-American History (Formerly 43.546) - Credits: 3

This graduate-level course examines important ideas and events in African-American history as well as debates among historians about how to interpret these ideas and events. We will examine slavery and its demise, the labor system that emerged after slavery, violence against and intimidation of blacks, the relocation of millions of African Americans from the rural South to the urban North, and the struggle for civil rights, among other topics. A theme that runs through the course is how African Americans were able to build a rich and vibrant culture as well as strong networks of kinship even as masters, landlords, and others sought to control their labor and deny then political and other rights.

HIST.5500 Graduate Reading Seminar: Imperial Japan, 1894-1952 (Formerly 43.550) - Credits: 3

This course is a reading and writing intensive study of the political, social, cultural, and economic history of Imperial Japan, from the First Sino-Japanese War (1894-1895) through the end of the American occupation after the Pacific War (1952).

HIST.5510 Reading Seminar on Modern China (Formerly 43.551) - Credits: 3

The course explores the intersection of tradition and revolution in modern Chinese history. It is a seminar where students do assigned readings and come to class prepared to discuss the readings. The objective of the course is to gain a critical understanding of China’s modernization process - the traditional and radical forces that shaped the process, the impact of the process on everyday life, and the blending of what is traditionally Chinese and what is modern or borrowed from the outside.

HIST.5511 Transformation of Rural China - Credits: 3

A reading seminar exploring political, economic, and cultural changes in rural China since the 1920s. Special emphases are given to the Western impact on traditional China, the Land Reform, the collective period, and the post-1978 economic reforms. Students will read investigative reports, anthropological field work, scholarly analysis, and memoirs on China’s rural transformation, engage in seminar-style discussions, write analytical and critical papers of assigned topics, and produce a final research paper on a topic of his/her own choice.

HIST.5515 Topics in Middle East History: Environmental History of the Middle East and North Africa - Credits: 3

This course is designed to introduce students to the intensive study of a particular aspect of Middle East History. In this course, with a focus on environmental factors, we will consider various historical perspectives on colonialism, nationalism, capitalism, gender and sexuality, empire, race, and class. What are some of the benefits of these interpretations? Are there also drawbacks? Students will explore this history through reading both primary and secondary sources. They will also pursue their own research project on a topic of their choosing in Middle East environmental history.

HIST.5520 Enterprise in Latin America (Formerly 43.552) - Credits: 3

This M.A.-level course introduces students to the history of enterprise in Latin America through four case studies and a research project. No prior knowledge of Latin American history is required or expected. Each of the case studies, including the students’ own research projects on an enterprise in Latin America, will consider the wide range of factors that impact a business. These include infrastructure, government regulations and policy, labor, markets, and environmental concerns, among others. The case studies and readings may change from semester to semester, but will be representative of different time periods and regions within Latin America. Throughout the semester, the class will also consider the historical legacies of each enterprise and how it continues to affect the region’s economic and political development today.

HIST.5590 Reconstructing America: Upheaval, Immigration, and Reform (Formerly 43.559) - Credits: 3

The second year of the Teaching American History Project, involving UMass Lowell and eight school districts in the Greater Boston Area, will include a week-long Summer Institute, title "reconstructing America: Upheaval, Immigration, and Reform". The institute’s seminars, readings, and field trip will focus on several topics tied to immigration, internal migration, social and economic struggle, and reform. This encompasses a history of the major immigrant groups in late 19th and early 20th century America; settlement, acculturation
and resistance; Jim Crow and the Great Migration in the early 20th century; and post World War II immigration and refugee settlement. The Summer Institute will offer a blend of U.S. history and local history, namely Lowell and Lawrence, Massachusetts, with readings tied to recent scholarship in African-American, Latino, and Euro-American immigrant history.

HIST.5900 Topics in History - Credits: 3
An advanced course of study and examination of a variety of issues and topics in history, intended for graduate students. Instructor permission required. Subject matter to be announced in advance.

HIST.5910 Directed Study (Formerly 43.491/591) - Credits: 1-4
Directed study offers the student the opportunity to engage in an independent study or research project under the supervision of a department member. Working closely with the instructor, students define and investigate a research topic in an area of special interest and present the results of their investigation in a significant paper. Juniors and seniors only.

HIST.5990 Thesis in History - Credits: 3-6
For History graduate students actively engaged in research leading toward the submission of a written thesis for completion of their degree. A program of supervised study will be arranged between the student and a faculty supervisor.
MUHI.5940 Graduate Directed Study in Musicology  
(Formerly 74.594) - Credits: 3  
MUHI.5950 Graduate Directed Study in Musicology  
(Formerly 74.595) - Credits: 3  
MUTH.5950 Graduate Directed Study in Music Theory  
(Formerly 71.595) - Credits: 3  
MUTH.6100 Structure, Context and Style (Formerly 71.610) - Credits: 3  

This course will bring the student to a concept of music in its theoretical, historical and cultural contexts, building on the materials and techniques acquired in undergraduate studies. Required for all Master of Music Students.
MUBU.5040 Arts Administration and Marketing  
(Formerly 77.504) - Credits: 3

This course is designed to provide essential information regarding the structure and strategies for creating and maintaining a sustainable non-profit arts organization. Topics to be covered include: organizational structure; development; production; market research; and promotion.

MUBU.5250 Community Outreach Practicum 1  
(Formerly 77.525) - Credits: 1

The Community Outreach Practicum provides mentorship and initial hands-on training in the educational and arts management skills which will enable the student to build and direct community-based youth music programs.

MUBU.5260 Community Outreach Practicum 2  
(Formerly 77.526) - Credits: 1

The Community Outreach Practicum provides mentorship and initial hands-on training in the educational and arts management skills which will enable the student to build and direct community-based youth music programs.

MUBU.6250 Community Internship (Formerly 77.625) - Credits: 6

This course will provide students with the opportunity to gain real world experience in the administration of a Community Arts organization. Students will be required to undergo 300 hours of work under the direct supervision of the director of a Community Arts organization, in coordination with a University advisor. Students will conduct research into various arts organizations, revise resumes, and draft cover letters under the guidance of the course advisor in preparation for the internship application process. Students will be required to secure the internship pending approval of the course advisor.
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<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Description</th>
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<td>MUAP.5010</td>
<td>Graduate Applied Keyboard I (Formerly 72.501)</td>
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<td>MUAP.5020</td>
<td>Graduate Applied Keyboard 2 (Formerly 72.502)</td>
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<td>Graduate Applied Voice I (Formerly 72.511)</td>
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<td>Graduate Applied Voice 2 (Formerly 72.512)</td>
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<td>Graduate Applied Woodwinds 1 (Formerly 72.521)</td>
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<td>Graduate Applied Woodwinds 2 (Formerly 72.522)</td>
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<td>MUEN.5010</td>
<td>University Orchestra (Formerly 76.501)</td>
<td>1</td>
<td>A large chorus open to the campus and the community without audition. Performs larger works in the choral repertoire including oratorios, masses, motets and opera.</td>
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<td>MUEN.5020</td>
<td>Wind Ensemble (Formerly 76.502)</td>
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<td>MUEN.5030</td>
<td>Chamber Singers (Formerly 76.503)</td>
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<td>MUEN.5040</td>
<td>University Choir (Formerly 76.504)</td>
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<td>MUEN.5050</td>
<td>Concert Band (Formerly 76.505)</td>
<td>1</td>
<td>Open to all students by audition. Includes the study and performance of a wide variety of choral compositions.</td>
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<td>MUEN.5080</td>
<td>Studio Orchestra (Formerly 76.508)</td>
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<td>MUEN.5100</td>
<td>Opera Workshop (Formerly 76.210/510)</td>
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<tr>
<td>MUEN.5510</td>
<td>Choral Union (Formerly 76.551)</td>
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<tr>
<td>MUEN.5530</td>
<td>Percussion Ensemble (Formerly 76.553)</td>
<td>1</td>
<td>Open to all students by audition. Exploration of the growing body of literature for percussion ensemble. Public performance.</td>
</tr>
<tr>
<td>MUEN.5540</td>
<td>Classical Guitar Ensemble (Formerly 76.554)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>MUEN.5550</td>
<td>Brass Ensemble (Formerly 76.555)</td>
<td>1</td>
<td>Open to all students by audition. Provides a wide range of performance experience through varied brass literature.</td>
</tr>
<tr>
<td>MUEN.5560</td>
<td>Electric Guitar Ensemble (Formerly 76.556)</td>
<td>1</td>
<td>Open to all students by audition. Provides study and performance of literature for guitar, lute, etc. Required of all guitar majors each semester</td>
</tr>
<tr>
<td>MUEN.5580</td>
<td>Piano Ensemble (Formerly 76.558)</td>
<td>1</td>
<td>Open to all students by audition. Provides performance experiences through varied piano ensemble literature for one and two pianos.</td>
</tr>
<tr>
<td>MUEN.5590</td>
<td>Mixed Chamber Ensemble (Formerly 76.559)</td>
<td>1</td>
<td>Open to all students by audition. Offers a wide range of performance experience through a selection of literature for varying combinations of instruments.</td>
</tr>
<tr>
<td>MUEN.5600</td>
<td>String Ensemble (Formerly 76.560)</td>
<td>1</td>
<td>Open to all students by audition. Provides experience in the performance of string orchestra literature.</td>
</tr>
<tr>
<td>MUEN.5610</td>
<td>Small Jazz Ensemble (Formerly 76.561)</td>
<td>1</td>
<td>Open to all students by audition. Provides experience in the performance of small jazz music.</td>
</tr>
</tbody>
</table>
performance of jazz literature for groups ranging from four to eight members.

MUEN.5620 Jazz Laboratory Ensemble (Formerly 76.562) - Credits: 1
Open to all students by audition. Provides students with a clear understanding of the skills, knowledge and attitudes necessary to satisfactory ensemble performance and practical experience in the application of such skills, knowledge and attitudes.

MUEN.5630 Recording Studio Ensemble (Formerly 76.563) - Credits: 1
This course introduces students to the music-making paradigm of the recording studio. Issues of musicianship and ensemble performance are addressed within the context of creating music recordings. Recording musicians must demonstrate music abilities in a range of spaces from live rooms to sound isolation booths, interacting with other musicians via microphones and headphones, contributing to music played live and previously recorded to a multitrack recorder by musicians at earlier recording sessions, collaborating with music producers and recording engineers. The ensemble includes a core rock/pop rhythm section of drums, electric bass, electric guitar, keyboards, and vocalists. Other musicians are welcome to contribute to the Studio ensemble as repertoire requires. Students will prepare representative recording studio works and original compositions. Students will complete several recordings by the end of the semester.

MUEN.5650 Jazz/Rock Big Band (Formerly 76.565) - Credits: 1
Open to all students by audition. Fusion big band covering a wide variety of contemporary jazz rock literature. Solo improvisational opportunities. Numerous performances.

MUEN.5700 Contemp Electronic Ensemble (Formerly 76.570) - Credits: 1
MUEN.6010 World Music Ensemble (Formerly 76.601) - Credits: 1
An immersion into the music of non-Western cultures, this course will provide instrumental and vocal instruction, as well as an introduction to the theory and cultural contexts that shape the practice of traditional music. The ensemble will meet weekly, with the goal of a public performance at the close of the semester.

MUEN.6020 Graduate Instrumental Ensemble (Formerly 76.602) - Credits: 2

MUEN.6250 Community Internship (Formerly 76.625) - Credits: 6
This course will provide students with the opportunity to gain real world experience in the administration of a Community Arts organization. Students will be required to undergo 300 hours of work under the direct supervision of the director of a Community Arts organization, in coordination with a University advisor. Students will conduct research into various arts organizations, revise resumes, and draft cover letters under the guidance of the course advisor in preparation for the internship application process. Students will be required to secure the internship pending approval of the course advisor.

MUPF.5630 Vocal Pedagogy (Formerly 75.463/563) - Credits: 3
Course will introduce students to the basics of teaching singing. It will include an overview of the anatomy of the respiratory and vocal mechanism and their application to singing; the categorization of voice types with suggestions for repertoire for young solo singers; an overview of vocal exercises for various technical goals and the diagnosis of common vocal problems and how to treat them. The class will also cover the child and adolescent voice and include in-class supervised teaching.

MUPF.5950 Graduate Direct Study: Research in Performance (Formerly 75.595) - Credits: 3
MUED.5000 Global Music for Classroom (Formerly 73.410/500) - Credits: 3
Focus on the music education profession’s response to multiculturalism in education as evidenced through the National Music Standards and an examination of resources and methodologies for teaching and understanding the music of diverse cultures, styles, and genres. As one of the core professional music education courses, the course includes the component of pre-practicum fieldwork. There will be an additional research project for Graduate Students enrolled in 73.500.

MUED.5010 Introduction To Brass Pedagogy 1
(Formerly 73.141/501) - Credits: 1
Intensive class instruction toward the development of basic performance proficiency on brass instruments and the development of pedagogical skills and techniques for beginning instruction and demonstration purposes.

MUED.5020 Introduction to Woodwind Pedagogy 1
(Formerly 73.144/504) - Credits: 1
Intensive class instruction toward the development of basic performance proficiency on woodwind instruments and the development of pedagogical skills and techniques for beginning instruction and demonstration purposes.

MUED.5030 Introduction to Woodwind Pedagogy 2
(Formerly 73.145/505) - Credits: 1
A continuation of 73.144. Intensive class instruction toward the development of basic performance proficiency on woodwind instruments and the development of pedagogical skills and techniques for beginning instruction and demonstration purposes.

MUED.5040 Introduction to Percussion Pedagogy
(Formerly 73.162/5060) - Credits: 1
Intensive class instruction toward the development of basic performance proficiency on percussion instruments and the development of pedagogical skills and techniques for beginning instruction and demonstration purposes.

MUED.5050 Introduction to Percussion Pedagogy
(Formerly 73.162/5060) - Credits: 1
Intensive class instruction toward the development of basic performance proficiency on percussion instruments and the development of pedagogical skills and techniques for beginning instruction and demonstration purposes.

MUED.5070 Introduction to Strings Pedagogy 1
(Formerly 73.241/507) - Credits: 1
Intensive class instruction toward the development of basic performance proficiency on string instruments and the development of pedagogical skills and techniques for beginning instruction and demonstration purposes.

MUED.5080 Introduction to String Pedagogy 2
(Formerly 73.242/508) - Credits: 1
Intensive class instruction toward the development of basic performance proficiency on string instruments and the development of pedagogical skills and techniques for beginning instruction and demonstration purposes.

MUED.5100 Foundations Of Music Education
(Formerly 73.510) - Credits: 3
This course is intended for undergraduate students preparing for teacher certification in music. Course participants will explore the historical, psychological, and philosophical foundations upon which current practices in music education are built. Students will explore these concepts through readings, class discussions, individual and group presentations, and other dynamic and interactive processes.

MUED.5150 Special Topics in Music Education
(Formerly 73.515) - Credits: 3
A variety of topics in Music Education will be explored such as children and the composition process, curriculum design, assessment and technology, which will vary from semester to semester.

MUED.5160 Introduction to Voice Pedagogy 1
(Formerly 73.244/516) - Credits: 1
Intended to cultivate the fundamental principles of singing. The psychology of singing and the psychology of the singing voice are considered as they apply to tone production and resonance.

MUED.5170 Introduction to Voice Pedagogy 2
(Formerly 73.245/517) - Credits: 1
A continuation of Voice Pedagogy 1. Intended to cultivate the fundamental principles of singing. The psychology of singing and the psychology of the singing voice are considered as they apply to tone production and resonance.

MUED.5220 Curriculum Design in Music Education
(Formerly 73.522) - Credits: 3
This course will focus on how to design developmentally appropriate learner centered music curricula. We will explore what it is we are looking to achieve through the arts, what types of learning we are looking to develop and what are the instructional materials and methods needed to achieve these goals.

MUED.5440 General Music Methods 1 (Formerly
73.420/544) - Credits: 3

A course designed to present the basic fundamentals of general music pedagogy, including lesson planning and the writing of instructional objectives. The course discusses basic principles of curriculum and instruction, assessment, learning styles, and developmental psychology. These are related to state curriculum frameworks and National Music Standards 1-5. As one of the core professional music education courses, the course includes the component of pre-practicum fieldwork in selected settings.

MUED.5450 General Music Methods 2 (Formerly 73.430/545) - Credits: 3

Investigation of some of the most popular methods of teaching general music, including Orff, Kodaly, Dalcroze, and comprehensive musicianship. Discussion of contemporary issues including music in special education, multicultural music education, and National Music Standards 6-9. As one of the core professional music education courses, the course includes the component of fieldwork in selected settings.

MUED.5630 Choral Repertoire and Rehearsal Techniques (Formerly 73.563) - Credits: 3

Examination of appropriate choral repertoire for the secondary school level and effective choral rehearsal techniques. Covers auditioning, warmups, choral tone, diction, score preparation, and development of fundamental musicianship skills necessary for a successful choral ensemble. Serves as a choral laboratory setting for the practice of score preparation and rehearsal techniques.

MUED.5770 Instrumental Music Workshop (Formerly 73.577) - Credits: 1-3

This workshop is designed for music educators working with elementary, middle or high school instrumental & choral ensembles, and for students seeking materials for practical application. Participants will explore instrumental & choral music through performance on instruments. Clinician will provide additional information as to technical facility and instrument/vocal specific rehearsal techniques.

MUED.5780 Music/Way of Knowing (Formerly 73.578) - Credits: 2

Nick Page presents a unique and practical fusion of ideas and skills, combining multiple intelligence and multicultural theories to create a powerful vision for music education. Using his book “Music as a Way of Knowing,” Nick Page will show how music can come alive in a creative, positive environment with music as the center of a school’s curriculum - to teach history, culture, and science as well as an amazing aid to listening skills, memory, and emotional well being. Nick is a master song leader who has inspired music educators throughout North America. He is also the author of Sing and Shine On! An Innovative Guide to Leading Multicultural Song, and his choral music is published by Boosey & Hawkes and by World Music Press.

MUED.5830 Intro to Technology Applications for the Music Classroom (Formerly 73.583) - Credits: 2-3

Introduction to the role of computers and technology in music education programs. Course includes the development of computer literacy, including knowledge of word processing, database and spreadsheet applications as essential to educators, and explores MIDI, the Internet, music software, recording, multimedia and other technologies as educational tools.

MUED.5950 Practicum & Analysis (Formerly 73.595) - Credits: 9

This is the culminating experience in the Graduate Music Education Teaching Masters under the supervision of a public school supervising practitioner and a UMass Lowell Program Supervisor. Students are required to spend 8 weeks (minimum) teaching in an elementary placement and 8 weeks (minimum) in a secondary placement. Candidates are required to have passed both Communications and Literacy and Music portions of MTEL examinations and maintained an overall GPA of 3.0.

MUED.5960 Graduate Directed Study: Music Education (Formerly 73.596) - Credits: 3

Participants will develop a focused line of investigation with the supervision of a faculty member in Music Education. Approval of advisor is required.

MUED.6010 Seminar In Music Education (Formerly 73.601) - Credits: 3

This course examines the impact of popular culture on today's youth and its implications for the study of music. Students in this course will explore teaching strategies that link musical styles and conventions from other time periods to the present. Using music from various media as a springboard, there will be an emphasis on the development of technology rich teaching strategies for the K-12 music classroom.

MUED.6250 Community Internship (Formerly 73.625) - Credits: 6

This course will provide students with the opportunity to gain real world experience in the administration of a Community Arts organization. Students will be required to undergo 300...
hours of work under the direct supervision of the director of a Community Arts organization, in coordination with a University advisor. Students will conduct research into various arts organizations, revise resumes, and draft cover letters under the guidance of the course advisor in preparation for the internship application process. Students will be required to secure the internship pending approval of the course advisor.

MUED.6500 Research in Music Education (Formerly 73.650) - Credits: 3

This is a required music graduate class that will highlight fundamental research techniques while focusing on multi-disciplinary aspects of writing about music. Relevant skills and practices: Students will learn how different project types are structured; students will discuss how research acts in the real world and its relevance to their field; The semester will be divided into writing the sections of a professional research paper, with students producing an article as their final project.

MUED.6950 Direct Study and Research (Formerly 73.695) - Credits: 3

Participants will develop a focused line of investigation with the supervision of a faculty member in Music Education. Approval of advisor is required.

MUED.6960 Project Report (Formerly 73.696) - Credits: 3

Original research through action research projects conducted in one's classroom. Students investigate learner-centered approaches to teaching, learning and evaluation. Written reports required.

MUED.7430 Master's Thesis, Music Education (Formerly 73.743) - Credits: 3

For graduate music education students actively engaged in research leading toward the submission of a written thesis. A program of supervised work will be arranged between the student and a faculty supervisor. Permission of the faculty member who will supervise the thesis is required.
PCST.5010 Strategies of Conflict Transformation
(Formerly PCS 501) - Credits: 3
This course will examine the underlying connections between causes of conflict on the local, national and global levels and the processes that advance peaceful resolution. The course is designed to provide a cross-disciplinary approach to the relevant social, political, economic and cultural conditions leading to conflict and the variety of approaches to solve such conflict through both violent and nonviolent means. The beginning of the course will focus on issues of power and inequality related to class, race (and related divisions of ethnicity, religion, caste, nationality, immigration status) and gender. We will look at structures and system of power ranging from the family, to the community, the workplace and the national and international dimensions. The goal is to link theoretical analysis with the study of practical problem solving.

PCST.5020 Seminar in Peace and Conflict Studies
(Formerly PCS 473/502) - Credits: 3
Offered from time to time to highlight specialized areas of faculty interest and to acquaint the student with new developments from a broad range of theory and research and how these developments might affect the field of Peace and Conflict Studies.

PCST.5030 Diplomacy and Cross Cultural Negotiations - Credits: 3
This course introduces the students to the breadth and depth of diplomatic historical practices, and theories. It will also introduce methods of negotiation and conflict resolution utilizing the different models focusing on cross-cultural negotiations. The role of cultural differences in the processes of negotiation and diplomatic practice and the multiple layers of public diplomacy will also be analyzed stressing the role of cultural differences in the processes of negotiation and diplomatic practice. The course will lastly examine democratic transition in conflicted countries and how to advocate for the transition as part and parcel of peace building.

PCST.5040 Restorative Justice: Repairing Harm Through Dialogue - Credits: 3
This course introduces students to the principles, values, and practices of restorative justice to repair harm through dialogue and build positive peace. Students develop a working knowledge of the general theories of restorative justice and gain practical experience with peacemaking techniques. Traditional assumptions about justice and the adversarial legal process will be explored and challenged. Students will critically examine how restorative justice addresses the needs and harms of multiple stakeholders, draws from indigenous approaches, and challenges interpersonal and structural forms of harm, including practical challenges in implementing restorative justice and the relationship between restorative justice, restorative practices, and other conflict resolution methods.

PCST.5060 Research Methods (Formerly 57.506) - Credits: 3
This course is an applied survey of research methods appropriate for regional economic and social development. Students will learn data presentation and basic descriptive and inferential statistics, as well as the basics of researching data sources and primary data-gathering techniques (survey, case study, archival), and a framework for deciding when particular methods of data-gathering and analysis are appropriate. Students will apply the techniques as they learn them.

PCST.5080 Theories of Political and Criminal Violence - Credits: 3
The study of violence has been a central piece of debates in comparative politics that range from the causes of revolution to the analysis of civil wars. Since the 1990s, and as a result of the crucial changes the world experienced with the end of the Cold War, interest and research on civil wars increased notably, bringing in innovative theoretical insights. Yet, for the most part, research on political and criminal violence remains scattered across these different subfields, with research on civil war being the most active research field. This course aims to provide a broad overview of different bodies of research on violence and to analyze whether more dialogue between subfields could contribute to the accumulation of knowledge.

PCST.5120 Community Conflict Resolution (Formerly PCS 512) - Credits: 3
This course gives students an understanding of the main issues and solutions involved in community level conflict resolution; e.g., in neighborhoods, workplaces, and other institutions. It develops students’ skills in practicing conflict resolution and/or evaluating programs in the field of dispute resolution. It is important to understand why conflict happens and how to resolve conflict.

PCST.5230 Everyday Peace: Community-based Approaches to Peace and Peacebuilding (Formerly PCS 523) - Credits: 3
This course will introduce students to a range of issues in community-based approaches to everyday conflict and peacebuilding. Premised on the idea that peace cannot be understood or studied in isolation of other of other social processes, the course will allow students to collectively engage with key conceptual, methodological and praxis related issues.
in peacebuilding drawing from community-based and critical perspectives in the social sciences, we will focus on developing the notion of ‘everyday peace’, that is, building community capacities and promoting social justice as an antidote to the normalized and endemic violence in society. The course will critically examine relevant empirical literature as well as ongoing peace initiatives that utilize community-based approaches.

**PCST.5250 Gender, Work and Peace (Formerly PCS 525) - Credits: 3**

“Gender, Work and Peace” will explore the relationship between human rights, gender and nonviolence in the 21st century. We will examine how current and future reality can be shaped by related policies, specifically those on the micro and macro level concerned with gender. Today we live in a period of global transition comparable to the period that followed the Industrial Revolution. It presents us with enormous challenges and opportunities regarding factors we will address in class: economic globalization, government restructuring, work-family balancing, environmental safety at work, gender inequalities and the connection between human rights and dignity at work.

**PCST.5270 Sustainable Housing Development and Land Use: Conflict, Policy, and Practice (Formerly PCS 527) - Credits: 3**

Housing is fundamental to the quality of life in communities, and housing conflict, policy and practice shape the availability of this fundamental good. This course will examine the economic, environmental, social, and cultural factors that shape housing and its sustainability. The contentious nature of housing and land use policy in the United States will be summarized, with students learning how housing policy impacts communities, states, and regions. The course will then give students a detailed understanding of the conflictive process through which housing is developed and the role the market, government, funders, workers, and housing consumers play in influencing the creation and development of housing. The course will highlight ways in which current housing development policy and practices are not sustainable, and will examine more recent efforts to establish standards and practices that enhance consensus and sustainability. Students will learn how to manage conflict and take a housing project through the various stages, such as project conceptualization, market analysis, design, site acquisition, financing, construction, and occupancy. While the course focuses on the U.S. context, students will learn of international efforts to achieve greater sustainability in housing. The course will provide students with both practical and theoretical knowledge of housing and land use conflict, policy and development practices. Case studies of actual projects will be presented.

**PCST.5390 Bridging Minds for Peace: Interfaith Perspectives and The Universal Moral System (Formerly PCS 539) - Credits: 3**

There has been a consensus among the intellectuals and followers of religions that one of the major reasons for the accumulating political, economical, and environmental crises in the Middle East and around world is the absence of a grand vision that can guide the future and inspire humanity to create peace everywhere. The core premises of this theory are: Without peace among religions, there is no peace among nations; Without dialogue among religions, there is no peace among religions; Without a universal moral system, there is no dialogue among religions; A new model of international relations based on a set of morals universally accepted, can help human race to live in peace and justice; and the major religions have the set of morals that can be universally accepted by all, even the non-religious. This course will examine the possibilities and obstacles to bridging the religious divide through a universal, interfaith moral code.

**PCST.5450 Politics of Repression and Dissent (Formerly PCS 545) - Credits: 3**

A focus on the dark side of politics - political repression, including politically motivated imprisonment, torture, murder, and disappearance- and the struggle of critics to bring about change through non-violent and violent demonstrations, general strikes and armed resistance.

**PCST.5500 Integrative Seminar in Peace and Conflict Studies I (Formerly PCS 550) - Credits: 0**

The purpose of the integrative seminar is to assist students in developing a robust and mature understanding of the three PCS core questions as they relate to PCS coursework within and across the three Professional Options. With a strong evidence focus, students identify patterns, principles, questions, and dilemmas relevant to the core questions that emerge from multiple courses they have taken within the Professional options. Students develop a reflective journal, a series of essays, a portfolio of their accumulated work, and a culminating portfolio presentation. The course consists of six 2-hour sessions each semester for two semesters.

**PCST.5530 Integrative Seminar in Peace and Conflict Studies (Formerly PCS 453/553) - Credits: 3**

The purpose of the integrative seminar is to assist students in developing a robust and mature understanding of the three PCS core questions as they relate to PCS coursework. With a strong evidence focus, students identify patterns, principles, questions, and dilemmas relevant to the core questions emerge from multiple courses they have taken within the PCS program. Students develop a reflective journal, a series of essays, a
portfolio of their accumulated work, and a culminating portfolio presentation. Meets Core Curriculum Essential Learning Outcome for Applied & Integrative Learning (AIL) and Written & Oral Communication (WOC).

PCST.5550 Mediation: Theory and Practice (Formerly PCS 455/555) - Credits: 3
Mediation is a form of dispute resolution in which a neutral person helps two or more parties discuss their conflict, explore wants and needs, generate options, and reach an agreement. Mediation has become more prevalent over the past few decades in the courts, community-setting, and schools because it empowers the disputing parties to reach a resolution that works for them. This course introduces mediation in the context of other forms of alternative dispute resolution, teaches the principles and theory behind mediation, and trains students in the fundamentals of the mediation process. Interactive exercises and mediation role-plays will be used to provide experiential practice. Upon completion of the course, students will be connected to opportunities to practice mediation in the local courts or with community organizations.

PCST.5580 Peace and Conflict Field Experience (Formerly PCS 458/558) - Credits: 3
A program of practical experience in the field of Peace and Conflict. Students can work in a variety of areas related to Peace and Conflict Studies. Students meet regularly as a class on campus with the designated instructor to discuss their experiences and to learn more about the settings in which they practice and the challenges that they confront.

PCST.5910 Directed Study in Peace and Conflict Studies (Formerly PCS 591) - Credits: 1-3
Through frequent consultation with the instructor, the student carries out the investigation of a particularly specialized area of interest. This course may be repeated for up to a total of 6 credits.

PCST.6010 Peace and Conflict Studies Study Abroad I (Formerly PCS 601) - Credits: 3
Graduate study abroad in an institution with a University approved Graduate level exchange program. The specific course to be taken will be approved by the Graduate Coordinator.

PCST.6030 Peace and Conflict Studies Study Abroad III (Formerly PCS 603) - Credits: 3
Graduate study abroad in an institution with a University approved Graduate level exchange program. The specific course to be taken will be approved by the Graduate Coordinator.

PCST.6310 Practicum in Peace and Conflict Studies I (Formerly PCS 631) - Credits: 3
The practicum allows students to intern at an organization related to the field of Peace and Conflict studies. The primary purpose of the Practicum is two-fold: 1) to allow students to apply, integrate, and evaluate the information and skills they have acquired in their masters level academic course work; 2) to gain new understandings and competencies while contributing to a field setting. Students participate in placements for approximately 10 hours per week.

PCST.7330 Project in Peace and Conflict Studies I (Formerly PCS 733) - Credits: 3
The project will consist of a scholarly investigation, such as a review, report, synthesis or design in the student’s field resulting in a written document.

PCST.7340 Project in Peace and Conflict Studies II (Formerly PCS 734) - Credits: 3
For a student who wants to complete a 2-semester project. The project will consist of a scholarly investigation, such as a review, report, synthesis or design in the student’s field resulting in a written document.

PCST.7430 Master’s Thesis in Peace and Conflict Studies (Formerly PCS 743) - Credits: 3
For graduate student actively engaged in research leading toward the submission of written thesis. A program of supervised study will be arranged between student and a faculty supervisor. This course may be repeated for credit, but only a total of 6 credits may be counted toward the Master’s Degree.

PCST.7460 Masters Thesis in Peace and Conflict Studies (Formerly PCS 746) - Credits: 6
For graduate students actively engaged in research leading toward the submission of a written thesis. A program of
supervised study will be arranged between the student and a faculty supervisor.

PCST.7610 Continued Graduate Research (Formerly PCS 761) - Credits: 1
POLI.5001 Islam and Politics - Credits: 3

The relationship between Islam and Politics changed little since the rise of Islam. The surge in academic and public interest in the topic started in 1979 with the Iranian Revolution. This course will explain the role that Islam plays in everyday life, and will distinguish myth from fact about Islam and politics. Initially, the course will focus on the Muslim Brotherhood of Egypt as the prototype and first Islamic organization that was heavily involved in politics, will continue on to examine a range of issues including Jihad, woman’s rights, and related topics.

POLI.5002 Islamic Activists and Their Political Ideologies - Credits: 3

Islamic Activists have championed certain ideologies since the beginning of the twentieth century, the groups as well as their leading ideologues have changed over time. This course will explain the changes in political ideology, the causes of change and the group’s ability to appeal to a wide audience. Groups discussed in the class will include, the Muslim Brotherhood, the Jihad group in the 1980s, ISIS and other groups. The class will analyze the texts that the groups utilize to attract an audience as well as develop an understanding of the legitimization process of the group itself.

POLI.5110 Dynamics Power and Authority (Formerly 46.411/57.511) - Credits: 3

This course surveys theories of power, authority, participation, and politics. Building on these theories, students will examine changing social, political, and economic patterns of inequality based on class, race (and related divisions of ethnicity, religion, caste, nationality), and gender. Reviews various approaches to altering these dynamics (business strategy, public policy, community and social movements). Cuts across units of firm, community, region, and nation, along with corresponding governmental institutions, and links theoretical analysis with study of practical problem solving. Instructor-initiated cases drawn from a variety of national experiences. Students will learn techniques of power analysis and prepare a power analysis project.

POLI.5440 Advanced Research Methods (Formerly 46.544) - Credits: 3

The purpose of this course is to introduce students to the fundamentals of research while also conveying the need for skepticism as the foundation of scientific inquiry. Both quantitative and qualitative methods will be examined. Students will gain first-hand knowledge of the research process by formulating their own research questions, locating current literature to frame their topic, developing causal theories and then empirically testing these theories. With that in mind, the first goal of this course is for students to become critical consumers of research in general and peace and conflict research in particular. The second goal is for students to develop theories about peace and conflict and research designs to test those theories. Students are encouraged to use this course to develop their thesis or projects.
Ph.D. in Applied Psychology & Prevention Science

- Program Overview
- Program Objectives
- Knowledge Competencies
- Skill Set
- Admission Requirements
- Transfer Credit
- Full-Time vs. Part-Time Study
- Graduate Advisor
- Degree Requirements
- Core Coursework
- Required Courses
- Approved Electives
- Comprehensive Qualifying Papers
- Dissertation
- Graduate Teaching Assistants and Graduate Research Assistants

Program Overview

Established in 2015, the UMass Lowell Ph.D. program in Applied Psychology & Prevention Science is designed to train students and current practitioners who seek advanced education in the application of psychological theories and methods to address real-world problems, as well as to promote optimal quality of life outcomes. APPS emphasizes four core areas of study:

1. Applied Cognitive Psychology
2. Community and Applied Social Psychology
3. Applied Developmental Psychology
4. Applied Behavior Analysis

An applied psychological approach that emphasizes the importance of preventing problems and promoting positive behavior in these areas builds on expertise of our faculty, enriches students understanding of the importance of prevention, expands involvement with communities, enhances research skills, and increases opportunities for students career success.

The Applied Cognitive Psychology core area is designed to teach our graduate students how to address real-world issues. Students will be trained to develop evidence-based reforms rooted in a rigorous study of cognitive processes. Such reforms can be applied to confront problems in the domains of education, law, health, and business. Ongoing research in the department explores how to improve the accuracy of both memory performance and meta-cognitive judgments to help students choose optimal study strategies and help legal actors assess eyewitness reliability. Other faculty study health campaign design, the relationship between language and cognition, memory for trauma, and/or issues that face individuals making decisions within the criminal justice system.

The Community and Applied Social Psychology core area is designed to train students to research and analyze the complex relationships between individual, family, and community well-being and the broader socioeconomic, physical, cultural, and geographic environment. This track will produce graduates with the analytic, creative, and practical skills needed to design and implement programs and services that will facilitate positive changes within and across communities. A number of members of our department specialize in issues facing immigrants, psychology and the law, peace and conflict issues both nationally and internationally, positive aging, intersectionality of race/ethnicity, diversity issues in the workplace, participatory action research, and gender-based violence.

The Applied Developmental Psychology core area will train our graduates to conduct research on typical and atypical challenges across the lifespan. Faculty areas of research include neuropsychology, psychophysiology, and autism spectrum disorders (ASD), child maltreatment, and the development of language, especially the ability to tell narratives of personal experiences. Other faculty address issues of family and parent-child relationships, child eyewitness testimony, and aging and social gerontology.

The Applied Behavior Analysis core area is designed to provide interdisciplinary training within psychology and behavior analysis. Students will be trained as both researchers and scientist-practitioners in the discovery and application of knowledge to solve problems of societal importance. Faculty research in this core area includes educational and occupational development of people on the autism spectrum and in particular members from culturally and linguistically diverse backgrounds, applications of verbal behavior, applications of behavior analysis to instructional design in higher education, as well as staff and parent training.

Program Objectives

The doctoral degree in Applied Psychology & Prevention Science at UMass Lowell is a psychology-based, research-oriented degree. The program is designed to provide a theoretically grounded and methodologically sophisticated education, and will train students and working professionals in the application of psychological knowledge for improving overall health and wellness at multiple levels, including health promotion and disease prevention. The curriculum of the APPS PhD program is geared toward gaining new knowledge and
skills through study, research, and experiential learning opportunities and to meeting the needs of public and private sectors that may serve as potential employers for the programs graduates.

Knowledge Competencies

- An understanding of the key concepts, theories, and methodology in the field of Applied Psychology and Prevention Science;
- Ability to assess the costs and benefits of intervention programs designed to prevent problematic behavior, promote health behaviors, and maximize individual and organizational potential and well-being.
- An understanding of and ability to work well with and empower diverse, underrepresented groups in real-world settings;
- A thorough grounding in the ethical conduct of research and practice in real-world settings.

Skill Set

- Utilize quantitative and qualitative methods to conduct psychological research on major issues related to promoting healthy outcomes, preventing problematic behaviors, and/or intervening to diminish existing problems;
- Assess the effectiveness of organizations and programs;
- Analyze social problems and design appropriate interventions;
- Develop the ability to carry out systemic interventions on multiple levels.

Admission Requirements

For more information about the Application Deadline, consult the Psychology Application Page (https://www.uml.edu/FAHSS/Psychology/Programs/Graduate/Phd-APPS/Application.aspx):

1. Applicants should arrange to have (an) official transcript(s) indicating that they have earned a Bachelors degree, and, if relevant, an official transcript indicating that they have earned a Masters degree (or will in the near future) mailed to the Office of Graduate Admissions by the degree-granting institution(s) at:

   Office of Graduate Admissions

   Cumnock Hall, Suite 110
   One University Avenue
   Lowell, MA 01854-5130

   Transcripts are required from every college or university attended with the following exceptions:

   - Transcripts are not required from colleges or universities where a one-semester study abroad or domestic exchange was completed;
   - Transcripts are not required from colleges or universities for which the course names and grades were transferred to the applicants bachelors or Masters degree-granting institution (and appear on those transcripts).

2. International students who are unable to provide official transcripts to the Office of Graduate Admissions must demonstrate that they have earned the equivalent of a Bachelors degree granted by an accredited United States institution before their application will be processed. Please note, the Office of Graduate Admissions reserves the right to have any application credential evaluated.

   Degree verification may be obtained for a fee at:

   Center for Educational Documentation, Inc.
   (http://www.cedevaluations.com/)
   P.O. Box 170116
   Boston, MA 02117
   Phone: 617-338-7171
   Fax: 617-338-7101
   Website: www.cedevaluations.com
   (http://www.cedevaluations.com)

3. An applicants preparation for doctoral study will be assessed using the following grade point average (GPA) criteria. For undergraduate work, adequate preparation is defined as an earned GPA of at least 3.25 (on a 4.0 grading scale). For graduate work, adequate preparation is defined as an earned GPA of at least 3.75 (on a 4.0 grading scale).

4. Due to the pandemic, we are temporarily waiving the GRE test requirement. In some cases, an applicant may be asked to submit test results to demonstrate that they have the quantitative, verbal and analytical skills required to succeed in the program. In addition, international applicants may submit the Duolingo Test of English as a replacement for the TOEFL or IELTS test.

Pre-pandemic:

All applicants are required to take the Graduate Record Examination (GRE) and provide their scores as part of their
application. Only the scores from the Verbal and Quantitative sections of the GRE are required to assess applicants for doctoral study.

International applicants are also required to take either the Test of English as a Foreign Language (TOFEL) or the International English Testing System Academic (IELTS Academic) examination and provide their TOEFL Scores or their IELTS Scores (for the Academic IELTS, not the General Training IELTS). This requirement is waived if the applicant has earned a Bachelors or Masters degree from an accredited U.S. academic institution.

Official test scores (GRE, TOEFL/IELTS) must be mailed to the university directly by the testing agency this requirement applies to all applicants including current UMass Lowell students or UMass Lowell alumni. Both the GRE and TOEFL are administered by ETS (Educational Testing Services); use the school code for UMass Lowell (3911) when requesting any scores from ETS. There is no school code for the IELTS; instead, test takers should provide the address for UMass Lowell Graduate Admissions to have their official scores sent (address listed above).

The GRE Psychology subject test is not required for admission. However, if an applicant has taken the GRE Psychology subject test and would like to report those scores, the applicant may include that information under Other Test Scores section of their application.

5. Three letters of recommendation are required as part of the application. All recommendations must be provided by sources familiar with applicant from an academic context. Please note that, to be considered for admission, all application materials (including letters of recommendation) must be received by the application deadline.

6. Applicants must submit a personal statement describing why they wish to pursue a doctoral degree in Applied Psychology & Prevention Science. This statement of purpose should be up to 3 double-spaced pages in length and describe the applicant's goals for graduate study, research experience, current and future research interests, and career goals.

7. Applicants are required to submit a curriculum vitae highlighting academic and professional achievements.

Admission decisions will be made based on applicants potential to succeed in the program. All newly accepted students regardless of degree prior to enrollment are required to have obtained a level of proficiency in psychological research prior to enrollment in APPS, as demonstrated by any one of the following:

1. Completion of a senior honors thesis in psychology or related field; or
2. Completion of a masters thesis in psychology or related field; or
3. Completion of two graduate-level research methodology courses, in psychology or related field, with a B or better

Student who have not met the required research proficiency will be required to take the following courses at UMass Lowell during their first year:

1. **PSYC.5120**
   ([https://www.uml.edu/catalog/courses/PSYC/5120](https://www.uml.edu/catalog/courses/PSYC/5120))
   Applied Research Methods
2. **CRIM.5900**
   ([https://www.uml.edu/catalog/courses/CRIM/5900](https://www.uml.edu/catalog/courses/CRIM/5900))
   Descriptive and Inferential Statistics

These courses may not be used to fulfill any doctoral program requirements.

**Transfer Credit**

The Graduate Admissions Committee may allow for up to 12 graduate credits previously earned with a grade of B or better from an accredited institution to be transferred toward the doctoral degree. Transfer credit will only be granted for courses that are substantially similar to those offered at UMass Lowell and that exceed the number required for the previously-granted Masters degree. Applicants are required to submit a Course Description and a Course Syllabus for each course to be considered for transfer credit. Such transfer credit is subject to the approval of the Graduate Coordinator and the Registrar's Office and must meet the University's Graduate Transfer Credit requirements ([https://www.uml.edu/catalog/pdf-pages/Graduate.pdf](https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)).

**Full-Time vs. Part-Time Study**

The Program Director and advisors in the Ph.D. program will guide graduate students through a program of study that can be taken either on a full-time or part-time basis. Full-time study is equivalent to 9 credit hours per semester. Part-time study is equivalent to 6 credit hours per semester.

**Graduate Advisor**
Each newly matriculated student in the program will be assigned to an academic advisor who is a full-time Psychology Department faculty member. The student will meet with his or her advisor on a regular basis throughout the years of study to discuss course selections, qualifying papers, and the development of the dissertation. When a student selects a faculty supervisor to serve as their dissertation committee chair, this faculty member takes over as graduate academic advisor.

Degree Requirements

A total of 42 academic credits, at least 30 of which must be taken at the University of Massachusetts Lowell, are required for the completion of the degree. APPS doctoral degree requirements are as follows:

- **Required Courses** 21 credit hours
- **Approved Electives** 9 credit hours
- **Dissertation** - 12 credit hours

Total must equal 42 credit hours.

Students may request permission to take related courses from other graduate programs at UMass Lowell.

**Core Coursework**

Students are required to take 21 credits of core coursework. PSYC.6400 [Theories of Change in Applied Psychology](https://www.uml.edu/catalog/courses/PSYC/6400) (3 credits), provides students with an integrative and meaningful experience that engages them with the theoretical, practical, and professional questions that applied psychologists address in their efforts to understand and promote change. PSYC.6500 [Advanced Quantitative Methods](https://www.uml.edu/catalog/courses/PSYC/6500) (3 credits), is designed to cultivate and further develop students’ understanding and skills in research methods and advanced data analyses as they prepare to become practitioners of research addressing a range of APPS issues. PSYC.6410 [Fundamentals of Prevention Science](https://www.uml.edu/catalog/courses/PSYC/6410) (3 credits), elaborates on areas introduced in Theories and emphasizes the principles on which prevention science is based. Students will also take two subject matter courses at the 5000 or 6000 level, each 3 credits, chosen from among three core areas of study: Community Social Applied Social Psychology, (CAS), Applied Cognitive Psychology (ACP), and/or Applied Developmental Psychology (ADP). PSYC.6500 [Advanced Community Social Psychology](https://www.uml.edu/catalog/courses/PSYC/6500) is a prerequisite for two more required advanced research methods or data analysis courses (6 credits). The selection of these advanced methods courses in the core is based on identified interests and needs of the student in consultation with the students advisor. Approved methods courses are available in Psychology and also from the Graduate School of Education, the School of Criminology and Justice Studies, and the Department of Work Environment. Students can request that another identified course meets this advanced methods requirement through consultation with their advisor and approval of the Program Director.

**Required Courses (21 credits total)**

- PSYC.6400 [Theories of Change in Applied Psychology](https://www.uml.edu/catalog/courses/PSYC/6400)
- PSYC.6410 [Fundamentals of Prevention Science](https://www.uml.edu/catalog/courses/PSYC/6410)

*Plus any two of the following content courses:*

- PSYC.5000 [Introduction to Community Social Psychology](https://www.uml.edu/catalog/courses/PSYC/5000)
- PSYC.5010 [Applied Developmental Psychology](https://www.uml.edu/catalog/courses/PSYC/5010)
- PSYC.5030 [Applied Social Psychology](https://www.uml.edu/catalog/courses/PSYC/5030)
- PSYC.5880 [Advanced Cognition](https://www.uml.edu/catalog/courses/PSYC/5880)
- PSYC.6650 [Advanced Community Social Psychology](https://www.uml.edu/catalog/courses/PSYC/6650)
- PSYC.6670 [Advanced Applied Cognitive Psychology](https://www.uml.edu/catalog/courses/PSYC/6670)
- PSYC.6690 [Advanced Applied Developmental Psychology](https://www.uml.edu/catalog/courses/PSYC/6690)
- PSYC.6940 [Mentored Research Experience](https://www.uml.edu/catalog/courses/PSYC/6940)
- PSYC.6xxx [Special Course](https://www.uml.edu/catalog/courses/PSYC)
Topics in Behavior Analysis
plus three advanced methods courses:

- **PSYC.6500**
  (https://www.uml.edu/catalog/courses/PSYC/6500)
  Advanced Quantitative Methods (required)

and any two of the following:

**Psychology Department:**

- **PSYC.7010**
  (https://www.uml.edu/catalog/courses/PSYC/7010)
  Narrative Methods
- **PSYC.7020**
  (https://www.uml.edu/catalog/courses/PSYC/7020)
  Participatory Action Research

**Work Environment:**

- **PUBH.5770**
  (https://www.uml.edu/catalog/courses/PUBH/5770)
  Introduction to Biostatistics
- **PUBH.6890**
  (https://www.uml.edu/catalog/courses/PUBH/6890)
  Advanced Regression Modeling

**Graduate School of Education:**

- **EDUC.7040**
  (https://www.uml.edu/catalog/courses/EDUC/7040)
  Qualitative Research Methods
- **EDUC.7050**
  (https://www.uml.edu/catalog/courses/EDUC/7050)
  Survey Research

**Criminology and Justice Studies:**

- **CRIM.5900**
  (https://www.uml.edu/catalog/courses/CRIM/5900)
  Descriptive and Inferential Statistics
- **CRIM.7920**
  (https://www.uml.edu/catalog/courses/CRIM/7920)
  Survival Analysis & Longitudinal Data

Approved Electives (choose any three from among any of the above courses not taken, or from among the following for 9 credit hours)

- **PSYC.5220**
  (https://www.uml.edu/catalog/courses/PSYC/5220)
  Psychology of Diversity
- **PSYC.5270**
  (https://www.uml.edu/catalog/courses/PSYC/5270)
  Immigrant Psychology & Communities
- **PSYC.5460**
  (https://www.uml.edu/catalog/courses/PSYC/5460)
  Grant Writing
- **PSYC.5710**
  (https://www.uml.edu/catalog/courses/PSYC/5710)
  Autism and Developmental Psychopathology
- **PSYC.5740**
  (https://www.uml.edu/catalog/courses/PSYC/5740)
  Community & Social Interventions in Autism
- **PSYC.6110**
  (https://www.uml.edu/catalog/courses/PSYC/6110)
  Program Evaluation
- **PSYC.6640**
  (https://www.uml.edu/catalog/courses/PSYC/6640)
  Child Maltreatment
- **PSYC.6680**
  (https://www.uml.edu/catalog/courses/PSYC/6680)
  Primary Care Behavioral Health
- **PSYC.6750**
  (https://www.uml.edu/catalog/courses/PSYC/6750)
  Seminar in Health Psychology
- **PSYC.6760**
  (https://www.uml.edu/catalog/courses/PSYC/6760)
  Seminar in Language Acquisition
- **PSYC.6770**
  (https://www.uml.edu/catalog/courses/PSYC/6770)
  Applying Cognitive Psychology to Education
- **PSYC.6780**
  (https://www.uml.edu/catalog/courses/PSYC/6780)
  Seminar in Metacognition
Program of Study

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<th>Year</th>
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<td>PSYC.6500 (<a href="https://www.uml.edu/catalog/courses/PSYC/6500">https://www.uml.edu/catalog/courses/PSYC/6500</a>) Advanced Quantitative Methods CAS, ACP, or ADP 5000/6000 course</td>
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<td>Advanced Methods Course</td>
<td>Comprehensive Qualifying Paper 2</td>
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* Optional electives supplement required courses beyond the minimum of 30 credits of coursework
** 12 dissertation credits are required

Comprehensive Qualifying Papers

In the second year of doctoral study, students will complete 2 comprehensive doctoral papers: one paper will be a literature review paper focused on a topic within one of the three core areas of study (Community and Applied Social Psychology, Applied Cognitive Psychology, or Applied Developmental Psychology) and one paper will include a quantitative analysis of data.

Upon successfully passing the Comprehensive Qualifying Papers, a student can begin their dissertation research.

Dissertation

Completion of the dissertation requires:

1. submission of a written dissertation proposal to the students dissertation committee,
2. successful oral defense of the written dissertation proposal,
3. completion and submission of three manuscripts for publication to peer-reviewed journals, and
4. successful oral defense of the three manuscripts.

The minimum number of dissertation credits is 12. Dissertation credits in excess of the required 12 may not be used to substitute for any of the 30 credits of required coursework.

Graduate Teaching Assistants and Graduate Research Assistants

The APPS program has a limited number of Graduate Teaching Assistant (GTA) and Graduate Research Assistant (GRA) positions to support graduate students in the pursuit of their degrees. These positions are awarded to students based on close collaboration between the Program Director, the Dean of FAHSS, and Department Chairs. Graduate assistants work 18 hours per week and are assigned to faculty members within a department of FAHSS to assist in research, instruction, and other professional duties. GTAs and GRAs are assigned as instructors or researchers within departments that match their competencies and research interests.
PSYC.5000 Introduction to Community Social Psychology (Formerly 47.500) - Credits: 3

Introduces history and contemporary trends of community and social psychology with focus on how social and environmental forces affect individual and group quality of life. This course surveys the history, theoretical frameworks, core values, methods/approaches and orienting concepts in the field.

PSYC.5010 Applied Developmental Psychology (Formerly 47.501) - Credits: 3

Provides a life span developmental perspective on individual and social adaptation and change. Examines appropriate theory and research, and illustrates the influences of environmental, social and cultural factors.

PSYC.5020 Seminar in Community Social Psychology (Formerly 47.502) - Credits: 3

Offered from time to time to highlight specialized areas of faculty interest and to acquaint the student with new developments from a broad range of current psychological theory and research and how these developments might affect social and community life.

PSYC.5030 Applied Social Psychology (Formerly 47.503) - Credits: 3

Introduces students to social psychology as an applied discipline. Covers such applied topics as attitude change, aggression, helping behavior, attribution, and interpersonal influence.

PSYC.5040 The Family System (Formerly 47.504) - Credits: 3

Studies family processes and the interplay between the family and other social, cultural, and socio-economic systems. Topics include parental roles, changing family structures, racial and ethnic factors, and interactions between family, work, and community.

PSYC.5090 Psychological Approaches to Child Maltreatment (Formerly 47.509) - Credits: 3

The course addresses the painful topic of Child Maltreatment in the context of research on optimal, typical, and unacceptable treatment of children, as maltreatment cannot be considered apart from acceptable and even optimal treatment. The impact of maltreatment on the development of the child from the first growth of physical organs in the prenatal infant through the development of moral reasoning in the adolescent is addressed. Both theories and research will be discussed.

PSYC.5120 Applied Research Methods (Formerly 47.512) - Credits: 3

Considers strengths and limitations of various approaches to community and social psychological research. Develops skills for formulating research questions and translating them into practical study designs. Sensitivity to research ethics as well as research practicality and validity are emphasized. Pre- or Co-requisite: 47.500

PSYC.5220 Psychology of Diversity (Formerly 47.522) - Credits: 3

This course introduces students to theoretical, philosophical and experiential frameworks for thinking about diversity in our communities and society. It includes an examination of the experiences of diverse groups, especially traditionally oppressed groups and individuals. This course is designed to engage students in a process of introspection and self-examination about issues such as racism, sexism, classism, and homophobia. Emphasis will be placed on challenging one's own world view and the way it fits into institutional oppression, as well as the way it may affect our work as community change agents.

PSYC.5230 Women in the Community (Formerly 47.523) - Credits: 3

An examination of women’s roles in the home, community, and work place; examines psychological consequences, social structural influences, and options for change. Topics include: housework and childcare; violence against women; work place stratification issues; and women’s contributions to their communities.

PSYC.5260 Workplace Diversity (Formerly 47.526) - Credits: 3

This course will explore the challenges presented by the increasingly diverse workforce within the United States. Students will consider how work groups and organizations can effectively incorporate a diversity of perspectives. Students will consider issues of oppression, discrimination and bias, with particular attention paid to the situation here in the Merrimack Valley. There will also be some focus on personal awareness and the development of skills for addressing diversity concerns.

PSYC.5270 Immigrant Psychology and Communities (Formerly 47.527) - Credits: 3

This course will focus on the immigrant experience and the various immigrant groups in the United States with emphasis on recent immigrants in Lowell and Massachusetts. Theories of
acculturation and adaptation to a new cultural environment will be extensively examined in the course. An experiential approach will be integrated throughout the course via the incorporation of guest speakers, films, autobiographies/novels, and food. Students will have ample opportunities to read, reflect, discuss and write about the immigrant experience. As our country is a country of immigrants, this course should have relevance to anyone working in the community.

PSYC.5420 Working with Groups (Formerly 47.542) - Credits: 3

This course uses a community-based approach to working with groups. Guided by an understanding of theoretical principles, students will gain insights about group dynamics and process. Students will develop and apply various skills, including assessment, enhanced communication, conflict resolution, problem solving, decision-making, and evaluation. Emphasis is placed on working within diverse groups, attaining outcomes, and utilizing resources. Organizational, prevention/intervention, and focus groups are examined.

PSYC.5430 Psychology and Law (Formerly 47.543) - Credits: 3

This course focuses on applications of psychological research and practice to the legal system. Drawing from the areas of social, cognitive, developmental, clinical, and neuropsychology, students will critically examine the legal process and compare the law's informal theories of human behavior to what psychologists know on the basis of theories and research. Topics covered include including the practice of scientific jury selection, jury deliberation and decision-making, police interrogations and confessions, use of the polygraph as a lie-detector test, eyewitness testimony, repressed and recovered memories, the use of hypnosis, child witnesses in sex abuse cases, the death penalty, the insanity defense, and the role of psychologists as trial consultants and expert witnesses.

PSYC.5450 Community and Organizational Change (Formerly 47.545) - Credits: 3

A review of skills, techniques, and qualities associated with effective community and organizational interventions. Topics include the possibility and desirability of change, methods for studying change, assessment of needs and resources, visioning and planning, membership recruitment and retention, strategy and tactics, leadership styles, publicizing, funding, advocacy, evaluation techniques, and the personal qualities of the change agent. Both cultural factors and the community context of interventions will be discussed. Application to specific cases will be made. Students will have the opportunity to apply course material to settings outside the classroom.

PSYC.5460 Grant Writing (Formerly 47.546) - Credits: 3

This course will be a hands-on course in grant writing. One of the first lessons that you will learn is that grant writing is only to a small degree about writing. Successful grants emerge from working effectively with others to draw out ideas, capture those ideas to create a program or a plan for research, show how the plan is an appropriate one to respond to the "Request for Proposals", and package those ideas so that they make sense to the people who will review the proposal. Grant writing is increasingly a team building activity. Whether or not you obtain the funding is sometimes less important than the networking and planning that you do as a part of developing a grant proposal.

PSYC.5610 Introduction to Behavioral Intervention in Autism (Formerly 47.561) - Credits: 3

This course provides an introduction to the causes and diagnosis of autism, scientific validation, applied behavior analysis, and ethical treatment. Students also learn to write functional objectives, plan positive reinforcement, and design an applied measurement system in the context of developing Individualized Family Service Plans and Individualized Education plans. The issue of culturally appropriate interventions is addressed Prerequisite: coursework in the psychology of child development, or permission.

PSYC.5611 Introduction to Behavioral Intervention in Autism for 3rd - Credits: 3

This course is for students who took 5610 prior to fall 2014 and who need additional hours to qualify for the BCBA exam. It provides an introduction to the causes and diagnosis of autism, scientific validation, applied behavior analysis, and ethical treatment. Students also learn to write functional objectives, plan positive reinforcement, and design an applied measurement system in the context of developing individualized Family Service Plans and Individualized Education plans. The issue of culturally appropriate interventions in addressed Prerequisite: coursework in the psychology of child development, or permission.

PSYC.5620 Teaching and Positive Behavioral Support in Autism (Formerly 47.562) - Credits: 3

This course covers the application of specific behavioral teaching procedures, including prompting, reinforcement, shaping, chaining, error correction and generalization methods, and the development of instructional plans. Emphasis is placed on procedures and plans to teach communication, social, self-help and per-academic skills. Application of such methods in inclusive classroom settings is also considered.
PSYC.5621 Teaching and Positive Behavioral Support in Autism for 3rd - Credits: 3

This course is for students who took 5620 prior to fall 2014 and who need additional hours to qualify for the BCBA exam. This course provides instruction on areas of the 4th edition task list related to ethically providing behavior analytic services as established by the Behavior Analysis Certification Board and codes of conduct for behavior analysts in the field of applied behavior analysis. Building on knowledge of applied behavior analysis and autism gained in the two prerequisite courses, students will enhance their understanding of best practices in the assessment and treatment of individuals diagnosed with an autism spectrum disorder and how ABA strategies are implemented and evaluated.

PSYC.5630 Management Strategies in Applied Behavioral Intervention - Credits: 3

This course provides instruction on areas of the 4th edition task list related to ethically providing behavior analytic services as established by the Behavior Analysis Certification Board and codes of conduct for behavior analysts in the field of applied behavior analysis. Building on knowledge of applied behavior analysis and autism gained in the two prerequisite courses, students will enhance their understanding of best practices in the assessment and treatment of individuals diagnosed with an autism spectrum disorder and how ABA strategies are implemented and evaluated.

PSYC.5650 Measurement and Experimental Design in Behavioral Intervention (Formerly 47.565) - Credits: 3

This course provides advanced coverage of measurement methods used in behavioral intervention. It also offers in-depth coverage of the "within-subject" experimental designs commonly used in behavioral research and practice. Component analysis and parametric analysis methods, and ethical considerations in research, are also covered.

PSYC.5651 Measurement and Experimental Design in Behavioral Intervention for 3rd - Credits: 3

This course is for students who took 5650 prior to Fall 2014 and who need additional hours to qualify for the BCBA exam. This course provides advanced coverage of measurement methods used in behavioral intervention. It also offers in-depth coverage of the "within-subject" experimental designs commonly used in behavioral research and practice. Component analysis and parametric analysis methods, and ethical considerations in research, are also covered.

PSYC.5660 Functional Analysis and Treatment of Challenging Behavior (Formerly 47.566) - Credits: 3

This course covers the purpose, rationale and methods used in conducting and interpreting functional analyses of challenging, or "maladaptive", behaviors (self-injury, stereotypy, aggression). It also describes the full range of behavioral procedures used to decrease or eliminate these behaviors, with emphasis placed on ethical interventions and the desirability of least restrictive and non-aversive strategies.

PSYC.5661 Functional Analysis and Treatment of Challenging Behavior for 3rd - Credits: 3

This course is for students who took 5660 prior to Fall 2014 and who need additional hours to qualify for the BCBA exam. This course covers the purpose, rationale and methods used in conducting and interpreting functional analyses of challenging, or "maladaptive", behaviors (self-injury, stereotypy, aggression). It also describes the full range of behavioral procedures used to decrease or eliminate these behaviors, with emphasis placed on ethical interventions and the desirability of least restrictive and non-aversive strategies.

PSYC.5680 Behavioral Intervention Program Models in Autism (Formerly 47.568) - Credits: 3

This course is designed to explore Autism Spectrum Disorders (ASDs) in the developing person and in changing social contexts (e.g., family, school, employment) across development. An empirical and theoretical review of developmental transformations and reorganizations across the lifespan provides the basis for examining biological, social, psychological, and cultural contributions to the continuity and discontinuity of both adaptive and maladaptive processes over time as well as an analysis of individual and environmental risk and protective factors across development. Special attention is given to the changing competencies and challenges of developmental periods and their role in the assessment, display,
meaning, and implications of ASDs from infancy through adulthood.

**PSYC.5720 Legal and Ethical Issues in Professional Practice (Formerly 47.572) - Credits: 3**

This course will explore the legal and ethical issues facing professionals working with individuals diagnosed with disabilities, particularly those on the autism spectrum. The goal is to provide behavior analysts and other professionals the opportunity to develop skills in dealing with the complex legal and ethical issues that arise when working in human service fields.

**PSYC.5740 Community and Social Interventions in Autism (Formerly 47.574) - Credits: 3**

This course will focus on current perspectives of community-based programming for individuals on the autism spectrum, particularly among the adolescent and adult age range. We will overview the challenges experienced by those with an autism spectrum disorder (ASD) during adolescence and adulthood, and consider the issues involved in designing, implementing, and evaluating social and community interventions for this population.

**PSYC.5810 Concepts and Principles of Behavior Analysis - Credits: 3**

This course is designed to provide students with foundational knowledge regarding the basic concepts and principles of behavior analysis. Students will gain an introduction to what behavior analysis is and how it differs from other approaches that study behavior. Students will be asked to define and identify examples of the basic principles, then apply that knowledge to describe and diagram original, real-world examples. Students will look at how the environment promotes the development of both adaptive and maladaptive behaviors, shapes behavior over time, and how the environment can be modified to help change behavior.

**PSYC.5820 Measurement and Experimental Design - Credits: 3**

This course provides advanced coverage of the measurement methods that are important to the effective use of applied behavior analysis. It also offers in-depth coverage of the within-subject: experimental designs commonly used in behavioral research and practice. Component analysis and parametric analysis methods, and social validity and generalization considerations in research, are also covered.

**PSYC.5830 Philosophical Underpinnings of Behavior Analysis - Credits: 3**

This course will focus on the scientific and philosophical underpinnings of behavior analysis. In this course, students will review basic assumptions about the nature of behavior, including comparison of the philosophical positions of free will and determinism. Emphasis will be placed on verbal behavior and the problems that can arise when practitioners are confronted with mentalistic explanations of behavior. Students also will explore complex conceptual issues, such as knowledge and understanding, purpose and intention, problem-solving, reasoning, creativity, culture, ethics, and rights and values, in ways that illustrate how they are important to everyday life. The historical perspective of how radical behaviorism evolved, and how it compare to other conceptual systems will be reviewed.

**PSYC.5840 Behavioral Assessment - Credits: 3**

This course covers the assessment of behaviors and skills. We will review many types of assessments used in applied behavior analysis and the reliability of these common assessments. Specific topics to be covered include functional behavior assessments, functional analysis, preference and reinforcement assessments, skill assessments, identification of goals, how to write goals, and the development of a treatment plan. Emphasis will be placed on the use of assessments to inform treatment.

**PSYC.5850 Professional and Ethical Issues in Behavior Analysis - Credits: 3**

This course will explore the legal and ethical issues facing professionals working with individuals diagnosed with disabilities, particularly those on the autism spectrum. The goal is to provide behavior analysts and other professionals the opportunity to develop skills in dealing with the complex legal and ethical issues that arise when working in human service fields.

**PSYC.5860 Community Service Learning (1, 2, or 3 credits) (Formerly 47.486/586) - Credits: 1-3**

Students will take an applied role in the community where they will have the opportunity to provide some form of meaningful service to individuals, groups or communities. Students will meet regularly with a designated faculty member on campus to consider their experiences in the context of current psychological thought. In some instances, the commitment to community service may extend over the course of a full year. Graded as Satisfactory or Unsatisfactory. 1, 2 or 3 credits. This course may be repeated but no more than 12 credits total from any combination of PSYC.4860, PSYC.4880 and PSYC.4910 may be counted toward the degree.

**PSYC.5870 Behavior Change Procedures - Credits: 3**

This course covers the design and application of behavior
change procedures commonly used by behavior analysts. We will review the importance of cultural considerations and ongoing monitoring of progress. Specific topics to be covered include reinforcement, antecedent manipulations, transfer of stimulus control, and programming for maintenance and generalization. Emphasis will be placed on procedures used for skill acquisition including social, communication, self-help, and academic skills.

PSYC.5880 Advanced Cognition - Credits: 3

This course will provide an advanced overview of the scientific study of mental processes. Specifically, we will read a number of experimental and review articles that describe or contribute significant advancements to our understanding of memory, decision-making, language, attention, perception, etc. Readings will be critically evaluated and synthesized through discussions and a variety of in-class review activities, with particular emphasis on the role of cognition in a broader human context.

PSYC.5890 Implementation and Supervision Practices in Behavior Analysis - Credits: 3

This course covers implementation of simpler to more complex behavior change procedures and the management and supervision of the staff who implement those procedures. We will review the importance of ethical and safety considerations, data analysis to monitor progress and problem-solve any lack of progress, and initial staff training and ongoing supervision of staff. Specific topics to be covered include reinforcement procedures to impact behavior, positive and negative punishment, group contingencies and programming for maintenance and generalization of behavior changes, staff training and supervision effectiveness. Emphasis will be placed on procedures used for behavior reduction and socially-valid replacement behaviors as well as best practices in personnel management and supervision.

PSYC.5900 Professional Seminar in Applied Behavior Analysis - Credits: 0

A monthly meeting for students in the ABA option of the Applied Behavior Analysis and Autism Studies graduate program designed to address questions related to the supervised practicum experience. Student will be required to be in a setting accruing fieldwork experience under the supervision of a Board Certified Behavior Analyst.

PSYC.6110 Program Evaluation (Formerly 47.611) - Credits: 3

A skill-oriented approach that considers both formative and summative evaluation techniques. Emphasizes mastery of the technical aspects of the evaluation process, and includes consideration of the importance of program evaluation in community psychology, health, education, etc.

PSYC.6250 Advanced Community Dynamics: Lowell (Formerly 47.625) - Credits: 3

An examination of principles that influence community structure, function, and evolution over time. Students will learn how community patterns and activities can best be understood and how community problems and concerns can best be addressed, employing psychological and other conceptual frameworks and perspectives. Specific emphasis will be placed on the historic and diverse city of Lowell. Prerequisites: 47.500 and 47.512.

PSYC.6310 Capstone Practicum I in Community Social Psychology (Formerly 47.6310) - Credits: 3

Provides supervised field experience in a setting appropriate to the student’s area of specialization, plus on-campus class meetings. An average of approximately ten hours of fieldwork in an approved setting for two consecutive semesters is required.

PSYC.6320 Capstone Practicum II in Community Social Psychology (Formerly 47.632) - Credits: 3

Continuation of PSYC.6310, which is pre-requisite.

PSYC.6400 Theories of Change in Applied Psychology (Formerly 47.640) - Credits: 3

Examines major theories of development and change relevant to Applied Psychology; and discusses the use of theories in posing and answering research questions. A major focus of research and practice is on understanding and promoting change (in structures, functions and processes of cognition, emotion, behavior and relationships) over time. In this course, students will examine major theories of change (development, therapeutic and school/community/contextual change), learn to place these theories in comparative, historical and philosophical context, examine efforts in theory integration, and test the direct relevance of theories to posing and answering their own research questions.

PSYC.6410 Fundamentals of Prevention Science - Credits: 3

This graduate course will examine theoretical, empirical, and practical foundations of prevention science for designing and evaluating diverse interventions to prevent human social problems and promote healthy development. The seminar will cover the origins and multidisciplinary roots of prevention science, key concepts, current trends and directions, theoretical approaches, program theory, methodology, research to
practice, policy development, and dissemination. Special consideration will be given to conceptual issues in the field such as prevention versus promotion, stages of program development, scaling up, methodological approaches such as randomized controlled trials, quasi-experiments, process and impact assessment, cost-benefit analysis, statistical methodology, dissemination.

**PSYC.6500 Advanced Quantitative Methods** (Formerly 47.700/PSYC.7000) - Credits: 3

This course is designed to provide an overview of the most widely used methods employed by psychologists and other behavioral scientists. You will learn about the common research tools and strategies that psychologists’ use in the production of knowledge. The course will provide you with a basic understanding of the strengths and weaknesses of the various research strategies used by psychologists so that you can become an informed consumer of research both in the behavioral sciences and the media. In addition, you will begin to develop and practice a set of research skills that will prepare you for advanced study in the behavioral sciences.

**PSYC.6630 Experimental Analysis of Behavior** (Formerly 47.663) - Credits: 3

This course will explore the basic principles of the experimental analysis of behavior and their application to an understanding of learning. Emphasis will be placed on the historical underpinnings of the field, the methods of analysis, and current issues in the field.

**PSYC.6710 Supervised Practicum in Behavioral Intervention in Autism: I** (Formerly 47.671) - Credits: 3

This is the first of a two-semester practicum course to supplement supervised fieldwork experience students receive as a requirement for the Master of Science in Applied Behavior Analysis and Autism Studies. Students practice engaging in the necessary skills to become an effective behavior analyst and a scientist-practitioner. The assignments, activities, and discussions will enhance student’s understanding of the fundamental concepts, principles, and behavior change programs used in the field. All students must have an off-site, approved placement that includes direct work with clients.

**PSYC.6720 Supervised Practicum in Behavioral Intervention in Autism: II** (Formerly 47.672) - Credits: 3

This is the second of a two-semester practicum course to supplement supervised fieldwork experience students receive as a requirement for the Master of Science in Applied Behavior Analysis and Autism Studies. Students practice engaging in the necessary skills to become an effective behavior analyst and a scientist-practitioner. The assignments, activities, and discussions will enhance student’s understanding of the fundamental concepts, principles, and behavior change programs used in the field. All students must have an off-site, approved placement that includes direct work with clients.

**PSYC.6750 Seminar in Health Psychology** - Credits: 3

This course focuses on the application of psychological principals to the subspecialty of health psychology. Students will learn about the major topics in health psychology, including health behaviors, stress and health, health moderators, and prevention. Students will be exposed to psychological theories and research methodologies used in health psychology, and to current literature in the field.

**PSYC.6810 Health Campaigns: Effects and Processes** (Formerly 47.681) - Credits: 3

The intent of this course is to provide the student with a thorough understanding of the effects and processes of health campaigns -- including theoretical foundations, empirical findings, and practical applications. The emphasis will be on applying this information to diverse aspects of human health, including individual physical and mental health as well as the broader fabric of public health and societal functioning. As the course evolves, students will apply and extend the course concepts through critical analysis of existing health campaigns and through the design of a proposed campaign of their choosing.

**PSYC.6910 Directed Study in Community and Social Psychology** (Formerly 47.691) - Credits: 3

This course is designed as an independent study under the supervision of a member of the department of a subject not offered in the standard curriculum.

**PSYC.6920 Directed Study in Applied Behavior Analysis and Autism Studies** (47.692) - Credits: 1-3

This course is designed as an independent study under the supervision of a member of the department of a subject not offered in the standard curriculum.

**PSYC.6930 Directed Study in Applied Psychology and Prevention Science** (Formerly 47.693) - Credits: 3-9

Designed as an independent study under faculty supervision in a topic not offered elsewhere in the curriculum.
PSYC.6940 Mentored Research Experience - Credits: 1-6
Students will take an applied role in faculty-supervised research, with prior approval of primary advisor, where they provide a meaningful contribution to a faculty member’s research program or particular study. Students will be involved in various stages of the research process, including literature review, research design, procedures, data collection, entry, and/or analysis. Activities will be substantive enough for the students to earn co-authorship in research dissemination, including research papers, presentations, and policy briefs. Graded as Satisfactory or Unsatisfactory, 3 credits or 6 credits. This course may be repeated but no more than 12 credits total from an combination of PSYC.6930, PSYC.6940, PSYC.6950 may be counted toward the degree.

PSYC.6950 Applied Field Research - Credits: 3-6
Students will work in an applied setting, with prior approval of primary advisor, where they will have the opportunity to perform various research tasks, including grant writing, needs assessments, gaps analyses, and provide evidence-based workshops and training to staff and community members at the applied setting. These activities may culminate in research papers, presentations, policy briefs. Graded as Satisfactory or Unsatisfactory, 3 credits or 6 credits. This course may be repeated but no more than 12 credits total from any combination of PSYC.6930, PSYC.6940, PSYC.6950 may be counted toward the degree.

PSYC.7010 Narrative Methods (Formerly 47.701) - Credits: 3
Narrative refers to real or imaginary events related often by means of language, but also by means of pictures, songs, and dance. Narrative often involves a sequence of events, representation of the meaning of those events, and description of the context in which they occurred. Narrative is the primary means by which we make sense of our experiences and represent ourselves to and develop intimacy with others. There are important documented differences in narration due to culture, cognition, emotion, age, and gender. To adequately analyze narration requires expertise in a wide variety of analytic methods and is the overarching goal of this course.

PSYC.7030 Selected Topics in Applied Psychology and Prevention Science (Formerly 47.703) - Credits: 3
Presents a careful consideration of selected topics in the area of Applied Psychology and Prevention Science.

PSYC.7050 Intro to Structural Equation Modeling - Credits: 3
introduction to basic concepts, principles, and applications of structural equation modeling including path analysis, confirmatory latent variable models, multiple-group modeling, and latent growth curve modeling. Students will learn how to use these techniques in relation to various examples of social science research data.

PSYC.7220 Master’s Project in Autism - Credits: 3
For master’s graduate students actively engaged in a research or intervention-based project leading to the submission of a written project report. A program of supervised study will be arranged between the student and a faculty supervisor. This course may be repeated once. Permission of instructor.

PSYC.7330 Master’s Project in Community-Social Psychology (Formerly 47.733) - Credits: 3
For graduate students actively engaged in developing a change-oriented intervention leading to the submission of a written project report. A program of supervised study will be arranged between the student and a faculty supervisor. Prerequisite: Approval of major advisor.

PSYC.7430 Master’s Thesis in Community Social Psychology (Formerly 47.743) - Credits: 3
For graduate students actively engaged in research leading toward the submission of a written thesis. A program of supervised work will be arranged between the student and a faculty supervisor. This course may be repeated for credit, but only a total of 6 credits may be counted toward the Master’s degree. Prerequisite: 47.500 and 47.512 and permission of the faculty member who will supervise the thesis.

PSYC.7440 Master’s Thesis in Applied Behavior Analysis and Autism Studies.(Formerly 47.744) - Credits: 3
For graduate students actively engaged in research leading toward the submission of a written thesis. A program of supervised work will be arranged between the student and faculty supervisor. This course may be repeated for credit, but only a total of 6 credits may be counted toward the Master’s degree.

PSYC.7460 Master’s Thesis in Community Social Psychology (Formerly 47.746) - Credits: 6
For graduate students actively engaged in research leading toward the submission of a written thesis. A program of supervised work will be arranged between the student and faculty supervisor. Only a total of 6 credits may be counted toward the Master’s degree. Prerequisite: 47.500 and 47.512
and permission of the faculty member who will supervise the thesis.

PSYC.7630 Dissertation (Formerly 47.763) - Credits: 1-9

Faculty supervision of doctoral dissertation.
CRIM.5010 Criminological Theory: Foundations (Formerly CRIM 501/521) - Credits: 3
This course provides a detailed examination of the best known and most influential theories of crime causation. Topics include: theory construction, hypothesis testing, theory integration, and the links among theory, research, and policy.

CRIM.5200 Administration of Justice (Formerly 44.503/CRIM 520) - Credits: 3
An examination of the components of the criminal justice system and a review of the administration of federal, state and local criminal justice agencies, including a focus on criminal law and procedure.

CRIM.5210 Managing Justice Organizations (Formerly 44.570/CRIM 521) - Credits: 3
A range of criminal justice management issues are addressed, including organizational structure, purpose, rewards and relationships, leadership and management styles, and the development of effective change strategies by criminal justice agencies. The complex role of the criminal justice manager in both the adult and juvenile justice system is emphasized.

CRIM.5240 Issues in Corrections (Formerly 44.550/CRIM 524) - Credits: 3
This course reviews the development of institutional corrections and the issues surrounding the punishment of criminals in secure settings. The course also surveys the management of correctional institutions, including custody, classification, reception, programming, release, staffing, scheduling, collective bargaining, prisoners' rights, and other related issues.

CRIM.5250 Juvenile Justice and Youth Crime (Formerly CRIM.525) - Credits: 3
Examines the historical development of juvenile justice in the U.S., how the juvenile justice system operates, the rationale for treating juveniles differently from adults, and the extent of youth crime in the United States according to official statistics and self-report data.

CRIM.5400 Criminal Profiling (Formerly 44.542/CRIM 540) - Credits: 3
An overview of the development and characteristics of violent offenders, some of whom will evolve to become criminal psychopaths. The class provides an analytical understanding of the unique characteristics of serial criminals and the methodologies used to commit their crimes.

CRIM.5410 Forensic Psychology (Formerly 44.543/CRIM 541) - Credits: 3
This course applies psychological theories, principles, and research to issues of concern to the criminal justice system with a special focus on the intersection of the mental health and criminal justice systems.

CRIM.5600 Gender, Race & Crime (Formerly 44.560) - Credits: 3
The implications of criminal laws, criminal justice practices and programs. Focus on inequalities based on gender, race and class.

CRIM.5660 Transportation Systems Safety and Security (Formerly 44.566) - Credits: 3
This course will look at safety, security and emergency management with regard to transportation operations; multi-modal transportation security threats, vulnerabilities, risk and strategies to mitigate and incident; and the security of supply chains and critical infrastructure. The course will use case studies to provide the student with the knowledge, skills, and abilities to effectively safeguard the movement of assets within interconnected transportation networks.

CRIM.5700 Crisis and Emergency Management (Formerly 44.513/CRIM 570) - Credits: 3
This course will provide a broad introduction to the critical challenges of disaster management. The course will address past and present strategies for reducing and responding to hazards posed by both manmade and natural disasters. Emphasis will be placed on what we can learn from the history of disasters, and on how we can apply those lessons to the management of future events.

CRIM.5710 Domestic Terrorism and Violent Extremism (Formerly 44.526/CRIM 571) - Credits: 3
This course examines the evolution and contemporary nature of domestic terrorist threats and violent extremist movements that the U.S. has confronted over the past several decades. Special attention is focused on right-wing militias, religious extremists, racial supremacist/hate groups, and extreme environmental and animal rights groups. Students will also learn about political and socioeconomic factors that enable a terrorist group’s ideological resonance, prison radicalization, the role of the Internet in mobilizing individuals toward violent behavior, and the legal and criminal justice dimensions of responses to terrorism.
CRIM.5720 Comparative Terrorism and Counterterrorism (Formerly 44.549/CRIM 572) - Credits: 3

This course examines a broad spectrum of terrorist groups and counterterrorism responses in over a dozen countries, including Colombia, Germany, India, Israel, Italy, Northern Ireland/UK, Pakistan, Somalia, Spain, Sri Lanka, Turkey and Yemen. This comparative analysis will help students develop understanding of patterns and trends within political violence (including radicalization, tactics, financing, targeting behavior, malevolent creativity, disengagement and de-radicalization) and the many different policies and strategies adopted by governments in response to terrorist threat.

CRIM.5730 Threat Assessment and Risk Management (Formerly 44.554/CRIM 573) - Credits: 3

The goal of this course is to enhance understanding and increase expertise regarding risk management and the impact of terrorism on economic and other critical infrastructures in the United States. The course will provide the tools (operational and statistical) and technology required to mitigate these risks. A second purpose of the course is to examine and critically discuss current and future methods to create best practices in security management.

CRIM.5740 Overview of Homeland Security (Formerly 44.567/CRIM 574) - Credits: 3

The U.S. has embraced the homeland security monolith without a full understanding of what it encompasses. This course provides a comprehensive overview of homeland security and defense as undertaken in the United States since 9/11. The course critically examines the current body of knowledge with a specific focus on understanding security threats, sources, and reasons for these threats. The roles of the key players at the federal, state and local levels, the policies and procedures enacted since 9/11, and the homeland security system in practice are also examined.

CRIM.5750 Contemporary Security Studies (Formerly 44.568/CRIM 575) - Credits: 3

This course examines the complex nature of key domestic and international security threats and responses. Topics include terrorism and insurgency, transnational organized crime, WMD proliferation, cyber-security, intelligence, national and homeland security strategies, critical infrastructure protection, and theories of international security.

CRIM.5780 Intelligence Analysis Policy and Practice (Formerly CRIM.578) - Credits: 3

Students will examine the tradecraft of intelligence collection and analysis from various perspectives. Topics will include strategies, tactics, legal and ethical implications, sources, means, methods, limitations, covert action, methods of analysis, and case studies of prominent intelligence successes and failures in the last half century.

CRIM.5830 Master’s Thesis - Criminal Justice (Formerly 44.743/CRIM 583) - Credits: 3
CRIM.5860 Master’s Thesis - Criminal Justice (Formerly 44.746/CRIM 586) - Credits: 6
CRIM.5900 Descriptive & Inferential Statistics (Formerly 44.580/44.590) - Credits: 3

This course is a rigorous introduction to statistical inference: probability theory, confidence intervals, and hypothesis tests. The course also covers regression analysis, which is developed in a non-technical way, with an emphasis on interpretation of regression results, using examples from recent research.

CRIM.5910 Research Design (Formerly CRIM.591) - Credits: 3

Research design is a graduate-level introduction to methodology as used in criminology/criminal justice. The course surveys the research design enterprise and covers a host of issues on the measurement and collection of data, and other procedures that influence whether a research study will lead the investigator to scientifically rigorous information. This course explains various strategies for devising social science studies, compares the relative benefits of various designs, and identifies the tools necessary to conduct studies that will yield data worthy of analysis and interpretation. This material will be valuable for students who will conduct research and administrators who must evaluate the research of others.

CRIM.5920 From Data to Practice and Policy - Credits: 3

This course provides students with the tools and understanding needed to collect, process, and analyze data, turn it into useful information, and communicate knowledge to a variety of audiences via written and visual means. Students will earn how they can take unprocessed, messy, and complex data from a variety of sources, turn this into something useful (and reliable), and then effectively communicate the underlying ‘so what’ to other people to help influence policy and practice. As part of this process, students will learn the skills needed to spot incomplete, suspect, and/or fake data, and to identify misinformation, disinformation, and propaganda. Students will learn these skills through a combination of different modalities.
At the conclusion of the course, students will be able to produce their own impactful policy briefs and data visualizations to effectively communicate impactful information to a variety of audiences.

CRIM.5950 Program Evaluation (Formerly 44.595) - Credits: 3

A detailed examination of methods of evaluating criminal justice programs. Focuses on both process and outcome evaluation.

CRIM.6000 Professional Development - Credits: 3

This course is designed to support the professional development of doctoral students as they pursue a research-oriented graduate degree. Specific material will sensitize students to the expectations for the quality of their work, as well as enhance preparation for developing a research agenda, publishing scholarly manuscripts, seeking external funding, and navigating the job market. This course will also discuss topics relevant to preparing graduate students for teaching at the undergraduate level, including course development, lecture/activity planning, and classroom management.

CRIM.6010 Criminological Theory Advanced (Formerly 44.601) - Credits: 3

The course examines contemporary criminological thought by assessing major theories that anchor the discipline of criminology. Also explores the causal structure of these theories, the level of analysis at which they reside, the assumptions that underlie them, their strengths and weaknesses, and their policy implications.

CRIM.6020 Nature and Extent of Crime and Criminals (Formerly CRIM 602) - Credits: 3

Exposes students to the major measurement methods for the incidence of crime and prevalence of criminals. Students will become versed in using data derived from any of the three primary sources of crime statistics: police-based measures (UCR, NIBRS), victim surveys (NCVS), and self-reports of criminal behavior (Monitoring the Future, National Youth Survey).

CRIM.6030 Correlates of Crime and Justice (Formerly CRIM 603) - Credits: 3

This course examines the nature of the relationships among attributes and indices at the individual, situational, and aggregate levels to various forms of crime and systems of justice. The implications of criminal laws, criminal justice practices, and programs are examined with a focus on inequalities based on gender and race.

CRIM.6050 Advanced Theory of Political Violence - Credits: 3

The course aims to provide advanced understanding of the various ways in which social scientists explain the manifestations of political violence, such as terrorism, insurgency, and political assassinations. Theories from the fields of political science, sociology, criminology, international relations, and economics will be introduced, and critically analyzed, to examine their utility in answering questions such as: How does violence differ from other types political action? When and why is violence employed in place of peaceful solutions to conflict? How is violence being rationalized? The course will force students to grapple with research from different disciplinary traditions, and with various methodologies, and in general, exercise an interdisciplinary approach.

CRIM.6110 Law and Social Control (Formerly CRIM 611) - Credits: 3

This course examines and analyzes the various means by which society attempts to control criminal conduct. Social control encompasses both formal and informal mechanisms and a variety of institutions and social processes to deter inappropriate conduct, if possible, and/or punish and reform such conduct. Social control has evolved considerably over time and various social control philosophies and techniques have been prevalent at one time but not others. Because social control is a response to inappropriate conduct, the course will also provide a brief introduction to the concepts of deviance and crime and the differential social control needs and priorities posed by different kinds of inappropriate conduct.

CRIM.6120 Drugs, Crime and Justice (Formerly CRIM 612) - Credits: 3

This course surveys the historical development and contemporary context of the use of criminal sanctions to combat the use of illicit drugs. The relationship between drug use/abuse and crime is explored. The course also provides a policy analysis of the alternative means available to deal with the drugs-crime issue (legalization, decriminalization, interdiction, tougher criminalization).

CRIM.6130 Law and Public Policy (Formerly 44.573/CRIM 613) - Credits: 3

The course is an introduction to crime and the efforts to control crime through public policy. We explore the foundations of the policy-making process at the federal, state, and local levels. The course also considers broad theoretical
applications pertaining to public opinion, national culture, and comparative analyses among Western democracies and their differing approaches to crime. This course employs a variety of learning tools, from roundtable discussions to policy cases.

CRIM.6220 Seminar in Policing (Formerly CRIM 622) - Credits: 3
This seminar examines the contemporary research literature in policing with a focus on the key research issues. Through a critical examination of the literature, students gain an understanding of the significant topic areas that have been pursued and develop an agenda for further research.

CRIM.6230 Seminar in Courts and Sentencing (Formerly CRIM.623) - Credits: 3
This seminar examines the contemporary research literature in adjudication and sentencing with a focus on the key research issues. Through a critical examination of the literature, students gain an understanding of the significant topic areas that have been pursued and develop an agenda for further research.

CRIM.6250 Seminar in Juvenile Justice and Youth Crime (Formerly CRIM 625) - Credits: 3
This seminar examines the contemporary research literature concerning juvenile justice with a focus on the key research issues. Through a critical examination of the literature, students gain an understanding of the significant topical areas that have been pursued and develop an agenda for further research.

CRIM.6260 Community Based Correction (Formerly 44.650/CRIM 626) - Credits: 3
This course presents a detailed examination of current theory, research, and policy development in the field of community corrections, both nationally and internationally. Topic areas include sentencing, probation, parole, fines, community service, and intermediate sanctions (intensive supervision, house arrest/electronic monitoring, boot camps). Issues include the punishment vs. control argument, community justice models, special offender populations (drug offenders, sex offenders, mentally ill offenders, AIDS), and the cost effectiveness of community corrections.

CRIM.6300 Victimology (Formerly CRIM 522) - Credits: 3
This course examines the study of crime victims and of the patterns, impact, and formal responses to criminal victimization. Particular attention is given to research issues such as measurement of victimization, fear of crime and related measures, and conducting research with victimized populations, as well as discussion of current issues in the field of Victimology. Substantive topics may include theories of victimization, the overlap between victims and offenders, social-psychological and other impacts of victimization on primary and secondary victims, media coverage of victimization, and evaluation of prevention and intervention programs for victims (criminal justice system based programs and others).

CRIM.6310 Intimate Partner Violence (Formerly 44.622/CRIM 631) - Credits: 3
An examination of the nature and extent of intimate partner violence and an analysis of the causes and consequences of violence between partners as well as the latest research regarding the criminal justice response.

CRIM.6320 Responding to Child Maltreatment (Formerly 44.623/CRIM 632) - Credits: 3
Introduction to empirical findings and theoretical perspectives concerned with the maltreatment of children and youth. Includes an examination of prevalence rates, risk factors, consequences, and system responses.

CRIM.6400 Criminal Mind and Behavior (Formerly 44.545) - Credits: 3
This course is designed to address a broad range of topics relevant to criminal behavior and the development of the so called criminal personality. Factors that are considered to influence the evolution of criminal mentality are examined and the laws and the past and current response of the criminal justice system to repeat offenders are explored.

CRIM.6410 Mental Health & Criminal Justice (Formerly 44.546/CRIM 641) - Credits: 3
The course focuses on how and why individuals with serious mental illness become involved in the criminal justice system, and on how the criminal justice and public mental health systems respond to that involvement. Topics include law enforcement responses, court-based strategies, mental health and corrections, community supervision of individuals with mental illness, violence and mental disorder, and unique challenges associated with female and juvenile populations.

CRIM.6420 Sex Crimes and Offenders (Formerly 44.646/CRIM 642) - Credits: 3
This course examines the nature of sex offenses as well as the mind of the sex offender, and focuses on motives, possible
victims, and rehabilitation. The responses of the mental health and criminal justice systems are examined and the effectiveness of those responses is assessed.

CRIM.6500 Violence in America (Formerly CRIM 650) - Credits: 3

This course provides an in-depth analysis of the causes, context, and control of a wide range of violent crimes. Topics covered in this class include: Murder, rape, robbery, assault, and violence in the helping professions, the workplace, school, gang violence, cult violence, and institutional violence. For each form of violence, we examine issues related to (1) the extent of the problem, characteristics of the crime, victim, and offender, (2) causation, (3) crime prevention, and (4) crime control strategies.

CRIM.6510 Criminal Homicide (Formerly 44.575/CRIM 575) - Credits: 3

A survey of the nature and extent of criminal homicide. There will be five main components: statutory definitions of homicide; theories of homicide; homicide rates over time and across jurisdictions; trends and patterns in homicide characteristics; and cross-cultural comparisons. Homicide is an important topic in criminology for three reasons: (1) it is the crime of greatest severity in any penal code; (2) it is a fairly reliable barometer of all violent crime; and (3) at a national level, no other crime is measured as accurately, precisely, and comprehensively.

CRIM.6540 Elite Deviance and White Collar Crime (Formerly 44.523) - Credits: 3

This course introduces the concept of white collar crime as an area of scientific inquiry and theory formation. It critically examines the latest scholarship on the subject by looking at white collar crime from a multiplicity of perspectives and reference points, ranging from a focus on the offense, offender, legal structure, organizational structure, individual and organizational behavior, to victimization and guardianship, with special attention on the interaction between these components. The course also pays special attention to definitional issues, typologies of white collar crime, and assesses the nature, extent and consequences of white collar crime nationally and internationally. To enhance the understanding of white collar crime in today's IT development and society, the course will pay a special attention to roles of information and technology and E-commerce within white collar crime. Finally, the course examines current criminal justice system efforts at controlling white collar crime.

CRIM.6550 Substance Abuse and Crime (Formerly 44.563/CRIM 655) - Credits: 3

This course examines the dynamics of substance abuse, the interrelationship between substance abuse and crime, and the use of both criminal and civil law to deal with the problems posed by substance abuse.

CRIM.6580 Issues in Computer Crime and Cyber Security (Formerly 44.642/CRIM 658) - Credits: 3

This course will examine the history and evolving nature of the relationship between technology, crime, and security, with a particular focus on legitimate and illegitimate Internet commerce, and cyber criminal methodologies and techniques. We will study major issues in cyber security including criminal and state-sponsored hacking; data, intellectual property, and identity theft; financial and personal data security; cyber-terrorism; tools and methods used to exploit computer networks, and strategies to protect against them; and new and emerging technologies. This course will be taught specifically for non-computer science majors, although students with computer science backgrounds are welcome for the experiences that they can bring to the class discussions.

CRIM.6640 Weapons of Mass Destruction (Formerly 44.643/CRIM 664) - Credits: 3

This course explores the threats that weapons of mass destruction (WMD) pose to the U.S. and its interests along with the strategies to meet those threats. The course will examine the technical aspects, history, and contemporary threat of each category of weapon Chemical, biological, radiological, and nuclear followed by a critical analysis of U.S. and global efforts to limit access to these weapons and prohibit their production, proliferation and use. The course will also review some aspects of WMD attack response, recovery, and mitigation.

CRIM.6650 Global Trafficking and Criminal Networks (Formerly 44.644/CRIM 665) - Credits: 3

Illicit economic activities are a global phenomenon with local impact. This course will examine the threat that global trafficking poses to a nation's security, political stability, economic development, and social fabric. The lessons in this advanced graduate-level seminar are organized around the trafficking activities of greatest concern to the United Nations, Interpol, IAEA and other international agencies' as well as to the U.S. Departments of State, Defense, Justice, and Homeland Security.

CRIM.6660 Terrorism Networks (Formerly 44.577/CRIM 666) - Credits: 3

This course will explore the dynamics of terrorist networks and will equip students with an understanding of the drivers of
terrorist network formation, development and disintegration. The course will also provide students with knowledge and understanding of how, why and when networks expand, affiliate, and occasionally splinter. And finally, students will be guided through the applicability of network theory and analysis to the design of hypothetical operational responses and contingency planning surrounding the disruption or containment of terrorist networks.

CRIM.6670 Advanced Security Studies (Formerly CRIM 667) - Credits: 3

This course examines the complex nature of key domestic and international security threats and how nations respond to them. While the traditional focus of security studies has been the phenomenon of war, the past two decades have seen tremendous growth and expansion of the field. Some scholars have studied the threat, use and control of military force, while others have studied various forms of political violence such as terrorism, organized crime, and insurgency or armed rebellion. Research in this field also incorporates scholarship on the politics of defense and foreign policymaking, traditional theories of international relations, comparative analysis of national and regional case studies, ethics and morality of security policies, and transnational issues like arms trafficking, piracy, and the proliferation of materials and technology for weapons of mass destruction. Overall, the study of national and international security has evolved into a complex, interdisciplinary field, as demonstrated on the list of journals and websites provided on the last page of this syllabus. Each lesson in this course draws on a large and diverse body of readings, including academic journal articles, government reports, and original source materials.

CRIM.6680 Scientific & Technological Dimensions of National Security (Formerly 44.569/CRIM 668) - Credits: 3

In this required course for the MS in Security Studies program, students will take this course to learn all about the efforts in the public and private sector to design new sensors, scanner, and the general role of science and technology in homeland and national security.

CRIM.6690 Counterterrorism Policies and Strategies (Formerly 44.576/CRIM 669) - Credits: 3

This course examines the formulation and implementation of U.S. national strategies for combating terrorism, protecting critical infrastructure, and preventing the proliferation of chemical, biological, radiological and nuclear weapons or materials that could be used by terrorists. Students will develop an understanding of the structure and operations of key federal agencies, state and local fusion centers, and examine the political, legal, moral and ethical issues of countering modern terrorism threats.

CRIM.6700 Seminar in Terrorism Studies (Formerly CRIM 670) - Credits: 3

This course will offer an in-depth examination of one more special topics within the field of terrorism. Examples include terrorist psychology, the use of women and children by terrorist groups, models of successful hostage negotiation or the use of social network analysis to understand the evolving nature of a terrorist threat. Students should consult with their advisor and the program director before registering for this course.

CRIM.6800 Selected Topics (Formerly 44.680) - Credits: 3

A comprehensive examination of a current issue in criminal justice.

CRIM.6830 Directed Study (Formerly CRIM 683) - Credits: 3

This course is designed as an independent study of a subject not offered in the standard curriculum.

CRIM.6860 Directed Study (Formerly 44.696/CRIM.686) - Credits: 6

This course is designed as an independent study of a subject not offered in the standard curriculum.

CRIM.6890 Special topics in Criminal Justice and Criminology (Formerly CRIM.689) - Credits: 3

Special topics classes are used to address timely issues that do not fit into the regular course offerings.

CRIM.6900 Advanced Regression Analysis (Formerly CRIM 690) - Credits: 3

This course focuses on statistical methods that are useful in the investigation of hypotheses in the social sciences and the analysis of public policies and programs. The bulk of the course is a detailed examination of the bivariate and multiple regression models estimated using Ordinary Least Squares (OLS), with an emphasis on constructing regression models to test social and economic hypotheses. Several special topics in regression analysis are addressed as well, including violations of OLS assumptions and the use of dummy variables, and interaction effects. Throughout, examples are drawn from the literature so students can see the models and methods in action.
CRIM.6910 Advanced Research Design (Formerly 44.691) - Credits: 3
This course focuses on measurement and data development strategies and techniques to facilitate effective statistical analysis. Topics include the logic of causal inquiry and inference, the elaboration paradigm and model specification, handling threats to internal validity, hierarchies of design structure (experimental, quasi-experimental and non-experimental), linking design structure to affect estimation strategies, and analyzing design elements in published literature. Students will select a research topic in consultation with the instructor and prepare a written comparative design analysis.

CRIM.6919 Directed Study in Criminal Justice (Formerly CRIM.691) - Credits: 3
This course is designed as an independent study of a subject not offered in the standard curriculum.

CRIM.6920 Qualitative Research Methods (Formerly CRIM 692) - Credits: 3
This course is designed to increase students' knowledge and understanding of the design and process of qualitative research in criminology. The material covered in this course includes the nature and uses of qualitative research; the design of qualitative research; grounded theory and the use of qualitative research to advance new theories and critically evaluate tenants or assumptions of widely held explanations of criminal behavior and justice system functioning; and the ethics of qualitative research. Qualitative research methodologies including ethnography, case studies, participant observation, interviewing, content analysis, and life history narrative / life course analysis will be studied. Students will develop and initiate their own qualitative research and learn first-hand about the conduct of such research, the sequencing of data collection, data analysis, and more data collection. Students will learn the uses of computer assisted software programs designed to assist qualitative data analysis.

CRIM.6930 Survey Methods (Formerly CRIM 693) - Credits: 3
This course exposes students to the use of survey methods in social science research. Emphasis is placed on interview and questionnaire techniques and the construction and sequencing of survey questions as well as the use of Likert and Thurstone sales. Attention is also devoted to sampling theory, sampling designs, and sampling and non-sampling errors.

CRIM.6940 Crime Analysis and Mapping (Formerly 44.594/CRIM 694) - Credits: 3
This course examines the use of new technologies to analyze crime patterns and develop crime prevention strategies. Students study theories that explain the geographic distribution of crime and learn how to use Geographic Information Systems to study crime in ways that draw upon theory as well as how to apply GIS techniques in the law enforcement and corrections fields.

CRIM.6990 Security Studies Capstone Research Paper (Formerly 44.699/ CRIM.699) - Credits: 3
This course represents the culminating capstone experience for students in the MA in Security Studies program at UMass Lowell. Incorporating the tools learned in CRIM.5900, Research Design and Methods, students are required to design a research question, gather and analyze information, and write a Masters level research paper of at least 50 pages on a topic of their choosing related to security studies. Students will provide drafts of their paper to their faculty supervisor periodically during the semester, and the final version will be submitted for grading on the basis of quality research and writing.

CRIM.6993 Capstone Research Paper in Criminal Justice - Credits: 3
This course is the culminating, final core requirement for the Masters in Criminal Justice. In this course, students will write an integrative research paper (generally 50-60 pages in length, double-spaced) on a topic of their choosing related to the realm of criminal justice. By integrative, we mean you are expected to draw upon material you have covered in several of the courses in this program, including (but not limited to) Administration of Criminal Justice, Criminological Theory: Foundations, Descriptive and Inferential Statistics, Research Design, Managing Criminal Justice Organizations, or Law & Public Policy. You may enroll in this course at the same time as one of your elective courses, but it is assumed that you have already completed all requirements for the Masters in Criminal.

CRIM.7000 Dissertation Seminar I (Formerly CRIM.701) - Credits: 3
This is the first part of a two-semester sequence in which students develop a plan and a template for the conduct of the various stages of the doctoral dissertation. Topics include: theoretical foundations, hypothesis development, sampling design, construct measurement, data collection, and analysis of quantitative or qualitative data.

CRIM.7010 Dissertation Seminar II (Formerly CRIM.702) - Credits: 3
This is the second part of a two-semester sequence in which students develop a plan and a template for the conduct of the various stages of the doctoral dissertation. Topics include: theoretical foundations, hypothesis development, sampling design, construct measurement, data collection, and analysis of quantitative or qualitative data.

CRIM.7030 Dissertation Supervision (Formerly CRIM 703) - Credits: 3
Direct supervision with a dissertation advisor (3 credits).

CRIM.7060 Dissertation Supervision (Formerly CRIM 706) - Credits: 6
Direct supervision with a dissertation advisor (6 credits).

CRIM.7090 Dissertation Supervision (Formerly CRIM 709) - Credits: 9
Direct supervision with a dissertation advisor (9 credits).

CRIM.7100 Advanced Research in Terrorism (CRIM 710) - Credits: 3
This course focuses on describing and understanding how research and evidence-based analysis helps us to understand, explain and predict changes in terrorist behavior. The course makes use of case studies to illustrate quantitative and qualitative research methods, and to approach research questions on terrorism from multiple levels of analysis. The course will also examine successful examples of interdisciplinary research and will help students navigate the pathway from theoretically informed research on terrorism to policy and practitioner-relevant counter-terrorism.

CRIM.7110 Continued Dissertation Review (Formerly CRIM 711) - Credits: 1
Direct supervision with a dissertation advisor (1 credit).

CRIM.7160 Dissertation Seminar Accelerated (Formerly CRIM.716) - Credits: 6
This course is an accelerated version of the CRIM 701/702 sequence. It is suitable for students who have already acquired the data for their doctoral thesis research and thus can accomplish the plan and template for the conduct of the various stages of the doctoral dissertation in one semester. Topics include: theoretical foundations, hypothesis development, sampling design, construct measurement, data collection, and analysis of quantitative or qualitative data. Prerequisite: Doctoral Candidacy in Criminology.

CRIM.7900 Categorical and Limited Dependent Variables (Formerly CRIM 790) - Credits: 3
The estimation of empirical models is essential to public policy analysis and social science research. Ordinary Least Squares (OLS) regression analysis is the most frequently used empirical model, and is appropriate for analyzing continuous dependent variables that meet certain distributional assumptions. This course examines several types of advanced regression models for dependent variables that violate one or more of the assumptions of the OLS regression model. For example, some dependent variables may be categorical, such as pregnant or not, employed or not, etc. Other dependent variables may be truncated or censored, such as contributions to an individual retirement account that are limited by law to certain dollar amounts. Still others may be counts of things, like the number of children born to a given woman or the number of traffic accidents on a given day. The principal models examined in the course are binary logit and probit, multinomial logit, ordinal logit and probit, tobit, and the family of Poisson regression models. The Heckman correction for selection and Event History Analysis are also addressed. All these models are estimated using maximum likelihood estimation (MLE). The course focuses on the application and interpretation of the models, rather than statistical theory.

CRIM.7910 Structural Equation Modeling (Formerly CRIM 791) - Credits: 3
This course is an introduction to structural equation modeling (SEM). SEM represents a general approach to the statistical examination of the fit of a theoretical model to empirical data. Topics include observed variable (path) analysis, latent variable models (e.g., confirmatory factor analysis), and latent variable SEM analyses.

CRIM.7920 Survival Analysis and Longitudinal Data (Formerly CRIM 792) - Credits: 3
Criminological research often involves the study of change over time in both individuals and groups. Analyzing such over time poses a number of methodological and statistical challenges, however, and these must be addressed to derive valid inferences from data analysis. This course will examine several techniques that are appropriate for such analyses. These include the family of univariate, bivariate and multivariate techniques collectively known as "survival" or "event history analysis" that are appropriate for studying processes such as recidivism and length of time individuals spend in various programs. The course will also describe zero-inflated Poisson trajectory and latent growth curve models, as well as multilevel models for change. Emphasis will be on application as opposed to theory.

CRIM.7940 Multi-Level Modeling - Credits: 3
This course covers multilevel statistical models, which are increasingly being used in the social sciences to analyze clustered data. The course will introduce students to the theory and concepts of multilevel model and will address both the statistical and theoretical advantages to using multilevel models to analyze clustered data. The course will largely take an applied approach, meaning that it is designed to prepare students for putting the techniques covered in the course to use in a "real world" context. As such, course lectures and assignments will cover a range of relevant issues, including data acquisition, data exploration, estimation of multilevel models with statistical software, and reporting of results from multilevel analyses.

CRIM.7950 Advanced Qualitative Methods - Credits: 3

This course is designed to train graduate students in qualitative research methods in criminology and criminal justice, using an applied and collaborative approach. Students in the course will actively engage in designing and collecting data for a primary research project. The collaborative project will best fit, to the extent possible each student's research interests. Data collection will be a joint effort, with each student in the course responsible for collecting data and conducting analysis, the merged dataset will be utilized by each student to develop an independent research paper on a specific topic pertinent to the project's larger research goals.
SOCI.5020 Managing Human Service Organizations -
Credits: 3

The purpose of this course is to introduce students to the specific context of managing a human service organization in a nonprofit or public environment. Topics covered may include strategic planning in a mission-driven organization, budgets in a nonprofit context, human resources management, human services leadership, the role of fundraising and development, public sector advocacy, and working a Board of Directors. This course is required for MPA students in Human Service Management (HSM) Option.

SOCI.5100 Asylum and Refugee Policy - Credits: 3

This course provides an introduction to asylum and refugee policy, including its historical development, current implementation, and interdisciplinary considerations. After understanding the legal underpinnings of current policy, students will examine the journey of a refugee or asylum applicant, beginning with push/pull migration factors and moving to experiences in the receiving context. Students will leave the course with practical knowledge for working with asylum and refugee populations.

SOCI.5150 Social Policy and Inequalities - Credits: 3

Social Policy and Inequalities is a semester-long course that analyzes the social policies in the United States and Massachusetts that address persistent and structural inequalities in education, health and healthcare access, immigration, workforce, and human services. We will pay particular attention to social policies that contribute to or seek to alleviate inequalities based on race, gender, income and wealth, sexuality and disabilities. The course will identify key features of policy development, implementation and evaluation and interrogate the underlying patterns of inequalities at each stage. The course will analyze case studies of policies such as those related to poverty and income inequality; affirmative action; education; workforce development and employment.
MUSR.5200 Recording Analysis (Formerly 78.520) - Credits: 3
Recognition of the unique dimensions of audio recordings, and evaluation of how they can be crafted to support musical expression. Aural analysis of audio device performance, integrity of audio quality, recording environments, and sound source characteristics. Understanding of the mix as musical interpretation and performance.

MUSR.5210 Sound Synthesis 2 (Formerly 78.421/521) - Credits: 3
Advanced sound synthesis techniques are studied and supplemented with sound synthesis studio laboratory work. The course will cover MIDI implementation in analog and digital sound synthesis, the historic origins of computer music and electro-acoustic music, live electronic music performance, audio equipment and applications of MIDI-based and functional devices and processors, advanced music production and sound synthesis via MIDI. Permission of Coordinator and Chair.

MUSR.5310 Special Topics in Sound Recording Technology - Credits: 1-6
Contemporary topics in sound recording technology and related disciplines. Course content is chosen by instructor to meet needs and interest of students.

MUSR.5450 Advanced Mix Techniques (Formerly 78.545) - Credits: 3
This course develops deep technical mastery and advanced aesthetic achievement in the multitrack mixdown phase of sound recording. Key families of effects are covered form first principles and technical basics to advanced applications. Processes are integrated into contemporary production strategies for music, film, game, broadcast, and live mixing.

MUSR.5500 Advanced Video Production (Formerly 78.550) - Credits: 3
Extends basic music production skills into the professional sphere. Hands on experience is emphasized. Students are involved with exercises that teach approaches to dramatic lighting, audio-recording skills for challenging environments, specialized camera techniques used in Hollywood productions, and refined editing techniques. After completing several short video presentations, students will produce a multi-tracked production that demonstrates their competency in video and audio recording, sound effects, narration, and refined editing techniques. Prerequisite: 78.350

MUSR.5900 Advanced Acoustics for Audio (Formerly 78.590) - Credits: 3
This course includes measuring, predicting and modifying the acoustic behavior of rooms, instruments, and speaker enclosures, culminating in original student designs. An in-depth study of sound perception will also be included along with the latest research in live sound reinforcement and related technologies. Students must complete an original research project by the end of the term.

MUSR.5950 Graduate Directed Study in SRT (Formerly 78.595) - Credits: 3
MUSR.6300 Technologies of Audio (Formerly 78.630) - Credits: 3
In-depth study of historical, current, and cutting edge technologies of audio devices, systems, and software; includes performance specifications, design and operational parameters, and interface considerations at all systems levels.

MUSR.6400 Production Practicum (Formerly 78.640) - Credits: 3
Experimental and current recording production techniques, and historically significant approaches to recording. Performance of advanced production work including acoustic and electronic sound sources, automated mixdown, stereo and surround mixing, synchronization and MIDI, audio for visuals, multimedia. Studio production work led by lecture/demonstration classes and individual student research.

MUSR.6500 Research in Sound Recording Technology (Formerly 78.650) - Credits: 3
An introduction to the knowledge and skills common to research in all areas of music: finding resources, reading and interpreting research, and understanding and applying the principles of objective investigation. The research paradigms of technology and engineering, the humanities, the natural sciences, and the social and behavioral sciences are explored and contrasted. This course consists of a sequence of lectures on the fundamental topics, followed by a series of modules or case studies in specific research areas pertaining to SRT. Each class meeting involves a project or lab for which the student must write a report or research document.

MUSR.6600 Seminar in Audio (Formerly 78.660) - Credits: 3
Current topics are explored in a seminar setting requiring student participation and research. Topics selected for in-depth examination might include advanced SRT-related research.
methods and materials; advanced facility and systems design; experimental technologies and media; experimental production practices or artistic projects; evaluations of recordings; audio industry trends; facility and career management. Prerequisite: 78.630.

MUSR.6950 Directed Study and Research in SRT. (Formerly 78.695) - Credits: 3
An in-depth independent study with a member of the Sound Recording Technology faculty. The topic and scope of the study must be approved by the faculty member and the Coordinator of SRT.

MUSR.7400 Masters Recording Project (Formerly 78.740) - Credits: 6
Planning and execution of a substantial recording project under the supervision of an SRT faculty member.

MUSR.7410 Masters Recording Project A (Formerly 78.741) - Credits: 3
Planning and execution of a substantial recording project under the supervision of an SRT faculty member. First part of two-course sequence. 78.742 - Masters Recording Project B must subsequently be taken to satisfy masters degree capstone requirement.

MUSR.7420 Masters Recording Project B (Formerly 78.742) - Credits: 3
Planning and execution of a substantial recording project under the supervision of an SRT faculty member. Second part of two-course sequence to satisfy masters degree capstone requirement.

MUSR.7430 SRT Masters Thesis (Formerly 78.743) - Credits: 6
The thesis is a scholarly investigation in SRT or an audio-related field resulting in a comprehensive written document. The student must complete acceptable research and defend it before a thesis committee. The choice of a thesis topic and a thesis advisor, the formation of a thesis committee, and the procedures for the preparation of the thesis and its defense are described in detail in the Master's Degree Requirements section of the University of Massachusetts Lowell Graduate Catalog. The specific procedures required by the Department of Music are published by the Department and are available in the main office. Second part of two course sequence to satisfy masters degree capstone requirement.

MUSR.7440 SRT Masters Thesis A (Formerly 78.744) - Credits: 3

MUSR.7450 Continued Graduate Research SRT (Formerly 78.745) - Credits: 1-3
Thesis/Project Continued Research

MUSR.7460 SRT Masters Thesis B (Formerly 78.746) - Credits: 3
The thesis is a scholarly investigation in SRT or an audio-related field resulting in a comprehensive written document. The student must complete research and defend it before a thesis committee. The choice of a thesis topic and a thesis advisor, the formation of a thesis committee, and the procedures for the preparation of the thesis and its defense are described in detail in the Master's Degree Requirements section of the University of Massachusetts Lowell Graduate Catalog. The specific procedures required by the Department of Music are published by the Department and are available in the main office. Second part of two course sequence to satisfy masters degree capstone requirement.
Graduate Certificates in Biomedical & Nutritional Sciences

The UMass Lowell Department of Biomedical and Nutritional Sciences offers the following graduate certificate programs:

- Clinical Pathology
- Pharmaceutical Sciences

**CLINICAL PATHOLOGY**

To apply, visit [graduate admissions](https://www.uml.edu/Grad/Graduate-Applicants/default.aspx).

**Contact:** Suzanne Moore, D.V.M (mailto:suzanne_moore@uml.edu), 978-934-6264

Clinical Pathology combines the theoretical and technical knowledge of human anatomy and physiology, clinical chemistry, genetics, immunology, microbiology, hematology, histocompatibility, cellular pathology and other fields as they pertain to the diagnosis, monitoring and prevention of disease.

The Certificate in Clinical Pathology requires 12 credits. There is one required course and 3 electives, to be selected from the approved list. Courses available fully online are noted below with an asterisk (*)

**Prerequisites:**

- Baccalaureate degree from an accredited institution with a minimum GPA of 3.00
- Completion of undergraduate coursework in junior-level biochemistry receiving a grade of C or better.

**Required Courses:**

- HSCI.5500 (https://www.uml.edu/catalog/courses/HSCI/5500) Clinical Pathophysiology *(Fall, Spring & Summer)*
- MLSC.5600 (https://www.uml.edu/catalog/courses/MLSC/5600) Molecular Pathology

**Electives:**

Students may select 3 courses from this list. Only one of the courses may be from the Department of Public Health (PUBH). Other electives may be substituted with prior approval from the Graduate Coordinator.

- MLSC.5120 (https://www.uml.edu/catalog/courses/MLSC/5120) Medical Bacteriology
- MLSC.5310 (https://www.uml.edu/catalog/courses/MLSC/5310) Clinical Immunohematology
- MLSC.5500 (https://www.uml.edu/catalog/courses/MLSC/5500) Foundations in Biomedical Research *
- MLSC.5750 (https://www.uml.edu/catalog/courses/MLSC/5750) Emerging Topics in Clinical Chemistry
- MLSC.6000 (https://www.uml.edu/catalog/courses/MLSC/6000) Biomarker Discovery & Application with Lab
- MLSC.6100 (https://www.uml.edu/catalog/courses/MLSC/6100) Clinical Toxicology
- MLSC.6130 (https://www.uml.edu/catalog/courses/MLSC/6130) Infectious Disease *
- MLSC.6150 (https://www.uml.edu/catalog/courses/MLSC/6150) Medical Mycology and Parasitology
- NUTR.5720 (https://www.uml.edu/catalog/courses/NUTR/5720) Nutrigenetics
- PUBH.5140 (https://www.uml.edu/catalog/courses/PUBH/5140) Healthcare Management *
- PUBH.6070 (https://www.uml.edu/catalog/courses/PUBH/6070) Healthcare Information Systems *
- PUBH.6350 (https://www.uml.edu/catalog/courses/PUBH/6350)
Healthcare Project Management*

- **PHRM.6100**
  (https://www.uml.edu/catalog/courses/PHRM/6100)
  Principles of Pharm Science or **PHRM.6501**
  (https://www.uml.edu/catalog/courses/PHRM/6501)
  Drug Discovery

- **PHRM.6600**
  (https://www.uml.edu/catalog/courses/PHRM/6600)
  Pharmacokinetics & Drug Metabolism

- **PHRM.6410**
  (https://www.uml.edu/catalog/courses/PHRM/6410)
  Drug Delivery
MLSC.5120 Medical Bacteriology I (Formerly 36.311/512) - Credits: 3
A study of the cultural, biochemical, genetic, serological and pathogenic characteristics of disease producing microorganisms. Emphasis will be placed on the pathophysiology of the infectious diseases and their relationship to isolation and identification of the pathogenic microorganisms.

MLSC.5310 Clinical Immunohematology (Formerly 36.531) - Credits: 3
Lecture and case study discussions look at the major red cell antigen/antibody systems that are of importance in understanding transfusion therapies, compatibility testing, and pathological diseases. Emphasis is on differentiation and clinical significance of each system. Donor selection regulations, component preparation, and hemotherapy will also be discussed. Students will be required to do a presentation, poster, and paper on an advanced topic in Clinical Immunohematology.

MLSC.5410 Introduction to Public Health and the Public Health Laboratory (Formerly 36.541) - Credits: 3
This course is designed to provide an overview of public health and the public health laboratory covering topics such as the legal basis and history of public health, public health structure, communications and interactions, and epidemiology. Emphasis will be placed on the role of the public health laboratory and its core functions, its role in policy development, infectious disease, environmental issues, emergency preparedness, newborn screening, global issues, and public health research. Public health laboratory methodology, regulation and improvement, and quality assurance will also be examined.

MLSC.5500 Foundations of Biomedical Research - Credits: 3
This course prepares graduate students in the MS in Clinical Laboratory Science for biomedical research. Students will learn clinical and basic research design and experimental aspects through applying critical thinking skills and engaging in outcome evaluation of research studies and quantitative data analysis and interpretation. Students will develop an understanding of the key differences between clinical, translational and basic research and their implications and relation to diagnostic, treatment and health management. The course will introduce students to literature review, identifying basic and key gaps and formulating key questions for scientific experimental pursuit. The course also reviews basic statistics research methods, including statistical significance.

MLSC.5510 Advanced Pathophysiology (Formerly 36.551) - Credits: 3
Disease processes as appropriate and inappropriate as variants of normal physiological functions. A detailed examination of certain important and illustrative diseases rather than a survey of diseases in general.

MLSC.5530 Emerging Topics in Clinical Chemistry (Formerly 36.553) - Credits: 3
This course is designed to give an in-depth understanding in clinical chemistry. Topics include: analytical techniques and the selection of methodologies. The course allows for a detailed examination and discussion of selected articles from the Journal of Clinical Chemistry.

MLSC.5600 Molecular Pathology (Formerly 36.560) - Credits: 3
This graduate course is designed to study the molecular aspects of disease. Applications and techniques utilized in the field of molecular pathology are emphasized. This course is intended to provide students with information required to understand the increasing role of molecular pathology in the daily practice and management of chronic disease in medicine. Major emphasis on strength and limitations of clinical diagnostics technologies and their utilization in these applications are presented. This course will also provide a review of current molecular pathology literature and principles as they relate to specific organ systems.

MLSC.5750 Emerging Topics in Clinical Chemistry - Credits: 3
This course will provide an advanced perspective on the discipline of clinical chemistry. In depth discussions of new discoveries in clinical chemistry biomarkers, new understanding of disease pathogenesis as they pertain to clinical chemistry will be pursued in this course. System and disease-based approaches to clinical chemistry analytical methods will be used to discuss emerging challenges and opportunities in the field, including analytical challenges. Emphasis will also be placed on theoretical concepts of clinical chemistry instrumentation, including components and design of modern instrumentation and analytical methodologies. The course will also discuss the role of the clinical chemist in ensuring that testing performed in clinical trials meets the highest standards and provides meaningful data.

MLSC.5750 Topics in Clinical Laboratory Science I (Formerly 36.575) - Credits: 3
This course provides students with the knowledge that is
fundamentally necessary to understand the routine operations of the clinical diagnostic laboratory. The course will familiarize students with the diagnostic application of the most current testing methodologies and also provide a forum to discuss and critically review primary literature pertinent to current clinical laboratory issues.

MLSC.6000 Biomarker Discovery & Applications - Credits: 3

This course will cover the burgeoning field of biomarkers research, with a special focus on biomedical and clinical applications. The course is organized in three main sections: (I) Biomarker discovery and validation, including types of biomarkers and platforms for discovery (proteomics, metabolomics, multiplex technologies); (II) biomarker applications in clinical and health research; and (III) new frontiers in biomarkers research. Examples of biomarker applications will include organ systems, disciplines (clinical lab sciences and clinical trials, environmental health, toxic tort and forensic litigation), and regulatory perspectives.

MLSC.6001 Biomarkers Discovery and Application Lab - Credits: 1

This course provides hands-on laboratory experience that will illustrate and enhance critical concepts related to biomarker discovery and validation. Techniques will include LC-ESI-MS/MS and multiplexing technologies for biomarker analysis in human biological samples, including urine, and blood.

MLSC.6100 Clinical Toxicology - Credits: 3

Clinical toxicology traditionally studied the toxic effects of therapeutic agents - substances intended to treat or ameliorate disease. Modern clinical toxicology has a broader scope: to examine complex toxicological events that result from the interaction of toxins with normal physiology, including therapeutics, drugs, natural poisons and inadvertent chemical exposures, as well as the clinical management of toxicity. The course places special emphasis on the temporality of events, from the developments of signs, to symptoms, to pathology. Analytical tools, such as mass spectrometry, needed to measure toxins and their metabolic byproducts in biological fluids of living organisms are discussed.

MLSC.6101 Clinical Toxicology Lab - Credits: 1

This course provides hands-on laboratory experience that will illustrate and enhance critical concepts related to clinical toxicology. Techniques will include immunoassay, advanced spectroscopy techniques and emerging technologies for toxicology analysis in human biological samples, including urine, and blood.

MLSC.6130 Infectious Disease (Formerly 36.613) - Credits: 3

This course is designed for graduate students in the health sciences focusing on the pathophysiology of infectious disease. Major infectious organisms will be discussed as biological models and presented in the way they affect major systems of the body. Emphasis will be placed on journal readings describing significant episodes of emerging infections and current technology in diagnosis and treatment of infectious diseases.

MLSC.6150 Medical Mycology and Parasitology (Formerly 36.615) - Credits: 3

This course is designed to instruct students in diagnostic medical mycology and parasitology. Diseases, specimen collection and handling, laboratory identification and treatment of medically significant fungi and parasites will be studied. Discussion of AIDS related infections and prophylactic treatment will be evaluated. Life cycles of parasites, prevention and environmental protection plans will be analyzed.

MLSC.6400 Quality Assurance, Control and Improvement in the Clinical and Public Health Lab (Formerly 36.640) - Credits: 3

This course is designed to provide an overview of total quality management issues in the Clinical and Public Health laboratory. Topics presented will include CLIA and quality control in the laboratory, clinical and public health laboratory QC calculations, charts and graphs, regulations involving new control lots, out-of-control QC situations, method comparison, instrument validation, and quality assurance. Emphasis will be placed on meeting all federal regulations including the FDA, state regulations, as well as meeting professional agency regulations such as JCAHO, CAP, and APHL.

MLSC.7330 Graduate Project - Clinical Laboratory Sciences (Formerly 36.733) - Credits: 3

An independent study or laboratory project which has been approved and is under the direction of the project advisor. Projects are approved by the graduate coordinator in conjunction with the project advisor.

MLSC.7340 Graduate Project - Clinical Laboratory Sciences (Formerly 36.734) - Credits: 1-4

An independent study or laboratory project which has been approved and is under the direction of the project advisor. Projects are approved by the graduate coordinator in conjunction with the project advisor.
MLSC.7430 Master’s Thesis - Clinical Lab Sciences  
(Formerly 36.743) - Credits: 3

Analytical and/or experimental work conducted under the direction of a thesis advisor and in accordance to the Graduate School Guidelines. Students are required to submit a written proposal for approval by a thesis committee and to present an oral defense at a college seminar.

MLSC.7440 Master’s Thesis - Clinical Laboratory Science  
(Formerly 36.744) - Credits: 4

Research Design and Methodology. Analytical and/or experimental work conducted under the direction of a thesis advisor and in accordance to the Graduate School Guidelines. Students are required to submit a written proposal for approval by a thesis committee and to present an oral defense at a college seminar.

MLSC.7530 Doctoral Research  
(Formerly 36.753) - Credits: 3

MLSC.7560 Doctoral Research  
(Formerly 36.756) - Credits: 6

MLSC.7590 Doctoral Research  
(Formerly 36.759) - Credits: 9

NUTR.5060 Biochemistry of Lipids  
(Formerly 36.506) - Credits: 3

This advanced course in the nutritional biochemistry and physiology of lipids will detail the role of lipids in the normal and pathological processes at both the cellular and whole organism level. Topics will range from general discussions of the digestion, absorption and transport of lipids to the role of eicosanoids and lipid soluble anti-oxidants during normal and diseased states, such as atherosclerosis, diabetes and hypertension. Subject matter will also include a discussion of the various interventions for the prevention and treatment of certain of these disease states. There will also be discussion of the current issues in lipid nutrition.

NUTR.5630 Vitamins and Minerals  
(Formerly 36.563) - Credits: 3

Provides a foundation for understanding the role of vitamins and minerals in human nutrition. Emphasis is placed on their roles in human biochemistry and physiology. The mechanism of action for each nutrient is examined. The course will explore the effects of nutrient deficiency, and identify the best dietary sources for each vitamin and mineral.

NUTR.5720 Nutrigenetics  
(Formerly 36.572) - Credits: 3

Regulation of eukaryotic gene expression by specific nutrients, hormones, and metabolites will be discussed including transcriptional, post-transcriptional, and translational mechanisms with emphasis on disease development or prevention. Application of material will include determining how human dietary requirements are affected by gene variants and inherited biochemical characteristics. This course will enable students to link their knowledge of nutrition with the growing discipline of the effects of diet on the human genome and specific hereditary diseases.

NUTR.5820 Seminar in Advanced Nutrition  
(Formerly 36.582) - Credits: 3

Review and analysis of contemporary research publications in human nutrition. Recently discovered nutrients that may be essential to human health will be evaluated. We will critically examine the benefits of dietary modification in controlled investigations. Course will focus on published studies of the relation of dietary practices to health and disease. We will examine nutrition policy, and the way scientific findings in nutrition translate into public health practice. This course will be of value to students who wish to critically examine literature in human nutrition, and who seek to develop new directions for nutrition research.

NUTR.6000 Public Health Nutrition Practice  
(Formerly 36.600) - Credits: 3

This course provides advanced study in public health and community nutrition. Concepts related to cultural competency, public health and nutrition policy, health promotion, and the nutrition care process will be learned through lectures, quest lectures, in-class activities, case studies, and peer-led discussions. Students will have the opportunity to practice skills in community and public health nutrition settings such as food pantries and senior nutrition centers.

NUTR.6010 Nutrition Assessment  
(Formerly 36.601) - Credits: 3

This course provides an overview of tools used to assess nutritional health, dietary adequacy, dietary variety, and food security. Lectures and lab will be integrated together to demonstrate and provide experience in methods needed to assess, screen, and monitor physiological and dietary indicators of nutritional health. There will be an emphasis on methods and tools for assessing body composition, biochemical indicators, dietary intake, energy expenditure, and physical activity. Students will learn how to select and apply these methods in community, clinical and research settings and determine the strengths and limitations of each assessment tool.
NUTR.6020 Community Based Interventions
(Formerly 36.602) - Credits: 3

This course will examine a broad range of community-based research and programs within the United States. Strategies for effective community-engagement and programming planning, implementation and evaluation will be discussed. Specific attention will be given to cultural tailoring of interventions. Students will engage in experiential learning and will work in teams to write a community funding proposal. Students will be required to present their funding proposal to a community panel. Field visits will allow students to interact with and learn from public health experts.

NUTR.6030 Global Nutrition(Formerly 36.603) - Credits: 3

This course is an examination of the food and nutrition issues around the world. The impact of food production and food intake on the environment and global nature of our food systems will be reviewed. The course will also include consideration of specific nutrient deficiencies, as well as nutrition-related aspects of infectious and chronic disease along with the programs and resources available to combat malnutrition for children and adults worldwide.

NUTR.6040 Nutrition Epidemiology (Formerly 36.604) - Credits: 3

This course is designed for graduate students who are interested in conducting or better interpreting epidemiologic studies relating diet and nutrition status to disease and health. There is an increasing awareness that various aspects of diet and nutrition may be important contributing factors in chronic disease. There are many important problems, however, in the implementation and interpretation of these studies. The purpose of this course is to examine methodologies used in nutritional epidemiologic studies in lecture and lab settings, and to review the current state of knowledge regarding diet and other nutritional indicators as an etiologic factor in disease.

NUTR.6050 Food and Nutrition Management - Credits: 3

This course provides advanced study in food and nutrition management principles. Topics include management theory, personnel selection, training, evaluation, organizational behavior, communication, governmental influences, labor management relations, marketing, and budgeting. This course requires group work, development of a business plan, and completion of management related case studies.

NUTR.6060 Advanced Clinical Nutrition - Credits: 3

This course provides advanced study in clinical nutrition. Topics include the nutrition care process, standardized language and documentation, evidence-based practice, confidentiality of medical records, JCAHO regulations, and coding and billing. Case studies will be completed to review and advanced learning about medical nutrition therapy for acute and chronic nutrition-related diseases. As part of this course, students will practice providing nutrition assessment, counseling, education, professional documentation, and evaluation in clinical nutrition settings.

NUTR.6660 Community Nutrition Supervised Practice - Credits: 1

This supervised practice experience is the application of knowledge and skills in community and public health nutrition. Students will practice nutrition assessment, nutrition counseling, and nutrition education for a wide range of populations at high nutritional risk. Students will develop cultural awareness and skills in cultural competency.

NUTR.6670 Food and Nutrition Management Supervised Practice - Credits: 1

This supervised practice experience is the application of knowledge and skills in food and nutrition management. There will be hands-on experience in human resource and financial management. Management skills specific to the food service industry, including management functions related to safety, security and sanitation, will also be incorporated. Students will also be able to apply knowledge in food production, distribution, and food service systems along with skills in menu planning. There will be an emphasis on using strategies to reduce waste and protect the environment.

NUTR.6680 Clinical Nutrition Supervised Practice - Credits: 1

This supervised practice experience is the application of knowledge and skills in clinical nutrition. Students will receive hands-on experience in nutrition assessment, diagnosis, and treatment of nutrition-related diseases while using skills in nutrition counseling and applying principles from behavior change theories. Students will be able to practice documentation of nutrition care and participate as members of an interdisciplinary team.
HSCI.5020 Graduate Global Health Experience -
Credits: 3

The Global Health Experience provides an experiential learning experience in health within a country outside of the United States. Students will study the health issues of a given country while examining the socio-cultural, economic and environmental determinants of health within that society. The strengths and weaknesses of the existing health care system will be analyzed. Students will explore the culture, environment, and health care system under the direction of College of Health Sciences faculty.

HSCI.5500 Human Development and Pathophysiology (Formerly 30.550) - Credits: 3

The physiological steady state of the human body and disruptions that result over the life span will be examined as well as the pathophysiological mechanism manifested in disease states. The course addresses defense, compensating, and adaptive responses to the pathophysiological processes as they apply to the various systems rather than being a survey course of diseases.

HSCI.5510 Clinical Pathophysiology - Credits: 3

The student will examine disease processes as variants of normal physiological functions with emphasis on understanding the pathophysiologic basis of common diseases in certain systems. This graduate level course is a comprehensive exploration of the etiology, pathogenesis, clinical manifestations, and treatment of disease.

PUBH.5130 Assessment and Planning in Public Health - Credits: 3

This course presents methods, concepts and techniques required for the identification of resources and needs, and planning of public programs and advocacy efforts to meet those a community, state, national, and global levels. Students will engage in community assessment and planning activities based on ethical and professional principles. This course will enhance skills needed for a health education specialist.

PUBH.6910 Advanced Program Evaluation - Credits: 3

The focus of this course is the development of skills needed to plan, conduct, and critique evaluations. Students will learn the major principles and methods associated with systematic evaluation of public health initiatives.
PHRM.6100 Principles of Pharmaceutical Sciences (Formerly PHSC 610) - Credits: 3

The purpose of this introductory course in the pharmaceutical sciences is to provide an overview of the drug development process, involving drug discovery, drug action, and drug delivery. The student will become acquainted with cutting-edge research in discovery, action, and delivery. This course provides a foundation in pharmaceutical sciences along with theoretical, practical, regulatory, and professional issues in the pharmaceutical sciences.

PHRM.6120 Principles of Pharmaceutical Sciences Laboratory - Credits: 1

The purpose of this introductory course in the pharmaceutical sciences is to provide an overview of the drug development process, involving drug discovery, drug action, and drug delivery. Laboratory experiments will be performed to exemplify and expand upon the principles covered in Principles of Pharmaceutical Sciences lecture.

PHRM.6200 Pharmacokinetics (Formerly PHSC 620) - Credits: 3

This course focuses on the study of the biochemical and physiological effects of drugs and the mechanisms of their actions. The quantitative aspects of drug absorption, distribution, metabolism, and excretion will be explored. The philosophy of pharmacokinetic modeling and its application in practice will be introduced.

PHRM.6300 Pharmaceutical Research Design and Ethics (Formerly PHSC 630) - Credits: 3

This course explores research methodologies and statistics that are commonly used in pharmaceutical research. Scientific integrity in research will be discussed, as well as ethical issues in conducting pharmaceutical research in the laboratory.

PHRM.6400 Pharmaceutical Analysis (PHSC 640) - Credits: 3

Students in this course learn about modern analytical methods used to analyze the purity, strength, and quality of drugs and pharmaceutics.

PHRM.6410 Drug Delivery (Formerly PHSC 641) - Credits: 3

The biological, biophysical and chemical factors that influence drug delivery systems will be analyzed. Principles of cellular drug transport, in vivo drug transport, and modern drug delivery, including drug targeting will be explored. The course will also address membrane trafficking and intracellular transport and the utilization of these mechanisms in drug delivery and targeting.

PHRM.6420 Pharmaceutical Analysis Laboratory - Credits: 1

Students in this course analyze the purity, strength, and quality of drugs and pharmaceutics by applying modern analytical methods. Raw materials and completed dosage forms will also be analyzed in the laboratory.

PHRM.6501 Drug Discovery - Credits: 3

Drug discovery is the translational application of biology, chemistry, medicine, business and law in the identification of new medicines. This course is designed to provide each student with a full understanding of the challenges and opportunities that face scientists engaged in this enterprise in the biotech and pharmaceutical industries. Active learning objectives (case studies; project team work) are included to supplement the more didactic course materials, and to provide a simulation of the approaches used in industry to accomplish the key goal—the nomination of a clinical drug candidate worthy of extensive investment and testing in humans.

PHRM.6600 Pharmacokinetics and Drug Metabolism - Credits: 3

This course focuses on the study of the biochemical and physiological effects of drugs and the mechanisms of their actions. The quantitative aspects of drug absorption, distribution, metabolism, and excretion will be explored. The philosophy of pharmacokinetic modeling and its application in practice will be introduced. An overview of the structure, function and regulation of major drug metabolic enzymes and transporters will also be emphasized.

PHRM.6600 Pharmacokinetics and Drug Metabolism - Credits: 3

This course focuses on the study of the biochemical and physiological effects of drugs and the mechanisms of their actions. The quantitative aspects of drug absorption, distribution, metabolism, and excretion will be explored. The philosophy of pharmacokinetic modeling and its application in practice will be introduced. An overview of the structure, function and regulation of major drug metabolic enzymes and transporters will also be emphasized.

PHRM.7070 Drug Metabolism (Formerly 36.707) - Credits: 3

This course provides an overview of the structure, function and regulation of major drug metabolic enzymes and transporters.

PHRM.7100 Advanced Topics in Pharmaceutical Sciences (PHSC 710) - Credits: 2

Select advanced topics and the evaluation of scientific literature in pharmaceutical sciences will be discussed in this seminar.

PHRM.7550 Graduate Research - Credits: 1-9

Enrolled students will be completing supervised research as
they progress toward the completion of their degree.

PHRM.7590 Doctoral Dissertation - Credits: 1-9

Enrolled students anticipate completion of all dissertation requirements during the semester in which they are enrolled for this course.
Doctoral Program in Physical Therapy

The Doctor of Physical Therapy (DPT) program at UMass Lowell prepares individuals for entry into the profession of physical therapy. The fully accredited program requires a baccalaureate degree for admission and a three-year full-time commitment, including part of each summer.

The curriculum provides a comprehensive foundation in the art and science of physical therapy. Methods of instruction include classroom lecture and discussion, small group / problem-based learning, and skill development during laboratory and clinical experiences. Emphasis is placed on the development of clinical decision-making and critical inquiry skills across the curriculum.

The clinical education program consists of three extended clinical education experiences one 10-week and two 12-week for a total of 34 weeks. Students experience a variety of practice settings and patient populations in preparation for general practice.

Program Goals

- Program Goals
- Program Outcomes
- Program Philosophy
- Admission Requirements
- Course of Study

Program Goals

1. Prepare entry-level physical therapy clinicians in a manner consistent with contemporary professional norms. Graduates practice as competent, autonomous, collaborative, and doctoral-prepared providers who deliver services along the continuum of care from prevention to the remediation of impairments, activity, and participation restrictions in all populations.
2. Produce, disseminate, and incorporate scholarship that will advance the science, practice and education of physical therapy.
3. Promote, develop, and maintain effective community partnerships, cultivating proficiency in collaborative practice through modeling and experience in inter-professional education.
4. The program adheres to departmental policies and procedures regarding academic achievement and standards of professional behavior and conduct insuring that graduates are prepared to meet current standards of practice.
5. Faculty will promote, develop and maintain scholarship associated with clinical, community and curricular engagement activities.
6. The program, will prepare students to apply principles of the scientific method to conduct research and participate in evidence-based practice.
7. The program will develop and maintain local and international partnerships that deepen our commitment to communities and cultures promoting health and wellness.
8. The program will develop, promote and maintain opportunities consistent with Interprofessional Education and Collaborative practice in accordance with the Interprofessional Education Collaborative Core (IPEC) Competencies.

Program Philosophy:
The faculty of the Department of Physical Therapy
Kinesiology believe that individuals have intrinsic worth and a right to optimal health and function. Function is defined as those activities identified by an individual as essential to support physical, social, and psychological well-being and to create a personal sense of meaningful living.

Physical therapists provide services to patients/clients with alterations in body structure and function, activity and participation restrictions or changes in physical function and health status resulting from injury, disease, or other causes. Physical therapists utilize prevention and wellness strategies in individuals at risk for developing a reduction in physical function.

The physical therapist is professionally educated in a program that synthesizes graduate study with undergraduate knowledge, and experiential learning. The graduate of the Doctor of Physical Therapy program is prepared to function as an ethical and competent practitioner who management include examination, evaluation, diagnosis, prognosis, intervention and outcomes. The graduate is prepared to interact and practice in collaboration with a variety of health professionals, provide prevention and wellness services, consult, educate, and engage in critical inquiry. Finally, the graduate is prepared to direct and supervise physical therapy services, including support personnel. Graduate are expected to assume a leadership role in health care and to practice autonomously and cooperatively in a variety of practice settings such as: hospitals, rehabilitation centers, extended care facilities, schools, sports medicine clinics, community health and private practices, and industrial or workplace settings.

Students are active participants in the education process. The relationship between students and faculty is one in which there is mutual respect, understanding, and interchange of ideas. As experienced professionals, the faculty serve as a resource, mentor and role-model for the developing professional. The faculty are facilitators of the learning process. Students are expected to demonstrate commitment to learning as the basis for continued personal and professional growth, effective interpersonal and communication skills, problem-solving and critical thinking skills, and appropriate professional conduct. Effective use of time and resources, feedback, and stress management strategies are also important components of the behaviors of the successful student.

Minimum Admission Requirements

1. Baccalaureate Degree from an accredited university of college within past 10 years.
2. Undergraduate cumulative GPA of 3.0 or greater.
3. Prerequisite Science GPA of 3.0 or greater.
4. Graduate Record Examination, within the last 5 years: >290 combined. (quantitative + verbal) (GRE Code = 3911)
5. Documented personal experience in a physical therapy setting (volunteer or paid). Minimum 35 hours
6. Statement of Purpose (essay)
7. Three (3) Letters of Recommendation, one (1) of which must be submitted by a licensed physical therapist.
8. Computer literacy in word, excel, power point, etc., is expected.
9. Required prerequisites coursework:
   - General Pharmacology (200 level course >2 credits)
   - Psychology
   - Statistics
   - Science
   - Anatomy and Physiology with labs, 2 semesters
   - Chemistry with labs, 2 semesters
   - Physics with labs, 2 semesters
   - Exercise Physiology (upper-level [300+] course)
   - Kinesiology / Biomechanics (upper-level [300+] course)

   *** Must be taken in a traditional (on-campus/classroom) setting.

Important Notes:

- The Completed Application Deadline is November 1st for admission into the next class beginning matriculation the following May. All documents is support of the application are due at the deadline, e.g. letters of recommendation, official transcripts, official GRE scores, etc.
- No more then two (2) pre-requisite courses may be missing at the time of our application deadline to remain eligible for full consideration. (Courses which are “in-Progress” at the time of the application deadline are considered missing).
- All International Applicants: Must submit English competency test score TOEFL or IELTS
  - Test Of English as a Foreign Language (TOEFL) (https://www.ets.org/toefl): Minimum score of 79
  - Must submit official transcripts for evaluation by: Transcripts must be evaluated: Center for Educational Documentation (http://www.cedevaluations.com)
- All Applicants: Meeting the minimum application
requirements does not guarantee admission into the program. Students may be asked to provide documentation of equivalent course content proposed to meet admission criteria. Any/All applications deemed incomplete at the application deadline will be ineligible for full department review. The UMass Lowell DPT program does not offer deferred acceptance. All accepted students must begin matriculation the immediately subsequent summer term. The Faculty supports the position to recruit and retain students who by reason of ethnic, cultural, or socioeconomic background are more likely to serve areas of critical need.

Additional Program Requirements

1. Proof of yearly physical examination by a physician indicating satisfactory general health status and proof of immunization for measles, mumps, rubella, tetanus, polio, diphtheria, tuberculosis, and Hepatitis B is required prior to clinical education experiences.
2. A CORI check (Criminal Offender Record Information) prior to clinical education experiences is required.
3. Costs related to clinical education experiences including transportation, housing, meals and tuition/fees are assumed by the student. Students should expect and plan for out-of-state clinical placements.
4. Professional behavior (defined as Generic Abilities) is required during all academic and clinical education experiences.

For additional, DPT program-specific, information regarding our admission requirements, please contact:
Keith W. Hallbourg
Graduate Admissions Coordinator
Department of Physical Therapy
University of Massachusetts Lowell
Phone: 978-934-4402
Email: keith_hallbourg@uml.edu
Fax: 978-934-1069

Completed Application Deadline: November 1.

Please submit add documents in support of your application to our Office of Graduate Admissions (http://www.uml.edu/grad).

You will need Adobe Acrobat Reader (https://get.adobe.com/reader/) to view any pdf files. It can be downloaded for free from the Adobe website (https://get.adobe.com/reader/).

Read the UMass Lowell General Regulations for Graduate Students (http://www.uml.edu/Catalog/Graduate/Policies/General-Policies.aspx).

Course of Study

• DPT Degree Pathway
DPTH.6010 Clinical Anatomy (Formerly 34.601) - Credits: 3
Clinical Anatomy is a study of the structures of the human body, utilizing lectures, demonstrations and A.V. materials. It is a foundation course for physical therapy procedures courses. All physical therapy graduate courses (number 34.) are restricted to PT majors only.

DPTH.6020 Neuroscience: Anatomy (Formerly 34.602) - Credits: 3
Neuroscience anatomy presents the form and functions of the human nervous system. It is a foundation course for physical therapy procedure courses. The student is introduced to clinically relevant neuroanatomy through a close examination of the signs and symptoms of a variety of pathologies, including lesions, tumors, injuries, and congenital disorders. Clinical examples are freely used to highlight the integral relationship between structural anatomy and functional impairment.

DPTH.6030 Anatomy Laboratory (Formerly 34.603) - Credits: 1
This course will introduce anatomical terminology, anatomical structures, functions, and interrelationships of the human body to physical therapy students as a baseline of knowledge for future courses in the program.

DPTH.6040 Neuroscience: Physiology/Neurology (Formerly 34.604) - Credits: 3
Neuroscience presents the principles of neurophysiology, neurology, and motor control as related to the practice of physical therapy. Topics in neurophysiology include: conduction and transmission of the nerve impulse, neuromuscular synaptic transmission and skeletal muscle contraction, muscle tone and spinal reflexes, the neurophysiology of sensation and movement, and the transmission of pain. Neurological conditions will be integrated with these various neurophysiological topics through the use of case studies and will include: peripheral nerve injuries, neuromuscular conditions, and diseases/conditions of the central nervous system. An introduction to the major theories of motor control and their applications to physical therapy examination and intervention will be discussed through problem solving and case studies. All physical therapy graduate courses (number 34.) are restricted to PT majors only.

DPTH.6050 Physical Therapy Interventions I Lecture (Formerly 34.605) - Credits: 3
This course introduces the student to the principles of patient evaluation and treatment. Throughout this course, case studies will be used to promote student integration of didactic material into practical clinical situations. The use of appropriate evaluation procedures and the associated rationale for safe and effective treatment procedures are emphasized. Topics include: principles of biomechanical analysis, body mechanics, exercise prescription, postural evaluation, patient positioning, transfers, gait analysis, gait training, activities of daily living, wheelchair prescription and mobility, isolation/sterile technique, wound care, vital signs, heat and cold modalities, soft-tissue manipulation, and clinical documentation.

DPTH.6060 Neuroscience Laboratory (formerly 34.606) - Credits: 1
Neuroscience laboratory includes the study of the anatomy and function of the human brain, spinal cord, peripheral and autonomic nervous systems through prossection, audiovisual resources and experimental procedures. The gross anatomy of the human brain and spinal cord will be visualized using prossections of human specimens, models, and slides. The second half of the laboratory will focus on the Neurological Evaluation including evaluation of reflex function, assessment of sensory and cerebellar mechanisms, and testing cranial nerve function in typical and simulated atypical subjects. Motor learning activities and Cognitive Testing will be performed. To help synthesize the course content each student will present a neuropathology case study.

DPTH.6070 Physical Therapy Interventions I Laboratory (formerly 34.607) - Credits: 1
This laboratory course develops the psychomotor skills necessary to apply the didactic knowledge presented in the Physical Therapy Interventions I Lecture to clinical situations and patient care. The safe and effective performance of various evaluation and treatment techniques is emphasized. Topics include: principles of biomechanical analysis, body mechanics, exercise prescription, postural evaluation, patient positioning, functional mobility training, gait analysis and training, activities of daily living, wheelchair prescription and mobility, isolation/sterile technique, vital signs, heat and cold modalities, soft-tissue mobilization, and clinical documentation.

DPTH.6080 Musculoskeletal Physical Therapy I (formerly 34.608) - Credits: 3
This course is the first of a three-course series which explores physical therapy management of musculoskeletal dysfunction. In this first course, general models for physical therapy intervention will be presented. The evaluation, treatment and prevention of pathological conditions affecting the musculoskeletal system of the lower extremity will be emphasized. Normal function will be included as a basis for recognizing and therapeutically resolving dysfunction of
skeletal and joint structures, muscles and soft tissues. A problem-solving approach to resolve impairments, contributing to functional limitations and disabilities, will be stressed. All physical therapy graduate courses (number 34.) are restricted to PT majors only.

DPTH.6090 Medical/Surgical Pathology (formerly 34.609) - Credits: 3

This course presents an introduction to the study of diseases commonly seen in people with conditions treated by physical therapists. Mechanisms of cell growth, response to injury, cell death as well as the psychosocial effects on the patient and family are reviewed.

DPTH.6100 Musculoskeletal Physical Therapy I Laboratory (formerly 34.610) - Credits: 1

This lab course develops psychomotor skills and clinical application of didactic knowledge gained in MSPT I Lecture (DPTH.6080). The examination and treatment procedures are taught using demonstrations, peer practice and case studies as they pertain to the hip, knee and ankle/foot. Examination procedures are organized by body regions and include interview, observation, palpation, anthropometric measurements, goniometry, joint play mobility, muscle strength testing, and special tests. Treatment procedures focus on integrating joint mobilization, passive and active stretching techniques, progressive strengthening exercises, and edema control with the thermal modalities, therapeutic exercises and functional activities taught in PT Interventions.

DPTH.6110 Professional Issues/Clinical Practice (formerly 34.611) - Credits: 3

This course is divided into two sections. The first course section will provide an overview of the profession of physical therapy. Professionalism, cultural competence and communication skills will be discussed as they apply to classroom instruction and clinical practice. The APTA (American Physical Therapy Association) Standards of Practice, Code of Ethics, The Scope of Physical Therapy Practice, ethnography and Evidence-Directed Care and Massachusetts and New Hampshire practice regulations will be discussed. The second portion of the course will emphasize the development of effective documentation skills.

DPTH.6120 Cardiopulmonary Physical Therapy I (formerly 34.612) - Credits: 3

In Cardiopulmonary Physical Therapy students will learn the essentials of physical therapy examination, evaluation and intervention for patients with pathological cardiopulmonary conditions. The course emphasizes a problem solving, clinical decision-making approach. Successful completion of the course requires the ability to integrate and synthesize information from this course with prerequisite and other related courses in a variety of cardiopulmonary case based problem-solving experiences.

DPTH.6140 Cardiopulmonary Physical Therapy I Laboratory (formerly 34.614) - Credits: 1

Cardiopulmonary Physical Therapy Laboratory is taken concurrently with Cardiopulmonary Physical Therapy Lecture (DPTH.6120). The course emphasizes procedures employed by the physical therapist when treating cardiopulmonary conditions. These laboratory experiences are designed to provide an opportunity to practice examination, evaluation, and interventions as discussed in lecture and demonstrate psychomotor proficiency in each procedure. Students will be expected to integrate and synthesize information from related courses in a variety of cardiopulmonary problem solving experiences.

DPTH.6150 Clinical Education I Seminar (formerly 34.615) - Credits: 1

This course is the first in a series of two one-credit seminars. The first installment will provide an overview of the clinical education experience portion of the Doctor of Physical Therapy program. Topics include; the roles of clinical educators, the process of obtaining and assigning clinical sites, the clinical performance instrument (CPI), appropriate communication in the clinical setting, ethical practice, psychosocial aspects, and generic abilities.

DPTH.6160 Research Methods (formerly 34.616) - Credits: 3

This course presents the role of research in the development and critical analysis of physical therapy clinical practice. Students are guided through the process of clinical scientific research including the following content areas: philosophy of science and causation, problem and hypothesis identification, review and analysis of scientific literature, methods of hypothesis testing, data analysis and interpretation and critique/ evaluation of research results.

DPTH.6170 Neurological Physical Therapy Lecture I (formerly 34.617) - Credits: 3

This course presents current evidence-based practice, knowledge translation, and practical applications of the principles of neuroplasticity, motor control and motor learning. A variety of neurological conditions with different levels of impairment, activity limitation, and participation restriction will be examined. Emphasis is on the development
of clinical decision-making skills following the Guide to Physical Therapist Practice patient/client management model. Concurrent laboratory sessions emphasize the development of movement analysis and intervention skills to optimize restoration of function and participation.

**DPTH.6190 Neurological Physical Therapy Laboratory I (formerly 34.619) - Credits: 1**

This laboratory course must be taken concurrently with Neurological Physical Therapy I, DPTH.6170. Emphasis is on the development of problem solving and psychomotor skills necessary for successful management of the patient/client with neurological dysfunction. Videos and patient demonstrations are used to develop skills in examination, evaluation, and clinical decision making. Peer practice is used to promote the development of psychomotor skills in advanced therapeutic exercise and functional training. Problem solving in the application of interventions for different levels of impairments, activity limitations, and participation is stressed.

**DPTH.6200 Neurological Physical Therapy II (formerly 34.620) - Credits: 3**

This course is the second of two courses dealing with physical therapy management of adult patients/clients with neurological dysfunction. Concepts, practical applications, and strategies based on theories of motor skill development, motor control, and motor learning will be discussed. A variety of neurological conditions with different levels of impairments, activity limitations, and participation restrictions will be examined. Emphasis is on the development of clinical decision making skills using a problem solving approach. Practice is fostered in the development of appropriate plans of care. Concurrent laboratory classes emphasize the development of specific assessment and intervention skills.

**DPTH.6210 Musculoskeletal Physical Therapy II Lecture (formerly 34.621) - Credits: 3**

This course is the second of a three-course series which focuses on physical therapy management, and summarizes medical and surgical management of musculoskeletal dysfunction. The evaluation, treatment and prevention of pathological conditions affecting the upper extremity will be emphasized. Normal function will be included as a basis for recognizing and therapeutically resolving dysfunction of skeletal and joint structures, muscular and soft tissue. A problem-solving approach to resolve impairments, which contribute to activity limitations and participation restrictions, will be stressed.

**DPTH.6220 Neurological Physical Therapy II Laboratory (formerly 34.622) - Credits: 1**

This laboratory course must be taken concurrently with Neurological Physical Therapy II, DPTH.6200. Emphasis is on the development of problem solving and psychomotor skills necessary for successful management of the patient/client with neurological dysfunction. Videos and patient demonstrations are used to develop skills in examination, evaluation, and clinical decision making. Peer practice is used to promote the development of psychomotor skills in advanced therapeutic exercise and functional training. Problem solving using case studies in the application of interventions for different levels of impairments, activity restrictions and participation limitations is stressed.

**DPTH.6230 Musculoskeletal Physical Therapy II Laboratory (formerly 34.623) - Credits: 1**

This laboratory course develops the psychomotor skills to allow clinical application of didactic knowledge gained in Musculoskeletal Physical Therapy II Lecture. The safe and effective performance of examination and treatment procedures are taught using demonstrations, peer practice, case studies and mock evals as they pertain to the shoulder, elbow, forearm, wrist, and hand. Examination procedures, organized by body regions, include interview questions, observation, palpation, anthropometric measurements, goniometry, joint play mobility, muscle strength testing, and special tests. Treatment procedures focus on joint mobilization/manipulation, passive and active stretching techniques, and progressive strengthening exercises.

**DPTH.6250 Physical Therapy Interventions II (formerly 35.625) - Credits: 3**

This course is a study of advanced physical therapy procedures which utilize electrophysics and electrophysiology in evaluating and treating a variety of physical impairments. The course will emphasize theories and techniques used in electrodiagnosis, electromyography, functional electrical stimulation, iontophoresis, transcutaneous electrical stimulation, biofeedback, laser and therapeutic electrical currents including light and radar waves.

**DPTH.6260 Geriatric Physical Therapy (formerly 34.626) - Credits: 3**

This course will focus on the special needs of the elderly and on the physical therapy management of the geriatric client. The physical changes associated with normal aging as well as pathological changes will be discussed and analyzed. Program planning will stress holistic consideration of the rehabilitative, cognitive/behavioral, and psychosocial needs of the elderly. (Re)Evaluation including functional evaluation, treatment planning (and treatment plan evaluation), treatment cost effectiveness, documentation, reimbursement issues will be analyzed as they relate to the physical therapy management of the geriatric client. All physical therapy graduate courses
DPTH.6270 Physical Therapy Interventions II Laboratory (formerly 34.627) - Credits: 1
This course is a practical application of theories and principles presented in Physical Therapy Interventions II Lecture (DPTH.6250).

DPTH.6280 Musculoskeletal Physical Therapy III (formerly 34.628) - Credits: 3
This course provides the second-year physical therapy student with an introduction to physical therapy evaluation and management of dysfunction of the cervical, thoracic and lumbar spine, rib cage, and pelvis. The development of evaluation strategies, documentation skills, organized clinical decision making, and effective patient management techniques will be emphasized. Discussions and exercises will focus on developing patient diagnoses, functional problems lists, long and short-term goals, and treatment strategies. Critical thinking/problem solving strategies will be incorporated into all aspects of patient management. Emphasis will be on creating a climate that encourages learning. All physical therapy graduate courses (number 34.) are restricted to PT majors only.

DPTH.6290 Directed Research (formerly 34.629) - Credits: 1-3
The directed research experience provides students with the opportunity to develop a research project with the guidance of a faculty advisor. All physical therapy graduate courses (number 34.) are restricted to PT majors only.

DPTH.6300 Musculoskeletal III Laboratory (formerly 34.631) - Credits: 1
This laboratory course provides the student the opportunity to apply the didactic knowledge gained in the Musculoskeletal Physical Therapy II Lecture through a systematic clinical reasoning approach which focuses on the concept of-regional interdependence. Additionally, specific evidence-based evaluation and functional management techniques for the spine and pelvis will be demonstrated by instructors and practiced by students.

DPTH.6310 Pediatric Physical Therapy Lecture (formerly 34.631) - Credits: 3
This course focuses on the development of the individual from the prenatal period through adolescence within the context of the individual's family and cultural background. Emphasis will be on the examination, evaluation, diagnosis and formulation of a physical therapy plan of care for infants, children and adolescents with physical therapy related issues including wellness and prevention of disability. The framework for the course will be based upon principles of development, neural plasticity, motor control, motor learning, pediatric clinical decision making, the WHO ICF, and evidence directed care including clinical practice guidelines. The student will integrate the course material and synthesize appropriate plans of care using case studies and other interactive activities.

DPTH.6330 Pediatric Physical Therapy Laboratory (formerly 34.633) - Credits: 1
Through classroom and clinical laboratory experiences, the student will gain introductory level skill in the examination, evaluation, intervention, and development of a physical therapy plan of care for infants, children, and adolescents who have or are at risk for developing disabling problems requiring physical therapy intervention. Preventive and wellness strategies will also be developed and discussed. Problem solving and evidence directed practice including Clinical Practice Guidelines will be emphasized.

DPTH.6350 Clinical Education II Seminar (formerly 34.635) - Credits: 1
This course is the second in a series of two one-credit weekly seminars. The class will continue to explore the professional issues and application of didactic material in the clinical setting. Clinical education will be examined from the perspective of career development and physical therapy board preparation.

DPTH.6370 Integrating Clinical Practice (formerly 34.637) - Credits: 3
This course will focus on integrating clinical reasoning skills in physical therapy with an emphasis on application of evidence-based research and current concepts of disablement. Students will share clinical experiences focusing on utilization of - best practices and - Clinical Practice Guidelines.

DPTH.6390 Medical/Surgical -Orthopedics (formerly 34.639) - Credits: 3
Medical Surgical conditions (Orthopedics) present topics related to pathology and medical-surgical treatment of musculoskeletal disorders. Included will be bone development, bone repair, orthopedic examination, diagnostic examinations (including imaging), pathology and pathophysiology of musculoskeletal disease.

DPTH.6400 Professional Prep in PT (formerly 34.640) - Credits: 3
This course will focus on facilitating the students transition into the Physical Therapy Profession including successful completion of the professional licensure examination, the National Physical Therapy Exam: Student groups will outline and present review materials for the exam to each other including a list of sources for further study. The faculty facilitator will oversee the development and content of the presentations and supervise practice examinations. Students are guided through reflection in practice, development of a personal professional development plan, a Vision and Mission Statement including continuing education, pro bono and community service and participation in the American Physical Therapy Association. Other topics will include strategies for successful interviewing.

DPTH.6420 Health Policy & Admin (formerly 34.642) - Credits: 3

This course explores the social, political, and economic policies that impact the delivery of physical therapy services and health. The course underscores the issues of professionalism, leadership, management, and the advocacy to foster excellence in autonomous practice for the benefit of members and society. The course emphasizes leadership in promoting cultural competence, global and community health through the lifespan, social responsibility, effective application of technology, and health services research.

DPTH.6430 Evidence Directed Care (formerly 34.643) - Credits: 3

This course presents the role of evidence in the development and critical analysis of PT clinical practice guidelines and recommendations. Students practice analyzing, weighting, comparing and integrating sources of evidence. Methods of integrating various forms of evidence are covered including: examination and intervention systematic reviews, meta-analyses and clinical practice guidelines. The role of the PT’s experience and background, patient, family, and stakeholders in the development of clinical practice guidelines will be analyzed. Current topics such as the role of Telemedicine and theories of Behavioral Change will be discussed, compared and integrated into plans of care and clinical use.

DPTH.6440 Clinical Education Fieldwork II (formerly 34.644) - Credits: 1

This is the continuance of Directed Research experience providing students with the opportunity to complete and present a research project with the guidance of a faculty advisor. All physical therapy graduate courses (number 34.) are restricted to PT majors only.

DPTH.6450 Physical Therapy Interventions III (formerly 34.645) - Credits: 3

This course introduces the second year physical therapy student to various topics related to specialized physical therapy management of patients. Topics include, but are not restricted to: lower extremity prosthetic and orthotic management, hand orthotic fabrication, introduction to ergonomic principles, ergonomic design of seating systems and workstations, cumulative trauma disorders, work site analysis, functional capacity evaluation, lumbar stabilization exercises, the acute care environment, post-mastectomy management, and aquatic therapy interventions.

DPTH.6460 Complex Cases in Physical Therapy (formerly 34.646) - Credits: 3

This course, which runs concurrently with Clinical Education Experience III (DPTH.6530), is designed to promote evidence-based practice, intra-professional correspondence, and further socialization into the profession of physical therapy. Students are expected to incorporate evidence based practice in real-time clinical practice whenever possible and speak to the implementation, progress, and outcome(s) via on-line posting of related case studies. Furthermore, students are expected to critically evaluate the degree to which the current evidence supports or conflicts with the common practice intervention. Additionally, students will critically evaluate their classmate’s cases study postings offering feedback and/or treatment suggestions based upon their experience(s) and the evidence.

DPTH.6470 PT Interventions III Lab (formerly 34.647) - Credits: 1

All physical therapy graduate courses (number 34.) are restricted to PT majors only.

DPTH.6480 Service Learning in Physical Therapy (formerly 34.648) - Credits: 3

This three-credit course is designed to serve as a service-learning experience in the final year for doctoral physical therapy students. The course is designed to provide relevant and meaningful service opportunities for culturally competent physical therapy services with a focus on prevention, health promotion, fitness, and wellness to individuals, groups, and communities. The service learning experience will prepare students for active civic participation in a diverse society. Through the use of readings, discussion, reflection and presentations students will gain an understanding what it means to build the capacity of a community and develop the competency skills of an entry level physical therapy practitioner.

DPTH.6500 Clinical Education Experience I (formerly 34.650) - Credits: 3

This course introduces the first year physical therapy students to the role of evidence in the development and critical analysis of PT clinical practice guidelines and recommendations. Students practice analyzing, weighting, comparing and integrating sources of evidence. Methods of integrating various forms of evidence are covered including: examination and intervention systematic reviews, meta-analyses and clinical practice guidelines. The role of the PT’s experience and background, patient, family, and stakeholders in the development of clinical practice guidelines will be analyzed. Current topics such as the role of Telemedicine and theories of Behavioral Change will be discussed, compared and integrated into plans of care and clinical use.

DPTH.6510 Health Policy & Admin (formerly 34.651) - Credits: 3

This course explores the social, political, and economic policies that impact the delivery of physical therapy services and health. The course underscores the issues of professionalism, leadership, management, and the advocacy to foster excellence in autonomous practice for the benefit of members and society. The course emphasizes leadership in promoting cultural competence, global and community health through the lifespan, social responsibility, effective application of technology, and health services research.
34.650) - Credits: 3

A ten-week full time, clinical experience designed to integrate basic physical therapy evaluative and treatment procedures, foster development of an autonomous professional through the synthesis and utilization of advanced academic theory in evaluation and treatment. Students are expected to use sound scientific rationale and a problem solving approach in all aspects of patient care. Students are under the direct supervision of licensed physical therapists in general acute facilities and outpatient setting.

DPTH.6520 Clinical Education Experience II (formerly 34.652) - Credits: 3

This second, twelve-week, clinical experience designed to further promote the development of an autonomous professional as well as stimulate socialization into the profession. Students are expected to function as independently as possible using the problem solving process as a basis for all clinical decision making. Communication, coordination and consultation with other members of the health care team and responsibility for total client management are emphasized.

DPTH.6530 Clinical Education Experience III (formerly 34.653) - Credits: 3

This terminal, twelve-week, clinical education experience is designed as the final promotion of complete socialization and transition into the profession of physical therapy. Students are expected to function as independently as possible using problem solving processes as a basis for all clinical decision making. Communication, coordination, and consultation with other members of the health care team and responsibility for complete patient management are emphasized.
PUBH.5000 Analytical Context of the Work Environment (Formerly 19.500) - Credits: 3

An overview course to be taken in the first semester in the Master's program. Case studies are used to introduce students first to the hazard analysis methods, and second, to the prevention methods of each of the department's sub-disciplines. Interconnections between exposures and illness/accident development are reviewed at three levels: individual, work organization and society.

PUBH.5010 Social and Behavioral Determinants of Health (Formerly PUBH 501) - Credits: 3

This course introduces core concepts of social and behavioral determinants of health and provides a foundation for the analysis of social, political and economic influences on health and their role in contributing to health inequities. The core functions of public health and essential services are discussed as well as the history of public health, its philosophy and values. Upstream and downstream reforms to addressing fundamental determinants are evaluated. The influence of behavioral and psychological factors on health and disease are analyzed.

PUBH.5020 Organizational Behavior in Health Care (Formerly 32.502) - Credits: 3

This course reviews the organizational structure of healthcare facilities and the behavior of individuals within them. Students analyze the role of administration, human resources, providers and other support staff and apply organizational, behavioral, and social science practice and theory, to the operations of the healthcare organization. Comparison is made between healthcare and non-health care types of industry to highlight the unique characteristics of healthcare workers. An emphasis is also made on leadership styles, organizational culture, and change management within the healthcare organization.

PUBH.5021 Public Health Policy (Formerly PUBH 502) - Credits: 3

The course focuses on expanding students' knowledge and skills for developing and evaluating contemporary public health policy in the United States and international settings. Students will gain information about the current US national health care system as it relates to emergent public health topics and priorities in the US and globally. This course will focus on competencies for designing, implementing, evaluating and advocating for evidence-based policy, program and practices.

PUBH.5030 Toxicology and Health (Formerly 19.503) - Credits: 3

The course introduces students to the basic principles and mechanisms of toxicology with a focus on occupational and environmental health. Concepts of dose, dose rate, dose-response analysis, and test systems are presented in the context of the toxicology of major organ systems and toxic agents. The course covers toxicology of major organ systems (respiratory, dermal, immunologic, cardiovascular, neurological, reproductive systems, and cancers), major classes of contaminants (airborne particles, respirable fibers, vapors/gases, heavy metals, organic solvents, pesticides, sensitizers, emerging contaminants), and their mechanisms of action. A review of the necessary human biology and biochemistry of life is also provided.

PUBH.5050 Qualitative Research Methods (Formerly 19.505) - Credits: 3

This course explores and examines non-quantitative methodologies in the social sciences and political economy. The course will discuss hypothesis generation, survey design, research problem design, case studies, ethnographic methods, participatory research methods, content analysis, interviewing techniques and key informant interviews. Doctoral students in work environment policy are particularly urged to take this course. The course will be offered in collaboration with the Department of Regional Economic and Social Development as course 57.592.

PUBH.5060 Quantitative Methods in Health Management (Formerly 32.506) - Credits: 3

This course explores analytic methods that can be used to improve the decision making of management, clinicians and others within the healthcare industry. Students learn the conceptual foundations of quantitative analysis and common methods used in supporting decision-making: developing evidence-based practices; analyzing data and testing hypotheses. Students also learn how to use industry-standard data analysis software applications, statistical packages and common applications for the development and reporting of analytic findings.

PUBH.5061 Environmental Health (Formerly 19.506) - Credits: 3

This environmental health course explores the links between human activities and environmental systems and examines how these interactions can impact human health. The course is designed to provide knowledge and skills necessary to understand how human and industrial activities such as population growth, methods of food production, pollution of the air and water, waste, the built environment, toxic substances, pest control, and global climate change can result in human diseases and impact the environment. Understanding the links between human activities and environmental systems is essential to developing effective prevention strategies and
building sustainable communities.

PUBH.5070 Leadership and Management in Public Health - Credits: 3

The purpose of this course is to enhance the students' ability to effectively build and lead high-performing Public Health organizations. This course will integrate fundamental principles from the behavioral and social sciences to provide students with a coherent set of strategies and techniques to effectively collaborate with internal external stakeholders as well as to influence meaningful, sustainable change. This course will also provide students opportunities to self-reflect on their own leadership styles and develop growth plans.

PUBH.5080 Principles and Practices of Biological Safety (Formerly 19.508) - Credits: 3

This course is designed to provide an overview of hazard recognition, evaluation and control of potentially hazardous biological materials. This introduction to the field will cover the potential risks of working with biological materials, the use of engineering, work practices and administrative measures for hazard control and regulations governing the area of biosafety. Requires working knowledge of Microbiology, and permission of Instructor.

PUBH.5100 Fundamentals of Occupational Health (Formerly 19.510) - Credits: 3

This course provides an overview of key topics in the field of occupational health and safety including physical agents and biological and chemical hazards. The measurement and control of various physical agents are covered, including noise, ionizing and non-ionizing radiation, heat stress and extreme environments. Students will understand the health risks from biological hazards and blood borne pathogens, as well as the regulations and methods of prevention. They will also gain knowledge of hazard communication regulations, material safety data sheet and how to research chemical hazards.

PUBH.5110 Health Care Finance (Formerly 32.511) - Credits: 3

Provides broad exposure to the concepts and practices of healthcare finance and healthcare financial management. Teaches a practical understanding of basic healthcare financial issues, financial reporting and analysis, and provider payment structures. The course enables students to read, analyze and use healthcare financial information in today’s healthcare environment.

PUBH.5140 Healthcare Management (Formerly 32.514) - Credits: 3

This course focuses on a multi-disciplinary approach to operations analysis, process redesign and quality improvement in health care. Focus is placed on the tools, methods and processes used for improving work flow processes, patient safety and performance in a variety of health care settings. Students study the history, development and principles of quality improvement in healthcare.

PUBH.5141 Aerosol Science (Formerly 19.514) - Credits: 3

Basic properties of airborne particles, with particular regard to properties important to health. Includes basic properties of gas-borne particles, uniform particle motion, particle collection mechanisms, filtration, particle sampling, respiratory deposition, particle statistics, electrical properties, and optical properties. Course includes lectures and laboratory.

PUBH.5150 Applied Health Economics (Formerly 32.515) - Credits: 3

Students explore the economic dimensions of healthcare by considering the input, output, production and costs of producing quality healthcare which meets demand and evaluates the behavior of supply. Students consider provider payer systems and aspects relative to private and public health insurance in determining market power and competitive markets. Common economic evaluation methods are introduced to measure health service feasibility, and promote value judgment in the realm of healthcare reform and regulatory compliance.

PUBH.5160 Laboratory Environmental Health and Safety (Formerly 19.516) - Credits: 3

This course is designed to provide an overview of hazard recognition, evaluation and control in laboratory environments. This introduction to the field will cover the potential risks of working with chemicals, radioactive materials, animals and biological materials. It will also introduce the use of engineering, workpractices and administrative measures for hazard control and regulations governing the area of laboratory safety.
PUBH.5210 Introduction to Industrial Hygiene  
(Formerly 19.521) - Credits: 2

A survey course covering introductory topics in ergonomics and industrial hygiene. Ergonomics topics include work measurement, anthropometry, biomechanics, psychosocial stress and work reorganization, special emphasis is placed on the recognition and control of work-related musculoskeletal disorders. Industrial hygiene topics will cover the identification, measurement, and control of chemical and physical hazards in the work environment including principles of air sampling and analysis, ventilation and other control technologies, and the use of personal protective equipment with special attention to respiratory and hearing protection.

PUBH.5230 Introduction To Ergonomics  
(Formerly 19.523) - Credits: 2

PUBH.5250 Industrial Hygiene and Ergonomics  
(Formerly 19.525) - Credits: 3

This course explores the important aspects of planning and implementation of business strategies in a health service organization. Students learn about the multi-step process of creating and managing a successful business plan, as well as strategies and solutions for analyzing business situations while utilizing popular tools of the industry.

PUBH.5270 Business Strategies for Health Organizations  
(Formerly 32.527) - Credits: 3

An overview of the scientific basis for design of the workplace to optimize physical and mental interaction of workers with machines, tools, and work methods. Topics include work measurement, anthropometry, biomechanics, work physiology, cumulative trauma disorder and information presentation and processing.

PUBH.5300 Ergonomics and Work  
(Formerly 19.530) - Credits: 3

This course introduces healthcare professionals to the power of data and the importance of analysis. Students learn how population informatics, consumer health informatics, translational bioinformatics, and clinical research informatics are essential components in selecting the techniques and systems used for transforming clinical data into information, knowledge and improved decision-making. The past, current and future role of healthcare IT is also discussed.

PUBH.5310 Health Informatics  
(Formerly 32.531) - Credits: 3

The anatomical and physiological basis of human motor capabilities. Quantitative models are developed to explain muscle strength performance, motion control, physical fatigue, and acute and chronic musculoskeletal trauma, particularly static link models of lifting and other manual activities. Application to the evaluation and design of various tasks and occupations.

PUBH.5320 Occupational Biomechanics Laboratory  
(Formerly 19.532) - Credits: 3

A laboratory presentation of the biomechanical basis for understanding and predicting human motor capabilities using bioinstrumentation. Computerized data acquisition, electromyography and load cells for strength measurement are examples of the equipment used in this lab. Particular emphasis is placed on the evaluation of occupational activities.

PUBH.5330 Intervention Research  
(Formerly 19.533) - Credits: 3

This course covers the design, implementation and evaluation of interventions to reduce risk factors for poor health and related outcomes. Topics include the use of casual diagrams to identify possible intervention points; logic models for program evaluation; and design of formal evaluation research studies. Selected scientific articles will be used to illustrate topics covered in the lectures. Each student will select a public health problem of interest and develop a case study over the course of the semester.

PUBH.5400 Occupational Safety Engineering  
(Formerly 19.540) - Credits: 3

The purpose of this course is to introduce students to the principles of safety hazards in the work environment. This course is primarily designed to emphasize the safety aspects of the hazards at work. It begins with the historical development of occupational safety and health and progressively examines the fundamentals of recognition, measurement, evaluation, and control of occupational safety hazards.

PUBH.5420 Human Factors  
(Formerly 19.542) - Credits: 3

The functional processes of human systems in the workplace that affect psychosocial health and productivity. Review of associations between work design principles and effects on human well-being, learning, and performance. Human perceptive, cognitive, metabolic, and social-psycho logical limitations. Human-machine interactions affecting "stress" and learning at the level of individuals and of groups. Introduction
to "healthy" job redesign, "conducive production", and measurement strategies. Principles applied through practical design problems.

**PUBH.5490 Sustainable Housing Development and Land Use: Policy and Practice (Formerly 19.549)** - Credits: 3

Housing is fundamental to the quality of life in communities, and housing policies shape the availability of this fundamental good. This course will examine the economic, environmental, social, and cultural factors that shape housing and its sustainability. Overall housing and land use policy in the United States will be summarized, with students learning of the ways in which housing policy impacts communities, states, and regions. The course will then give students a detailed understanding of the process through which housing is developed and the role the market, government, funders, workers, and housing consumers play in influencing the creation and development of housing. The course will highlight the ways in which current housing development policy and practices are not sustainable, and will examine more recent efforts to establish standards and practices that enhance sustainability. Students will learn how to take a housing project through the various stages, such as project conceptualization, market analysis, design, site acquisition, financing, construction, and occupancy. While the course focuses on the U.S. context, students will learn of international efforts to achieve greater sustainability in housing. The course will provide students with both practical and theoretical knowledge of housing and land use policy and development practices. Case studies of actual projects will be presented.

**PUBH.5500 Environmental Law (Formerly 18/19.527)** - Credits: 3

The large body of law, which has developed since the early 1960’s, is examined in considerable detail. Federal laws relating to the environment, particularly with the Environmental Protection Agency and the Occupational Safety and Health Acts. State and local laws and ordinances are discussed where pertinent.

**PUBH.5510 Work Environment Policy and Practice (Formerly 19.551)** - Credits: 3

This course provides an overview of occupational safety and health (OSH) policy and practice. It focuses on the legal and administrative vehicles, especially the Occupational Safety and Health Administration (OSHA) and OSH Act of 1970. It demonstrates the public health and business case for safety via case studies, The course provides an analytical framework for examining social, economic, and political factors in the recognition and control of occupational hazards and a management program for identifying and preventing hazards at the worksite. The course covers national and international workplace management systems as well as business and organizational management policies to ensure safety and how these are translated to effective practice at the level of a specific worksite.

**PUBH.5550 Comparative Environmental (Formerly 19.555)** - Credits: 3

Human social and productive activities often harm the natural environment. Environmentally related health problems will become more prominent and put additional stress on industrial, as well as transitional and developing nations. A sustainable world is one that provides not only for environmental viability but also economic health, social justice and political participation. This course is designed to explore the dynamics and interactions of social, economic and political factors that aid or impede a community’s ability to contribute to global environmental sustainability. The course will be offered in collaboration with the Department of Regional Economic and Social Development as course 57.518.

**PUBH.5570 Toxic Use Reduction (Formerly 19.557)** - Credits: 3

Toxic Use Reduction (TUR) is a new approach to hazardous waste management and environmental protection. Rather than addressing chemical contamination as waste (after its generation), to be managed through permits and emission regulations, TUR focuses on chemicals while still in production. In Massachusetts, firms are required to prepare plans demonstrating how they will reduce or eliminate the use of toxic chemicals. The course is organized as a set of discussions and case studies from the real-life program.

**PUBH.5590 Conflict Resolution (Formerly 19.559)** - Credits: 3

This course gives students an understanding of the main issues and solutions involved in community level conflict resolution; e.g., in neighborhoods, workplaces, and other institutions. It develops students’ skills in practicing conflict resolution and/or evaluating programs in the field of dispute resolution. It is important to understand why conflict happens and how to resolve conflict.

**PUBH.5750 Epidemiology and Biostatistics** - Credits: 3

Epidemiology is the study of the distribution and determinants of disease in human populations, and the risk factors associated with diseases. This course provides an introduction to epidemiology and the associated biostatistical methods that constitute the principal quantitative methods for disease
prevention. Topics include: measures of disease frequency, measures of central tendency and spread, rates and risks, precision and validity, bias, simple linear regression, and the important study designs (population surveys, cohort, case-control and cross-sectional studies).

PUBH.5760 Biostatistical Programming - Credits: 3

This course is designed to provide familiarity with several types of statistical software commonly used in public health research. The course covers topics including: reading raw data and existing data sets; modifying data; combining data sets; applying basic statistical procedures; and sorting, summarizing, and printing data.

PUBH.5770 Biostatistics for Health Data - Credits: 3

This is a practical course in biostatistical methods for health research. Emphasis is placed on developing an understanding of the use and interpretation of standard biostatistical methods. Topics include probability and sampling distributions, regression and ANOVA, methods for analyzing rates and proportions, power and sample size calculations. Students will gain experience in using a statistical software package to apply and expand their data analysis skills.

PUBH.5790 Disability Outcomes and Interventions (Formerly 19.579) - Credits: 3

This course will address the epidemiology of disability outcomes through a mix of didactic presentation and critical discussion of the literature, covering both observational and intervention studies. Qualitative research methods will also be highlighted in terms of how they can enrich the study hypotheses, construct measures, etc. The first half of the course will cover observational studies of individual and environmental risk factors for disability outcomes, including features of both the workplace and the community. Then we will describe the key design features of clinical trials to evaluate interventions, again at both the individual and the organizational levels. Interspersed with lecture material, selected observational and intervention studies from the peer-reviewed scientific literature will be evaluated with respect to study design, methodologic rigor, and adequacy of statistical analysis.

PUBH.5910 Co-Op Internship CPT (Formerly 19.591) - Credits: 0-1

Practical training course for students to perform CPT. "Variable credit course, student chooses appropriate amount of credits when registering."

PUBH.5930 Directed Study (Formerly 19/31/32.593) - Credits: 1-3

PUBH.5980 Thesis Review (Formerly 19.598) - Credits: 1

PUBH.6000 Practicum/Capstone I (Formerly 19.600) - Credits: 3

This is the first course in a two-semester sequence that provides the opportunity to apply practical skills through a culminating practice experience for students in the Master’s programs in Work Environment and Public Health. The course is designed to provide students with the opportunity to examine an interdisciplinary problem in depth and propose a solution to the problem by applying technical knowledge and skills obtained in their program to a real world issue. The product will be a report and a public presentation of the project.

PUBH.6010 Practicum/Capstone II (Formerly 19.601) - Credits: 3

This is a second course in a two-semester sequence that provides the opportunity to apply practical skills through a culminating practice experience for students in the Master’s programs in Work Environment and Public Health. The course is designed to provide students with the opportunity to examine and interdisciplinary problem in depth and propose a solution to the problem by applying technical knowledge and skills obtained in their program to a real world issue. The product will be a report and a public presentation of the project.

PUBH.6030 Global Development and Health (Formerly PUBH.603) - Credits: 3

This course discusses global health efforts in relationship to human health and quality of life. Using a case methodology, this course will enable students to analyze complex health and development challenges in the less-developed world, and propose and evaluate interventions that address challenges. Topics include maternal and child health, nutrition, infectious and noninfectious diseases, natural disasters, sanitation and health inequality. Access to health care in developing and developed countries will be analyzed. The concept of positive deviance will also be explored.

PUBH.6050 Advanced Research Methods in Work Environment (Formerly 19.605) - Credits: 3

An advanced seminar focused on developing research skills needed for understanding the causes of health and safety hazards in the work environment as well as their solutions. The seminar topics will vary each semester, depending on the research fields of the students enrolled as well as the expertise of the participating faculty members. The goal is to provide depth in theory, background literature, state of the art.
measurement tools, and research methods at a level appropriate to students undertaking independent research. All doctoral students are required to take two semesters of this seminar.

PUBH.6070 Healthcare Information Systems (Formerly 32.607) - Credits: 3

This course provides a broad-range overview of the healthcare information systems industry, its history, recent developments and continuing challenges, as well as a practical understanding of healthcare information systems acquisition and implementation. Topics include EMR, Data, CMS Quality Programs, Clinical Integration and health information exchange.

PUBH.6090 Work in Progress Seminar (Formerly 19.609) - Credits: 1

This seminar course provides a forum for doctoral students (and advanced master’s students) to discuss research with their peers and the faculty in a supportive interdisciplinary community. Doctoral trainees from all Public Health fields are required to present their work in progress to their peers. Although all doctoral students must register for this seminar for credit in one semester during their career, they are expected to attend and present regularly while they are in the research and writing phase of their doctorate.

PUBH.6100 Exposure Assessment (Formerly 19.610) - Credits: 3

Concepts of quantification of occupational exposures (chemical and physical hazards) for purpose of correlating health effects with exposures. Topics discussed include reasons for conducting exposure assessment, sampling methods, sampling strategies (for epidemiology, compliance, control), and statistical considerations. Principles are illustrated through a series of case studies.

PUBH.6110 Physical Properties of Aerosols (Formerly 19.611) - Credits: 3

A seminar covering aspects of aerosol science not discussed in 19.514 but necessary for the completion of research projects involving aerosols. Topics covered include the electrical, thermal, and optical properties of aerosols, particle agglomeration, evaporation and condensation, and the generation and measurement of test aerosols. Course will consist of lectures and laboratory sessions.

PUBH.6120 Exposure Data Analysis (Formerly 19.612) - Credits: 3

An advanced seminar covering statistical considerations for exposure sampling and data analysis. Topics include sampling data distributions; the effects of averaging time, autocorrelation, multiple task jobs and limit of detection samples on the sampling distribution; the use of linear models to examine between and within worker variability in exposure; the determination of homogeneous exposure groups; the development of multiple regression models to predict exposure levels and evaluate exposure determinants; and methods of model development, interpretation and validation.

PUBH.6131 Design and Evaluation Of Ventilation Systems (Formerly 19.613) - Credits: 3

A seminar intended for students pursuing research involving industrial ventilation system design and evaluation. It covers material not included in 19.518, such as recent theoretical models which describe system performance, design of systems for high-temperature operation, trouble-shooting techniques, and advanced instrumentation techniques. Course consists of lectures and laboratory sessions.

PUBH.6140 Evaluation of Work Environment Hazards (Formerly 19.614) - Credits: 3

This course provides the work environment professional with a systematic method of evaluating chemical, ergonomics and work organizational hazards in the field. Basic industrial processes and their potential hazards are reviewed. Approaches for evaluation of indoor air quality are covered. Worksite surveys of hazards and control technologies and the evaluation of existing health and safety programs are implemented through a series of workplace walkthrough visits in a variety of industries. Team work skills are developed and utilized to produce professional final reports and presentations that cover rankings of worksite hazards and recommendations.

PUBH.6150 Solutions for Work Environment Hazards (Formerly 19.615) - Credits: 3

Techniques for controlling exposure to airborne contaminants. Basic controls include substitution, ventilation, isolation, administrative controls, and personal protective equipment. Special focus is placed on Toxic Use Reduction (TUR) and Pollution Prevention strategies.

PUBH.6160 Law and Ethics in Healthcare (Formerly 32.616) - Credits: 3

This course presents an overview of legal and ethical issues facing managers and providers in health care. It provides students with a foundation of health law and ethics and reviews health care legal and ethical situations and dilemmas. The goals are to provide students with practical knowledge of
health law and ethics and their application to the real world of health care.

PUBH.6161 Exposure and Risk Assessment (Formerly 19.616) - Credits: 3

This course covers quantitative and qualitative approaches to the development of sampling strategies. Statistical considerations in the quantification of occupational exposures are covered. Assessment of dermal exposures and the use of biomarkers for exposure assessment are also a focus of this class. An introduction to the methods of risk assessment will also be covered.

PUBH.6191 Measurement of Chemical Exposure (Formerly 19.619) - Credits: 3

Basic properties of airborne particles, with particular regard to properties important to health. Sampling and analysis methods used in the evaluation of occupational exposures to aerosols, gases, vapors. Direct reading instrumentation, calibration and data processing. Integrated sampling methods and chemical analysis of organic and inorganic compounds will be covered in class and lab.

PUBH.6200 Advanced Exposure Assessment (Formerly 19.620) - Credits: 3

An advanced seminar covering exposure assessment for studies of acute and chronic respiratory disease, pharmacologic modeling for exposure assessment and the design of models to evaluate the role of production process factors in determining workplace airborne exposures. The course assumes a prior background in epidemiology and biostatistics as well as industrial hygiene and toxicology.

PUBH.6210 Nanomaterials: Exposure, Health and Safety (Formerly 19.621) - Credits: 3

This course presents a comprehensive overview of environmental health and safety issues of nanotechnology, with focus on biologically based exposure assessment and control. Methods based on biology, toxicology, and knowledge of disease mechanisms are presented for identifying and quantifying nanoscale materials exposures found in occupational/environmental setting and consumer products and for designing exposure assessments for the study of health effects. This course is needed to fill a gap in the current curriculum offerings and to assist the various researchers in understanding possible risks associated with diverse nanotechnologies. The course will include introductory lectures, paper critiques, and laboratory sessions.

PUBH.6220 Biomarkers in Occupations and Environment (Formerly 19.622) - Credits: 3

PUBH.6230 Skin Exposure to Chemicals (Formerly 19.623) - Credits: 3

This new course, the only of its kind in the occupational & environmental hygiene program in the country, will discuss the significance of occupational environmental and household skin exposure to chemicals, skin exposure assessment and regulatory aspects. The course will address important topics, such as physiology and metabolism of normal skin, skin absorption of a variety of chemicals, including solids and nanomaterials, factors affecting skin permeation, permeability of compromised skin barrier integrity, skin sampling methods, skin-lung interactions and prevention of skin exposure, through a mix of didactic presentations and critical discussion of the scientific peer-reviewed literature. Each session will start with a presentation on the topic, followed by guided discussions of realistic, but provocative, scenarios. As laboratory space and instrumentation becomes available in the near future, a laboratory component will be added to the course to emphasize major sampling techniques and illustrate/visualize skin permeation of chemicals.

PUBH.6250 Health Policy (Formerly 32.625) - Credits: 3

This course provides students with a basic framework for health policy analysis and examines major aspects of U.S. health policy. Detailed consideration and discussion focus on the relationship of national policy to the planning, implementation and funding of healthcare services. The course covers topics such as the healthcare policy environment in the U.S., government-funded healthcare through Medicaid and Medicare, and the Massachusetts healthcare reform.

PUBH.6260 Leadership in Healthcare (Formerly 32.626) - Credits: 3

The purpose of this course is to encourage students to carefully analyze their leadership style and skills within the context of health care. The course includes the study and application of leadership theories, concepts, and skills. Students will also assess their own leadership potential through the completion of readings, personal and leadership self-assessments, values exploration, and leadership skill exercises.

PUBH.6270 Socioeconomic Inequalities in Health (Formerly 32.627) - Credits: 3

The course explores the relationship between social and economic justice and public health. Focusing primarily on the U.S., the forces that either establish and exacerbate or prevent socioeconomic inequities will be analyzed to understand the intricate links between social, behavioral, physical, and
biological determinants of health. Several theoretical orientations will be reviewed in order to better understand how each frames research and public health strategies that have been used to address health inequalities. Students will be able to competently articulate the relationships between social and health inequalities. They will be able to explain the strengths and limitations of different theoretical orientations to these issues and frame the policy needs to positively reduce health disparities.

PUBH.6320 Health Information System Design and Analysis (Formerly 32.632) - Credits: 3

This course introduces students to the health information system lifecycle. Students take a detailed look at the process of system planning, analysis, design, and implementation. Concepts are taught in a manner that applies to any discipline within the health organization and provides a practical understanding of the steps necessary for successful systems delivery and its importance to organization success. Skills learned will enable students to work effectively with and support the information systems planning effort to ensure better system alignment with information services, clinical and administrative objectives.

PUBH.6321 Advanced Biomechanics (Formerly 19.632) - Credits: 3

A course in advanced biomechanical modeling methods, covering three dimensional static models, optimization methods and dynamic models. Special emphasis will be placed on biomechanical models of the hand. Time will also be dedicated to reviewing current developments in the scientific literature.

PUBH.6330 Healthcare Database Design (Formerly 32.633) - Credits: 3

A practical approach to the design, and development of a relational database with an emphasis on healthcare. Analyzing the requirements of the database proceeds to the design of the structure of the relational database, which is then developed in a Relational Database Management System (RDBMS). Microsoft Access is used as the RDBMS platform.

PUBH.6350 Healthcare Project Management (Formerly 32.635) - Credits: 3

This is a graduate level course providing a comprehensive foundation for project management as it applies to healthcare. Students will be introduced to the theory and concepts of project management and the tools to manage projects with a focus on healthcare. At the end of this course, students should be able to develop, execute, and control a basic project plan that is capable of supporting organizational objectives linked to measures of success for a single project.

PUBH.6380 Health Information Technology Strategic Planning (Health Information Technology) (Formerly 32.638) - Credits: 3

A graduate-level course introducing healthcare professionals to strategic planning for the information systems organization. The concepts are taught in a manner that allows the skills learned to be applied to any discipline with the organization. The course is designed to give healthcare professional a practical understanding of strategic planning and its importance to a successful organization. Skills learned in this course will enable the student to work effectively with and support the information systems planning effort in order to ensure better IS, clinical and business alignment.

PUBH.6381 Methods In Work Analysis (Formerly 19.638) - Credits: 3

Criteria for selection of an approach to ergonomic job analysis depend on the combination of exposures (micro- and macro-level ergonomic stressors) observed to be present as well as the analytical goal. Many ergonomic analysis techniques are based on traditional industrial engineering approaches (time-motion study and work sampling), applied to the identification and evaluation of potential risks to workers' health. A variety of methods, both observational and instrumentational, will be discussed; laboratory sessions will permit hands-on application of several of these for critical evaluation.

PUBH.6390 Electronic Health Record Systems (Formerly 32.639) - Credits: 3

The course addresses Electronic Health Records (EHR) integration with patient care flow, clinical decision making and patient engagement, as well as patient registries and clinical quality reporting. Students also learn core EHR functions, strategies for EHR optimization, and how the EHR can be leveraged for population health management. The course uses industry-leading EHR software as a learning tool to demonstrate how electronic health record technologies are used in a healthcare setting.

PUBH.6400 Macroergonomics: A comprehensive approach to Job and Organizational Design (Formerly 19.640) - Credits: 3

The purpose of this course is to introduce students to the Macroergonomics field. Macroergonomics, also known as the third generation of ergonomics, is a top-down sociotechnical systems approach to the design of organizations, work systems,
and jobs. The goal of macroergonomics is a fully harmonized work system at both the macro- and micro-ergonomic level which results in improved productivity, job satisfaction, health and safety, and employee commitment.

**PUBH.6430 Health Work Organization Design**  
(Formerly 19.643) - Credits: 3

Rationales for prevention; determinant of job change feasibility, classic and alternative work organization theories, alternative productivity conceptions, health and growth assessment strategies, conducive work processes, work-group based re-design processes, communicative and network-oriented processes, organization-level change process, product redesign, occupational and political strategic issues.

**PUBH.6510 Work Environment Policy**  
(Formerly 19.651) - Credits: 3

This course provides an overview of occupational safety and health policy in the U.S. It focuses on the legal context, especially on OSHA, but also provides an analytical framework for examining the role of social, economic and political factors in the recognition and control of occupational hazards.

**PUBH.6540 Work, Technology and Training**  
(Formerly 19.654) - Credits: 3

This course examines the broader issues of the impact of technology on the work environment and on workers. Topics include technology and craft work, Taylorism and the development of mass production methods, labor in the "factory of the future", skill-based automation, shop floor programming, and other issues in technology policy. The course is offered in collaboration with the Department of Regional Economic and Social Development as 57.503.

**PUBH.6550 Introduction to Environmental and Natural Resource Economics**  
(Formerly 19.655) - Credits: 3

This course introduces students to the economic and policy aspects of environmental quality and natural resource issues. The course also incorporates relevant work-environment related issues. Simple and complex models are used to blend economic theory with environmental facts. Students will learn to derive policy insights form theoretical constructs. The primary objective is to show how the basic principles in economics can play a valuable role in analyzing and evaluating critical environmental issues and help in determining policy guidelines. Standard benefit cost of efficiency criteria will be applied to a wide variety of environmental, work-environment and natural resource problems. In attempting to do so we shall also emphasize how difficult it is to model actual environmental problems in the real world, We shall draw upon the basic tools of environmental and health economics to discuss current policy issues and questions that policy makers confront in practice. Graduate students in work environment will be required to do an economic analysis of an occupational health and safety intervention.

**PUBH.6580 Clean Product Design**  
(Formerly 19.658) - Credits: 3

This advanced seminar will provide an introduction to clean product design and management which includes the use of lifecycle thinking, eco-design concepts, materials analysis, inherent product safety, recycling and reuse, produce take back, and design for the environment. As background, the seminar will cover renewable resources, bio-based materials and green chemistry solutions and conclude with a consideration of new forms of sustainable consumption.

**PUBH.6590 Cleaner Production**  
(Formerly 19.659) - Credits: 3

This course will explore the rapidly expanding developments in cleaner production methods and policies. The course will focus on new directions in environmentally conscious manufacturing and product design in Europe. The subject will cover topics ranging from European demonstration projects, environmental auditing, cleaner technology assessment, eco-efficiency models, water and energy conservation, sustainable product design, eco-design and life cycle assessment, product take-back and extended product life, full cost accounting, industrial ecology, environmental management systems and ISO 14000. Special emphasis will be given to new information data sources and an introduction to new cleaner production methods software.

**PUBH.6660 MPH Practicum**  
(Formerly PUBH.666) - Credits: 3

This practicum is the first of two culminating experiences in the MPH program that requires a student to apply theories and principles from coursework in a public health setting. The practicum is a planned, supervised and evaluated practice experience under the supervision of a qualified preceptor. Students meet in a seminar with a faculty member who oversees the practicum experience. Students will finish work on their final applied practice project during the practicum and integrated practical learning courses.

**PUBH.6670 Integrated Practical Learning**  
(Formerly PUBH.667) - Credits: 3

This course is designed as the second of two applied learning courses following PUBH.6660 MPH Practicum. It is a culminating experience for students in the MPH program.
Students in this course will demonstrate the mastery of a body of public health knowledge and achievement of the MPH competencies. They will do this through completing their practicum experience and developing a high-quality written product.

**PUBH.6750 Introduction to Manuscript Writing**
(Formerly 19.675) - Credits: 3

This course helps doctoral students (and high-level master’s students) gain knowledge and critical practical skills in scientific writing and oral communication in public health. This includes writing dissertation proposals, dissertations, grant applications, scientific meeting abstracts, scientific manuscripts, factsheets, and presenting to scientific and non-scientific audiences. Specific content area includes study design and methodology, the structure of scientific documents, literature review, and communication strategies. Specific attention will be given to effective scientific writing and to guiding principles for ethical research.

**PUBH.6760 Introduction to Proposal Writing**
(Formerly 19.676) - Credits: 1

This seminar will cover the basics of how to write a thesis proposal or grant application. Participants will bring an idea for a project and, if possible, an outline or draft of a proposal to be developed further with peer and instructor feedback.

**PUBH.6800 Introduction To SAS**
(Formerly 19.680) - Credits: 0-1

This course is designed for researchers who will be doing data analysis using SAS. No prior programming experience is necessary, though familiarity with and general experience in use of a PC (DOS and Windows) is required. The course covers topics including: basics of SAS, reading raw data and existing SAS data sets, modifying data, combining data sets, basic statistical procedures, sorting, summarizing, and printing data. "Variable credit course, student chooses appropriate amount of credits when registering.".

**PUBH.6820 Applied Epidemiology Methods**
(Formerly 19.682) - Credits: 3

This course emphasizes the design and conduct of epidemiology studies. Major topics covered include: casual inference in epidemiology, point and interval estimation for cohort and case control studies, exposure assessment for epidemiology, control of confounding, the identification and interpretation of effect modification, as well as cross-sectional designs and meta-analysis.

**PUBH.6830 Risk Assessment**
(Formerly 19.683) - Credits: 3

This course will review both the methods and policy implications of risk assessment in the development of occupational and environmental standards. Students will conduct risk assessments on real problems, and study important cases in which these methods have been used in setting public policy.

**PUBH.6840 Musculoskeletal Epidemiology**
(Formerly 19.684) - Credits: 3

An advanced course on methods and content of research on work-related musculoskeletal disorders. Reviews pathophysiology, diagnosis, prevalence, latency and surveillance issues. The key literature is examined with attention to study design, quality of exposure assessment, control of bias and adequacy of statistical analysis.

**PUBH.6850 Applied Public Health Research and Practice**
- Credits: 3

The focus of this course is to provide students with advanced skills necessary to collect quantitative and qualitative data for public health research and practice. Students will learn quantitative methods including questionnaire development, survey planning, data collection, data coding and data management. The course will prepare students to design, conduct, analyze and interpret qualitative research. Strategies for mixed methods research in social and behavioral sciences will be discussed.

**PUBH.6860 Program Development and Implementation**
- Credits: 3

This course is designed to equip students with the knowledge and skills necessary to systematically develop and implement public health programs. Models for program planning are utilized to inform program design. In addition to didactic work, students are guided through the creation of a program and implementation strategies to accelerate the translation of evidence into practice.

**PUBH.6870 Quantitative Models for Public Health**
- Credits: 3

This course introduces quantitative models commonly used in public health research and practice. Emphasis is placed on understanding the logic and underlying assumptions of theses models. Students will gain knowledge and skills in properly selecting and applying these models in various practical settings. Topics include probability sample surveys, quantitative risk assessment, quasi experimental design, propensity matching, interrupted time series, epidemics of
infectious diseases, Monte Carlo simulations, and predictive analytics.

PUBH.6871 Health Communication and Technology - Credits: 3

Students will explore the theories and practice of communication in public health, with a particular emphasis on the role of technology in sharing public health information. The impact of social and environmental factors on the success of health messages, and the relevance of social media and other technology to positively impact issues in population health will be analyzed. The strategic and ethical use of media in developing and implementing effective public health communications is a focus of the course. The targeting of health communication campaigns to populations for the purpose of influencing behaviors and health policy will be examined.

PUBH.6890 Advanced Regression Modeling
(Formerly 19.689) - Credits: 3

This course will introduce linear, generalized linear and time-to-event regression models that are commonly used in epidemiologic research, community needs assessment and public health program/policy evaluations. Topics include regression models for continuous, binary, ordinal, multinomial, count, time-to-event, and longitudinal data.

PUBH.6900 Critical Review Health Regulations
(Formerly 19.690) - Credits: 3

Course designed to explore the practical applications of epidemiologic methods to the setting of actual standards. Students gain experience in distinguishing minor from major design and analysis flaws. Course is presented as a seminar with four case studies and problem analysis.

PUBH.6950 Chemical Process/Sustainability
(Formerly 19.695) - Credits: 3

This course surveys the basis of chemical engineering process design and fundamentals of unit operations. The student will be able to understand the basics of chemical engineering design methods for the purpose of enhancing sustainability of chemical production processes.

PUBH.7020 Independent Study: Industrial Hygiene
(Formerly 19.702) - Credits: 1

Advanced topics in industrial hygiene, exposure assessment or exposure control not offered in the regular curriculum. Topics may vary from year to year.

PUBH.7040 Independent Study: Ergonomics
(Formerly 19.704) - Credits: 1

Advanced topics in biomechanics, work physiology, occupational safety or human factors not covered in the regular curriculum. Content may vary from year to year.

PUBH.7080 Independent Study: Epidemiology
(Formerly 19.708) - Credits: 1

Advanced topics in occupational epidemiology, design and confounding, exposure-response modeling, or surveillance not covered in the regular curriculum. Content may vary from year to year.

PUBH.7090 Independent Studies: Occupational Epidemiology
(Formerly 19.709) - Credits: 1

Advanced topics in occupational epidemiology, design and confounding, exposure-response modeling, or surveillance not covered in the regular curriculum. Content may vary from year to year.

PUBH.7110 Independent Study: Industrial Hygiene
(Formerly 19.711) - Credits: 1-3

Advanced topics in industrial hygiene, exposure assessment or exposure control not offered in the regular curriculum. Topics may vary from year to year.

PUBH.7120 Independent Study: Industrial Hygiene
(Formerly 19.712) - Credits: 1-3

Advanced topics in industrial hygiene, exposure assessment or exposure control not offered in the regular curriculum. Topics may vary from year to year.

PUBH.7130 Independent Study: Ergonomics (Formerly 19.713) - Credits: 3

Advanced topics in biomechanics, work physiology, occupational safety or human factors not covered in the regular curriculum. Content may vary from year to year.

PUBH.7150 Independent Study: Work Environment Policy
(Formerly 19.715) - Credits: 3

Advanced topics in work environment policy, risk perception, risk communication and management, regulatory affairs or labor-management programs not covered in the regular curriculum. Content may vary from year to year.
PUBH.7170 Independent Study: Epidemiology (Formerly 19.717) - Credits: 3
Advanced topics in occupational epidemiology, design and confounding, exposure-response modeling, or surveillance not covered in the regular curriculum. Content may vary from year to year.

PUBH.7190 Independent Study: Clean Production (Formerly 19.719) - Credits: 3
Advanced topics in clean production, pollution prevention, and environmental protection efforts. Not offered in the regular curriculum. Topics may vary from year to year.

PUBH.7210 Selected Topics: Industrial Hygiene (Formerly 19.721) - Credits: 1-3
PUBH.7230 Selected Topics: Ergonomics (Formerly 19.723) - Credits: 3
PUBH.7250 Epidemiologic Theory (Formerly 19.725) - Credits: 1-3
An advanced seminar in epidemiologic theory. The goal of the course is to develop each student’s own theoretical perspective on the field to ground practical problems of study design and analysis. Students read a major text in modern chronic disease epidemiology as well as relevant papers, and discuss and evaluate the perspectives of different authors. Topics include: causality, study designs, measures of disease frequency, measures of association, statistical inference, biases, and confounding.

PUBH.7270 Sel Top: Epidemiology (Formerly 19.727) - Credits: 3
PUBH.7280 Sel Top: Work Env Policy (Formerly 19.728) - Credits: 3
PUBH.7290 Selected Topics: Clean Production (Formerly 19.729) - Credits: 3
PUBH.7330 Capstone Project (Formerly 32.733) - Credits: 3
Near the end of one’s Master’s Degree program, students register for Capstone Project and complete a real world case study report and presentation. The Capstone Project applies concepts and skills learned in the program. It involves research and development, and culminates in a substantial business-type report. 3 credits, Requires Instructor Permission.

PUBH.7331 Graduate Project (Formerly 19.733) - Credits: 3
Advanced research project required of all master’s degree candidates in the ergonomics, industrial hygiene, occupational epidemiology and work environment policy concentrations.

PUBH.7350 Independent Study: Policy (Formerly 19.735) - Credits: 3
PUBH.7360 Graduate Project - Work Environment (Formerly 19.736) - Credits: 6
PUBH.7370 Independent Study: Epidemiology (Formerly 19.737) - Credits: 3
PUBH.7390 Graduate Project - Work Environment (Formerly 19.739) - Credits: 9
Advanced research project required of all master’s degree candidates in the ergonomics, industrial hygiene, occupational epidemiology and work environment policy concentrations.

PUBH.7430 Master’s Thesis Research (Formerly 19.743) - Credits: 3
PUBH.7590 Doctoral Dissertation (Formerly 19.759) - Credits: 1-9
Faculty supervision of doctoral dissertation.

PUBH.7610 1-Credit Continued Graduate Research (Formerly 19.761) - Credits: 1
1-Credit Continued Graduate Research course is for students with less than one year to defend or complete program. Part of reduce course load program for international students.

PUBH.7630 Continued Graduate Research (Formerly 19.763) - Credits: 3
PUBH.7700 Directed Readings: Epidemiology Biostatistics (Formerly 19.770 - Credits: 3
PUBH.7750 Capstone/Thesis Review (Formerly 32.775) - Credits: 1
PUBH.7760 Curricular Practical Training (CPT) (Formerly 32.776) - Credits: 0-1
An internship, practicum or other type of employment that is either required by the students academic program or an experience for which a student receives academic credit. To be eligible the student must be in legal F-1 status and have been enrolled full-time for one academic year. CPT work experience
must be in the students field of study and contain a curricular component. “Variable credit course, student chooses appropriate amount of credits when registering.”

PUBH.9990 Intercampus Graduate Research (Formerly 19.999) - Credits: 0

This course will allow doctorate students to remain active while they are taking courses/research at the other UMASS campuses.
Master of Science in Nursing

The UMass Lowell School of Nursing offers a master’s program in nursing that emphasizes depth of knowledge and excellence in nursing in two areas of specialization: Adult-Gerontological Nursing and Family Health Nursing.

- Description of Program
- Program Outcomes
- Admission and Degree Requirements
- Degree Pathway
- Areas of Specialization

Description of Program

The objectives of the masters program curriculum are to provide advanced practice nursing education which focuses on:

1. Health promotion of individuals, families and groups from diverse populations;
2. Management of health problems in collaboration with client, families, and health professionals;
3. Leadership in the profession; and

The graduate program is designed for a four-semester, two-calendar year schedule, although part-time study is possible. Within each major area of specialization all students are prepared with knowledge and skills necessary for leadership in a variety of settings. Methods of inquiry, research and scholarly techniques are integral parts of the curriculum.

Program Outcomes

The masters degree program educates graduates who are prepared to:

1. Practice in the advanced nursing role of the specialty
2. Collaborate with clients, peers, and other health professionals
3. Demonstrate leadership in the profession

Admission and Degree Requirements

Requirements for the master’s program are:

- A baccalaureate degree with a major in nursing from an accredited program,
- An undergraduate scholastic average of 3.0 or better,
- Official transcripts, from all of your previous degree coursework (Associates and Bachelors in Nursing) as well as any completed or in progress graduate courses.
- An introductory course in statistics. Course grade must be on transcripts
- License to practice nursing in the Commonwealth of Massachusetts. Out of state RN licenses are accepted for application review, but all accepted students will need to obtain Massachusetts License prior to practicum courses.
- Experience working as an RN prior to enrolling in Advanced Health Assessment and subsequent Specialty courses.
- A resume, summarizing educational and professional nursing experience and any other related honors, special skills or certifications.
- Two letters of recommendation preferably from nursing faculty, supervisors or nurse leader in your organization. All recommendations should be sent to graduate admissions using the link and if addendum documents are attached they should be on hospital/school/agency letterhead and signed by the author of the recommendation. Recommendation should address your academic ability and professional qualifications as well as your potential for success in a graduate NP program.
- Written Statement: A goal statement that briefly highlights relevant work history and immediate and long term professional goals as an advanced-practice nurse. Goal statements should be congruent with the specialty tracks offered at UMass-Lowell (FNP or AGNP) and demonstrate an understanding of the scope of the advanced practice nurse in ambulatory, long term care settings.
- Computer literacy with WORD, email, internet searches and electronic learning platforms and programs.
- Completed application and fees.
- GREs are not required for the MS program
A minimum of 42 credits of course work is required for graduation with an MS for all students. A research project or a thesis is an option but not required for graduation.

Students may be admitted for part-time study. Part-time students must meet the same admission requirements for graduate study as full-time students. Part-time students will meet with their assigned advisor and plan a schedule for their program of studies. All admitted students are advised to contact their assigned advisors for program of study recommendations and to register for courses during University advisement periods (April and November).

Transfer of credits for non-matriculated students: The maximum number of credits that can be transferred from non-UMass Lowell programs is 6 credits. Prospective students can take up to an additional 6 credits from UMass Lowell prior to matriculation and can be applied to the MS degree.

Those taken at another accredited institution may be transferred if appropriate to the MS degree program in nursing and after approval by the faculty of record for the UMass Lowell course and the petition signed by the Graduate Coordinator. To quality for transfer, the course must have been taken within 5 years prior to the date of matriculation. Transfer of credits may not be granted for Advanced Health Assessment, Specialty Courses or Specialty Practicum courses.

Admission is competitive. Admission is competitive and only completed applications will be reviewed. It is the responsibility of the applicant to check their electronic admission file for completion of checklist items. Applications are accepted on a Rolling Admission basis for the Fall and Spring matriculation. Full-Time Students are generally admitted to the Fall Semester and can complete the degree in 2 years (4 semesters). Part-Time students can complete the degree in 3-5 years. Please seek advice from Lisa Marchand (Lisa_Marchand@uml.edu) Coordinator of the MS/NP program for appropriate courses to take as a non-matriculated student. Upon admission, these courses can be transferred via petition.

Additional Information

The following health and professional documentation is required upon admission: Current CPR certification, RN nursing license, required immunizations (or titers indicating immunity) influenza, Hepatitis B, MMR, Tdap, varicella, PPD; and recent health exam by health care provider. In addition, every student must be cleared by CORI (Criminal Offender Record Information). Students who cannot provide this information will be unable to complete required clinical practicum.

Degree Pathway for Master of Science in Nursing Advanced Practice Registered Nurse (full time option*)

Areas of Specializations:

Adult-Gerontological Nursing
This specialty focuses on promoting health of young adults age 13 and up, adults and older adults during the process of normal aging and identifying and treating common health problems. Students develop advanced skills in communicating with young adults, adults and older adults, health assessment, health teaching and nursing intervention and evaluation. Students are prepared as nurse practitioners and eligible to sit for the adult gerontological primary care nurse practitioner certification exam.

Family Health Nursing
This specialty focuses on facilitating the health practices of families during the process of normal development and identifying and treating common health problems across the life span. Students develop advanced skills in communicating with families, health assessment, health teaching and nursing intervention and evaluation. Students are prepared as nurse practitioners and are eligible to sit for the family nurse practitioner certification exam.

Doctorate in Nursing Practice (DNP) Program

About the Program
Our DNP program educates advanced practice registered nurses and nurse leaders who seek to develop or expand their leadership roles in the health care system. With the knowledge and skills acquired through UML’s DNP program, our graduates will be prepared to propose solutions to improve patient care and health care outcomes. This is achieved through an interdisciplinary curriculum which provides nurses with knowledge and skills in evaluation research, health policy, organizational leadership and financing, evidence-based practice and health care informatics. Our DNP graduates will have a positive impact on the health care system by using an evidence-based approach to improve health care delivery.

By enriching our DNP program with content on cultural competency, DNP graduates are prepared to reduce health care disparities for culturally diverse and underserved populations. Our graduates will also have advocacy skills that are essential in influencing governmental and organizational policy decisions.

The DNP Program offers 4 pathways for the completion of the DNP degree:
**Post Baccalaureate DNP (BS-DNP)** - may be completed in 4 years full time, including summer semesters, or 5 years, part-time, including summer semesters. Courses are delivered in a hybrid format. Students choosing this option have up to 8 years to complete the requirements for graduation. The BS-DNP pathway offer 2 options: Adult-Gerontology Primary Care Nurse Practitioner (A-GPCNP) Family Nurse Practitioner (FNP).

**Post Master’s DNP (MS-DNP)** - may be completed in 3 academic years part time or 2 academic years full time. Courses are delivered in an online format with 5 on campus intensives. Students have up to 5 years to complete requirements for graduation.

**Fast Track BS-DNP** - GPA of 3.5 is required for applicants from UMass Lowell Solomont School of Nursing baccalaureate program. Applicants may transfer up to 12 credits from approved BS courses (5000 or higher) toward the DNP degree. Students who are completing their BS program in the spring are eligible to apply for the Fast Track BS-DNP option for admission in the following fall term. Courses are delivered in a hybrid format with online courses, some requiring 1 Saturday a month on campus. Students have up to 8 years to complete the requirements for graduation. The BS-DNP pathway offer 2 options in preparation: Adult-Gerontology Primary Care Nurse Practitioner (A-GPCNP) Family Nurse Practitioner (FNP).

**Fast Track MS-DNP** - GPA of 3.5 is required for applicants from UMass Lowell Solomont School of Nursingmaster’s program or students from universities with which UMass Lowell has an agreement. Applicants may transfer up to 6 credits from approved master’s courses toward the DNP degree. Students who are completing their master’s program in the spring are eligible to apply for the Fast Track Master’s DNP option from admission in the following fall term. Courses are delivered in an online format and students have up to 5 years to complete requirements for graduation.

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**See below for the:**

- **Doctor of Nursing Practice Scholarly Project**

**Post Baccalaureate Doctor of Nursing Practice Option (BS-DNP)**

**Specific application requirements include:**

- Program application and all required documents submitted through the Graduate Admissions office.
- A baccalaureate degree with a major in **Nursing** from an accredited program.
- An undergraduate scholastic average of 3.0 or better.
- Official transcripts, from all of previous degree coursework (Associates and Bachelors in Nursing) as well as any completed or in progress graduate courses.
- An introductory course in statistics. Course grade B (3.0 or better) must be on transcripts.
- License to practice nursing in the Commonwealth of Massachusetts. Out of state RN licenses are accepted for application review, but all accepted students will need to obtain Massachusetts License prior to practicum courses.
- Experience working as an RN prior to enrolling in Advanced Health Assessment and subsequent Specialty courses.
- A resume, summarizing educational and professional nursing experience and any other related honors, special skills or certifications.
- Two letters of recommendation preferably from nursing faculty, supervisors or nurse leader in your organization.
- A goal statement highlighting: relevant work history, immediate and long term professional goals as an advanced-practice nurse, and the reason you chose the BS-DNP Doctor of Nursing Practice degree option. Goal statements should be congruent with the specialty tacks offered at UMass-Lowell (FNP or AGNP) and demonstrate...
and understanding of the Doctor of Nursing Practice degree.

- Computer literacy with WORD, email, internet searches and electronic learning platforms and programs.
- Completed application and fees.
- An interview.

**Degree Pathway Information**


Post-Masters Doctorate of Nursing Practice Option (MS-DNP)

**Specific application requirements include:**

- Program application submitted to the Graduate Admissions office.
- MS in Nursing with APRN preparation with national certification as an APRN or board eligible for certification OR MS in Nursing with a current RN license.
- Prior official transcripts from undergraduate and graduate programs.
- Two letters of recommendation (one academic recommendation preferred).
- Interview with nursing faculty.
- Minimum cumulative GPA of 3.0 on a 4.0 scale in a nursing Masters degree program, 3.3 GPA preferred.
- Written narrative of professional goals.
- 500 Master’s or Post-Master’s practicum hours. Applicants who are not APRNs must provide evidence of practice hour equivalents from their master’s program or ANCC certification in their area of practice which affords 250 hours.
- Resume.
- TOEFL if appropriate.

**Specific Application Requirements include:**

- Application and all required documentation submitted through Graduate Admissions Office.
- Application fee being waived.
- Applicants must be in their final year of their BS program at UMass Lowell.
- A 3.5 or better GPA in the SSON BS program at the time of application, graduation and a acceptance will be conditional upon passing the NCLEX exam.
- Two letters of recommendation, one from faculty and one from current employer.
- A goal statement highlighting: relevant work history, immediate and long term professional goals as an advanced-practice nurse, and the reason you chose the Doctor of Nursing Practice degree option. Goal statements should be congruent with the specialty tracks offered at UMass-Lowell (FNP or AGNP) and demonstrate and understanding of the Doctor of Nursing Practice degree.
- An interview.

**MS-DNP Option (Fast track)**

**Specific Application Requirements include:**

- Program application submitted to the Graduate Admissions office.
Admissions office with the application fee being waived.

- Students must be in their final year of their MS NP program at UMass Lowell or a university with which UMass Lowell has a current agreement for Fast Track MS to DNP admission. Non-UMass Lowell students must submit official transcripts.
- The student must have maintained a 3.5 or better GPA in their masters program at the time of application and graduation.
  - Students must submit 2 letters of recommendation, one from faculty and one from current employer.
  - Students must submit a letter of purpose identifying immediate and long-term goals and a resume with evidence of working in a professional role.
  - Interview with UMass Lowell faculty.
  - Within six months of completing the masters NP program the student must show evidence of passing the national APRN certification exam and obtain a state license to practice as an APRN.
  - Up to 6 credits of approved graduate level courses (5000 or higher) which were awarded to the MS degree may be applied toward the DNP degree as long as a grade of B or higher was obtained in the courses.

Contact

Susan Parker (https://www.uml.edu/Health-Sciences/Nursing/faculty/parker-susan.aspx), DNP, APRN, GNP-BC, ACHPN
Phone: 978-934-4685

Doctor of Nursing Practice Scholarly Project

Criteria for DNP Project

Types of DNP Projects

DNP Scholarly Project Guidelines

DNP Proposal

Completing the DNP Project

The DNP scholarly project reflects the culmination of academic studies completed throughout the DNP program that demonstrates the ability of the student to effect positive change in a health care setting/arena through the careful synthesis of evidence as well as to evaluate the effectiveness of the change.

Criteria for the DNP Scholarly Project

The DNP Scholarly Project Should:

- Focus on a change that impacts healthcare outcomes either through direct or indirect care.
- Have a system (micro-, meso-, or macro-level) or population or aggregate focus.
- Demonstrate implementation in the appropriate arena or area of practice.
- Use a systematic approach and collect data using methods and tools that meet accepted standards.
- Be conducted according to ethical principles and is approved by UMass Lowell Institutional Review Board if applicable.
- Include a plan for sustainability (e.g. financial, systems, or political realities).
- Include an evaluation of processes and/or outcomes (formative or summative).
- Be disseminated to the appropriate audiences.

Types of DNP Scholarly Projects

Some examples of scholarly projects include, but are not limited to:

- Quality improvement projects to address gaps in practice.
- Evaluation of implementation of evidence-based practice guidelines.
- Development of models of care or programs.
- Evaluation of financial analyses to compare models of care.
- Analysis of policies related to health care practice.
- Development of inter-professional and/or intra-professional collaborative projects to implement policy or evaluate care models.
DNP Scholarly Projects Guidelines
Students choose a DNP Project Chair at the designated point in course work. The Chair, a UMass Lowell faculty member or emeritus with a terminal nursing degree, guides the student through the development to the conclusion of the project acting as the PI if an IRB is required at UML. A Community Mentor, who represents the health care setting, is selected by the student and the Chair, and is the third member of the DNP Scholarly Project Team. The UMass Lowell IRB may determine that the project is expedited or exempt. IRB status may be determined by the health care setting in which the project is conducted. Students are required to complete the DNP Scholarly Project Team Request Form (https://na2.docusign.net/Member/PowerFormSigning.aspx?PowerFormId=%20bc386b3-a7eb3-4b3c-99fa-4140365375c&envna2&acct1414feb7-5343-%204689-999f-c3b89141ef7&v2) (DocuSign).

DNP Proposal
The Scholarly Project Proposal must be approved by the Scholarly Project Team. A proposal hearing is required, and upon successful completion of the hearing, the DNP Scholarly Project is completed and signed.

DNP Scholarly Project Proposal Approval Form (https://na2.docusign.net/Member/PowerFormSigning.aspx?PowerFormId=%2014274354-a446-42c3-a84c-b1ce6c969c14&envna2&acct1414feb7-5343-%204689-999f-c3b89141ef7&v2) (DocuSign).

Oral Presentation
Students are required to present a final oral presentation of their DNP Scholarly Project. Upon successful completion of the presentation the student's DNP Project is approved and the DNP Scholarly Project Approval is signed.

DNP Scholarly Project Approval Form (https://na2.docusign.net/Member/PowerFormSigning.aspx?PowerFormId=%2030d20acc-a3bc-476d-9cd6-d07b0d187dff&envna2&acct1414feb7-5343-%204689-999f-c3b89141ef7&v2) (DocuSign).

Completion of the DNP Scholarly Project
Students are required to complete all course work, present a final oral presentation, prepare a manuscript of publishable quality, disseminate the project through an approved means, and complete their portfolio. The Project Approval Form is completed and signed.

DNP Project Paper Approval Form (https://na2.docusign.net/Member/PowerFormSigning.aspx?PowerFormId=%20b341d381-98dd-45f8-8a1f-0fb64652db89&envna2&acct1414feb7-5343-%204689-999f-c3b89141ef7&v2) (DocuSign).

Stop Out Procedure
Students accepted into DNP Program who elect to stop out of the BS-to-DNP Program and earn a master's degree have one of two options:

1. The student who has earned 60 credits which includes successful completion of all 5000 and 6000 level courses, and NURS.7170 (https://www.uml.edu/catalog/courses/NURS/7170), NURS.7700 (https://www.uml.edu/catalog/courses/NURS/7700), NURS.7740 (https://www.uml.edu/catalog/courses/NURS/7740) and NURS.7710 (https://www.uml.edu/catalog/courses/NURS/7710) with at least a B, may petition to earn a master's degree and graduate from the university. This student must be in good standing and have a GPA of at least 3.0 with no more than 6 credits below a B (3.00). The student who wishes to return to complete the DNP Degree must reapply, however, if it is within 3 semesters, only a new application form and statement of purpose are needed. Students may be readmitted on a space available basis. Graduating students must complete the clearance process at the Registrar's Office. All graduate courses whether taken for

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**Notes:**

- DNP Scholarly Projects Guidelines
- DNP Proposal
- Oral Presentation
- Completion of the DNP Scholarly Project
- Stop Out Procedure

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**Related Links:**

- DNP Scholarly Project Team Request Form
- DNP Proposal Approval Form
- Oral Presentation Approval Form
- DNP Project Paper Approval Form
- Stop Out Procedure
the doctoral program or as part of the master’s degree will be included in the point average and listed on the student’s transcript.

2. The student with less than the 60 credits completed of the required courses who wishes to stop out with a master’s degree, may petition to drop down to the master’s program on a space available basis in the master’s program. This student must have an earned GPA of at least a 3.0, be in good standing with GPA attainment as indicated above. The student who wishes to return to complete the DNP degree must reapply. Students may be readmitted on a space available basis.
NURS.5220 Independent Study Health Promotion
(Formerly 33.522) - Credits: 1-3
Health Promotion gerontological clinical practicum is designed to be taken as a co-requisite to 33:611 Gerontological Nursing II didactic, in which the student focuses on comprehensive assessment and diagnosis of health problems in older adults with complex, multi-system health issues. Students utilize evidence-based research to design, implement and evaluate intervention strategies to promote optimum functioning and wellness. Pharmacological and complementary therapies are applied. Client teaching is included.

NURS.5520 Social, Cultural and Policy Issues in Health Care (Formerly 33.552) - Credits: 3
This course links health and illness to other central domains of life: gender, kinship, and culture within the context of the family, community and the current health care system. It draws on concepts from the social, health, and policy sciences to critically examine factors relating to health and health-seeking behaviors across the life course. Ethical dimensions of health policy formation and implementation are analyzed.

NURS.5530 Scholarly Writing - Credits: 2
This course provides an overview of, and introduction to the concepts and skills of scholarly writing as it pertains to scientific reports and papers. Course topics will include scientific literature searches, organizations of research papers and reports, ethical and authorship considerations, and steps in critiquing one’s own and others’ writing. Course objectives will be accomplished by reading and critiquing professional writing, creating original written work, and integrating feedback to improve work.

NURS.5540 Palliative and End of Life Nursing Care
(Formerly 33.554) - Credits: 3
Through didactic, discussion and field experiences, participants in this course explore research and theory related to death, dying, grief, bereavement, and end-of-life-care throughout the lifespan. Personal, professional, cultural, and ethical barriers and facilitators to the provision of palliative care will be examined using a holistic approach. Comfort and restorative care will be considered within the context of the family and the community in a variety of settings where palliative care is provided.

NURS.5580 Geropsychiatric and Mental Health Nursing (Formerly 33.558) - Credits: 3
The focus of this course is on the nursing care of older adults with psychiatric and mental health problems. This course promotes a holistic approach to mental health care of older adults within the community and long-term care setting. Nursing implications of psychopharmacology, behavioral, and complementary interventions will be discussed. Community resources for older adults with psychiatric and mental health problems will be explored.

NURS.5590 Advanced Pharmacology (Formerly 33.559) - Credits: 3
This nursing course focuses on clinical pharmacology and the mechanisms of drug action which determine therapeutic efficacy in clinical practice. Content includes basic pathophysiology, clinical pharmacology and monitoring parameters and standards of practice. Emphasis is given to implications of patient safety, patient diversity and patient teaching.

NURS.6000 Theoretical Foundations for Advanced Nursing Practice (Formerly 33.600) - Credits: 3
Course focuses on the analysis, critique, and application of theory as a basis for advanced practice nursing. Relationships among theories, research, and nursing practice are emphasized.

NURS.6010 Research for Evidence-Based Practice
(Formerly 33.601) - Credits: 3
Course focuses on the critique of research studies for the purpose of determining implications for evidence-based practice. The research process will be applied to researchable nursing problems. The role of frameworks, ethics, research designs, sampling theory, and measurement strategies are emphasized.

NURS.6020 Clinical Psychopharmacology
(Formerly 33.602) - Credits: 3
This survey course aims to educate advanced practice nurses for safe and effective prescribing practices in the treatment of psychiatric illnesses. The course utilizes a symptom management framework that integrates concepts from normative psychobiology with pathophysiology of the psychiatric diseases. From this perspective, emphasis is placed on gaining a fundamental understanding of the hypothesized compliment between the pathophysiologic basis of the disease state and mechanism of action of the drug treatment as a basis for rational selection of pharmacologic treatment. Current standards of practice and treatment algorithms are emphasized in helping the student to develop a working knowledge of psychopharmacology for the practice arena.

NURS.6040 Directed Study: Multiple Topic - Credits: 4
NURS.6100 Adult Gerontological Nursing I (Formerly 33.610) - Credits: 4
The focus of this course is on the advanced practice nursing role in the holistic assessment and management of health problems of the adult and older adult within a family and community context. Evidence-based strategies to prevent and treat common health problems and to maintain and promote health through the application of advanced knowledge, theory, relevant research and critical decision making are emphasized. Community resources, pharmacological therapies, and complementary strategies are addressed.

NURS.6110 Adult Gerontological Nursing II (Formerly 33.611) - Credits: 4
The focus of this course is on health promotion and biopsychosocial well-being of young, middle aged and older adults from diverse cultures. Utilizing current scientific research, physical/natural sciences, social sciences, and the humanities, implications for advanced nursing interventions and health policy are identified. Principles of pharmacology and pharmacological therapies, and complementary therapies are addressed.

NURS.6120 Adult/Gerontological Nursing III (Formerly 33.612) - Credits: 4
This capstone course builds on the adult/gerontological nursing curriculum of the previous three semesters. Issues related to health care policy and legislation relative to their impact on the role of the nurse practitioner within primary care are analyzed. Advanced knowledge of the management of complex health issues is integrated in nursing practice. Transition to the role of the advanced practice nurse is examined and actualized through an intensive, precepted, clinical experience.

NURS.6130 Adult Gerontological Nursing Practicum I (Formerly 33.613) - Credits: 3
This course focuses on comprehensive assessment and diagnosis of health problems in adults and older adults with complex, multi-system health issues. Students utilize evidence-based research to design, implement and evaluate intervention strategies to promote optimum functioning and wellness. Pharmacological and complementary therapies are applied. Group leadership, client and peer teaching are included.

NURS.6140 Adult-Gerontological Nursing Practicum II (Formerly 33.614) - Credits: 3
The focus of this course is on promotion of biopsychosocial well-being of adults and older adults through comprehensive assessment of health, the diagnosis of age-related changes and health problems, and the design, implementation and evaluation of pharmacologic and complementary intervention strategies. The application of scientific knowledge, theory and research findings to clinical practice is emphasized.

NURS.6500 Family and Adult-Gerontological Advanced Practice Nursing I - Credits: 4
Focus is on the advanced practice nursing role in the holistic assessment and management of health problems of the adolescent, adult, and older adults, within a family and community context. Evidence-based strategies are applied to the prevention, treatment, and management of acute and chronic health problems. Health promotion and maintenance are emphasized through the application of advanced knowledge, theory, research, and critical decision-making. Community resources, pharmacological therapies, and complementary strategies are integrated throughout the course.

NURS.6510 Advanced Health Assessment and Diagnostic Reasoning (Formerly 33.651) - Credits: 3
This course focuses on the development of advanced critical thinking and clinical judgment skills through comprehensive health assessment. Health promotion and health maintenance content, including relevant research findings are utilized to evaluate health status and to evaluate health risk among individuals and groups. Age, gender, and cultural variations in health and implications for advanced practice are included. Advanced practice health assessment skills are developed and refined.

NURS.6511 APRN Practicum 1 - Credits: 3
This course focuses on comprehensive assessment and diagnosis of health problems in adolescents, adults and older adults with complex, multisystem health issues. Students utilize evidence based research to design, implement, and evaluate intervention strategies to promote optimum functioning and wellness. The application of advanced knowledge, theory, relevant research, and critical decision making are emphasized. Pharmacological and complementary therapies are applied. Group leadership, client and peer teaching are included. Transition of the role of the advanced practice nurse is examined and actualized through an intensive, precepted clinical experience.

NURS.6512 APRN Practicum II - Credits: 3
This course focuses on comprehensive assessment and diagnosis of health problems in adolescents, adults and older adults with complex, multisystem health issues. Students utilize evidence based research to design, implement, and evaluate intervention strategies to promote optimum functioning and wellness. The application of advanced knowledge, theory, relevant research, and critical decision making are emphasized. Pharmacological and complementary therapies are applied. Group leadership, client and peer teaching are included. Transition of the role of the advanced practice nurse is examined and actualized through an intensive, precepted clinical experience.

NURS.6513 Family and Adult-Gerontological Advanced Practice Nursing II - Credits: 4
Focus is on the advanced practice nursing role in the holistic assessment and management of health problems of the adolescent, adult, and older adults, within a family and community context. Evidence-based strategies are applied to the prevention, treatment, and management of acute and chronic health problems. Health promotion and maintenance are emphasized through the application of advanced knowledge, theory, research, and critical decision-making. Community resources, pharmacological therapies, and complementary strategies are integrated throughout the course.
NURS.6513 APRN Practicum III - Credits: 3
Advanced knowledge of the management of complex health issues of individuals across the life span is integrated in advanced nursing practice. Transition to the role of the advanced practice nurse is examined and actualized through an intensive, precepted clinical experience.

NURS.6520 APRN Care of Adults - Credits: 3
Focus is on the advanced practice nursing role in the holistic assessment and management of health problems of the adolescent, adult, and older adult, within a family and community context. Evidence-based strategies are applied to the prevention, treatment, and management of acute and chronic health problems. Health promotion and maintenance are emphasized through the application of advanced knowledge, theory, research, and critical decision making. Community resources, pharmacological therapies, and complementary strategies are integrated throughout the course.

NURS.6521 APRN Care of Children and Adolescents - Credits: 3
This course focuses on the advanced practice nursing of children adolescents in the primary care setting. Health promotion, disease prevention, diagnosis and management principles are applied to alterations in health within a family and community context. Evidence-based strategies to prevent, assess, diagnose and treat common health problems are emphasized as the scientific foundation for independent practice. Additionally, this course emphasizes collaborative partnership development among individuals, families, and intra-professional teams.

NURS.6522 APRN Women's Health Across the Lifespan - Credits: 3
The focus of this course is on health promotion and management of common health issues pertaining to women, from menarche to older adulthood. Based on current scientific research, students will develop knowledge to assess, diagnose and manage alterations in health and develop holistic plans of care that address the health promotion, illness prevention, and primary care needs of women across the lifespan. Sociocultural and political factors that affect the health of women will be discussed.

NURS.6523 APRN Care of Older Adults - Credits: 3
Focus is on the advanced practice nurse in the holistic assessment and management of health problems of the adult and older adult in a family and community context. Evidence-based strategies to prevent and treat common health problems and to maintain and promote health through the application of advanced knowledge, theory, relevant research and critical decision making are emphasized. Community resources, pharmacological therapies and complementary strategies are addressed.

NURS.6524 APRN Role Transition - Credits: 1
This course builds on the APRN curriculum of the previous three semesters. Issues related to health care policy, legislation, transition to the APRN role, ethical and fiscal concepts relative to their impact on the role of the nurse practitioner are analyzed.

NURS.6600 Family Health Nursing I (Formerly 33.660) - Credits: 4
Focus is on the advanced practice-nursing role in the holistic assessment and management of health problems of the family across the lifespan within a family and community context. Evidence-based strategies to prevent and treat common health problems and to maintain and promote health through the application of advanced knowledge; theory, relevant research and critical decision-making are emphasized. Community resources, pharmacological therapies, and complementary strategies are addressed.

NURS.6610 Family Health Nursing II (Formerly 33.661) - Credits: 4
The focus of this course is on health promotion and management of common health issues pertaining to woman and to infants, children, and adolescents. Based on current scientific research, students develop skills in analyzing data, differential diagnosis, and developing holistic plans of care that address the health promotion, illness prevention, and primary care needs of a wide-variety of client populations.

NURS.6620 Family Health Nursing III (Formerly 33.662) - Credits: 4
This capstone course builds on the family nursing curriculum of the previous three semesters. Issues related to health care policy and legislation relative to their impact on the role of the nurse practitioner within primary care are analyzed. Advanced knowledge of the management of complex health issues is integrated into nursing practice. Transition to the role of the advanced practice nurse is examined and actualized through an intensive, precepted, clinical experience.

NURS.6630 Family Health Nursing Practicum I (Formerly 33.663) - Credits: 3
The focus of this course is on the advanced practice-nursing role in the holistic assessment and management of health
problems of the family across the lifespan within a family and community context. Evidence-based strategies to prevent and treat common health problems and to maintain and promote health through the application of advanced knowledge, theory, relevant research and critical decision-making are emphasized. Community resources, pharmacological therapies, and complementary strategies are addressed.

NURS.6640 Family Health Nursing Practicum II (Formerly 33.664) - Credits: 3
This course focuses on health promotion, illness prevention, and treatment through the comprehensive assessment and management of common health issues of infants, children, adolescents and women in the context of family and social environments. Application of theory, knowledge, and research findings to clinical practice is emphasized. The utilization of current clinical technologies is introduced.

NURS.6890 Scholarly Project/Capstone (Formerly 33.689) - Credits: 3
This capstone project affords the student the opportunity for further knowledge development in an area of interest and learning need. The faculty-guided experience involves the development of a scholarly project which may involve a number of options: a scholarly review of the literature in a specific area; development of clinical teaching materials related to some dimension of sleep and/or sleep disorders; or a translational research project whereby a body of current research is interpreted for application to practice. The project will be negotiated with the faculty of record to meet the objectives of the course.

NURS.7010 Philosophy of Science (Formerly 33.701) - Credits: 3
This course provides doctoral students in nursing with philosophical perspectives in science, the nature of knowledge and its development, nursing knowledge development and philosophical underpinning to theory development, methods in scientific inquiry.

NURS.7020 Theoretical Foundations of Health Promotion (Formerly 33.702) - Credits: 3
This course critically examines conceptual frameworks and theories of health promotion and health behavior. The content includes theoretical perspectives from multiple disciplinary perspectives including nursing, psychology, sociology, and public health. Health promotion orientations will include behavioral change and lifestyle modification, environmental enhancement and restructuring, and social ecological approaches.

NURS.7060 Measurement in Health & Behavioral Research (Formerly 33.706) - Credits: 3
This course provides students with theoretical principles of measurement and design in health and behavioral research. The strategies, techniques, and issues in survey research, sampling methods, and the development and administration of survey instruments will be critically examined. Psychometric properties using standardized approaches to measurement will be analyzed. Students will be required to select an appropriate instrument and conduct a comprehensive psychometric evaluation of the instrument.

NURS.7070 Epidemiology of Health Promotion (Formerly 33.707) - Credits: 3
This course provides an in-depth exploration of the concepts and methods of epidemiological research. Students will critique the principles of epidemiology with an emphasis on health promotion research. Students will analyze and develop epidemiological approaches, which seek to promote health and prevent disease.

NURS.7130 Curriculum and Teaching In Nursing (Formerly 33.713) - Credits: 3
The focus of this course is on development, implementation, and evaluation of nursing curricula and academic courses. Contemporary theories of learning are applied to analysis of student learning needs, teaching strategies and educational methodologies. This course is intended for those nursing students post-MS or enrolled in doctoral study who wish to teach in the academic and/or practice environment. However, students in a MS program who are interested may register for the course with permission.

NURS.7150 Independent Study (Formerly 33.715) - Credits: 3
This independent study course is designed to enhance the international student’s verbal and writing skills in order to successfully integrate in a doctoral level program. The student will meet weekly with the course instructor in addition to participating in a formal communication and writing course for international students.

NURS.7160 Qualitative Methods (Formerly 33.716) - Credits: 3
The study of predominating qualitative methodology in the health sciences literature. Emphasis is on phenomenology, ethnography, life history/narrative, critical incidents, grounded theory, case study, and associated methodologies.
NURS.7170 Evaluation Research (Formerly 33.717) - Credits: 3
This course focuses on the basic concepts of evaluation research and their application to education, health and social programs. Specific design and analytic approaches that affect quality evaluation research will be reviewed. Students will design a mock evaluation study. Prerequisites: Completion of a graduate level research methods course.

NURS.7180 Directed Study (Formerly 33.718) - Credits: 1-4

NURS.7300 Quantitative Research Methods and Grantsmanship (Formerly 33.730) - Credits: 3
This course introduces students to strategies and methods in research including an analysis of theoretical and empirical links, operationalization of concepts, research design, and ethics in behavioral research. Students will identify appropriate funding sources and complete a research grant application.

NURS.7310 Health Promotion Research (Formerly 33.731) - Credits: 3
This course focuses on interdisciplinary health promotion research that targets diverse individuals, families, groups, and communities/society. Students will identify and analyze ethical issues, philosophical and conceptual underpinnings, measurement principles and major gaps in current knowledge in nursing and health promotion. Students will critique research approaches to health promotion studies and propose a research study in a topic relevant to health promotion.

NURS.7330 Graduate Project - Nursing (Formerly 33.733) - Credits: 3
Course focus is on application of the nursing research process. The student actively engages in at least two aspects of research under the guidance of a faculty mentor. The course product has practical implications for nursing practice.

NURS.7370 Advanced Qualitative Methods (Formerly 33.737) - Credits: 3
This course will focus on the in-depth historical and philosophical underpinnings of qualitative research. The student will examine and critique various analytic qualitative methods. The student will complete a project incorporating qualitative analysis using a qualitative software program.

NURS.7390 Mentored Research Experience (Formerly 33.739) - Credits: 3
In this course, students participate in a mentored research experience. Students actively contribute as a member of a research study that will contribute to scientific knowledge. Opportunities are provided for the application of research skills and the dissemination of research with an emphasis on an interdisciplinary approach. This course also includes a monthly seminar, which focuses on ethical underpinnings, cultural considerations and disparities in health research.

NURS.7430 Master’s Thesis - Nursing (Formerly 33.743) - Credits: 3
Course focus is on the application of the full research process to a topic relevant to nursing practice and/or health outcomes. The student is expected to propose, conduct and defend the study under the guidance of a designated faculty thesis committee.

NURS.7520 Independent Study - Credits: 9
Independent Study

NURS.7530 Doctoral Dissertation (Formerly 33.753) - Credits: 1-6
A structured series of sequenced seminars which guides students through dissertation proposal development, defense, collection and analysis of data. The first seminar concludes with the development of Chapters I and II of the dissertation; the second seminar concludes with defense of the proposal; and the third seminar culminates in the development of discussion and conclusions of the dissertation effort.

NURS.7560 Doctoral Dissertation (Formerly 33.756) - Credits: 6
A structured series of sequenced seminars which guides students through dissertation proposal development, defense, collection and analysis of data. The first seminar concludes with the development of Chapters I and II of the dissertation; the second seminar concludes with defense of the proposal; and the third seminar culminates in the development of discussion and conclusions of the dissertation effort.

NURS.7590 Doctoral Dissertation (Formerly 33.759) - Credits: 9
A structured series of sequenced seminars which guides students through dissertation proposal development, defense, collection and analysis of data. The first seminar concludes with the development of Chapters I and II of the dissertation; the second seminar concludes with defense of the proposal; and the third seminar culminates in the development of discussion and conclusions of the dissertation effort.
NURS.7610 Continued Grad Research (Formerly 33.761) - Credits: 1
Continued Grad Research

NURS.7630 Continued Graduate Research (Formerly 33.763) - Credits: 3
NURS.7690 Continued Graduate Research (Formerly 33.769) - Credits: 9
NURS.7700 Evidence Appraisal (Formerly 33.770) - Credits: 3

In this course, the student will explore the role of the DNP in evaluating evidence to inform practice. The student will also identify a critical issue or influential trend within the health care system that impacts health care delivery. Methods relevant to reviewing, analyzing, synthesizing, and applying evidence from the scientific literature will be discussed. Models of systematic reviews of the literature will be explored and implemented. Decisions will be made relative to the student’s topical area of interest and identification of the Scholarly Project Chair.

NURS.7710 Advanced Nursing Leadership and Management (Formerly 33.771) - Credits: 3

This course consists of a seminar and leadership experience. The seminar will explore the major concepts in leadership and management and their application in the health care setting. The role of DNP will also be discussed in terms of leadership in the health policy, education, and clinical settings. A leadership project will be completed by the end of the semester.

NURS.7720 Scholarly Project Implementation (Formerly 33.772) - Credits: 3

In this course, students will implement their DNP Projects according to DNP Scholarly Project guidelines. Building on the course work of previous semesters, students will share progress on their projects and discuss issues related to implementation. Course work will guide students through the phases of implementation and evaluation.

NURS.7730 Evidence Dissemination, Advocacy & Policy (Formerly 33.773) - Credits: 3

this course will include a weekly seminar. The students will complete the scholarly project by undertaking dissemination activities. The student will analyze policies influencing DNP practice and quality, cost, and access to health care and participate in the policy making process.

NURS.7740 Scholarly Project Design (Formerly 33.774) - Credits: 3

In this course, the student will design and present the Scholarly Project proposal. Students will meet biweekly with the scholarly project chair to develop the DNP scholarly project using knowledge acquired in previous course work. Students will complete a University of Massachusetts Lowell Institutional Review Board application that considers ethical and cultural issues related to the scholarly project.

NURS.7760 DNP Immersion - Credits: 3

This course focuses on the synthesis of advanced practice leadership and evidence-based practice by the DNP student in the health care specialty of their choice. In preparation for the translation of acquired knowledge to practice in the scholar practice role of the DNP, the student completes this practicum under the guidance and mentor-ship of faculty and a preceptor. The DNP student utilizes this opportunity to refine and incorporate evidence-based practice into the care and education of patients, families and other professionals. The DNP student will assume a leadership role in some aspect of the care and/or education provided in a specialty practice. Students will utilize core concepts from the DNP Essentials.

NURS.7770 Independent Study: Practicum in Nursing Education (Formerly 33.777) - Credits: 3

In this independent study practicum students will apply knowledge of curriculum and teaching in nursing in an educational setting under the mentorship of a nursing faculty member. Students will actively engage in curriculum development, evaluation and refinement, course preparation, classroom and clinical teaching, and student evaluation. The nurse educator role will be explored.

NURS.7930 Cooperative Education (Formerly 33.793) - Credits: 1
Kennedy College of Sciences

The UMass Lowell Kennedy College of Sciences fosters critical and creative thinking for future solutions to environmental, economic and human problems, while helping students to develop the capacity to respond to a changing world.

A wide range of ongoing research and project opportunities exist within the various degree programs, and interdisciplinary study is emphasized. Graduates of these programs are heavily recruited both regionally and nationally by industry and governmental agencies.

Faculty in the Kennedy College of Sciences
(https://www.uml.edu/Sciences/faculty-list.aspx)

NOTE: links to department catalog section at bottom of this page.

Graduate Programs Offered

Master of Science (MS) - degree awarded in the following fields:

- Bioinformatics Science
- Biotechnology Option
- Education, Communication and Outreach Option (This program does NOT lead to teaching licensure)
- Chemistry
- Computer Science
- Environmental Studies
- Atmospheric Sciences (Concentration)
- Marine Sciences and Technology
- Professional Science Master’s Option (Coastal and Ocean Administration, Science and Technology)
- Mathematics
- Applied Mathematics Option
- Mathematics for Teachers Option
- Probability and Statistics Option
- Scientific Computing Option
- Professional Science Master’s Option (Industrial Mathematics)
- Physics
- Optical Sciences Option
- Radiological Sciences and Protection

Professional Science Master’s Option (Radiological Protection)

Doctor of Philosophy (Ph.D.) - degree awarded in the following fields:

- Chemistry
  - Biochemistry Option
  - Environmental Studies Option
  - Green Chemistry Option
- Computer Science
  - Bio/Cheminformatics Option
  - Mathematical Science Option
- Earth System Science
- Marine Sciences and Technology
- Physics
  - Applied Mechanics Option
  - Atmospheric Sciences Option
  - Energy Engineering Option
  - Radiological Sciences Option
- Polymer Science
- Polymer Science/Plastics Engineering Option

Links to Department Sections in This Graduate Academic Catalog:

- Biological Sciences (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- Chemistry
- Computer Science
- Environmental, Earth & Atmospheric Sciences
- Marine Sciences and Technology (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
BIOL.5000 Professional Experience (Formerly 81.500) - Credits: 3

3 Credits will be given to individuals who present evidence of having at least one full year of current experience in an academic, hospital, or industrial laboratory setting, or in secondary school science teaching.

BIOL.5050L Bioinformatics - Credits: 4

There is a growing need for bioinformaticians in research and industry as datasets are getting bigger and more complex, making computational methods necessary for analysis. This hands-on course introduces principles, databases, software, and programming for the analysis and interpretation of molecular datasets. Emphasis is on practical assignments using computational approaches from a biologist’s perspective. Topics include genome assembly, variant detection, comparative genomics and transcriptomics, metagenomics, as well as data retrieval from databases and basic programming using Bash and R. A term project and computer-based exercises are designed to showcase the capabilities and limitations of bioinformatics tools used in genome research, as well as to develop skills in coding literacy.

BIOL.5062 Bioinformatic Tools in Sequence Analysis - Credits: 3

This hands-on course introduces databases, approaches, and software for the analysis and interpretation of molecular sequences. Practical assignments and a term project emphasize the application of computational approaches from a biologist’s perspective. Topics include genome assembly, transcriptomic analysis, and data retrieval from databases using both graphical user interfaces and basic computer programming using Bash and R. The class assignments are all computer-based exercises that are designed to showcase the capabilities and limitations of bioinformatics tools used in sequence analysis, as well as to develop skills in coding literacy.

BIOL.5062L Bioinformatic Tools in Sequence Analysis Lab - Credits: 1

This lab accompanies the Bioinformatic Tools in Sequence Analysis lecture, with hands-on practical assignments to achieve a firmer understanding of bioinformatics tools and principles. Assignments and a term project emphasize the application of computational approaches from a biologist’s perspective. Topics include genome assembly, transcriptomic analysis, and data retrieval from databases using both graphical user interfaces and basic computer programming using Bash and R. The class assignments are all computer-based exercises that are designed to showcase the capabilities and limitations of bioinformatics research and tools used in sequence analysis, as well as to develop skills in coding literacy.

BIOL.5072 Data Science for Biologists - Credits: 3

Like many other areas of science and business, biology is increasingly defined by increasing amounts of available data. The ability to analyze, visualize, and make inferences from this data will become increasingly valuable for future biologists. Data science can be defined as the intersection between computer science, applied statistics, and knowledge of the application domain—in this case, biology. In this class we will apply methods such as generalized linear models, multi-level models, unsupervised learning, and basic neural networks to biological problems. Hands-on activities using Python will give students experience with steps of data science project, including simulating, exploring, visualizing, drawing conclusions with statistics, and creating a reproducible analysis.

BIOL.5072L Data Science for Biologists - Credits: 1

Like many other areas of science and business, biology is increasingly defined by increasing amounts of available data. The ability to analyze, visualize, and make inferences from this data will become increasingly valuable for future biologists. Data science can be defined as the intersection between computer science, applied statistics, and knowledge of the application domain—in this case, biology. In this class we will apply methods such as generalized linear models, multi-level models, unsupervised learning, and basic neural networks to biological problems. Hands-on activities using Python will give students experience with steps of data science project, including simulating, exploring, visualizing, drawing conclusions with statistics, and creating a reproducible analysis.

BIOL.5080 Cell Biology for Teachers (Formerly 81.508) - Credits: 3

This online course will examine the structure and function of cells and the regulation of cellular processes characteristics of living organisms. Students will explore the complexity of the eukaryotic cell and gain an understanding of the mechanisms of cellular control and regulation. Course activities will make connections to state frameworks and national standards, and lead to the development of grade-appropriate curriculum materials for use in the elementary and middle school classroom. Class activities will include discussions, quizzes, lesson plans, web reviews, current events, and a final project.

BIOL.5090 Photobiology (Formerly 81.509) - Credits: 3

Biological process involving light in plants and animals. Topics include mechanisms of light absorption, energy transduction, light reactions in photosynthesis, functions of color in flowering plants, visual systems and structural and pigment coloration in animals, pigmentation in animals affecting camouflage and reproductive strategies. In addition, the
genetics involved in responses to light such as photoperiods, circadian rhythms, and seasonal cycles will be covered.

**Biol. 5170 Vertebrate Animals in Biological Research** (Formerly 81.517) - Credits: 3

Vertebrate Animals in Biological Research: History, Protocols, Regulations and Techniques is a lecture, discussion, and techniques-based course to cover the principles of vertebrate animal research in biology. This course covers topics ranging from the history of animal research, ethics, regulations, institutional compliance, experimental design, research techniques, disease models, and animal welfare during research. The course will involve literature review and discussions regarding all topics being covered as well as the creation of an IACUC protocol. The protocol will then be reviewed in a mock IACUC meeting. There will also be hands-on portions involving research techniques using training analogues and familiarization with animal research tools.

**Biol. 5190 Biochemistry I** (Formerly 81.519) - Credits: 3

Primarily for M.S. students in biological sciences. Lecture and text assignments on the subjects of protein, carbohydrate, lipid, enzyme and membrane biochemistry will be supplemented with research journal readings.

**Biol. 5200 Biochemistry II** (Formerly 81.520) - Credits: 3

This course will focus on protein dynamics where students will gain facility with thermodynamics of protein folding/misfolding, catalysis, kinetics and binding equilibria as they apply to proteins and other molecules in biological systems. The central theme of this course is that living systems can be understood in terms of the fundamental principles defining the structure and energetics of biological molecules. Attention will be given to quantitative aspects of enzyme kinetics and molecular binding. Examples of how these principles apply to the understanding and treatment of human disease will be discussed.

**Biol. 5210L Biochemistry Techniques** (Formerly 81.521) - Credits: 2

Biochemistry Required of M.S. students in the Biotechnology Option. Emphasis on common techniques and instrumentation employed in modern research laboratories.

**Biol. 5225 Advanced Topics in Biochemistry** - Credits: 2

This seminar course will focus on the detailed discussion of structure of proteins and other biological molecules, and how the structure determines the function of biological molecules. Students will be first introduced to each topic by the instructor through a short introductory lecture, then will be assigned to read an original research paper on the topic. During the next class, a group of preassigned students will present the paper to the class, followed by the class discussion of the paper. Students who are not presenting will be expected to read each paper before class, then ask questions and participate in the discussion of that paper during class.

**Biol. 5230 Biology of Global Change** (Formerly 81.523) - Credits: 3

Lectures deal with the patterns and processes of biological evolution. Covers the history of evolutionary thought, the evidence for evolution, the generation and maintenance of population-level variation, natural selection, adaptation, sexual selection, speciation, phylogenetics, molecular evolution, the fossil record and extinctions. In addition to lecture and textbook material, the course surveys classic and contemporary primary literature from evolutionary biology. A written paper and/or seminar presentation will be required.

**Biol. 5260 Evolutionary Biology** (Formerly 81.526) - Credits: 3

Lectures deal with the patterns and processes of biological evolution. Covers the history of evolutionary thought, the evidence for evolution, the generation and maintenance of population-level variation, natural selection, adaptation, sexual selection, speciation, phylogenetics, molecular evolution, the fossil record and extinctions. In addition to lecture and textbook material, the course surveys classic and contemporary primary literature from evolutionary biology. A written paper and/or seminar presentation will be required.

**Biol. 5280 Molecular Biotechnology: Recombinant Protein Production** (Formerly 81.528) - Credits: 3

Proteins are major targets of Pharmaceuticals, and are themselves increasingly used as therapeutics. However both basic research and the pharmaceutical industry depends on availability of purified proteins that are often difficult to isolate from native sources. This course will provide both didactic and hands-on instruction in recombinant protein purification. Furthermore, students will be introduced to some downstream applications such as crystallization screens and biochemical/biophysical studies. Student will choose a term project for oral and written presentation.

**Biol. 5290 Recombinant Protein Production Techniques** (Formerly 81.429 & 81.529) - Credits: 4

This course introduces students to the principles and practice of recombinant protein expression and purification’s. Proteins are major targets of pharmaceuticals, and are themselves increasingly used as therapeutics. However both basic research and pharmaceutical industry depends on availability of purified proteins that are often difficult to isolate from native sources. This course will provide both didactic and hands-on instruction in recombinant protein purification. Furthermore, students will be introduced to some downstream applications such as crystallization screens and biochemical/biophysical studies. Student will choose a term project for oral and written presentation.
laboratory instruction. It is comprised of a series of lecture and laboratory exercises, with an emphasis on practical techniques and hands-on experience of recombinant protein purification. The course will cover a variety of expression systems, including prokaryotic and eukaryotic cells, and address traditional and new methods in protein purification.

BIOL.5300 Cancer Genomics - Credits: 3

Cancer is usually the result of genetic alterations acquired over a lifetime that enable a tumor to grow and spread. As a result, each tumor is unique and involves a complex combination of mutations—a part of the reason that cancers can be so hard to treat. To better understand the characteristics of these diseases and discover appropriate treatments, institutions have comprehensively profiled the genomic changes across thousands of people’s tumors. That data is available for anyone with the right skills to analyze. In this class, we will delve into the world of the genomics of cancer, as a way to learn how cancers develop, how molecular profiling technologies generate data about these cancers, and how bioinformatics approaches can harness these data to gain insight and discover treatment.

BIOL.5320 Genomics (Formerly 81.532) - Credits: 3

This course surveys the field of genomics, examining current technologies and their biological applications. Lectures cover genome organization, genome sequencing and annotation, functional genomics, evolutionary genomics, transcriptomics, proteomics and the role of bioinformatics in organizing and interpreting genomic data. Students will be expected to submit written papers and to make oral presentations.

BIOL.5340L Genomics Laboratory (Formerly 81.534) - Credits: 1

A series of molecular laboratory and computer-based bioinformatics exercises providing practical experience in the collection and analysis of genomic-level data.

BIOL.5360 Behavioral Ecology - Credits: 3

Animals learn songs, practice agriculture, and craft tools. They build elaborate structures without a blueprint and migrate across the globe without a map. This course explores the mechanistic and evolutionary causes of animal behavior. A combination of lectures, discussions, and animal demos will introduce students to major themes in the field, while emphasizing experiments and ecological context as fundamental to the study of behavior. Students will discuss historic debates and emerging research on the evolution of exaggerated sexual ornaments and defensive structures, sensory bias, heritability of behavior, reciprocity & kinship, and the emergence of animal societies. By the end of the course, students will be able to interpret the behaviors of animals in the evolutionary framework.

BIOL.5370 Biology and Evolution of Arthropoda (Formerly 81.537) - Credits: 3

A detailed examination of phylum Arthropoda from developmental, ecological, genetic, morphological and paleontological perspectives. Specific topics include arthropod origins and relationships to proto-arthropods, the evolution of segmentation, and current perspectives on relationships within the phylum.

BIOL.5380 Advanced Genetic Analysis - Credits: 3

This course explores fundamental concepts in classical and molecular genetics. We will examine how studies in genetic model organisms (including budding yeast, Drosophila, and C. elegans) have yielded remarkable insight into a host of biological mechanisms, including cell-signaling pathways, animal development, and gene regulation. Special emphasis will be placed on how geneticists design and interpret their studies. The semester will cover strategies ranging from the classical (screens, selection, complementation, and conditional mutants) to the modern approaches enabled by the genomic revolution (genetic engineering, gene misexpression, and genome-wide association studies).

BIOL.5390L Biology and Evolution of Arthropoda (Formerly 81.539) - Credits: 1

An exploration of protoarthropod and arthropod diversity using live and preserved specimens of the major taxa including Tardigrada, Onychophora, Chelicerata, Crustacea, Myriapoda and Hexapoda. Students will learn to collect, dissect, identify, handle and care for live specimens.

BIOL.5420 Advanced Cell Biology (Formerly 81.542) - Credits: 3

This is an advanced course in cell biology. In this course we will examine different areas of eukaryotic cell biology including: membrane structure and function, cell adhesion, intercellular communication, signal transduction, chemotaxis, receptor-mediated endocytosis and intracellular trafficking. Mechanisms underlying relevant human diseases will also be discussed. Upon completion of the course the student will have a strong understanding of cell biology, develop critical thinking processes, proficiency in scientific reading and how to communicate material succinctly.

BIOL.5470 Evolution in Context for Teachers (Formerly 81.547) - Credits: 3

This course empowers life science teachers of all levels with the skills and knowledge to more effectively foster student understanding of evolution by natural selection. By exploring
evolution in multiple contexts, the Darwinian framework for how life evolved (and continues to evolve) are presented in an interactive and engaging manner. Teachers learn to use virtual resources to enhance their students learning while digging deep into some of the most profound and interesting science conducted in the last 100 years. Evolution in context makes the science of evolution come alive in a real and relevant manner. From the historical and scientific to the environmental and political, Teachers will learn about evolution in ways they never imagined.

**BIOL.5480 Form Feeds Function in Vertebrate Evolution - Credits: 4**

This course will provide you with a solid comparative knowledge of how vertebrates including humans have evolved, focusing on how anatomy (form) feeds function (physiology, biomechanics) in movement biology (cardiorespiratory, sensing, locomotion, feeding). It is only by understanding our evolutionary history that you understand e.g. how vertebrates became Olympian movers, how humans became bipedal, why we use parts of the ancestral jaw to hear, and how we avoid choking when we swallow. Such knowledge is key for medical and veterinary school, but will also support you in biomedical and biotechnology fields as well as in various general science disciplines. This course emphasizes modes of thought, including the differences between evidence and inference, and between correlation and causality.

**BIOL.5490L Biology of Muscle - Credits: 4**

This course takes integrative approaches to exploring architecture, physiology and mechanics of vertebrate skeletal muscle as the main driver of movements in organisms including humans. Combining presentations and discussions of important publications with simple experiments and report-writing, the course hones a specialist-level understanding of how the organ structure is constructed, how cell-level phenomena govern contraction, how the nervous system controls muscle function, how muscle contractions are constrained by physics, and how muscle as an organ structure is able to mitigate those constraints. We will also build and use actuators inspired by muscle function.

**BIOL.5550 Entomology - Credits: 3**

This course explores the diversity, evolution, and behavior of insects. Insects are pollinators, undertakers, and parasites. They are master architects, and the inventors of flight and agriculture. Their societies can tower over elephants or fit in the palm of your hand. Plagues of locusts have shaped human history and wars have been won on the backs of fleas. This course emphasizes natural history as the foundation of innovation in entomology. Students will develop a solid understanding of the principles of insect biology that can be applied to medical, forensic, veterinary, agricultural, conservation and academic fields.

**BIOL.5550L Entomology Lab - Credits: 1**

This laboratory focuses on insect classification, development and behavior. Students will travel to local field sites to study and collect insects. Each student will curate a professional insect collection and develop a working knowledge of insect taxonomy through dissection and comparison of preserved specimens, including economically and medically important insects. Students will also rear a variety of social and solitary insects under experimental conditions and report their results. Labs on behavior will focus on insect communication, parental care, eusociality, and orientation.

**BIOL.5570 Metazoan Parasitology (Formerly 81.557) - Credits: 3**

An introduction to the diversity of metazoans (animals) that parasitize humans, livestock, other animals (both vertebrate and invertebrate), and plants. Lectures emphasize the morphology, form and function, physiology, systematics, evolution, lifecycles and pathogenesis of several major parasitic groups.

**BIOL.5590L Metazoan Parasitology Laboratory ( Formerly 81.559) - Credits: 1**

The purpose of the laboratory is to provide students an opportunity to identify and work with a variety of parasites that we discuss in lecture. We will work with preserved specimens, slide material, necropsies, and live specimens. Students will learn how to identify parasites and appreciate where they live in the vertebrate body.

**BIOL.5600 Stem Cell Biology (Formerly 81.560) - Credits: 3**

The molecular and genetic characteristics of stem cells and their developmental potential will be explored. Lectures and readings will cover the development of embryonic, fetal and adult stem cells, and will examine their use in treating human disorders receiving widespread attention, including neurodegenerative diseases, heart disease, spinal cord injury and leukemia. The ethical, legal and social implications of stem cell research will also be discussed. Additional library investigation and a term paper or seminar will be required.

**BIOL.5620 Cardiovascular Physiology (Formerly 81.562) - Credits: 3**

This course will focus on human cardiovascular physiology in normal and diseased states. The objective of Cardiovascular Physiology is to reinforce the concept that that the
cardiovascular system can be understood in terms fundamental biophysical and cellular physiological principles. Quantitative aspects will be reinforced with problem sets in the accompanying lab course 81.563. Key concepts in the course will be placed in a medical context showing the underlying physiological concepts that lead to disease states such as: altered blood pressure, heart failure, valvular disease and arrhythmias.

BIOL.5630L Cardiovascular Physiology Lab (Formerly 81.563) - Credits: 1
Cardiovascular Physiology Lab is designed to supplement Cardiovascular Physiology 81.562. The objective of the course is to teach cardiovascular system function using problems sets as well as clinical and pathophysiological examples.

BIOL.5670 Molecular Biology (Formerly 81.567) - Credits: 3
A study of the principles and specialized techniques of cloning, purifying, and manipulating recombinant DNA molecules.

BIOL.5690L Molecular Techniques (Formerly 81.569) - Credits: 4
Laboratory experiments and independent projects designed to illustrate current techniques and instrumentation used in genetic engineering. Included are restriction mapping, cloning, plasmid purification, blot hybridization, and DNA sequencing. Students are introduced to computer software utilized for DNA sequence analysis and manipulation.

BIOL.5720 Virology (Formerly 81.572) - Credits: 3
A study of bacterial, animal, and plant viruses, including viral structure, modes of replication, biochemistry of the infected cell, genetic properties, and viral oncogenesis. Emphasis is on virusscell interaction at the molecular level.

BIOL.5760 Cell Culture (Formerly 81.576) - Credits: 4
A series of lecture and laboratory exercises that will focus on the in vitro culture and analysis of multiple cell type commonly used in biomedical research laboratories. The lecture component will review methodologies used to establish immortalized cell lines, medium component for specific cell types, and techniques for genetically manipulating and analyzing cell lines. The laboratory exercises will emphasize the mastery of sterile techniques used to grow both established cell line and primary cultures, and molecular tools used for introducing recombinant genes and for analyzing cell growth and differentiation.

BIOL.5800 Developmental Biology (Formerly 81.580) - Credits: 3
An in depth discussion of contemporary topics related to reproduction and embryogenesis. Lecture material is supplemented with reading assignments in a recently published textbook and current literature taken from research journals. Emphasis is on the dynamic nature of the interactions between developing cells as well as the events that occur during fertilization, implantation and the development of the mammalian embryo which lead to birth. Students examine how studies with nonmammalian model systems such as Drosophila and Xenopus have enhanced our knowledge of mammalian development. Among the topics discussed are the role of adhesion molecules, HOX genes, apoptosis, hypomethylation of genes, axis formation and hormonal control of differentiation. Class participation is expected. Critical scientific reading and thinking is encouraged by having students present to the class published original research papers on topics of current interest in the field of developmental biology.

BIOL.5810L Developmental Biology Lab - Credits: 1
This course provides hands on experience in current methods and model systems used to investigate questions in developmental biology. Students will be exposed to a wide variety of embryonic systems, including intensively studied genetic model systems (e.g. C. elegans, zebrafish, mouse) and others with well-established experimental attributes (e.g. chick, sea urchin). Analytical and experimental techniques used to explore invertebrate and vertebrate development include embryological manipulation, molecular and cell biology approaches. Conceptual topics include cell specification and differentiation, pattern formation, morphogenesis, and comparative embryology. This lab supplements the Developmental Biology lecture (BIOL.5800).

BIOL.5820 Cancer Biology (Formerly 81.582) - Credits: 3
A study of the genes and proteins implicated in the cause of human cancer and discussion of the complex behaviors of cancer cells that differ from their normal counterparts in human tissue. Lectures and original research papers will be used.

BIOL.5840 Comparative Vertebrate Embryology - Credits: 3
A comparative study of vertebrate embryological development focusing on the morphological development (e.g., Differentiation of tissues, organs, and systems) of vertebrates. Evolutionary relationships of the classes of vertebrates will be investigated through their anatomy. This course builds on
concepts taught in Developmental Biology, providing more detailed analysis of tissue development in a comparative context.

**BIOL.5860 Experimental Design and Analysis in Life Science - Credits: 3**

Through discussion of practical issues arising in biology research, reading of the literature and performing applied exercises students will move principles of sound experimental design, analysis and presentation from their "recognition vocabulary" to their "active vocabulary". The objective is for students successfully completing this course to be able to serve as a statistical consultant for researchers (including themselves) wishing to conduct experiments requiring moderately complex statistical designs.

**BIOL.5880 Structural Biology (Formerly 81.588) - Credits: 3**

Structural basis of the molecular biology of cells and the regulation of cellular processes will be discussed. This course will cover the fundamental knowledge about protein, nucleic acid and membrane structure in relation to central systems in biology. Topics to be discussed include structural enzymology, macromolecular assemblies for replication, transcription, translation, membrane proteins, signal transduction, cell motility and transport, cell-cell interactions, the immune system, and virus structure. Students will choose a recently published primary research article for an oral presentation, and will lead a class discussion on that topic.

**BIOL.5890 Practical Protein Crystallography (Formerly 81.589 & 81.489) - Credits: 4**

This course provides grounding in the principles and practice of protein x-ray crystallography. The course will be unique in format and provide both didactic and laboratory instruction. It is comprised of a series of lecture and laboratory exercises, with an emphasis on practical techniques and hands-on experience of modern protein crystallography. The course will cover the fundamental knowledge about x-ray physics, instrumentation and geometrical diffraction, protein crystallization, macromolecular data collection and processing, phase estimation and improvement, model building and refinement, and model assessment. Student will also be given a recently published structural paper for writing a report on the subject.

**BIOL.5892 Crystallography and Structural Bioinformatics - Credits: 3**

This course provides grounding in the principles and practice of protein x-ray crystallography, with some applications in structural bioinformatics and drug discovery. This course is comprised of a series of lecture with an emphasis on practical methodologies of modern protein crystallography and structural bioinformatics. The course will cover the fundamental knowledge about x-ray physics, instrumentation and geometrical diffraction, protein crystallization, macromolecular data collection and processing, phase estimation and improvement, model building and assessment, and some exploration of bioinformatics tools employed in molecular docking and virtual screening.

**BIOL.5894L Crystallography and Structural Bioinformatics Lab - Credits: 1**

This lab course provides grounding in the principles and practice e-ray crystallography, with some applications in structural bioinformatics and drug discovery. It covers topics correlated with the co-requisite lecture course BIOL.5892.

**BIOL.5900 Human Neurobiology (Formerly 81.490 & 81.590) - Credits: 3**

A study of cellular and systems neurobiology with a focus on how these relate to human health and disease. Particular attention will be given to illustrating functional neuroanatomy and neurophysiology of the human CNS using investigations into the pathogenic mechanisms of a variety of human neurodegenerative diseases including epilepsy, Alzheimer’s Disease, Huntington’s Disease, ALS among others. Note: Graduate level enrollees will be responsible for additional reading and writing.

**BIOL.5940 Immunology II, Current Topics - Credits: 3**

This course will focus on recent advances in the field of immunology including the study of immune development and activation, response to infection, vaccines, immunoregulation, cancer immunotherapy, and immune dysfunction. Expanding upon the foundational immunologic concepts covered in BIOL.4930/BIOL.5930, students will gain knowledge of the innate and adaptive immune system at the structural, molecular, cellular, and functional levels. The objectives of Advanced Topics in Immunology are to gain a comprehensive and practical understanding of current immunological principles in research and clinical/applied sciences, learn to critically read and evaluate scientific literature, learn to interpret data, and design experiments that rigorously test hypotheses.

**BIOL.5945 Host-Pathogen Interactions - Credits: 3**

This transdisciplinary course will examine the interface between pathogens and their hosts a multiple levels. We will begin with molecular and cellular interactions between host and pathogen species and will expand to include ecological patterns, behavioral biology, and host-pathogen co-evolution.
Following an introduction to infectious disease, microbiology, and immunology, we will critically read and evaluate scientific literature. The objectives of Host-Pathogen Interactions are to gain a comprehensive and practical understanding of host-pathogen dynamics, patterns of disease ecology, and host-pathogen co-evolution. Students will learn to critically read and evaluate scientific literature, interpret data, and design experiments.

BIOL.6030 Graduate Colloquium Biology (Formerly 81.603) - Credits: 1

Presentations of current topics by visiting scientists and staff. Required of all graduate students.

BIOL.6040 Professional Communication in Science and Technology (Formerly 81.604) - Credits: 3

The course instructs students in developing effective writing and speaking skills required for preparation of publishable scientific manuscripts and presentations. The importance of clear, concise writing style and delivery of presentations to both research, scientists and non-scientists is emphasized. Guest speakers discuss commercialization of technology, intellectual property, and electronic literature searches/citation. Experimental design, statistical analyses, research grant preparation, and poster presentations are also reviewed. Outside readings are used to critically evaluate contemporary issues related to disclosure, conflict of interest, publishing ethics, biosecurity, and electronic science collaborations/team research.

BIOL.6050 Graduate Proposal Writing Seminar - Credits: 1

The primary purpose of this course is to enable students to apply their broad biological sciences perspectives and intellectual skills to solve complex problems and to catalyze new discoveries. To achieve these goals, students will gain effective skills in preparing professional proposals. Key concepts in the course highlight hypothesis formation and proposal development. This approach will help bridge-the-gap between classroom-based and research-based curriculum components of the Applied Biology PhD program. Exposure to the diverse range of specialties represented by students studying in the biological sciences field will enrich and diversify student knowledge.

BIOL.6060 Applied Biology I - Credits: 1

This is the first in a two-semester sequence of courses that will introduce students to the range of research topics being addressed at UMass Lowell as well as to professional applications of Biology. Applied Biology is at the forefront of scientific research and technological development and underpins a number of growing industries. This course will provide an opportunity for students to learn about key areas in Applied Biology including Microbiology, Biochemistry, Biotechnology, Genetics, Evolution, and Healthcare. To achieve these objectives this course will be divided into three topic blocks (4-5 weeks each) where a faculty member will provide didactic overview of that topic, and will then bring in guest lecturers who will use half the class time.

BIOL.6070 Applied Biology II - Credits: 1

This is the second course in a two-semester sequence of courses that will introduce students to the range of research topics being addressed at UMass Lowell as well as to professional applications of Biology. Applied Biology is at the forefront of scientific research and technological development and underpins a number of growing industries. This course will provide an opportunity for students to learn about key areas in Applied Biology including Microbiology, Biochemistry, Biotechnology, Genetics, Evolution, and Healthcare. To achieve these objectives this course will be divided into three topic blocks (4-5 weeks each) where a faculty member will provide a didactic overview of that topic, and will then bring in guest lecturers who will use half the class time.

BIOL.6660 Selected Topics in Molecular and Cellular Biology (Formerly 81.666) - Credits: 3

Topics will focus on the central dogma of molecular Biology (DNA to RNA to protein) and how they relate to the structure and function of the cell. Course material will be taken directly from the current, primary literature with emphasis on student presentations and discussion. Multidisciplinary groups will select topics of interest to present to the class, and topics will vary by semester depending on student interests. Student groups will be expected to organize presentations into background and discussion sections and will lead class discussions.

BIOL.7070 Internship Biology (Formerly 81.707) - Credits: 1

BIOL.7080 Graduate Course Review (Formerly 81.708) - Credits: 1

Internship or co-op.

BIOL.7100 Supervised Instruction in Undergraduate Biology Education - Credits: 1-3

Graduate students will assist with the preparation of course materials, teaching and/or grading in selected courses offered by the Department of Biological Sciences. Students will be expected to work well independently, while also working under the supervision of a faculty mentor. Through these activities,
the student will learn about materials used, as well as teaching and learning techniques implemented in undergraduate biology education. Required for the MS in Biological Sciences option: Education, Communication, and Outreach.

BIOL.7210 Special Problems In Biology (Formerly 81.721) - Credits: 1-3
BIOL.7310L M.S. Project in Biology (Formerly 81.731) - Credits: 1-9
BIOL.7430 Master's Thesis - Biology (Formerly 81.743) - Credits: 1-9
BIOL.7530 PhD Dissertation Biological Sciences (Formerly 81.753) - Credits: 1-9
BIOL.7590 PhD Dissertation Biochemistry (Formerly 81.759) - Credits: 9
BIOL.7690 Continued Graduate Research (Formerly 81.769) - Credits: 9
Department of Chemistry

The following graduate programs are offered:

- **Doctor of Philosophy in Chemistry**
  - Specializations include:
    - Analytical
    - Inorganic
    - Organic
    - Physical
    - Option in Biochemistry
    - Option in Environmental Science
    - Option in Polymer Science or Polymer Science/Plastics Engineering

- **Master of Science in Chemistry**
  - Specializations include:
    - Analytical
    - Biochemical
    - Inorganic
    - Materials
    - Organic
    - Physical
    - Polymer Science

- **Master of Science in Chemistry - Professional Science Master's (PSM)Options**
  - Chemistry and Polymer Science
  - Pharmaceutical Biochemistry

- **Graduate Certificates**
  - Chemistry

The Department of Chemistry at University of Massachusetts Lowell offers both the Master's Degree in Chemistry and the Doctor of Philosophy Degree in Chemistry. The options and specializations allow interdisciplinary study and involve interaction between chemistry and other departments at the University of Massachusetts Lowell.

**Overall Departmental Entrance Requirements:**

1. A Bachelor's Degree in Chemistry or a related discipline (which requires a solid base in Chemistry).
2. An Undergraduate GPA of 3.0 (or its equivalent).
3. A minimum combined score of 310 on the GRE. (A score of 315 for polymer science applicants).
4. English proficiency testing for International students whose native language is not English TOEFL: a minimum score of 30 or IETLS: a minimum score of 6.0
5. 3 letters of recommendation

6. Students not meeting these requirements are invited to enroll in the Graduate Certificate Program (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf) and reapply.

**Master's Programs in Chemistry**

Specializations are offered in analytical, biochemistry, inorganicchemistry, material chemistry, organicchemistry, physical chemistry, and polymer science. This program provides opportunity for advanced study and research training in chemistry, both general and specialized. Provision also is made for the student to elect certain advanced subjects in related fields of mathematics, physics, and engineering.

The Department of Chemistry also offers two Professional Science Master's Options in Chemistry (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf) (one in chemistry and polymer science and the other in pharmaceutical biochemistry) which have different requirements than those outlined below.

**Credit Requirements (Thesis Option)**

A minimum of 30 credits is required for the Master of Science degree in Chemistry, with 18 credits being earned in courses; and 12 credits earned in graduate research. Of the 18 course credit minimum, exclusive of research, a minimum of 15 credits must be taken in chemistry. The remaining course credits (3 or more) may be taken in chemistry or in related fields such as physics, mathematics, biology or engineering. Credit normally is not allowed for 400 level subjects in chemistry except for those designated in the catalog or approved by a student’s advisor. Each graduate program in chemistry must include at least three advanced subjects from three of the following areas: analytical chemistry, biochemistry, inorganic chemistry, material chemistry, organic chemistry, physical chemistry, or polymer chemistry, unless such requirements have been met previously and approved by the department.

**Requirements**

**Specialization in Analytical Chemistry**

- **CHEM.5140**
  - Advanced Analytical Chemistry

and two courses of the following:

- [CHEM.5230](https://www.uml.edu/catalog/courses/CHEM/5230)
Organic Reaction Mechanism

- or CHEM.5680
  Structural Analysis]
- CHEM.5260
  Chromatography
- CHEM.5320
  Advanced Physical Chemistry
- CHEM.5500
  Biochemistry I
- CHEM.5430
  Modern Inorganic Chemistry
- CHEM.5800
  Advanced Analytical Biochemistry

Specialization in Biochemistry

- CHEM.5500
  Biochemistry
- CHEM.5510
  Biochemistry II

and any three courses of the following:

- CHEM.5680
  Structural Analysis
- CHEM.5140
  Advanced Analytical Chemistry
- CHEM.5260
  Chromatography

Specialization in Inorganic Chemistry

- CHEM.5430
  Modern Inorganic Chemistry
- CHEM.5320
  Advanced Physical Chemistry
- CHEM.5230
  Organic Reaction Mechanisms

and two courses of the following:

- CHEM.5140
  Advanced Analytical Chemistry
- CHEM.5500
  Advanced Analytical Biochemistry
Biochemistry I
- CHEM.5510
(http://www.uml.edu/catalog/courses/CHEM/5510)

Biochemistry II

Specialization in Material Chemistry
- POLY.5030
(http://stage.uml.edu/catalog/courses/POLY/5030) Advanced Polymer Science I
- CHEM.5130
(http://stage.uml.edu/catalog/courses/CHEM/5130) Spectroscopy
- CHEM.5221
(http://www.uml.edu/catalog/courses/CHEM/5221) Solid-State Materials Chemistry

and two courses of the following:
- CHEM.5430
(http://stage.uml.edu/catalog/courses/CHEM/5430) Modern Inorganic Chemistry
- CHEM.5360
(http://www.uml.edu/catalog/courses/CHEM/5360) Advanced Materials Chemistry I
- CHEM.5660
(http://www.uml.edu/catalog/courses/CHEM/5660) Nanomaterials and Nanostructures
- CHEM.6720
(http://www.uml.edu/catalog/courses/CHEM/6720) Surface and Colloid Chemistry
- POLY.5040
(http://stage.uml.edu/catalog/courses/POLY/5040) Advanced Polymer Science II
- POLY.5110
(http://www.uml.edu/catalog/courses/POLY/5110) Biopolymers
- POLY.5050
(http://www.uml.edu/catalog/courses/POLY/5050) Polymer Preparation and Characterization

Specialization in Organic Chemistry
- CHEM.5230
(http://www.uml.edu/catalog/courses/CHEM/5230) Organic Reactions, Mechanisms
- CHEM.5240
(http://www.uml.edu/catalog/courses/CHEM/5240) Organic Synthesis
- CHEM.5680
(http://www.uml.edu/catalog/courses/CHEM/5680) Structural Analysis

and at least two courses from the following:
- CHEM.5320
(http://www.uml.edu/catalog/courses/CHEM/5320) Advanced Physical Chemistry
- CHEM.5500
(http://www.uml.edu/catalog/courses/CHEM/5500) Biochemistry I
- CHEM.5430
(http://www.uml.edu/catalog/courses/CHEM/5430) Modern Inorganic Chemistry
- Specialization in Physical Chemistry
- CHEM.5310
(http://www.uml.edu/catalog/courses/CHEM/5310) Statistical Thermodynamics
- CHEM.5320
(http://www.uml.edu/catalog/courses/CHEM/5320) Advanced Physical Chemistry
- CHEM.5130
(http://www.uml.edu/catalog/courses/CHEM/5130) Spectroscopy
- CHEM.5230
(http://www.uml.edu/catalog/courses/CHEM/5230) Organic Reaction Mechanisms
- CHEM.5430
(http://www.uml.edu/catalog/courses/CHEM/5430) Modern Inorganic Chemistry
- CHEM.5400
Specialization in Polymer Science

Required: select from the following courses:

- POLY.5030
  Advanced Polymer Science I
- POLY.5040
  Advanced Polymer Science II
- POLY.5050
  Polymer Preparation and Characterization
- CHEM.5680
  Structural Analysis
- POLY.5530
  Organic Chemistry of Macromolecules
- POLY.6070
  Polymer Science Seminar
- POLY.7010
  Graduate Research in Polymer Science
- POLY.5490
  Physical Chemistry of Macromolecules
- CHEM.5230
  Organic Reaction Mechanisms

Although the design of the academic program is the responsibility of the student’s advisory committee, the following listing provides recommended courses for program development.

**First Semester Subjects**

- POLY.5030
  Advanced Polymer Science I
- POLY.5050
  Polymer Preparation and Characterization
- CHEM.5680
  Structural Analysis

**Second Semester Subjects**

- POLY.5040
  Advanced Polymer Science II
- POLY.5120
  Advanced Physical Chemistry
- CHEM.5230
  Organic Reaction Mechanisms
- CHEM.6720
  Surface and Colloid Chemistry
- CHEM.5240
  Organic Synthesis
- PLAS.5230
 
Plastics Processing Techniques

Seminar Requirement

Each semester the student is required to attend and participate in the chemistry seminar/colloquium program CHEM.6010 (https://www.uml.edu/catalog/courses/CHEM/6010), 6020, 6030 and 6040. In addition, a master’s candidate is required to present one seminar.

Thesis Advisory Committee

An advisory committee should be selected jointly by the student and advisor at the earliest possible opportunity. A minimum of three (3) faculty members are required for the master’s thesis committee. The student’s advisor will serve as the chairperson of this advisory committee. The purpose of this committee is twofold. First, it will be responsible for ascertaining that the student's research was conducted and presented in final form, in a professional and acceptable manner. Perhaps of more importance, the committee will serve in an advisory capacity during the course of the research project. In this spirit it is recommended that the student convene a meeting of the selected committee prior to starting his/her research. The purpose of this meeting is to informally present an outline of the proposed research project.

Non-Thesis Masters in Chemistry (NTMC)

This program provides opportunity for advanced study in chemistry that must include at least three of the following areas: analytical chemistry, biochemistry, inorganic chemistry, organic chemistry, physical chemistry, or polymer chemistry.

Credit Requirements

The NTMC degree requires 30 credits (10 courses). The following NTMC requirements must be met:

1. A total of 18 course credits (CHEM or POLY prefix) must be taken within the Chemistry Department at University of Massachusetts Lowell.
2. The remaining credits may be satisfied by either additional CHEM or POLY courses or by transfer of up to 12 credits from a closely related program at a domestic university, including University of Massachusetts Lowell.

Note: Students who wish to pursue the NTMC degree who currently hold a B.S. or B.A. degree in chemistry or a related science, but do not have previous laboratory experience, may be required to take up to three undergraduate chemistry laboratory courses to ensure that they have sufficient laboratory skills upon completion of their NTMC degree.
CHEM.5130 Spectroscopy (Formerly 84.513) - Credits: 3

This course covers both basic theory and practical applications of modern photon, electron, and X-ray spectroscopies. The techniques covered will include infrared, Raman, visible, circular dichroism, UV, X-ray photoelectron, and X-ray absorption spectroscopies. Qualitative and quantitative applications of these methods to chemistry (organic and inorganic), materials, catalysis, and biochemistry will be discussed.

CHEM.5140 Advanced Analytical Chemistry (Formerly 84.514) - Credits: 3

Designed to provide graduate students and senior undergraduate students with an understanding of the principles and the theory of analytical measurements and instrumentation. The course is divided into three sections consisting of a) analytical measurements including potentiometry and voltammetry, b) spectrophotometric measurements (i.e. molecular spectrometry), and c) ionic equilibria and statistics. This course is required for graduate programs in Analytical Chemistry and Environmental Studies (Ph.D.) and is recommended for students in other graduate programs such as Biology, Biochemistry and Environmental Studies (MS) and other areas of chemistry.

CHEM.5190 Environmental Chemistry (Formerly 84.519) - Credits: 3

Covers chemical processes and measurements in marine and estuarine systems. Emphasis is placed on water column processes; however, air-water and sediment-water interface phenomena are covered as well. Topics include but are not limited to: ionic equilibria, trace metal complexation, redox processes, mathematical modeling applied to chemical systems, and oceanographic sampling.

CHEM.5220L Organic Synthesis and Characterization Laboratory - Credits: 3

An advanced project-based organic chemistry laboratory course. Students will separate mixtures of compounds by chromatographic methods, elucidate structures using spectroscopic techniques and consult the chemical literature to design and execute a multi-step synthesis. Students will also propose a multi-step synthesis of a compound of interest. Emphasis on laboratory work with a discussion of theoretical background.

CHEM.5221 Solid-State Materials Chemistry - Credits: 3

This course is an introductory course to materials and solid-state chemistry for graduate students. Topics covered include the electronic and optical properties of solids, the properties of metals and semiconductors, optical properties of materials and their physical origins, and special topics in nanomaterials and materials science. Qualitative and quantitative applications of these materials will be included for energy, electronics, batteries, lighting, catalysis, and coatings.

CHEM.5230 Organic Reaction Mechanisms (Formerly 84.523) - Credits: 3

The course is designed to provide an advanced understanding of the principles controlling structure/reactivity and the experimental techniques used to elucidate the mechanisms of modern organic reactions. The material covered includes: molecular orbital theory applied to bonding and reactivity, stereoelectronic and conformational effects, intermolecular interactions, potential energy surfaces, reaction kinetics, reaction mechanisms, catalytic methods, pericyclic reactions, and photochemistry. Introductory applications of computational chemistry are covered. The course is open to undergraduate students (with permission) interested in a stronger foundation in organic reactions.

CHEM.5240 Organic Synthesis (Formerly 84.524) - Credits: 3

Mechanism, scope and limitations of important selected types of reactions and design of synthetic sequences. Emphasis is placed on methodology of synthesis and current literature.

CHEM.5260 Chromatography (Formerly 84.526) - Credits: 3

Coverage includes the components, theory and performance of chromatographic separations including packed and capillary gas chromatography (GC) and high performance liquid chromatography (HPLC). Modern injectors, detectors, pumping systems, and other hardware used in chromatography are also discussed in detail.

CHEM.5320 Advanced Physical Chemistry (Formerly 84.532) - Credits: 3

Extension of introductory physical chemistry. Open to undergraduates and graduate students in chemistry and related fields. Emphasis is placed on classical and statistical thermodynamics; surface and colloid chemistry; and electronic and vibration-rotation spectra.

CHEM.5340 Quantum Chemistry - Credits: 3

This course will start with the basics of Quantum Mechanics.
and Quantum Chemistry followed by use of the molecular modeling software GAUSSIAN. Topics to be covered include: Schrödinger equation and wave functions; Particle in a box; Particle in a ring; Heisenberg uncertainty principle; QM operators, Eigenvalue problem; Eigenvectors & eigenvalues; Hermitian operators and commutators; Harmonic oscillator & IR spectroscopy; Rigid Rotator & Rotational Spectroscopy; H-atom, H_2+ ion; using Mathematics to solve QM problems (e.g. atomic/molecular orbitals visualization); He-atom and variational method; Electron spin and Pauli exclusion principle; EPR/NMR; Semiempirical methods; Many-electron systems; Slater Determinants, Hartree and Hartree-Fock methods; Diatomic molecules; Born-Oppenheimer approx.

CHEM.5360 Advanced Materials Chemistry I - Credits: 3
This course covers the concepts, principles, and applications of physical properties of organics- and polymer-based materials. In a broad sense, organic electronics and photonics, as a modern research and technology field, encompass both molecular organics and polymers in design, synthesis, and fabrication processes in the light of device application. For the practical purpose, this course discusses a collection of technologies that include conducting organics and polymers, organic light emitting diodes (OLED), organic photovoltaics (OP), dye sensitized solar cells (DSSC), optical nonlinear (NLO) two-photon absorption (2PA) chromophores, electro-optical (EO) polymers, and photodynamic therapeutic (PDT) and antibacterial inactivation (aPDI) drugs.

CHEM.5380 Biochemical Mechanisms (Formerly 84.538) - Credits: 3
Discussion of various biochemical reactions from the point of view of organic reaction mechanisms. Kinetics, coenzymes and methods of the study of enzyme action and catalysis and mechanisms are emphasized.

CHEM.5430 Modern Inorganic Chemistry (Formerly 84.543) - Credits: 3
A theoretical treatment of atomic structure and chemical bonds, included are such topics as Russell Saunders’ coupling, molecular orbital theory, ligand field theory, and descriptive coordination chemistry.

CHEM.5500 Biochemistry I (Formerly 84.550) - Credits: 3
An advanced study of the structure and properties of proteins, nucleic acids, carbohydrates and lipids, including kinetics and mechanisms of enzyme action and detailed description of metabolic pathways of carbohydrates and lipids.

CHEM.5510 Biochemistry II (Formerly 84.551) - Credits: 3
A continuation of 84.550 with emphasis on metabolic pathways of amino acids and nucleic acid, biosynthesis of proteins and selected topics in molecular biology and various areas of biochemistry.

CHEM.5550L Laboratory in Modern Biochemistry and Biophysics - Credits: 2
This is a laboratory course designed to teach basic biochemical techniques using a series of well-characterized proteins in a research-like setting. The course will meet twice a week throughout the semester. The first half of the semester will be focused on teaching specific biochemical techniques. In the second half of the semester, students will develop an independent research question using protein(s) from a list using the techniques that were learned in the first half of the semester. Students will produce a report using an ACS Journal style based on their results and they will also present their results to the class at the end of the semester. Students will also prepare a review on the protein that they are using for their independent project.

CHEM.5600 Advanced Physical Biochemistry (Formerly 84.560) - Credits: 3
Physical chemistry encompasses a group of principles and methods helpful in solving many different types of problems. This course will present selected principles of thermodynamics, kinetics, statistical thermodynamics and quantum mechanics as they are applied to biochemical systems. Various experimental techniques will be strongly emphasized in view of their importance in biochemical research.

CHEM.5620 Biopharmaceutical Development (Formerly 84.562) - Credits: 3
Pharmaceutical Biochemistry examines the biochemical and molecular mechanisms of drug interaction. Topics include basic aspects of molecular complementarity (molecular recognition), specificity and stability of ligand binding (energetic), as well as crystallographic and computational approaches.

CHEM.5630 Chemistry Of Natural Products (Formerly 84.563) - Credits: 3
Covers the proof of structure of various types of natural products, approaches to the total synthesis of these products and the biosynthetic pathways.

CHEM.5660 Nanomaterials and Nanostructures
(Formerly 84.566) - Credits: 3

Nanoscience and nanotechnology focus on the understanding and control of matter at the dimension of 1-100 nanometers, i.e., the nanoscale. Nanoscale structures, materials and devices have unique properties and functions solely because of their sizes. Research and technology development in nanoscience and nanotechnology aim at understanding the fundamental nanoscale phenomena, synthesizing, fabricating and imaging nanomaterials and nanostructures, and constructing nanoscale systems that offer unprecedented properties and functions. In this course, we will discuss the fundamental nanoscale phenomena. We will learn variety of nanomaterial characterization techniques including scanning probe, electron probe, absorption and particle spectroscopies. Fabrication processes of top-down and bottom-up approaches will be discussed, including molecular and material self-assembly. We will study surface phenomena and surface energy that are of critical importance for nanomaterials and nanostructures. We will also learn various ways to control the structures and properties of nanomaterials and surfaces. A variety of nanomaterials and nanostructures will be discussed, including metal, semiconductor, organic and inorganic nanoparticles, carbon nanomaterials, and various natural and synthetic nanostructured surfaces. Applications of these nanomaterials in nanomedicine and nanorobotics will also be discussed.

CHEM.5670 Computational Biochemistry (Formerly 84.567) - Credits: 3

This course will provide an introductory survey of the basis of theory/simulations of biomolecules. It is accessible to anyone who has completed two semesters of undergraduate chemistry and who has some background in physical chemistry. Topics/examples will be borrowed from modern biological chemistry and biophysics of single biomolecules. The course will be useful for senior undergraduates and beginning graduate students. Chem/Bioinformatics 84.567 will attempt to cultivate computational skills, which on needs to tackle current scientific problems of biology and biophysics.

CHEM.5680 Structural Analysis (Formerly 84.568) - Credits: 3

Practical applications of instrumental data in the determination of the structure of organic compounds and polymers. Includes mass spectrometry, ultra-violet spectroscopy, infrared spectroscopy and nuclear magnetic resonance spectroscopy. Open to undergraduate students with permission.

CHEM.5700 Protein Chemistry (Formerly 84.570) - Credits: 3

This course outlines the assembly process, structural and functional attributes of protein. Special attention will be given to three-dimensional structures, folding, post translational modifications, misfolding and degradations, as well as biochemical and biophysical techniques used to elucidate protein structure and function.

CHEM.5800 Bioanalytical Chemistry (Formerly 84.580) - Credits: 3

Analytical biochemistry involves the separation, detection, and analysis of biological molecules. This course addresses advanced theory and applications of contemporary biochemical techniques and instrumentation. Topics covered include chromatographic and electrophoretic separation techniques, detection of biomolecules by spectroscopy and radiochemical methods, biological preparations, and structural analysis of proteins, nucleic acids, polysaccharides and lipids.

CHEM.5850 Modern Organic Chemistry - Credits: 3

This course aims to provide deepened and widened knowledge of concepts, reactivity, and synthesis in modern organic chemistry. It encompasses: main group chemistry, carbonyl/enol/enolate chemistry, heterocyclic compounds, fragmentations, rearrangements, frontier molecular orbital theory, pericyclic reactions, reactive intermediates, organometallic chemistry, selective synthesis, stereochemistry, catalysis, asymmetric synthesis, and multi-step synthesis.

CHEM.5950 Supramolecular Chemistry - Credits: 3

Supramolecular Chemistry is a rapidly growing area at the interfaces between chemistry, biology, physics, and engineering. It can be described as Chemistry Beyond the Molecule and the chemistry of molecular assemblies. Inspired by Nature, it involves the study of complex structures held together by reversible, mostly non-covalent interactions, and encompasses the design and development of functional systems based on multiple chemical components. This course will provide detailed understanding of the general principles and concepts of the field, including host-guest chemistry, molecular recognition, and self-assembly, as well as highlight a wide variety of examples and applications of supramolecular systems in chemistry, biology, nanotechnology, and materials science.
topics by graduate students. "Variable credit course, student chooses appropriate amount of credits when registering."

CHEM.6030 Chemistry Colloquium (Formerly 84.603) - Credits: 0-1

Required of all graduate students. Presentation of current topics by visiting scientists and staff. "Variable credit course, student chooses appropriate amount of credits when registering."

CHEM.6040 Chemistry Colloquium (Formerly 84.604) - Credits: 1

Required of all graduate students. Presentation of current topics by visiting scientists and staff.

CHEM.6310 Principles of Medicinal Chemistry I (Formerly 84.631) - Credits: 3

This course teaches fundamental principles of drug development, including small organic compounds and biologics. Key aspects of their synthesis, physical characteristics, and pharmaceutical properties are discussed. Topics covered include discovery strategies, statistic-based modeling (e.g., QSAR), structure-based and mechanism-based design methods, and combinatorial techniques.

CHEM.6410 Co-Op Internship (Formerly 84.641) - Credits: 0-1

Practical training for International Students in a Co-operative agreement with Industry or a Government Laboratory for 1 semester. "Variable credit course, student chooses appropriate amount of credits when registering."

CHEM.6510 Selected Topics: Chemistry (Formerly 84.651) - Credits: 3

Advanced topics in various fields of chemistry. Content may vary from year to year so that students may, by repeated enrollment, acquire a broad knowledge of contemporary chemistry.

CHEM.6530 Chemical Oceanography (Formerly 84.653) - Credits: 3

CHEM.6720 Surface and Colloid Chemistry (Formerly 84.672) - Credits: 3

Surface and colloid chemistry describes the nanoscopic and mesoscopic regimes that connect molecular and macroscopic length scales. The course focuses on how phenomena at macroscopic surfaces and interfaces arise from molecular interactions. Intermolecular and surface forces discussed in detail include van der Waals and electrostatic forces, and how these together with steric interactions give rise to different molecular aggregates (self-assembled structures of surface active molecules and polymers) in bulk solution and in the vicinity of solid surfaces. Examples of modern experimental techniques for measurements of surface forces and for characterization of surfaces and aggregates are discussed and demonstrated.

CHEM.7050 Supervised Teaching Ch & Ps (Formerly 84.705) - Credits: 0

CHEM.7310 Graduate Project in Chemistry (Formerly 84.731) - Credits: 1

Continued research project supplementing the research credits for a doctoral student. This course will require special permission from the Graduate Coordinator.

CHEM.7330L Graduate Project - Chemistry (Formerly 84.733) - Credits: 3

CHEM.7410 Master's Thesis - Chemistry (Formerly 84.741) - Credits: 1

Master's Thesis - Chemistry

CHEM.7430 Master's Thesis - Chemistry (Formerly 84.743) - Credits: 3

CHEM.7460 Master's Thesis - Chemistry (Formerly 84.746) - Credits: 6

CHEM.7490 Master's Thesis - Chemistry (Formerly 84.749) - Credits: 0-9

CHEM.7510 Graduate Doctoral Research Credit (Formerly 84.751) - Credits: 1

CHEM.7530 Doctoral Dissertation/Chemistry (Formerly 84.753) - Credits: 3

CHEM.7560 Doctoral Dissertation/Chemistry (Formerly 84.756) - Credits: 6

CHEM.7590 Doctoral Dissertation /Chemistry (Formerly 84.759) - Credits: 0-9

CHEM.7630 Continued Graduate Research (Formerly 84.763) - Credits: 3

CHEM.7690 Continued Graduate Research (Formerly 84.769) - Credits: 3
POLY.5030 Polymer Science I (Formerly 97.503) - Credits: 3
A study of the principles of condensation, free radical, ionic, coordination and ring opening polymerization. The topics include the effect of polymerization techniques on reaction kinetics and molecular weight, and the evaluation of reactivity ratios in copolymerization reactions.

POLY.5040 Polymer Science II (Formerly 97.504) - Credits: 3
Introduction to chain statistics and thermodynamics of macromolecular solutions, methods of study of molecular weight and chain conformation, and the properties of polymers in bulk including viscoelasticity and crystallinity.

POLY.5050 Polymer Preparation Characterization I - Credits: 3
In this graduate-level laboratory class, the students will learn a variety of valuable techniques for the syntheses and characterization of high molecular weight polymers. This course offers a combination of traditional/historical polymer synthesis (i.e. Urea/Formaldehyde thermoset formation, interfacial polymerization of Nylon, determination of reactivity ratios for copolymerizations) and modern polymerization techniques (i.e. RAFT, ATRP, Living ROP) along with relevant polymer characterization techniques used in today's synthetic polymer landscape (i.e. GPC, MALDI, light scattering, NMR, TGA, DSC, etc.).

POLY.5110 Biopolymers (Formerly 97.511) - Credits: 3
Topics include conformation and configuration of vinyl polymers and polypeptides, energetics of chain folding and examination of the forces dictating ordered structures, helix to coil transitions in biopolymers with emphasis on polypeptide structures, instrumental analysis of biopolymer conformation, synthesis of biopolymers including polypeptides, polysaccharides and polynucleotides, and examination of relationships between synthetic polymers and naturally occurring polymers.

POLY.5530 Macromolecules Organic Chemistry (Formerly 97.553) - Credits: 3
An advanced study in polymer science concerned with the synthesis of macromolecules and their mechanisms of formation.

POLY.6010 Polymer Science Seminar (Formerly 97.601) - Credits: 0-2
Required of all Polymer Science graduate students. Presentation of current topics in polymer science by graduate students. "Variable credit course, student chooses appropriate amount of credits when registering."

POLY.6020 Seminar in Polymer Science (Formerly 97.602) - Credits: 0-2
Required of all Polymer Science graduate students. Presentation of current topics in polymer science by graduate students. "Variable credit course, student chooses appropriate amount of credits when registering."

POLY.6030 Polymer Science Colloquium (Formerly 97.603) - Credits: 0-1
Required of all Polymer Science graduate students. Presentation of current topics in polymer science by visiting scientists and staff.

POLY.6040 Polymer Science Colloquium (Formerly 97.604) - Credits: 0-1
Required of all Polymer Science graduate students. Presentation of current topics in polymer science by visiting scientists and staff.

POLY.6490 Introduction to Conjugated Polymers (Formerly 97.649) - Credits: 3
This course is an introduction to the fundamental science and potential applications of conjugated polymers in optical and electronic technologies. The topics covered include history, synthesis and molecular structure, including solid state polymerization; crystallinity and morphology, including assembly methods; electronic structure including energy bands, conjugation defects and photoelectron spectroscopy; properties of the insulating forms including light absorption and emission, thermochromism, carrier transport, electroluminescence and nonlinear optical properties; properties of the conducting forms, including "doping"; some specific devices.

POLY.7050 Supervised Teaching in Polymer Science (Formerly 97.705) - Credits: 0
POLY.7430 Master's Thesis in Polymer Science (Formerly 97.743) - Credits: 3
POLY.7460 Master's Thesis in Polymer Science (Formerly 97.746) - Credits: 6
POLY.7490 Master's Thesis in Polymer Science (Formerly 97.749) - Credits: 9
POLY.7510 Thesis Review (Formerly 97.751) - Credits: 1
This is a one credit thesis review course.

POLY.7530 Doctoral Dissertation in Polymer Science (Formerly 97.753) - Credits: 3
POLY.7560 Doctoral Dissertation in Polymer Science (Formerly 97.756) - Credits: 6
POLY.7590 Doctoral Dissertation in Polymer Science (Formerly 97.759) - Credits: 0-9
POLY.7690 Continued Graduate Research (Formerly 97.769) - Credits: 9
Department of Computer Science

The UMass Lowell Computer Science graduate program provides computer scientists with an education of sufficient breadth and depth to prepare them for leadership positions in both industrial and academic environments. It is distinguished by a balanced mixing of the practical, engineering aspects of computer science, with substantial exposure to the theoretical foundations of the field. This mission is supported by departmental and university research labs and Centers. Our graduate program is intended primarily for students with undergraduate degrees in computer science, or for those who have completed a degree in a related area (Engineering, Mathematics, Physics, etc.) and who possess a substantial background in computer science.

Programs

- Doctor of Philosophy
- Master of Science
- Graduate Certificate (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

Resources

The Computer Science Department has strong industrial ties through its faculty members, its participation in the research activity in various University Centers, its internal laboratories and institutes, its continuing relationships with many local computer and software manufacturers, and its industrial advisory committee. These relationships provide sources of short and long range research projects, hardware donations and student funding, while also providing insight to and understanding of the short and long term directions of local industry. To support instructional and research activities, the Department of Computer Science maintains a large heterogeneous network, including PCs, workstations, and a collection of more specialized equipment. All systems and servers are connected to /accessible via the Universitys network.

Financial Support

The Department has a limited number of teaching assistantships available to qualified graduate students. These assistantships can be renewed for up to four semesters. Other support is available through funded research programs in the departmental laboratories and, possibly, through support from other university departments.

Master of Science Degree in Computer Science

The Master of Science degree program in Computer Science serves several audiences, from the professional with extensive industrial experience to the recent graduate aiming ultimately for an advanced research degree. In all cases, a major objective is to prepare the student for a professional work environment in which continued growth is the norm.

- Admission Requirements
- Master of Science
- Master of Science, Bioinformatics Option
- Master of Science, Cybersecurity Option
- Master of Science, Information Technology MSIT (Online Program)
- Bachelor's-Master’s Program

Admission Requirements

In order to be fully matriculated into the MS program, students must demonstrate competency in the following six knowledge areas:

- Data Structures and Programming in C, C++, or Java
- Operating Systems
- Analysis of Algorithms
- Calculus
- Discrete Mathematics
- Probability and Statistics

Competency is typically demonstrated by producing a transcript of previous academic experience which contains passing grades in courses related to these six areas, or by earning a B or better in the courses below. Knowledge in areas that have not been satisfied at the time of entrance into the M.S. program become conditions on full matriculation. It is the student's responsibility to fulfill his/her conditions at the earliest possible time. The following is the list of courses which satisfy each of the six knowledge areas.

Data Structures and Programming in C, C++ or Java:

- COMP.1020 (https://www.uml.edu/catalog/courses/COMP/1020) Computing II

Operating Systems:

- COMP.3080 (https://www.uml.edu/catalog/courses/COMP/3080) Introduction to Operating Systems

Algorithms:
• COMP.4040
(https://www.uml.edu/catalog/courses/COMP/4040) Analysis of Algorithms

Calculus:

• MATH.1310
(https://www.uml.edu/catalog/courses/MATH/1310) Calculus I and MATH.1320
(https://www.uml.edu/catalog/courses/MATH/1320) Calculus II

Discrete Math:

• MATH.3210
(https://www.uml.edu/catalog/courses/MATH/3210) Discrete Math I and MATH.3220
(https://www.uml.edu/catalog/courses/MATH/3220) Discrete Math II

Probability and Statistics:

• MATH.3860

Master of Science, General Option

Each degree candidate will be required to pass, with an average of B or better, and not more than two grades below B, the following minimum number of credits, distributed to include core courses and electives.

• 30 Courses Credits (10 courses)
• Four graduate level core courses in Computer Science and six graduate level courses selected from five categories (see the degree pathway)

Degree Pathway for the Master of Computer Science, General Option (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

Master’s Thesis:

An optional master’s thesis can be substituted for at most six credits, and can be used to substitute for two elective courses. Students who wish to do a thesis must file a

Proposed Thesis Committee

form with the Graduate Coordinator prior to begin working on the thesis.

Master of Science, Bioinformatics Option

Course Requirements:

• 30 Courses Credits (10 courses)
• Eight Graduate level courses in Computer Science and two graduate level courses in Biology, under the direction of the Graduate Coordinator, from an approved list of courses.

Degree Pathway for the Master of Science, Bioinformatics Option

Master of Science, Cybersecurity Option

Course Requirements:

• 30 Courses Credits (10 courses)
• Four graduate level core courses in Computer Science and six graduate level courses selected from five categories (Foundations, Systems & Networks, Human-Computer Interaction, Visualization, Robotics & AI, Information Management & Analysis, Interdisciplinary and Other Approved Electives)

An optional Master’s thesis can be substituted for two elective courses (a maximum of six credits). Students who wish to do a thesis must file a Proposed Thesis Committee form with the Graduate Coordinator prior to beginning work on the thesis.

Degree Pathway for the Master of Science, Cybersecurity Option (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

Master of Science, Information Technology (Online Program)

The program is offered fully online, providing a pathway for students who have completed a Bachelor’s in Information Technology degree and for working professionals who want to pursue advanced graduate studies in information technology. The online delivery framework provides an accessible format for students juggling work and family responsibilities.

Students may also count course from two graduate IT certificate programs in Systems Models and Management and Network Security towards the Master’s Degree in Information Technology.

The 10-course master’s degree program is designed to provide
both a principled and applied exposure toward designing, managing and deploying networked systems of computers. The program places emphasis on practical skills based on Linus/Unix, Windows and Apple platforms, but also teaches general principles along with their technical and ethical foundations.

Admissions Requirements:

1. Completion of an undergraduate BS or BA degree from an accredited institution.
2. Mathematical Maturity: Students should have completed a minimum of one semester of precalculus mathematics, one semester of discrete mathematics and one semester of statics as part of their undergraduate studies, or possess the equivalent experience.
3. C Programming proficiency, to include a minimum of one semester of C Programming and one semester of Data Structures, or the equivalent experience.

Note: Students who do not meet the above requirements, may need to take additional undergraduate courses in order to meet the requirements.

Course Requirements:

30 Course Credits (10 Courses)

System Infrastructures Courses:(Choose 2 of the following)

- MSIT.5110 [Network and Systems Administration](https://www.uml.edu/catalog/courses/MSIT/5110) (3 credits)
- MSIT.5170 [Operating Systems Foundations](https://www.uml.edu/catalog/courses/MSIT/5170) (3 credits)
- MSIT.5190 [Virtual Systems](https://www.uml.edu/catalog/courses/MSIT/5190) (3 credits)
- MSIT.5140 [Systems Security and Auditing](https://www.uml.edu/catalog/courses/MSIT/5140) (3 credits)

Network Infrastructure Courses:(Choose 2 of the following)

- MSIT.5600 [Network Infrastructures](https://www.uml.edu/catalog/courses/MSIT/5600) (3 credits)
- MSIT.5610 [Computer Network Security](https://www.uml.edu/catalog/courses/MSIT/5610) (3 credits)
- MSIT.5620 [Digital Forensics](https://www.uml.edu/catalog/courses/MSIT/5620) (3 credits)
- MSIT.5630 [Secure Mobile Networks](https://www.uml.edu/catalog/courses/MSIT/5630) (3 credits)
- MSIT.5650 [Cloud Computing](https://www.uml.edu/catalog/courses/MSIT/5650) (3 credits)

Software Management Courses:(Choose 2 of the following)

- MSIT.5180 [Large Scale Application Deployment](https://www.uml.edu/catalog/courses/MSIT/5180) (3 credits)
- MSIT.5310 [Project Management](https://www.uml.edu/catalog/courses/MSIT/5310) (3 credits)
- MSIT.5320 [Managing Large Data](https://www.uml.edu/catalog/courses/MSIT/5320) (3 credits)

Program Electives:(Choose 4 additional MSIT.xxxx courses from this Program Electives or from any of the first three categories above, as long as you have not already taken the course to fulfill the above category requirements).

- MSIT.5350 [Agile and Iterative Project Management](https://www.uml.edu/catalog/courses/MSIT/5350) (3 credits)
- MSIT.5360 [Data Mining](https://www.uml.edu/catalog/courses/MSIT/5360) (3 credits)
- MSIT.5410 [Information Security, Privacy and Regulatory Compliance](https://www.uml.edu/catalog/courses/MSIT/5410) (3 credits)
Admission into the Doctor of Philosophy degree program requires a Masters degree in Computer Science. If the student does not already have an MS in CS, they may be admitted into the MS/Ph.D. program; in this program, students must complete the required coursework for the MS in CS as well as degree requirements for the Ph.D. in CS.

**Candidates Requirements**
Despite acceptance into the program, in order to be admitted to candidacy, student must:

- Complete the degree requirements for the MS in CS (unless he or she possesses an MS in CS or a closely related engineering, scientific, or mathematical discipline)
- Pass the departmental qualifying examinations.

**Course Requirements:**
- 6 courses (18 credits) from the Masters course group list (http://www.cs.uml.edu/%7Egcoord/MS_Degree_Course_Requirements.pdf) (pdf), with at most 4 courses from a single Masters course group (pdf). No course applied towards an MS degree can be used to satisfy course distribution requirements for the Doctoral degree.
- Thesis Credits: 24 Credits
- Total: 42 credits

**Additional Requirements**
- passing qualifying exams (rules (https://www.uml.edu/docs/QualRules_tcm18-148146.pdf) pdf)
- submission and defense at an oral examination of a thesis proposal
- completion of the thesis
- final defense of the thesis during another oral examination
- acceptance of two papers for publication in a peer-reviewed (refereed) journal or conference approved by the thesis advisor. At least one of these publications must be in the thesis area. This rule applies to students whose thesis proposals were defended on or after July, 2007.
- Students are required to report completion of each of these milestones according to the Procedures for Student Progress Through the Ph.D. Program
Computational Mathematics Option
Requirements: (beyond a master’s degree)

- 18 Course Credits (6 courses)
- Four Graduate level courses in Computer Science and two graduate level courses in Mathematics, under the direction of an advisor, from an approved list of courses
- 24 Dissertation Credits
- Supervised by faculty from the Mathematics and Computer Science Departments
- Any student interested in this program should contact the Chair of the CS Department and/or the Chair of the Mathematics Department.

M.S. in Computer Science Bio/Cheminformatics Option

- Admissions Criteria and Requirements
- Core Courses
- Course Pairs
- Electives

Admissions Criteria and Requirements

Applicants for admission to the Master of Science Program with a Bio/Cheminformatics option typically have an undergraduate degree in computer science or a related discipline such as mathematics, physics, biochemistry or engineering. Students wishing to enroll in the Master’s program in Computer Science with Bio/Cheminformatics option must demonstrate competency in the knowledge areas listed below. Competency in these areas is usually demonstrated by producing a transcript of previous academic experience which contains related courses passed with a B or better, or by earning a B or better in the courses listed below. Competency in the biology and chemistry area may be demonstrated by successfully passing a CLEP exam. Additional information regarding these exams may be obtained at the CollegeBoard website. The following are the knowledge areas in which competency must be demonstrated:

- Biology BIOL.1110 Principles of Biology I
- Chemistry CHEM.1210 Chemistry I and CHEM.1220 Chemistry II
- Discrete Mathematics MATH.3210 Discrete Structures I and MATH.3220 Discrete Structures II
- C or C++ through Data Structures
- COMP.2500 Accelerated C with Data Structures or COMP.1010 Computing I and COMP.1020 Computing II
- Programming Languages
- COMP.3010 Organization of Programming Languages
- Computer Architecture
- COMP.3050 Computer Architecture
- Operating Systems
- COMP.3080 Introduction to Operating Systems
- Analysis of Algorithms
- COMP.4040 Analysis of Algorithms
- Calculus MATH.1250 Calculus A and MATH.1260 Calculus B or MATH.1310 Calculus I and MATH.1320 Calculus II

Core courses: Total 9 credits

- COMP.5020 Foundations of CS
- COMP.5030 Algorithms
- COMP.5310 Design of Programming Languages

Course Pairs:

The following course pairs are selected from the approved list of Computer Science pairs, these courses have been chosen because they complement the goals of the bio/cheminformatics option.

Total 12 Credits (Two pairs of courses from the approved list of CS pairs.)

- COMP.5030 Algorithms I
- COMP.5460 Graphics I
- COMP.5040 Algorithms II
- COMP.5470 Graphics II
- COMP.5730 Database I
• COMP.5730 or COMP.5740 Database I or II
• COMP.5740 Database II
• COMP.5500 Data Mining

• COMP.5730 or COMP.5740 Database I or II
• COMP.5460 or COMP.5470 Graphics I or II
• COMP.5220 Analysis and Design
• COMP.5411 Scientific Data Visualization

• COMP.5230 or COMP.5250 Software Engineering I or II
• COMP.5500 Data Mining
• COMP.5230 or COMP.5250 Software Engineering I or II
• COMP.5210 SWD in Context
• COMP.5260 Project Management

• COMP.5030 or COMP.5040 Algorithms I or II
• COMP.5430 Artificial Intelligence

• COMP.5530 Parallel Processing
• COMP.5500 Advanced Data Mining

• COMP.5030 or COMP.5040 Algorithms I or II
• COMP.5130 Internet and Web Systems I

Topics

Course

Data Mining

• COMP.5140 Internet and Web Systems II

• COMP.5030 or COMP.5040 Algorithms I or II
• COMP.5030 or COMP.5040 Algorithms I or II

• COMP.5100 Computational Methods in Molecular Biology
• COMP.5430 Artificial Intelligence

Electives - Total 9 credits

Three additional courses will be taken from the list of approved bio/cheminformatics approved courses. The list below is for example only and it includes the current approved courses. This list will be updated as new courses are added to the program.

• BIOL.5050* (3 credits) Bioinformatics
• BIOL.5070* (1 credit) Bioinformatics Laboratory (coreq. BIOL.4050)
• BIOL.5190 (3 credits) Biochemistry I
• BIOL.5200 (3 credits) Biochemistry II
• BIOL.5010 (3 credits) Selected Topics I
• BIOL.5020 (3 credits) Selected Topics II
• BIOL.5670 Recombinant DNA Techniques
• CHEM.6510 Selected Topics in Chemistry: Protein and Chemical Informatics
• CHEM.5500 (3 credits) Biochemistry I
• CHEM.5510 (3 credits) Biochemistry II
• CHEM.5670 (3 credits) Biocheminformatics
• CHEM.5680 (3 credits) Computational Chemistry
• CHEM.5700 (3 credits) Advanced Protein Chemistry
• CHEM.5800 Advanced Analytical Biochemistry

MATH.5930 (3 credits) Experimental Design (Mathematics Department)

Although Organic Chemistry is not required as a prerequisite, some of the courses offered as part of this degree rely on knowledge of this subject.

Students should be aware that the above courses may only be used toward the Bio/Cheminformatics option. If the entire requirements of the option are not completed then these courses cannot be applied in isolation toward the M.S. in Computer Science.

Program Total: 30 credits (assuming prerequisites have been filled)

An optional master’s thesis can be substituted for at most 6 credits, and may be used to substitute for one pair of related courses.
COMP.5020 Foundations of Computer Science  
(Formerly 91.502) - Credits: 3
An advanced introduction to theoretical computer science. This course will cover the fundamentals of automata, formal languages, and computability theory.

COMP.5030 Algorithms (Formerly 91.503) - Credits: 3
Advanced algorithms and complexity analysis. Dynamic programming; greedy algorithms; amortized analysis; shortest path and network flow graph algorithms; NP-completeness; approximation algorithms; number-theoretic algorithms; string matching; computational geometry. Additional topics may include linear programming, parallel algorithms, fast Fourier transforms, polynomial, integer, and matrix algorithms. Readings may include conference and journal papers from the algorithms literature. Abstract types, lists, trees, graphs, sets; relevant algorithms and their worst and average case analyses; fast transforms; polynomial, integer, and matrix algorithms; NP-completeness.

COMP.5040 Advanced Algorithms: Computational Geometry (Formerly 91.504) - Credits: 3
Advanced algorithms topics, such as design and analysis of geometric and combinatorial algorithms, computability and complexity.

COMP.5100 Computational Complexity Theory  
(Formerly 91.510) - Credits: 3
This course covers polynomial-time hierarchy and polynomial space, circuit complexity, structure of NP, probabilistic machines and complexity classes, complexity of counting, interactive proof systems, probabilistically checkable proofs, complexity of approximation problems, and average-case NP-completeness.

COMP.5130 Internet And Web Systems I (Formerly 91.513) - Credits: 3
This course is a survey of Web programming technologies. It begins with a discussion of what Web servers and clients are, how they interact, and how one sets them up. We then explore a wide variety of Web technologies including HTML, JavaScript, JavaServer Pages, Java Servlets, and XML and its many related technologies. Our goal in this course is to provide the basic understanding and knowledge of how the Internet and World Wide Web operate and the technical knowledge required to establish and maintain an Internet/Web site and to develop and introduce new capabilities and features on such sites.

COMP.5140 Internet & Web Systems II (Formerly 91.514) - Credits: 3
A continuation of 91.513 with a focus on current topics and topics of special interest. Examples of recent topics include: The semantic Web and ontologies, Web services, Peer-to-peer networks, Information Search and Retrieval, Autonomous intelligent agents and Multi-modal presentations.

COMP.5150 Operating Systems I (Formerly 91.515) - Credits: 3
This course provides insight into multiprocessing operating systems including processor memory, peripheral, and file systems management in batch, timesharing, real time, and distributed systems targeted for various hardware. Particular emphasis will be placed on techniques of virtual memory as well as the problems of concurrency in both centralized and distributed systems. An OS simulation is a required programming project. Some topics to be covered are process synchronization; high-Level mechanisms for concurrency; processor scheduling and system analysis; deadlock; virtual memory; distributed systems; computer security.

COMP.5160 Operating Systems II (Formerly 91.516) - Credits: 3
The design and implementation of an interactive multiprocessing operating system to run on a bare hardware system. Separate teams manage the major subsystems with in-class design reviews to coordinate system integration. A functioning system is a class requirement.

COMP.5230 Computer Vision I (Formerly 91.423 & 91.523) - Credits: 3
Computer vision has seen remarkable progress in the last decade, fueled by the ready availability of large online image collections, rapid growth of computational power, and advances in representations and algorithms. Applications range from 3-D scene reconstruction, to visual Simultaneous Localization and Mapping (SLAM) for robotics, to real-time human body pose estimation. This introductory computer vision course explores various fundamental topics in the area, including the principles of image formation, local feature analysis, segmentation, multi-view geometry, image warping and stitching, structure from motion, and object recognition.

COMP.5270 Human Computer Interaction (Formerly 91.527) - Credits: 3
The purpose of this class is to ground students in the basics of how humans interact with technology, and make students aware of the breadth of topic areas related to human-computer interaction.
interaction (HCI). This course emphasizes theoretical constructs such as the Model-Human Processor, and includes seminal readings by the original researchers. Further, the course emphasizes techniques for understanding users’ tasks, formulating users’ requirements, and assessing proposed designs using heuristic evaluation. As part of understanding users’ needs, students will consider social, organizational, and ethical perspectives on information technology. Students are also exposed to specialty topics in human-computer interaction such as multi-user computing, universal access to computer applications, and internationalizing interfaces. This course includes a project to design, develop, document, and orally present a prototype interface. At the end of the course students will be able to cite basic principles of human interaction and devise and carry out a usability engineering plan to aid in developing new human interfaces.

COMP.5280 Evaluation of Human-Computer Interaction (Formerly 91.528) - Credits: 3

This course is an introduction to methods used to evaluate the design of human-computer interaction (HCI). Students will apply examples of all three of the major types of HCI evaluation techniques: inspection, analytical, and empirical techniques. The course also covers HCI experiment design and data analysis, including threats to experimental validity. The course project consists of a formal usability test. This project requires students to learn principles of ethical treatment of human subjects, complete the University’s Institutional Review Board applications and training for human-subject testing, conduct testing sessions, analyze data, recommend design changes, and document results in a professional manner. At course completion, students will have demonstrated skills for assessing the effectiveness of interface designs and will understand how evaluation fits into computer products’ lifecycles.

COMP.5300 Special Topics (Formerly 91.530) - Credits: 0-3

Topics of mutual interest to the instructor and student(s). “Variable credit course, student chooses appropriate amount of credits when registering.”

COMP.5310 Design of Program Languages (Formerly 91.531) - Credits: 3

A one-semester course designed to provide students with hands-on understanding of the underlying concepts of programming languages, the principles of their design, and the fundamental methods for their implementation. An executable metalanguage such as Scheme or SML is used throughout the course, facilitating the design of high-level, concise interpreters that are easy to comprehend. The approach is analytical because the salient features of the imperative, functional, object-oriented, and logic programming paradigms are described in the executable meta-language.

COMP.5340 Compiler Construction I (Formerly 91.534) - Credits: 3

This course implements a compiler for a complete language. Topics include grammars, syntax, elements of parsing and recursive descent, semantics, basic code generation, fast compilation runtime support. Programming project required.

COMP.5400 Visual Analytics (Formerly 91.540) - Credits: 3

This course covers the basic topics for the interdisciplinary field of visual analytics. This course is not just for computer science students but also for analysts and scientists in different disciplines. The topics include visual analytics science and technology, perception, cognitive processes and human tasks and reasoning, data and knowledge representation, visualization and interaction, statistical and analytic methods, data mining and knowledge discovery, and evaluation and usability. Numerous examples of systems, tools and applications will be presented.

COMP.5411 Data Visualization (Formerly 91.541) - Credits: 3

This course looks at classical and novel methodologies for the visualization of large and complex data sets. The course covers both scientific and information visualization starting with data modeling, human perception and cognition, basic and advanced techniques, interaction, formal models, real time systems, and frameworks for integrated analysis and visualization. Examples used come from numerous areas including the biomedical literature and security.

COMP.5420 Natural Language Processing (Formerly 91.442 & 91.542) - Credits: 3

This course introduces principles and techniques behind natural language processing (NLP), and covers a large selection of important automatic text processing tasks. Selected topics include n-gram language models, part-of-speech tagging, statistical parsing, word sense disambiguation, discourse segmentation, information extraction, sentiment analysis, machine translation. Quantitative techniques are emphasized, with a focus on applying statistical models to large collections of text. The course provides students with a hands-on experience in building a substantial NLP application of their choice.

COMP.5430 Artificial Intelligence (Formerly 91.543) - Credits: 3
Search and games, knowledge representation paradigms, natural language understanding, planning, perception. Use of the LISP language for one or more programming projects.

COMP.5440 Data Mining (Formerly 91.544) - Credits: 3

This introductory data mining course will give an overview of the models and algorithms used in data mining, including association rules, classification, clustering, etc. The course will teach the theory of these algorithms and students will learn how and why the algorithms work through computer labs.

COMP.5450 Machine Learning (91.545) - Credits: 3

This introductory course gives an overview of machine learning techniques used in data mining and pattern recognition applications. Topics include: foundations of machine learning, including statistical and structural methods; feature discovery and selection; parametric and non-parametric classification; supervised and unsupervised learning; use of contextual evidence; clustering, recognition with strings; small sample-size problems and applications to large datasets.

COMP.5455 Graph Machine Learning - Credits: 3

This course focuses on computational and modeling challenges in real world graphs (networks), with a particular emphasis on key advancements in graph representation and its applications. At the end of this course, students should have good understanding of computational techniques that can be applied to a variety of networks, as well as hands-on experience on a range of tasks from identifying important nodes to detection communities to tracing information diffusion in networks. Guest lectures by distinguished researchers and course assignments emphasize the subtleties of translating these techniques into practical applications that reveal insights on a variety of networks. Students should have a strong interest in conducting (or learning how to conduct) research to succeed in this course.

COMP.5460 Computer Graphics I (Formerly 91.546) - Credits: 3

Introduction to the hardware, software and mathematics of 2- and 3-dimensional interactive computer graphics systems, including standards, modeling, transformations, hidden-surface removal, shading, and realism.

COMP.5470 Computer Graphics II (Formerly 91.547) - Credits: 3

Lighting models, photo-realism, animation, constructive solid geometry, and distributed graphics.

COMP.5480 Robot Design (Formerly 91.548) - Credits: 3

A broad interpretation of robotics to mean systems that interact with people, each other, and the world around them, using sensors, actuators, communications, and a control program. Project- and lab-based course that involves electronics, embedded coding, mechanical design, and research.

COMP.5490 Mobile Robots (Formerly 91.549) - Credits: 3

This course will focus on the artificial intelligence side of robotics in a project- and lab-based course. Topics to be covered include robot architectures, mapping and localization, learning, vision, multi-agent systems and current research areas.

COMP.5495 Robot Learning - Credits: 3

This course will cover a variety of machine learning approaches that allow robots to learn manipulation tasks from their own actions and experiences, as well as through interaction with humans. Topics will include methods from a) imitation learning, b) learning from demonstration, and c) Reinforcement Learning. We will discuss methods including, but not limited to, data gathering and pre-processing, skill encoding, reproduction, and generalization, skill refinement, obstacle avoidance, symbol grounding, symbolic planning, feature selection and segmentation, and active learning. The course includes student presentations and a final project where students develop an existing approach and extend it further by applying and implementing their own ideas. There are no formal pre-requisites however, this course covers material that utilize a good deal of machine learning and there will be no time to cover all the background material. Therefore, I strongly recommend having a graduate-level machine learning course (COMP.5450), equivalent research experience, or the willingness to do significant studying outside of class. Students are also expected to have fair knowledge of (a) Linear algebra, (b) calculus, and (c) statistics.

COMP.5500 Topics (Formerly 91.550) - Credits: 3

Topics of mutual interest to the instructor and student(s).

COMP.5510 Bioinformatics for CS - Credits: 3

Complete genomic sequences of human, other mammals, and numerous other organisms are known for some time. From early on, comparisons or analyses of genomic sequences require aids on computer programming. After brief introductions to molecular biology for Computer Science students, the course will examine computer algorithms used in bioinformatics problems including sequence alignment, phylogeny, DNA
sequencing, and data analyses.

**COMP.5520 Foundations in Digital Health - Credits: 3**

Digital health is concerned about utilizing computational technologies to develop health systems, in order to improve healthcare quality. These technologies include various software and hardware solutions such as web apps and wearable devices. This will introduce the foundations and methods in digital health and hand on lab sections to both undergraduate and graduate students, which include the scientific problems, challenges, and application tools of the domain, the tasks we need to handle with, and the applications of various methods such as statistics, machine learning and deep learning. After taking this course, students will obtain a clear concept about what is digital health and knowledge of a wide range of resources and tools to solve the problems and tasks in this domain.

**COMP.5610 Computer & Network Security I (Formerly 91.561) - Credits: 3**

Basic concepts and techniques of computer network security; data encryption algorithms; public-key cryptography and key management; data authentication; network security protocols in practice; wireless network security; network perimeter security; the art of anti-malicious software; the art of intrusion detection. Students will implement encryption and authentication algorithms as network applications.

**COMP.5620 Computer Security II (Formerly 91.562) - Credits: 3**

Applied computer security topics such as a computer and network forensics, virtual private networks, denial of service, viruses and worms, intrusion detection systems, smart cards, biometrics, programming language security, web security and privacy, e-commerce; case studies of deployed systems; policy and legal considerations.

**COMP.5630 Data Communications I (Formerly 91.563) - Credits: 3**

Resource sharing; computer traffic characterizations; multiplexing; network structure; packet switching and other switching techniques; design and optimization; protocols; routing and flow control; simulation and measurement; communications processors.

**COMP.5640 Data Communications II (Formerly 91.564) - Credits: 3**

Continuation of 91.563

**COMP.5660 Malware Analysis - Credits: 3-33**

This class covers both introductory and advanced topics on binary reverse engineering techniques including virtual machines as sandboxes, basic and advanced dynamic analysis, a crash course on assembly language, reverse engineering tools, shellcode analysis and anti-reverse engineering techniques.

**COMP.5670 IoT Security and Privacy - Credits: 3**

The key objectives of this class include: understand IoT frameworks, applications and security and privacy concerns; be familiar with IoT hardware security; master IoT systems security; master IoT software security; master IoT network security; understand the IoT data security and privacy.

**COMP.5680 Seminar in Human-Computer Interaction (Formerly 91.568) - Credits: 3**

The two main purposes of this seminar course are to involve students in current human-computer interaction (HCI) research and to learn to critique others’ HCI research. Each offering of the seminar will center on a theme of applying HCI techniques to a particular type of interaction such as human interfaces for robots, pervasive computing, or social media. Students will be expected to read and critique a number of papers from the current literature in the designated topic area. Further, class members will form a research team (led by the course instructor) to perform original research in the topic area. Class members will co-author a paper based on their research results with the goal of submitting it to a conference. By the end of the course, students will be able to describe the state-of-the-art in the course topic, recognize examples of good and poor research techniques, document research to high academic standards, and become productive members of HCI research teams.

**COMP.5690 Computer and Network Forensics - Credits: 3**

This class introduces students to computer forensics and network forensics. Computer forensics tackles forensic investigation of stand-alone computers while network forensics deals with forensic investigation of networked computers and networks. The class will cover topics such as laws and legal compliance, forensic imaging and analysis, log-file analysis, network traffic analysis and case study.

**COMP.5700 Topics (Formerly 91.570) - Credits: 3**

Topics of mutual interest to the instructor and student(s).

**COMP.5730 Data Base I (Formerly 91.573) - Credits: 3**
Study of various database models including hierarchical, network, relational, entity-relationship, and object-oriented models. This course also covers data design, integrity, security, concurrency, recovery, query processing, and distribution.

COMP.5740 Data Base II (Formerly 91.574) - Credits: 3
Continuation of Data Base I. Various issues in the implementation of database systems will be covered.

COMP.5800 Topics in Computer Science (Formerly 91.580) - Credits: 3
Topics of mutual interest to the instructor and student(s).

COMP.5870 Computer Science Education in Secondary School (Formerly 91.587) - Credits: 3
COMP.5901 Directed Study in Computer Science - Credits: 3
Directed Study in Computer Science

COMP.5920 Special Topics: Computer Science (Formerly 91.592) - Credits: 3
COMP.5930 Cooperative Education (Formerly 91.593) - Credits: 0-1
"Variable credit course, student chooses appropriate amount of credits when registering."

COMP.6040 Network Optimization (Formerly 91.604) - Credits: 3
This course covers advanced topics in network optimization on continuous and discrete models, including the max-flow problem, the min-cost flow problem, simplex methods for min-cost flow, dual ascent methods for min-cost flow, auction algorithms for min-cost flow, nonlinear network optimization, convex separable network problems, and network problems with integer constraints.

COMP.6130 Advanced Topics in Information Retrieval and Mining (Formerly 91.613) - Credits: 3
This is a proposed new 600-level course. The topics are advanced topics in Information Retrieval and Mining, including (but not limited to) Search and Information Retrieval, Visual Text Mining, Document Retrieval and Analysis, Non-textual Retrieval (including Image-, Sound, Video-Retrieval). The course's format is a seminar: (advanced, doctoral) students will be reading and presenting the current state-of-the-art literature. Course requirements include weekly bibliography reports (at least 2 new entries each week) class presentations, two term papers, and a term project.

COMP.6410 Advanced Topics in Visualization (Formerly 91.641) - Credits: 3
This course covers advanced topics in data visualization. Coverage will be topical and may include advanced graph &text visualization, modern coordinated visualizations, collaborative visualization knowledge visualizations, security visualization, web-based visualization, and high-performance visualization. Theory will also be covered.

COMP.6440 Topics in Data Mining (Formerly 91.644) - Credits: 3
This course continues with 91.421/91.544 Data Mining and explores the state of the art research advances in mining large amount of data especially algorithms in association classification, clustering, and applications such as web mining and spatio-temporal data mining.

COMP.6610 Advanced Topics in Network Security (Formerly 91.661) - Credits: 3
This is a topic course, with a subtitle to be determined by the instructor. It covers advanced topics in network security of mutual interests to the faculty and students.

COMP.6730 Advanced Database Systems (Formerly 91.673) - Credits: 3
This course covers advanced topics in database management systems, including query processing and optimization, indexing, transaction management, data warehousing, data mining, etc. It also covers spatio-temporal databases, search engines, stream and sensor databases, and open problems for research.

COMP.7010 Computer Science Research (Formerly 91.701) - Credits: 1
COMP.7020 Computer Science Research (Formerly 91.702) - Credits: 6
COMP.7030 Computer Science Research (Formerly 91.703) - Credits: 3
COMP.7060 Directed Research (Formerly 91.706) - Credits: 6
COMP.7100 Approximation Algorithms (Formerly
This course covers advanced topics in approximation algorithms for NP-hard problems, including combinatorial algorithms and LP-based algorithms for set cover, k-cut, k-center, feedback vertex set, shortest superstring, knapsack, bin packing, maximum satisfiability, scheduling, Steiner tree, Steiner Forest, Steiner network, facility location, k-median, semidefinite programming. It also covers counting problems, shortest vector, hardness of approximation, and open problems for research.

COMP.7410 Thesis Review (Formerly 91.741) - Credits: 1
COMP.7430 Master’s Thesis - Computer Science (Formerly 91.743) - Credits: 3
COMP.7460 Master’s Thesis - Computer Science (Formerly 91.746) - Credits: 6
COMP.7490 Master’s Thesis - Computer Science (Formerly 91.749) - Credits: 9
COMP.7510 Doctoral Thesis Research (Formerly 91.751) - Credits: 1-3
COMP.7530 Doctoral Dissertation/Computer Science (Formerly 91.753) - Credits: 3
COMP.7560 Doctoral Dissertation/Computer Science (Formerly 91.756) - Credits: 6
COMP.7590 Doctoral Dissertation/Computer Science (Formerly 91.759) - Credits: 9
COMP.7690L Continued Graduate Research (Formerly 91.769) - Credits: 9
MSIT.5110 Network and Systems Administration (Formerly 94.511) - Credits: 3
MSIT.5140 Systems Security and Auditing (Formerly 94.514) - Credits: 3

This course examines the strategies for deploying and auditing secure systems. IT auditors primarily study computer systems and networks to form the point of view of examining the effectiveness of their technical and procedural controls to minimize risks. Risk analysis and the implementation of corresponding best practice control objectives will be studied. The material will include methodologies that help auditors to: Discover what’s really going on at a point in time; Find out about potential problems, before it’s too late to fix them; Evaluate business situations objectively; Make informed, if difficult decisions; Implement corrective actions, changes and improvements where needed.

MSIT.5170 Operating Systems Foundations (Formerly 94.517) - Credits: 3

This course investigates the organization and deployment of contemporary operating systems. The process model is examined both generically and in the context of the current Linux/Unix and Windows implementations. Process attributes such as address spaces, threads, channels and handles, access rights, scheduling behavior and states and state transitions will be studied. Memory management, deadlock management and the file system development are also evaluated. A subsystem of system configuration options will be considered during the course in order to highlight the functional deployment of the core OS issues discussed. Pre-req: BS in IT or equivalent. Cannot be used toward MS or PhD in Computer Science.

MSIT.5180 Large Scale Application Deployment (Formerly 94.518) - Credits: 3

This course will develop a systematic framework for the life cycle management of large scale applications. Beginning with requirements assessments, and impact analysis, and continuing through regulatory compliance, lifetime maintenance, scalability concerns, and end-of-life evolution, the material in this course will characterize the stages and transitions of large scale applications. Deployment and management tools will be examined in the context of live applications, with an emphasis on convergent analysis and configuration. Several case studies will be considered, including operating systems, database applications, mailing systems and collaboration systems.

MSIT.5190 Virtual Systems (Formerly 94.519) - Credits: 3

This course will investigate the current state of virtualization in computing systems. Virtualization at both the hardware and software levels will be examined, with emphasis on the hypervisor configurations of systems such as VMware, Xen and Hyper-V. The features and limitations of virtual environments will be considered, along with several case studies used to demonstrate the configuration and management of such systems. Para-virtualized software components will be analyzed and their pros and cons discussed. Processor and peripheral support for virtualization will also be examined, with a focus on emerging hardware features and the future of virtualization.
MSIT.5200 Digital Storage Architectures (Formerly 91.520 and COMP.5200) - Credits: 3

This course will focus on existing and proposed technologies for storing digital information. Both hardware and software issues will be examined, beginning with device and controller organization and proceeding through aggregation techniques, interconnect architectures and host consideration. At each level, specific components will be evaluated with respect to critical storage criteria, such as bandwidth and latency, fault tolerance, infrastructure requirements and cost. Students must already have completed a bachelor's degree in a related discipline and must meet all undergraduate prerequisite requirements specified for graduate IT programs to enroll in this course and in a graduate career.

MSIT.5310 Project Management (Formerly 94.531) - Credits: 3

This course explores the application of knowledge, skills, tools, and techniques that project managers use when managing information technology projects as well as the current IT factors that affect IT project management decision making. Special emphasis will be placed on learning the best practices currently used by organizations and practitioners to ensure the best chance for project success by learning and applying the concepts of managing scope, risk, budget, time, expectations, quality, people, communications, procurement, and externally provided services. Students will be expected to perform research in the above areas as well as using tools such as Microsoft Project to solve project management related problems. Special attention will also be placed on the issues affecting project managers today such as PMOs, virtualization, green IT, and out sourcing. Practical examples will be used to demonstrate the concepts and techniques, plus you will receive hands on experience by working on a case study.

MSIT.5320 Managing Large Data Sets (Formerly 94.532) - Credits: 3

The amount of data generated by businesses, science, Web, and social networks is growing at a very fast rate. This course will cover the algorithms and database techniques required to extract useful information from this flood of data. Data mining, which is the automatic discovery of interesting patterns and relationships in data, is a central focus of the course. Topics covered in data mining include association discovery, clustering, classification, and anomaly detection. Special emphasis will be given to techniques for data warehousing where extremely large datasets (e.g., many terabytes) are processed. The course also covers Web mining. Topics covered include analysis of Web pages and links (like Google) and analysis of large social networks (like Facebook).

MSIT.5330 Developer Operations (DevOps) - Credits: 3

"DevOps" is a set of practices to support software development and business operations in live production environments. By using agile practices and automation, these practices enable software to be developed and deployed to users quickly and with high quality. In this course you will learn DevOps tools and techniques. Tools include microservices, continuous integration and deployments, monitoring, and infrastructure-as-code. Techniques include oh DevOps engineers blur traditional roles of IT, development, release engineering, and quality assurance. Case studies in DevOps from companies such as Amazon and Facebook will be studied. For experimentation purposes, Linux will be used on AWS together with open source tools such as Jenkins, Ansible, and Kubernetes. Students must already have completed a bachelor's degree in a related discipline and must meet all undergraduate prerequisite requirements specified for graduate IT programs to enroll in this course and in a graduate career.

MSIT.5350 Agile and Iterative Project Management (Formerly 94.535) - Credits: 3

This course explores the differences between the Traditional Project management and the Agile management approaches, introduces the principles of Agile Development through applications within each major Project Management process: Project Initiation, Project Planning, Project Execution, and Project Closing. The project will be developed in a timely manner, using Agile techniques that encourage frequent adaptation, self-organization, accountability and with a focus towards rapid delivery. Upon completion, students will understand how to apply Agile principles and practices, recognize ways to increase team performance through better communication and close involvement of stake holders, and recognize the key success criteria for implementing Agile Projects.

MSIT.5360 Data Mining (Formerly 94.536) - Credits: 3

Today, we are surrounded by big data applications. Smartphone and sensor data, medical and scientific data, financial data, web and text data, and social network data are just a few examples. As a result, mining useful information and discovering knowledge from the big data are increasingly important. It is fair to say that, without data mining, we would not be able to make good use of this large amount of data. In this course, we learn the state-of-the-art techniques in data mining and analysis. Topics include types and properties of data, exploring data, classification, association analysis, cluster analysis, and anomaly detection.

MSIT.5410 Information Security, Privacy and Regulatory Compliance (Formerly 94.541) - Credits: 3
This course focuses on enterprise-level information security, privacy and regulatory compliance through study of the rapidly emerging Information Governance (IG) discipline which is applied to electronic documents, records management and output of information organization-wide. The key principles of IG will be examined including the security, privacy and compliance of corporate e-documents/records as well as email, social media, instant messaging, cloud computing, and mobile computing. The student will learn how IG leverages existing information technologies to enforce policies, procedures and controls to manage information risk in compliance with legal and litigation demands, external regulatory requirements, and internal governance objectives.

**MSIT.5430 Intrusion Detection Systems (Formerly 94.543) - Credits: 3**

Intrusion Detection Systems is a survey of the hardware and software techniques that are applied to the detection, identification, classification and remediation of compromised information systems. From this introduction to intrusion detection systems, students will develop a solid foundation for understanding IDS and how they function. This course will give students a background in the technology of detection network attacks. It will introduce all the concepts and procedures used for IDS (intrusion Detection Systems) and IPS (intrusion Prevention Systems). Students will have hands-on experience with implementing and configuring software and hardware based IDS in a network infrastructure. This course is designed with a network administrator in mind.

**MSIT.5450 Designing and Building a Cybersecurity Program (Formerly 94.545) - Credits: 3**

This course focuses on best practices for designing and building a comprehensive Cybersecurity Program based on the NIST Framework for Improving Critical Infrastructure Cybersecurity ("The Framework"). The Framework was issued on February 12, 2014, as directed by President Obama in Executive Order 13636. This framework provides guidance for reducing cybersecurity risk for organizations, and this course will examine its basic tenets of: "Cybersecurity Fundamentals", techniques applied to "Building a Controls Factory", "Cybersecurity Programs" "Establishing Cybersecurity Centers of Expertise" and "The Cybersecurity Program Implementation Roadmap".

**MSIT.5600 Network Infrastructures (Formerly 94.560) - Credits: 3**

This course provides an introduction to the fundamental concepts in the design and implementation of computer communication networks, their protocols, and applications. Topics to be covered include: an overview of network architectures, applications, network programming interfaces (e.g. sockets), transport, congestion, routing, and transport protocols, addressing, local area networks, network management, and emerging network technologies. Cannot be used toward MS or D.Sc. in Computer Science.

**MSIT.5610 Computer Network Security (Formerly 94.561) - Credits: 3**

This course is aimed to provide students with a solid understanding of key concepts of computer network security and practical solutions to network security threats. Topics to be covered include common network security attacks, basic security models, data encryption algorithms, public-key cryptography and key management, data authentication, network security protocols in practice, wireless network security, network perimeter security and firewall technology, the art of anti-malicious software, and the art of intrusion detection. Pre-Req: BS in IT or Equivalent. Cannot be used toward MS or D.Sc. in Computer Science.

**MSIT.5620 Digital Forensics (Formerly 94.562) - Credits: 3**

Identifying, preserving and extracting electronic evidence. Students learn how to examine and recover data from operating systems, core forensic procedures for any operating or file system, understanding technical issues in acquiring computer evidence and how to conduct forensically sound examinations to preserve evidence for admission and use in legal proceedings.

**MSIT.5630 Secure Mobile Networks (Formerly 94.563) - Credits: 3**

This course covers principles and practices of wireless networks, including cellular networks, wireless LANs, ad hoc mesh networks, and sensor networks. The potential attacks against these wireless networks and the security mechanisms to defend these networks will be discussed. Topics to be covered include cellular network architecture, wide-area mobile services, wireless LANs and MACs, introduction to emerging wireless networks, survey of malicious behaviors in wireless networks, securing wireless WANs and LANs, securing wireless routing, securing mobile applications, wireless intrusion detection and prevention, challenges in securing next-generation wireless networks, and privacy issues in wireless networks.

**MSIT.5650 Cloud Computing (Formerly 94.565) - Credits: 3**

This course starts with an overview of modern distributed models, exposing the design principles, systems architecture, and innovative applications of parallel, distributed, and cloud
computing systems. The course will focus on the creation and maintenance of high-performance, scalable, reliable systems, providing comprehensive coverage of distributed and cloud computing, including: Facilitating management, debugging, migration, and disaster recovery through virtualization. Clustered systems for research or ecommerce applications. Designing systems as web services. Principles of cloud computing using examples from open-source and commercial applications.

MSIT.5660 Advanced Cloud Computing (Formerly 94.566) - Credits: 3

This course is a continuation of the 94.565 Cloud Computing course and will cover in further detail such topics as Cloud Based Storage, Virtualization, Service Oriented Architecture (SOA), High Availability, Scaling, and Mobile Devices. The course will also study the role of Open Source cloud software such as Hadoop, OpenStack and others. Similar to the first course where hands-on projects included the use of Cloud Services such as Amazon Web Services (AWS), Google Apps and App Engine, and Windows Azure, this course will continue with those services and add others such as Rackspace and VMware. Current articles and publications in this fast moving field of Cloud Computing will also be followed.
Program Options

Doctoral Program in Earth System Science

- Ph.D. in Earth System Science
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

Master’s of Science in Environmental Studies

- Atmospheric Science Option
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- Environmental Geoscience Option
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- Professional Science Masters Environmental Geoscience Option
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- Professional Science Master’s Atmospheric Science Option
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

Graduate Certificate Programs

- Certificate in Environmental Geoscience
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- Certificate in Environmental Atmospheric Science
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

Professional Internship and Seminar

This professional internship is required for students in this program and is expected to represent a minimum of 350 hours and will have a 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 institutes. To be eligible for the internship students will be expected to have completed half of their STEM courses, two business/communication courses, attained a minimum GPA of 3.0 and received departmental permission. Through this experience the student engages in real-world work situations involving technical problems, teamwork, communication skills and decision-making. Students who are employed full-time in a pertinent field may fulfill the internship requirement by completing an approved project, which adds to the students current set of skills. All students will be required to submit a final written report and give an 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.
ATMO.5010 Boundary Layer Meteorology (Formerly 85.501) - Credits: 3
This course draws upon the equations of motion in the atmosphere to develop a theoretical understanding of the atmospheric boundary layer. This understanding is compared with real observations taken with the Department’s rawinsonde equipment, as well as published data. The emphasis is on blending theory and practice to enhance the student’s understanding of the behavior of the atmosphere.

ATMO.5020 Advanced Synoptic Meteorology (Formerly 85.502) - Credits: 3
This course is designed for graduate students who have a strong background in mathematics and physics, but whose meteorology preparation is weak. The basic concepts of weather forecasting and analysis on synoptic scales are covered theoretically as well as in application to case studies and current weather. The coursework encourages the development of three-dimensional visualization techniques and an appreciation of the physics which controls weather systems.

ATMO.5030 Remote Sensing (Formerly 85.503) - Credits: 3
This course is a survey of ground based, balloon, rocket probe, radar and satellite remote sensing techniques. Optical and radio frequency remote sensing techniques are surveyed. The focus is on the determination of physical, chemical and dynamical quantities by remote sensing measurements. The theory is presented used to interpret data obtained by remote sensing techniques. Various inversion methods are discussed used to obtain spatial discrete quantities from line-of-sight observations. Modeling and simulation techniques are described and practiced.

ATMO.5050 Atmospheric Measurements and Data Analysis - Credits: 3
Against the backdrop of unprecedented global environmental change, meteorological and climatological observations have been thrust into the scientific and public spotlight. ATMO.5050 explores the range of instrumentation, measurement principles, and data analysis techniques used to monitor Earth’s ever-changing weather and climate. From hands-on work with state-of-the-art field instruments, to computational data processing and visualization, students will gain a broad set of skills that will position them to succeed in both the observational and computational atmospheric science sub-fields.

ATMO.5080 The Climate System (Formerly 85.508) - Credits: 3
The main elements of the Climate System are the atmosphere, ocean, biosphere, land surface, and the cryosphere; the primary input of energy is from the Sun. This course examines these elements, the ways in which they interact and how they can be modeled. The Global Energy Budget is examined and both natural and human-caused climate change are considered.

ATMO.5100 Regional Weather and Climate Modeling (Formerly 85.510) - Credits: 3
Mesoscale atmospheric dynamics and regional climate dynamics. Application of regional weather and climate model to regional weather, climate modeling and forecast problems. Multi-scale physical processes, such as mesoscale and convective-scale phenomena, low-level jets, mountain waves and orographic precipitation, land/sea breezes, cyclones etc., will be discussed in order to understand the linkage between regional weather and climate.

ATMO.5130 Physical Meteorology (Formerly 85.513) - Credits: 3
This course explores the essentials of cloud physics, beginning with the basic laws of thermodynamics of both dry and moist atmospheres. Condensation, nucleation, and drop growth are studied in detail at an advanced level.

ATMO.5150 Atmospheric Structure and Dynamics (Formerly 85.515) - Credits: 3
The temperature, pressure and density structure of the atmosphere are reviewed, as well as the chemical composition. Topics include atmospheric and solar radiation, atmospheric heat budget and the hypsometric equation. Dynamics of the atmosphere explores the behavior of fluids on a rotating earth, global circulation, synoptic scale motions, perturbation theory of wave motions. Elements of climatic change and the effects of anthropogenic emissions on climate and weather will also be discussed.

ATMO.5160 Mesoscale Atmospheric Dynamics (Formerly 85.516) - Credits: 3
This course is designed for students to apply atmospheric dynamics and physical analysis techniques to mesoscale and convective-scale phenomena, including mesoscale convective systems, severe thunderstorms, tornadoes, dry lines, low-level jets, mountain waves and orographic precipitation, land/sea breezes, boundary layer rolls, and hurricanes. Emphasis will be given to the physical understanding of these processes instead of forecasting.
ATMO.5180 Forecasting and Synoptic Techniques I  
(Formerly 85.518) - Credits: 3

This is the first of a two-course sequence that provides graduate students a combined theoretical and applied understanding of synoptic-scale meteorology, with an emphasis on forecasting applications. The first course introduces the concepts of vorticity advection and the quasi-geostrophic approximation, and applies them synoptic-scale cyclones, including nor’easters. The graduate students will learn to use Gempak graphics and will be introduced to the National Weather Service Weather Event Simulator, a combined hardware and software package that simulates the NWS forecast environment.

ATMO.5230 Air Pollution Control (Formerly 85.523)  
- Credits: 3

This course describes air pollutants, their characterization, ambient concentrations, effects on human health and the ecology, and the environmental laws and regulations that set standards on emission rates and ambient concentrations. The basics of air pollutant dispersion and transport are also covered. The main focus of the course is on emission control technologies for particulate matter, carbon monoxide, sulfur oxides, nitrogen oxides, organic and inorganic toxic pollutants. The following technologies are discussed: cyclones, scrubbers, electrostatic precipitators, baghouses, adsorption, absorption and incineration. The automobile and its emission control are reviewed. Alternative methods are also discussed, such as fuel substitution, conservation and efficiency improvement.

ATMO.5240 Simple Atmospheric Models (Formerly 85.524)  
- Credits: 3

The basic wave types and fundamental dynamics of atmospheric motion are considered through analytical and numerical modeling of the main simplifications (models) of the full equations of motion for the atmosphere. These models are derived by making assumptions that greatly simplify the full equations and which isolate individual wave types and specific physical mechanisms. Together, these models describe the basic aspects of atmospheric motion: the maintenance and structure of the jet stream, the genesis and propagation of synoptic storms, and the forced and internal contributions to seasonal patterns of midlatitude climate variability.

ATMO.5290 Advanced Forecasting (Formerly 85.529)  
- Credits: 3

This course builds on the student’s basic understanding of storm systems and extends their theoretical knowledge to particular weather patterns. Topics include nowcasting, long-range forecasting, snow squalls, sea breeze, and especially deep convection. Particular attention is paid to the structure and development of supercells. Students will also be required to write a special report on a topic assigned by the professor, and present this in class as a special lecture.

ATMO.5400 Tropical Meteorology (Formerly 85.540)  
- Credits: 3

An introduction to the tropical atmosphere, including tropical climatology, structure and dynamics of easterly waves, tropical cyclones and monsoon circulation’s.

ATMO.5500 Satellite andrad Meteorology  
(Formerly 85.550) - Credits: 3

ATMO.5710 Air Pollution Phenomenology (Formerly 85.571)  
- Credits: 3

The course centers on transport, dispersion and transformation of air pollutants in the atmosphere. Atmospheric structure and dynamics are reviewed. The atmospheric dispersion equation is developed for instantaneous and steady-state releases of pollutants, including the Gaussian Plume Equation for point, line and area sources. The sources and transport of particulate matter are discussed, including haze and visibility impairment. Other topics are photooxidants (ozone), acid deposition, stratospheric ozone depletion and the greenhouse effect.

ATMO.5810 Meteorology for Teachers (Formerly 85.581)  
- Credits: 3

The purpose of this course is to provide the middle school teacher with: a thorough understanding of several key concepts and processes of meteorology; the ability to effectively present meteorology topics that are appropriate for the middle school science classroom; the tools necessary to develop inquiry based lessons for the classroom.

ATMO.5910 Directed Study (Formerly 85.591)  
- Credits: 1-3

ATMO.5950 Professional Experience Atmospheric Science (Formerly 85.595)  
- Credits: 1-3

Professional experience with a private or public employer. Written report and supervisor evaluation required.

ATMO.6410 Special Topics in Meteorology (Formerly 85.641)  
- Credits: 3

ATMO.6420 Special Topics in Meteorology  
(Formerly 85.642) - Credits: 3

ATMO.7010 Graduate Research Seminar (Formerly 85.701)  
- Credits: 1-3

ATMO.8000 Advanced Graduate Seminar  
(Formerly 85.800) - Credits: 1-3

ATMO.9000 Seminar (Formerly 85.900)  
- Credits: 1-3
ENVI.5000 Graduate Seminar in Environmental Sciences - Credits: 1

The Graduate Seminar in Environmental Sciences includes speaker presentations by invited external and internal faculty, as well as student presentations. Graduate seminar students will also be expected to evaluate professional papers and complete several writing assignments specific to presentations and/or research papers. The class includes interdisciplinary topics in Atmospheric Sciences, Geosciences, and Environmental Sciences. The goals are to improve oral and written communication skills and expand knowledge of state-of-the-art research approaches and research themes.

ENVI.5020 Freshwater Ecology - Credits: 3

Freshwater Ecology is a 3-credit lecture course that covers the basic concepts regarding the physical structure, water quality, and ecological communities of freshwater lake and pond as influenced by the environment. Physical and chemical concepts (e.g., lake circulation patterns, thermal stratification, nutrient budgets, etc.) are incorporated with the lake biota (e.g., phytoplankton, zooplankton, and fish) and synthesized to provide perspective on ecosystem function. Within this scientific framework, we will also study the application of practical lake management using current lake and watershed-based management tools and options.

ENVI.5040 Geographic Information Systems (Formerly 87.504) - Credits: 3

This course will cover most of the elements of a geographic information system commonly found in basic and mid-level GIS applications. Topics will include file organization, data entry including digitizing and image registration, geocoding, thematic mapping, Structured Query Language (SQL) applications, map algebra, raster operations, interpolative methods, distance mapping, density mapping, cost surfaces, and an introduction to modeling. This course will use the Arcview GIS platform.

ENVI.5100 Environmental Pollution - Credits: 3

This class is designed for graduate students in Environmental, Earth and Atmospheric Sciences, Environmental Engineering, Environmental Chemistry and Biology. The class describes the origin, transport, and transformation of pollutants in the environmental behavior and biological impacts of contaminants. Students also will learn about national and international regulations regarding pollutant emissions and technology for control and remediation.

ENVI.5160 Climate Change: Science, Communication, and Solutions (Formerly 81.516/BIOL.5160) - Credits: 3

Like many of the 'grand challenges' currently facing society, climate change is a complex problem that cuts across academic disciplines, including the physical sciences, biology, engineering, economics, political sciences, and behavioral psychology. In this course, we integrate recent research from many of these disciplines to explore the scientific basis of climate change, its impacts on the natural world and human society, and societal responses to it. Through interactive simulations, class discussions, lectures, current scientific literature, and student-led projects, the goal of this course is to empower students to come to their own decisions about how society can address the climate change challenge. Students taking this course at the graduate level will lead group projects.

ENVI.5170L Climate Change: Science, Communication, Solutions Recitation Lab - Credits: 1

This course is designed to integrate closely with the lecture course, Climate Change: Science, Communication, and Solutions. Students will use interactive simulations, build models, and create media projects that explore climate change and sustainability. Topics include the physical climate system
and carbon cycle, human energy systems, and climate policy and economics. Students take this course at the graduate level will lead group projects.

ENVI.5200 Methods in Environmental Impact Assessment and Analysis (Formerly 87.520) - Credits: 3

This course describes, and illustrates with case studies, environmental evaluation required to implement projects and policies potentially affecting the environment. Methods available to integrate technical impact predictions, prepare Environmental Statements, and make informed decisions regarding environmental effects will be covered. Incorporation of sustainability and permitting with environmental analyses will also be examined.

ENVI.5720 Energy and Environment (Formerly 87.572) - Credits: 3

This course discusses the world and U.S. primary energy resources and consumption, including fossil, nuclear and renewable energy sources. Principles of thermodynamics are reviewed, especially in regard to energy usage efficiency improvement. A significant part of the course is devoted to electricity production, including site visits to fossil and nuclear power plants. The environmental effects are discussed of energy extraction and consumption, such as SOx, NOx and particulate matter emissions, acid deposition, the greenhouse effect, radioactive waste disposal. Also the risks of accidents are discussed in fossil and nuclear fuel usage.

ENVI.5850 Climate Change in the Classroom (Formerly 87.585) - Credits: 3

The course is designed to help teachers from all levels improve their ability to foster student learning about the earth’s changing climate. The course addresses the scientific, sociological, and pedagogical dimensions associated with climate change science. How to incorporate climate change into existing curriculum across disciplines is considered.

GEOL.5010 Paleoclimatology (Formerly 89.501) - Credits: 3

This course provides students with an overview of paleoclimatology by examining the use of proxy records, such as marine and lake sediment sequences, ice cores, tree rings, corals and historical data to reconstruct past climatic conditions. Dating methods will be introduced. Throughout, we will critically analyze our understanding of past climates and environments and identify directions for future research. Topics include: abrupt climate change, human evolution and climate, biosphere-climate interactions and paleoclimate modeling.

GEOL.5020 Quantitative Gemorphology (Formerly 89.502) - Credits: 3

This course follows the path of material as it is weathered form bedrock, moved down hillslopes and transported via glaciers and rivers. Emphasis is on 1) quantifying erosion and sediment transport, 2) applying computer-based models and conservation of mass equations to earth surface processes and 3) understanding long-term landform evolution.

GEOL.5100 Geology of New England (Formerly 89.510) - Credits: 3

New England has an ancient and diverse geologic history. This course covers the tectonic and sedimentary processes that formed the bedrock of New England and New York, the Pleistocene history of ice sheet erosion and deposition, and the most recent period of human interactions with the landscape.

GEOL.5130 Exploring the Solar System - Credits: 3

We live in a remarkable era of robotic space exploration. In this course, we will walk through the formation of the Solar System and the comparative evolutions of the planets, moons, and other objects form a geological perspective, with special attention paid to the latest research and missions. We will also consider the prospects for life on other planetary bodies in our Solar System and in extrasolar planetary systems.

GEOL.5150 Topics in Environmental Geochemistry (Formerly 89.515) - Credits: 3

Case-based course dealing with the application of thermodynamics and kinetics, acid-base equilibria, oxidation-reduction reactions, radioactive and stable isotopes, and mineral chemistry to the understanding and solution of environmental problems. Other topics will be considered based on student interest.

GEOL.5200 Structural Geology (Formerly 89.520) - Credits: 3

An analysis of crustal deformation through detailed study of geologic structures with emphasis upon the response of geologic materials to stress and strain. Field techniques, tectonic principles, and geometrical analysis are employed.

GEOL.5240 Regional Hydrogeology (Formerly 89.524) - Credits: 3

Concentrating on the storage and steady state flow of ground water at a basin-wide scale, the course studies flow nets, fluid
potential, and numerical modeling of flow controlled by basing geometry and geology; water movement in the zone of aeration, the interaction of groundwater with surface water, the transport and dispersion of contaminants, and the use of modeling for groundwater management.

GEOL.5250 Groundwater Modeling - Credits: 3

This course covers the concepts and practice of mathematical and numerical modeling of saturated groundwater flow and solute transport. Students will use industry-standard groundwater modeling software, including MODFLOW, MODPATH, MT3DMS, SEAWAT, and PHT3D for single- and variable-density flow, particle tracking, and solute and reactive transport. Emphasis will be on formulating mathematical representations of flow, use of groundwater models with graphical user interfaces, and post-processing and analysis of model results.

GEOL.5310 Isotopes in Environmental and Geosciences (Formerly 89.531) - Credits: 3

The course will show how radioactive and stable isotopes can be used to understand environmental and geological systems. Topics to be covered include radiometric dating using short and long half-life isotopes, radiogenic isotopic tracers, and stable isotopes.

GEOL.5560 Applied Geophysics (Formerly 89.556) - Credits: 3

Application of geophysics to problems in geology and environmental science. Principles and techniques of gravity, magnetic, electrical, and seismic methods. Field projects and surveys.

GEOL.5850 Oceanography for Teachers (Formerly 89.585) - Credits: 3

This course will introduce students to basic oceanographic principles and processes. Content will be linked to National and State Science Standards. Students will create a number of oceanography-based lessons linked to the standards. Pedagogy will be modeled in relation to teacher instruction and student learning.

GEOL.5930 Special Topics: Environmental Geoscience (Formerly 89.593) - Credits: 3

Student/Instructor selected in-depth study of a specific topic(s) within the Environmental Geosciences of a closely related field.

GEOL.7310 Master's Research in Environmental Geoscience (Formerly 89.731) - Credits: 1-6

GEOL.7410 Master's Thesis in Environmental Geoscience (Formerly 89.741) - Credits: 1-9
ENVS.5010 Wetlands Ecology (Formerly 18.501) -
Credits: 3

Types, characteristics and definitions, functions and values, regulation and management of wetlands; with due regard given to geology, soils and hydrology, and biological/ecosystem interactions.

ENVS.5810 Understanding Massachusetts Contingency Plan (Formerly 18.581) - Credits: 3

The Massachusetts Contingency Plan (MCP) is a body of regulations designed to streamline and accelerate the assessment and cleanup of releases of oil and hazardous materials to the environment. This course serves as an introduction to the MCP and will explore the intent and use of key aspects of this working document. Though primarily a regulatory course, some topics to be covered are technical in nature. Prerequisites: None. Though not required, some familiarity with relevant environmental science and/or engineering principles is desirable.
IM.769 Continuing Graduate Research (Formerly IM.769) - Credits: 9
Graduate Research.

MARI.6300 Biological Oceanography (Formerly IM.630) - Credits: 3
MARI.6500 Physical Oceanography (Formerly IM.650) - Credits: 3
MARI.7430 Master’s Thesis (Formerly IM.743) - Credits: 3
MARI.7460 Master’s Thesis (Formerly IM.746) - Credits: 6
MARI.7490 Master’s Thesis (Formerly IM.749) - Credits: 9
MARI.7510 Doctoral Dissertation (Formerly IM.751) - Credits: 1-9
Doctoral Dissertation Research

MARI.7530 Doctoral Dissertation (Formerly IM.753) - Credits: 3
Doctoral Dissertation Research

MARI.7550 Doctoral Dissertation (Formerly IM.755) - Credits: 5
Doctoral Dissertation Research

MARI.7560 Doctoral Dissertation (Formerly as IM.756) - Credits: 6
Doctoral Dissertation Research

MARI.7590 Doctoral Dissertation (Formerly IM.759) - Credits: 9
Doctoral Dissertation Research

MARI.7690 Continuing Graduate Research (Formerly IM.769) - Credits: 9
Graduate Research.
MATH.5000 Discrete Structures (Formerly 92.500) - Credits: 3
An introduction to discrete mathematics, including combinatorics and graph theory. The necessary background tools in set theory, logic, recursion, relations, and functions are also included. Masters degree credit for Teacher Option Only.

MATH.5010 Real Analysis (Formerly 92.501) - Credits: 3
The class is aimed to give rigorous foundations to the basic concepts of Calculus such as limits of sequences and functions, continuity, Riemann integration. The main focus is given to rigorous proofs rather than computations. Tentative topics are: Real numbers (algebraic, order and distance structures); Archimedean property; Sequences and their limits. Bolzano-Weierstrass theorem; Cauchy sequences and completeness; Limit of a function; Continuity of a function at a point and on a set; Uniform continuity; Open and closed sets, idea of compactness, compactness of a closed interval; Sequences of functions, uniform convergence; Riemann integration. Prerequisites: Calculus I-III or equivalent, Discrete Structures or equivalent.

MATH.5070 Applied Functional Analysis I (Formerly 92.507) - Credits: 3

MATH.5090 Probability and Mathematical Statistics (Formerly 92.509) - Credits: 3
This course provides a solid basis for further study in statistics and data analysis or in pattern recognition and operations research. It is especially appropriate for students with an undergraduate science or engineering major who have not had a rigorous calculus-based probability and statistics course. The course covers the topics in probability models, random variables, expected values, important discrete and continuous distributions, limit theorems, and basic problems of statistical inference: estimation and testing.

MATH.5100 Computers and Calculators in Classroom (Formerly 92.510) - Credits: 3
Explores the roles of computers and calculators in instruction, examines some of the available software, and considers their use in a variety of areas of school mathematics, such as algebra, geometry (Euclidean and analytic) probability and statistics, and introductory calculus. Mathematics Masters degree credit for Teacher Option Only.

MATH.5130 Number Theory (Formerly 92.513) - Credits: 3
Study of primes, congruences, number-theoretic functions, Diophantine approximation, quadratic forms and quadratic number fields. Additional topics as time permits.

MATH.5260 Topology (Formerly 92.426/526) - Credits: 3
Metric spaces, topological spaces, connectedness, compactness, the fundamental group, classifications of surfaces, Brouwer's fixed point theorem.

MATH.5300 Applied Mathematics I (Formerly 92.530) - Credits: 3
Infinite Series, Complex Algebra, Ordinary Differential Equations, Special Functions, Fourier Series, Vector Spaces, Operators and Matrices.

MATH.5310 Applied Mathematics II (Formerly 92.531) - Credits: 3

MATH.5430 Ordinary Differential Equations (Formerly 92.543) - Credits: 3

MATH.5450 Partial Diff Equations (Formerly 92.545) - Credits: 3

MATH.5500 Mathematical Modeling (Formerly
92.550 - Credits: 3
Applications of mathematics to real life problems. Topics include dimensional analysis, population dynamics wave and heat propagation, traffic flow. Pre-requisite: 92.132 Calculus II.

MATH.5510 Calculus of Variations (Formerly 92.551) - Credits: 3
The first variational problem, necessary conditions. Euler’s equation. Generalization to dependent and independent variables. Constraints and Lagrange multipliers. Application to dynamics and elasticity. Direct methods.

MATH.5550 Applied Math for Life Scientists (Formerly 92.555) - Credits: 3
The objective of this course is to give students an opportunity to learn how to use a computer algebra system in the context of reviewing some of the key mathematical topics that are used in the life sciences. The first half of the course includes a review of mathematical topics ranging from trigonometry through differential equations. A parallel introduction to a computer algebra system is also included in the first half. In the second half, students will study a mathematical topic such as pattern recognition or models for growth and complete a project using the computer algebra system. (UMassOnline).

MATH.5630 Computational Mathematics (Formerly 92.563) - Credits: 3

MATH.5640 Applied Linear Algebra (Formerly 92.564) - Credits: 3
Use of iterative algorithms to find exact or approximate constrained solutions to large, and often spares, systems of linear equations, and on applications, such as medical imaging, in which such problems arise. Maximization of likelihood and entropy. Emphasis on exploiting sparseness, accelerating convergence, and stabilizing calculations in the presence of noise. Block-iterative methods and bounds for singular values will be included. Basic results in matrix theory presented as needed.

MATH.5650 Special Functions (Formerly 92.565) - Credits: 3
Introduction to functions beyond those studied in calculus and which arise in applied mathematics, including gamma, beta, elliptic, Bessel, orthogonal polynomials ... Asymptotic approximation will be introduced.

MATH.5680 Approximation Theory (Formerly 92.568) - Credits: 3
MATH.5720 Optimization (Formerly 92.572) - Credits: 3
Optimization without calculus; geometric programming; convex sets and convex functions; review of linear algebra; linear programming and the simplex method; convex programming; iterative barrier-function methods; iterative penalty-function methods; iterative least-squares algorithms; iterative methods with positivity constraints; calculus of variations; applications to signal processing, medical imaging, game theory.

MATH.5750 Applied Statistics with R (Formerly 92.575) - Credits: 3
This is a methods course focusing on the applications of statistics using R programming language. Topics include: Study designs, review of inference and regression, categorical data, logistic regression, rates and proportions, and nonparametric methods. Additional topics may be considered if time permits. Only one of 92.575(R) and 92.576(SAS) may be applied toward a Masters degree in Mathematics.

MATH.5760 Statistical Programming using SAS (Formerly 92.576) - Credits: 3
An introduction to creation and manipulation of databases and statistical analysis using SAS software. SAS is widely used in the pharmaceutical industry, medical research and other areas. Cannot be used as a Math Elective.

MATH.5780 Statistical Inference and Data Mining (Formerly 92.578) - Credits: 3
Topics in nonasymptotic direct computational methods for statistical inference in data mining. Background in probability and statistics required.

MATH.5840 Stochastic Process (Formerly 92.584) - Credits: 3
Markov chains and processes, random walks, stationary, independent increments, and Poisson processes. Ergodicity. Examples (e.g., diffusion, queuing theory, etc.).
MATH.5870 Measure and Probability Theory
(Formerly 92.587) - Credits: 3

This course presents the mathematical foundations of Probability Theory, including the concepts of Probability Space and random variable. Various types of convergence of sequences and measurable functions will be introduced, and precise statements and proofs of the probability limit theorems (Law of Large Numbers, Central Limit Theorems, etc.) will be given. Theory of measure and Lebesgue integration will be introduced. If time permits, conditional probabilities will be discussed.

MATH.5880 Mathematical Statistics (Formerly 92.588) - Credits: 3

Random variables, densities, joint and conditional distributions, expectations, variance, estimation, sufficiency and completeness, hypothesis testing, limiting distributions.

MATH.5900 Statistical Quality Control (Formerly 92.590) - Credits: 3

Overview of quality and managing quality, Define Measure Analyze Improve Control (DMAIC), the six sigma approach to quality, visual representation of data, Pareto charts, histograms, process capability vs specification (process) limits, t-tests, ANOVA, and other statistical hypothesis testing in quality, normal probability plots, control charts, measurement system analysis, application of regression analysis to manufacturing and/or design, Minitab.

MATH.5910 Linear Statistics Modeling and Regression (Formerly 92.591) - Credits: 3


MATH.5920 Multivariate Statistics (Formerly 92.592) - Credits: 3

Nonlinear model building via the method of least squares. Discriminant and factor analysis, principal components, profile analysis, canonical correlation, cluster analysis. Experience on real data sets.

MATH.5930 Experimental Design (Formerly 92.593) - Credits: 3

How to design, carry out, and analyze experiments.

Randomized block designs, randomization, blocking, matching, analysis of variance and covariance, control of extraneous variables.

MATH.6510 Selected Topics in Mathematics
(Formerly 92.651) - Credits: 3

Intended to satisfy individual student needs. Topics include various fields of mathematics.

MATH.6530 Selected Topics (Formerly 92.653) - Credits: 3

Advanced topics in various fields of mathematics and related fields. Since topical coverage varies from term to term, a student may be allowed to receive credit more than once for this course.

MATH.7060 Directed Research - Credits: 1-6

Direct supervision with a dissertation advisor.

MATH.7420 Thesis Review (Formerly 92.472) - Credits: 1

MATH.7430 Master's Thesis in Mathematical Sciences (Formerly 92.743) - Credits: 3

Master's Thesis Research.
PHYS.4780 Integrated Optics: Wave Guides and Lasers (Formerly 95.478/578) - Credits: 3

This course is a continuation of 95.477 and serves as an introduction to solid state electronic and optoelectronic devices. The course will cover bipolar junction transistors, field effect transistors, integrated circuits, lasers, switching devices, and negative conductance microwave devices. Three or four practical demonstrations will also be performed with the analysis of the generated data assigned as homework. (offered as 95.548 for graduate credit)

PHYS.5010 Energy, Force and Motion (Formerly 95.501) - Credits: 3

An introduction to the most fundamental area of physics: the nature of motion, what affects it, and how it is measured. We examine Newton’s laws, including the law of gravity, and how forces produce acceleration. The course also examines the nature of energy - potential and kinetic - and how it relates to motion and forces. We will concentrate on how to analyze physical situations and solve the basic equations of motion. This course is intended to help teachers develop their understanding of the physics of motion.

PHYS.5170 Space Science Mission Design (Formerly 95.417/517) - Credits: 3

This one-semester, 3-credit course intended for junior level science and engineering majors, is centered around the conceptual design of a spaceflight mission. In this project-based and team-based class, students will apply their science and technical knowledge to develop a spacecraft and mission concept tailored to answer a specific science question. Students will perform quantitative trade studies consistent with real-life constraints such as cost, schedule, manufacturability, team-expertise, operational environment, mission lifetime, etc. Students will 1) learn the fundamentals of key subsystems involved in a space flight mission and 2) apply their skills of inquiry, research, critical thinking to design a complete space science mission to solve a real-world problem while working within a multidisciplinary team.

PHYS.5210 Statistical Thermodynamics (Formerly 95.421/521) - Credits: 3

An integrated study of the thermodynamics and statistical mechanics, review of the experimental foundations and historical development of classical thermodynamics; probability and statistical methods of studying macroscopic systems; atomic basis of the laws of thermodynamics and microscopic definitions of thermodynamics quantities using the method of ensembles; entropy and related quantities; TdS equations, Maxwell relations, equation of state, and applications: canonical and grand canonical ensembles; phase transitions; quantum statistics; application to radiation, magnetism, specific heats. (offered as 95.521 for graduate credit)

PHYS.5360 Introductory Quantum Mechanics II (Formerly 95.536) - Credits: 3

The three dimensional Schroedinger equation, the deuteron nucleus, angular momentum, spin, the hydrogen atom, spin-orbit interaction, Zeeman effect, Pauli exclusion principle, atomic structure, multi-electron atoms, the Fermi gas, X-rays.

PHYS.5370 Geometric Optics - Credits: 3

This course will cover the use of lenses, mirrors, and other optics to construct optical systems. Topics will include paraxial optics, aberrations, two element systems (such as telescopes), and dispersive optics (such as diffraction gratings and binary optics). We will discuss transfer functions, zernike polynomials, ray tracing procedures, and other analysis techniques in order to understand the performance of systems and their aberrations. As time allows we will discuss wave effects including diffraction, interferometry, and other physical effects.

PHYS.5380 Physical Optics and Waves (Formerly 95.538) - Credits: 3

Wave nature of light, mathematics of wave motion, electromagnetic theory of light propagation, reflection and refraction, Fresnel coefficients, polarization, interference, Young’s experiment, fringe visibility and coherence, various interferometers, Newton’s rings and applications, Fraunhofer diffraction by single and multiple apertures and diffraction gratings, Fresnel diffraction.

PHYS.5390 Electro-Optics (Formerly 95.439/539) - Credits: 3

Optical properties of materials, including dispersion, absorption, reflection and refraction at the boundary of two media. Crystal optics and induced birefringence and optical activity. Polarization states and Jones matrices. Applications to electro-optic devices. Experiments and projects involving the study of optical sources and detectors, spectroscopy, polarization, birefringence, pockels’ effect, optical fibers, and optical communication. (offered as 95.539 for graduate credit)

PHYS.5550 Introduction to Space Physics (Formerly 95.555) - Credits: 3

The course introduces the present knowledge of space phenomena and the physical understanding of the plasma environment from the sun to the earth’s ionosphere and in the
heliosphere. Regions in space to be discussed include the solar surface, solar wind, bow shock, magnetosheath, magnetosphere, magnetotail, radiation belts, ring currents, and the ionosphere. Among space plasma physic theories, single particle theory, kinetic theory, and magnetohydrodynamics, which describe charged particle motion in electromagnetic fields and its consequences, are introduced and applied to the space environment.

**PHYS.5560 Radiative Processes in Astrophysics**  
(Formerly 95.456/556) - Credits: 3

Our knowledge of the universe beyond the Solar System is derived almost entirely from our interpretation of the radiation we receive from the universe; Our knowledge of the Earth's upper atmosphere and the atmospheres of other solar system objects is heavily dependent on observations of electromagnetic radiation. To understand the atmospheres of Earth and other planets, stars, galaxies and the universe, we need to understand the processes which produce electromagnetic radiation, and how radiation interacts with matter and propagates through space. This course describes the basic processes which create and alter such electromagnetic radiation before it's detected here in the Solar System. The course will consist of a combination of lectures, problem sets and class discussion sessions. The lectures will be expanded from the material in the text and will include additional material on the astrophysical and planetary context of radiative processes, drawn primarily from the following list of references. The discussion sessions will often be based on recent problem sets - regular participation of students in class discussions is expected.

**PHYS.5630 Computational Methods in Physics** - Credits: 3

The course aims to provide an overview of the main and common computational methods currently used in physics research. The course will cover the topics of basic concepts of computational physics, first and second order methods of integration of advection equations, kinetic methods and N-body methods, Monte Carlo and Particle in Cell (PIC) methods, finite elements, finite volume and Computational Fluid Dynamics (CFD), spectral methods, girding methods and Adaptive Mesh Refinement (AMR), and introduction to parallel computing.

**PHYS.5640 Particle Astrophysics**  
(Formerly 95.464/564) - Credits: 3


**PHYS.5670L Automation Techniques**  
(Formerly 95.567) - Credits: 3

**PHYS.5690 Plasma Physics** - Credits: 3

The course aims to provide upper level undergraduate and graduate students from Physics and Engineering background in plasma physics, focusing on the fundamental physics principles, not any specific application or field of research. The course will cover the topics of basic plasma concepts, single-particle motion in an electromagnetic field, magnetohydrodynamics, plasma waves, plasma instabilities, plasma kinetics, and some advanced topics in plasma physics.

**PHYS.5830 Astronomy and Astrophysics I**  
(Formerly 95.583) - Credits: 3

Physics based introduction to modern Astronomy and Astrophysics. Aimed at students who have already studied E&M Modern Physics, and Calculus. Focus on fundamentals of Stellar Astrophysics and Galactic Astronomy.

**PHYS.5870 Cloud Physics**  
(Formerly 95.587) - Credits: 3

This course explores the essentials of cloud physics, beginning with the basic laws of thermodynamics of both dry and moist atmospheres. Condensation, nucleation, and drop growth are studied in detail at an advanced level.

**PHYS.5930L Graduate Physics Laboratory**  
(Formerly 96.593) - Credits: 2

Experiments in various branches of physics including optics, atomic physics, solid state physics and nuclear physics.
PHYS.6050 Mathematical Methods of Physics I
(Formerly 95.605) - Credits: 3

Vector analysis; matrices and determinants; theory of analytical functions; differential equations, Fourier series, Laplace transforms, distributions, Fourier transforms. Students taking PHYS.6050/6060 cannot get credit for PHYS.6070.

PHYS.6060 Mathematical Methods of Physics II
(Formerly 95.606) - Credits: 3

Partial differential equations, boundary value problems, and special functions; linear vector spaces; Green's functions; selected additional topics; numerical analysis. Students taking PHYS.6050/6060 cannot get credit for PHYS.6070.

PHYS.6070 Mathematical Methods of Physics - Credits: 3

Vector and tensor analysis; Linear spaces; Special functions; Fourier transforms; Theory of complex variables. Students taking PHYS.6070 cannot get credit for PHYS.6050/6060.

PHYS.6110 Classical Mechanics (Formerly 95.611) - Credits: 3


PHYS.6150 Quantum Mechanics I (formerly 95.615) - Credits: 3


PHYS.6160 Quantum Mechanics II (formerly 95.616) - Credits: 3


PHYS.6165 Graduate Quantum Mechanics - Credits: 3

This single-semester course assumes prior exposure to quantum mechanics and is designed to train students in more complex concepts and tools of quantum mechanics. The topics include mathematical framework of complex vector spaces, exactly solvable systems such as harmonic oscillator and spin-half, path integral formalism, continuous and discrete symmetries, gauge invariance and quantum Hall effect, time-independent and time-dependent perturbation theory, second quantization of many-body quantum systems. The aim of the course is to provide foundational conceptual and technical background requisite for advanced elective courses, such as quantum information, quantum optics, quantum field theory, and/or quantum many-body physics. Students can get credit for either PHYS.6165 or for PHYS.6150/PHYS.6160 Sequence.

PHYS.6170 Advanced Quantum Mechanics I
(Formerly 95.617) - Credits: 3

Dirac equation as a single particle wave equation, free particle spinors and plane waves, matrices and relativistic covariance, nonrelativistic approximation and the fine-structure of the H atom. Quantization of the e.m. field in the coulomb gauge; interaction of an atom with the quantized radiation field; radiative transitions in atoms; Thomson scattering; classical and quantized Lagrangian field theory; symmetries and conservation laws: quantization of the real and complex Klein-Gordon field; Dirac Field and the covariant quantization of the e.m. field; Feynman propagators; the interaction picture and the S-matrix expansion in perturbation theory and the Wick’s Rule. Feynman diagrams and rules for calculating S-matrix elements in QED; formulas for cross-section and spin and photon polarization sums; calculation of cross-sections for (1) $e^+e^- \rightarrow l^+ l^-$ (2) $e^+e^- \rightarrow e^+e^-$ (3) Compton scattering and (4) scattering of electrons by an external e.m. field.

PHYS.6190 Physics of Quantum Information - Credits:
3

Introduction of physical concepts behind quantum information processing; Quantum description of physical systems, such as a harmonic oscillator and a single qubit, from an information processing point of view; More complex systems composed of entangled qubits; General tools, rooted in density-matrix formalism, used to describe entanglement and decoherence; Quantum error correction and how it can correct for qubit decoherence to realize fault tolerant computation; Recent advances in engineering quantum information processing platforms, teleportation, and quantum annealing.

PHYS.6310 Nonlinear Optics (formerly 95.631) - Credits: 3
Wave propagation in a linear anisotropic medium; Wave propagation in a nonlinear optical medium. Classical model for the origin of nonlinear optical effects; Second order nonlinear optical effects - second harmonic generation, sum and difference frequency generation, linear electro-optical effect; Third order nonlinear optical effects, Kerr effect and intensity dependent nonlinear index of refraction, stimulated Raman and Brillouin scattering; Photorefraction; Nonlinear optical devices.

PHYS.6570 Electromagnetic Theory I (formerly 95.657) - Credits: 3
Electrostatics and magnetostatics with special attention to boundary value problems. Quasistatic fields and displacement currents. Maxwell's equations, special relativity, wave-guides, scattering, radiation from accelerated charges, propagation in material media and plasmas, Kramers-Kronig relations.

PHYS.6580 Electromagnetic Theory II (Formerly 95.658) - Credits: 3
Electrostatics and magnetostatics with special attention to boundary value problems. Quasistatic fields and displacement currents. Maxwell's equations, special relativity, wave-guides, scattering, radiation from accelerated charges; propagation in material media and plasmas, Kramers-Kronig relations.

PHYS.6620 Nuclear Physics II (Formerly 95.662) - Credits: 3
The nucleon-nucleon force; nuclear models; nuclear reaction theory and partial wave analysis of scattering; fast neutron physics.

PHYS.6650 Space Physics (Formerly 95.665) - Credits: 3
This course provides in depth knowledge of space phenomena and physical understanding of the plasma environment form the sun to the earth’s ionosphere and in the heliosphere. Regions in space include solar surface, solar wind, bow shock, magnetosheath, magnetosphere, magnetotail, radiation belts, ring currents, and upper ionosphere. Among space plasma physics theories, single particle theory and magnetohydrodynamics are discussed in depth.

PHYS.6830 General Relativity - Credits: 3
Special relativity and Lorentz transformations; Scalar and electromagnetic fields; Curved spacetime and the metric tensor; The equivalence principle; Geodesics, covariant derivatives, and Killing vectors; Einstein's field equations; The energy conditions; Relativistic cosmology and the expanding Universe; (Special topics: Schwarzschild solution and black holes; Penrose-Carter diagrams; Quantum gravity)

PHYS.6840 Theoretical Cosmology - Credits: 3
Geometry, kinematics, and dynamics in an expanding Universe; Thermal history; Generation of standard model particles; Phase transitions; Inflation; quantum origin of primordial inhomogeneities; Scalar, vector, and tensor perturbations; Gravitational instability; Choice of gauge; Matter distribution; Galaxy bias; Redshift space distortions; Cosmic microwave background anisotropies; Baryon acoustic oscillations; Polarization.

PHYS.7010 Physics Colloquium (Formerly 95.701) - Credits: 0-1
A series of invited lectures on current research topics in Physics. "Variable credit course, student chooses appropriate amount of credits when registering."

PHYS.7020 Physics Colloquium (Formerly 95.702) - Credits: 0-1
A series of invited lectures on current research topics in Physics. "Variable credit course, student chooses appropriate amount of credits when registering."

PHYS.7040 Seminar in Nuclear Physics (Formerly 95.704) - Credits: 0-1
involve presentations by students, faculty members, and visiting scientists of advanced topics, original research or journal articles. "Variable credit course, student chooses appropriate amount of credits when registering."

PHYS.7050 Seminar in Solid State/Optics (Formerly 95.705) - Credits: 0-1
involve presentations by students, faculty members, and visiting scientists of advanced topics, original research or journal articles. "Variable credit course, student chooses appropriate amount of credits when registering."

**PHYS.7051 Supervised Teaching - Physics (Formerly 96.705) - Credits: 0**

**PHYS.7060 Seminar in Solid State/Optics (Formerly 95.706) - Credits: 0-1**

involve presentations by students, faculty members, and visiting scientists of advanced topics, original research or journal articles. "Variable credit course, student chooses appropriate amount of credits when registering."

**PHYS.7090 Seminar in Accelerator Physics (Formerly 95.709) - Credits: 0-1**

A weekly series of presentations and discussions by students and faculty concerning research in progress and planned research at the 5.5 MV Van de Graaff Accelerator. Enrollment in the course is limited to students whose research projects involve the Van de Graaff accelerator. "Variable credit course, student chooses appropriate amount of credits when registering."

**PHYS.7100 Seminar in Experimental Optics (Formerly 95.710) - Credits: 0-1**

A weekly series of presentations and discussions concerning experimental optics research in the University of Massachusetts Lowell Department of Physics and Applied Physics. "Variable credit course, student chooses appropriate amount of credits when registering."

**PHYS.7110 Graduate Seminar in Physics (Formerly 95.711) - Credits: 0-1**

Presentations by students of progress in their research projects. "Variable credit course, student chooses appropriate amount of credits when registering."

**PHYS.7120 Graduate Seminar in Physics (Formerly 95.712) - Credits: 0-1**

Presentations by students of progress in their research projects. "Variable credit course, student chooses appropriate amount of credits when registering."

**PHYS.7130 Seminar in Theoretical Research (Formerly 95.713) - Credits: 0-1**

"Variable credit course, student chooses appropriate amount of credits when registering."

**PHYS.7140 Seminar in Experimental Research (Formerly 95.714) - Credits: 0-1**

"Variable credit course, student chooses appropriate amount of credits when registering."

**PHYS.7150 Seminar in Terahertz Technology (Formerly 95.715) - Credits: 0-1**

Course involves presentations by students, faculty members, and visiting scientists of advanced topics, original research for journal articles relevant to technologies at terahertz frequencies. "Variable credit course, student chooses appropriate amount of credits when registering."

**PHYS.7160 Seminar in Biomedical Optics (Formerly 95.716) - Credits: 0-1**

Seminar in Biomedical Optics, offered at the Advanced Biophotonics Laboratory by Dr. Anna N. Yaroslavsky, covers topics related to recent advances in biomedical optics. Examples include, but are not limited to, the development of individualized, image-based methods of light dosimetry and planning for cancer treatments, concepts and implementation of full inverse Monte Carlo technique for reconstruction of tissue optical properties, investigation of light scattering by complex biological structures and live tissues, development of steady-state and time-resolved polarization, fluorescence and elastic scattering methods for diagnostics and treatment of pathology. "Variable credit course, student chooses appropriate amount of credits when registering."

**PHYS.7160L Special Problems In Physics (Formerly 96.716) - Credits: 1-9**

Reading in preparation for research, or research not for thesis. If results of the research are to be subsequently incorporated into a thesis, credits earned in this course may be used to satisfy thesis credit requirements in M.S. or Ph.D. Thesis Research with the written permission of the thesis supervisor, provided such permission is granted at the time of registration for this course. If the results are incorporated in an M.S. project, not more than 3 credits are allowed.

**PHYS.7170 Seminar in Heavy Ion Physics (Formerly 95.717) - Credits: 0-1**

Involves presentations by students, faculty members, and research scientists on advanced topics in heavy-ion spectroscopy, including both original research and journal articles. "Variable credit course, student chooses appropriate
PHYS.7180 Seminar in Space Physics (Formerly 95.718) - Credits: 0-1

This course is a weekly seminar covering the areas of conventional "space physics" and extending to "astrophysics" and "Upper atmospheric physics". Each seminar is focused on a topic that is currently at the cutting edge in these fields while an extended introduction will be given based on diverse background knowledge at graduate level in physics and engineering. "Variable credit course, student chooses appropriate amount of credits when registering."

PHYS.7190 Seminar in Nanoscale Physics and Technology (Formerly 95.719) - Credits: 0-1

Students will study the scientific literature on topics and concepts in nanoscale physics and technology, including nanoscale thermal properties, micro- and nano-fluidity, nano-optics, quantum confinement to electronic states, and other phenomena. Students will make presentations and lead discussions on these studies at the frontiers of the field. The presentations will help them to generate new ideas for their own graduate research. Every student will have the opportunity to lead more than one discussion session. "Variable credit course, student chooses appropriate amount of credits when registering."

PHYS.7200 Medical Physics Seminar - Credits: 0-1

Current research topics in medical physics, discussed by faculty, students and invited speakers. "Variable credit course, student chooses appropriate amount of credits when registering."

PHYS.7210 Selected Topics in Physics (Formerly 95.721) - Credits: 3

Selected topics courses cover recent advances and more advanced topics, not covered in the regular courses in these areas. Subject matter varies, depending on the interests of the instructor and the needs of the students. Subject matter varies sufficiently that these courses may be taken more than once for credit without repeating topics.

PHYS.7250 Selected Topics in Solid State (formerly 95.725) - Credits: 3

Selected topics courses cover recent advances and more advanced topics, not covered in the regular courses in these areas. Subject matter varies, depending on the interests of the instructor and the needs of the students. Subject matter varies sufficiently that these courses may be taken more than once for credit without repeating topics.

PHYS.7270 Selected Topics in Theoretical Physics (formerly 95.727) - Credits: 3

Selected topics courses cover recent advances and more advanced topics, not covered in the regular courses in these areas. Subject matter varies, depending on the interests of the instructor and the needs of the students. Subject matter varies sufficiently that these courses may be taken more than once for credit without repeating topics.

PHYS.7310 Advanced Projects In Physics I (formerly 96.731) - Credits: 3

Research project leading to the Graduate Research Admission Examination (for Ph.D. candidates only.)

PHYS.7320 Advanced Projects In Physics II (formerly 96.732) - Credits: 3

Research project leading to the Graduate Research Admission Examination (for Ph.D. candidates only.)

PHYS.7330 Graduate Project - Physics (formerly 96.733) - Credits: 3

PHYS.7460 Master's Thesis Research Physics (formerly 96.746) - Credits: 0-9

"Variable credit course, student chooses appropriate amount of credits when registering."

PHYS.7560 Doctoral Dissertation/Physics (formerly 96.756) - Credits: 1-9

Note: Courses with 98 prefix are described in the Radiological Sciences and Protection section of this catalog.

PHYS.7610 Continued Grad Research (formerly 96.761) - Credits: 1
Continued Grad Research

PHYS.7710 Physics Systems Analysis I (formerly 95.771) - Credits: 3
PHYS.7720 Physics Systems Analysis II (formerly 95.772) - Credits: 3
PHYS.7730 Physics Systems Analysis III (formerly 95.773) - Credits: 3
PHYS.8000 Cooperative Education in Physics (formerly 96.800) - Credits: 0-1

Cooperative Education in Physics. "Variable credit course, student chooses appropriate amount of credits when registering."
PSMA.5000 Professional Science Master’s (PSM)
Professional Development (Formerly PSM 500) - Credits: 0

Professional Science Master’s 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.

PSMA.5010 Professional Science Master’s (PSM)
Reflective Seminar. (Formerly PSM 501) - Credits: 1

Reflective seminar following the internship which will enable Professional Science Master’s (PSM) students to share and learn from the experiences of colleagues in other settings. The seminar is be conducted on campus and will include writing and oral presentation of experience.

PSMA.5100 Professional Science Master’s (PSM)
Internship (Formerly PSM 510) - Credits: 0

The internship component is expected to be 350 hour minimum and 3-6 month duration. The student will work within a business, government agency or research institute directly related to their area of study. Through this experience the student engages in real world work situations involving technical problems, teamwork, communication skills and decision-making. A student must have completed a minimum of 18 credit hours before commencing the internship. This course records the internship experience and carries zero credits.

PSMA.5350 Project Management for Scientists
(Formerly PSM 535) - Credits: 3

This course is designed to provide skills to prepare students to take on the role of project manager. The necessity for project Management is now realized by most companies where the entire business including most of the routine activities can be regarded as a series of projects. Project Management principles provide a systematic approach to running a business; both large and small businesses as well as a scientific laboratory.

PSMA.5550 Professional Leadership in Science and Engineering (PSM 555) - Credits: 3

This course is designed to provide awareness and skills to prepare students to take on the role of leader. Part of a technically competent professional’s responsibilities or opportunities for advancement may include leading small projects or work groups. This course will be organized around thematic video interviews with industry leaders to impart knowledge of and experience in leadership topics that support professional development.
RADI.5010L Radiation Safety and Control I (Formerly 98.501) - Credits: 3-4
This course provides a theoretical basis for radiological sciences and protection, with a rigorous review of the fundamentals of radiation physics including nuclear reactions, radioactivity and the kinetics of radioactive decay, natural and man-made radiation sources, the characteristics of ionizing radiation, radioactivity analysis, radiation dose quantities and measurement, external and internal radiation dosimetry, and radiation protection techniques.

RADI.5020L Radiation Safety and Control II (Formerly 95.420/98.502) - Credits: 3-4
This course provides a continuation of the theoretical and practical aspects of radiation protection provided in Radiation Safety and Control I (98.501). Topics include the statistical analyses and data reduction techniques that are used to analyze radiation measurements pertaining to the field of radiation protection. Laboratory sessions on alpha and gamma radiation measurements and air sampling will reinforce class lectures. Students also will experience applied radiation protection and dose assessment through a contamination control exercise that involves the use of protective clothing and respiratory protection.

RADI.5060 Nuclear Instrumentation (Formerly 98.506) - Credits: 3
This course provides the operating principles and applications of nuclear radiation detection systems, including detector theory, electronic signal processing, and measurement and data reduction techniques. The systems covered include gas-filled detectors (ion chambers, proportional counters, and Geiger-Mueller counters), inorganic and organic scintillators, and high-purity germanium detectors, for the detection of alpha, beta, gamma, and neutron radiation. This course also covers hypothesis testing, detection limits, and detector dead time.

RADI.5090 Nuclear Instrumentation (Formerly 96.409) - Credits: 3
This course provides the operating principles and applications of nuclear radiation detection systems, including detector theory, electronic signal processing, and measurement and data reduction techniques. The systems covered include gas-filled detectors (ion chambers, proportional counters, and Geiger-Mueller counters), inorganic and organic scintillators, and high-purity germanium detectors, for the detection of alpha, beta, gamma, and neutron radiation. This course also covers hypothesis testing, detection limits, and detector dead time. This course is adapted for Nuclear Engineering and Medical Physics majors. (offered as 98.509 for graduate credit).

RADI.5240 Environmental Health Physics (Formerly 98.524 & 94.424) - Credits: 3
Natural and man-made sources of environmental radioactivity and radiation; environmental transport in air, water, and soil; exposure pathways; environmental standards and regulations; environmental monitoring and surveys (MARSSIM); contaminated site characterization, and site remediation; environmental radiological impact of industry, accidents, and natural and man-made disasters.

RADI.5330 External Dosimetry and Shielding (Formerly 98.533) - Credits: 3
This course provides the theory and application of dosimetry and shielding for ionizing radiation sources outside the human body. Differential cross-sections, energy transfer and absorption coefficients, kerma, attenuation, and buildup are discussed for photons. Cross-sections, kerma factors, removal coefficients, diffusion, and point-source dose functions for fissioning sources are discussed for neutrons. Beta dosimetry concepts include stopping power, point-source dose functions, and the effects of attenuating materials. Heat generation and temperature profiles are discussed for irradiated materials and radioactive substances. Dosimetry concepts and barrier requirements also are described for particle accelerators, radiotherapy facilities, and medical x-ray imaging facilities.

RADI.5340 Internal Dosimetry and Bioassay (Formerly 98.534) - Credits: 3
RADI.5410 Radiochemistry (Formerly 98.541) - Credits: 3
This course provides the theory and application of several analytical techniques, including precipitation, solvent extraction, ion exchange chromatography, and electrophoresis, to the separation and analysis of radioactive substances in various samples. This course also covers some common radiation detection systems, measurement and data reduction techniques, radiotracer and isotope dilution techniques, neutron activation analysis, and radioimmunoassay.

RADI.5620 Radiation Biology (Formerly 98.562) - Credits: 3
Effects of ionizing radiation on cellular, molecular and organ systems levels of biological organization; Study of x-rays, gamma rays, accelerator beams, and neutrons in interaction with living systems; Cohesive treatment of radiation biophysics with applications in health physics and radiation oncology.
RADI.5650 Introduction to Radiation Therapy Physics
(Formerly 98.565) - Credits: 3

Introduction to the fundamental physics of radiation therapy, with emphasis on external beam photon and electron therapy and on brachytherapy. For these modalities, the basic operation of delivery equipment, treatment planning principles, methods of dose calculations, determination of time of irradiation from dose prescription, dose measurements, and quality assurance will be studied. This knowledge will prepare the student for an introduction to the practice of clinical physics in radiation therapy, for advanced radiation therapy physics, and research in radiation therapy physics.

RADI.5750 Certification Preparation in Radiological Sciences (Formerly 98.575) - Credits: 3

Advanced problem solving in radiological sciences including strategies for preparing for and taking professional certification examinations.

RADI.5820 Numerical Methods In Radiological Sciences (Formerly 98.582) - Credits: 3

This course provides a more advanced mathematical treatment of the topics covered in 98.481, with extensive application of computer techniques to numerical problem solving that is applicable to radiological sciences and protection.

RADI.5980 Medical Imaging I (Formerly 98.598) -
Credits: 3

Medical Imaging I is the first part of a two course sequence. Medical Imaging I provides an overview of the medical imaging modalities, teaches basic underlying physics and mathematics of medical imaging, describes key modalities in radiographic imaging, including general x-ray radiography, fluoroscopy, and mammography.

RADI.6050 Radiation Interactions and Transport
(Formerly 98.605) - Credits: 3

Photon, neutron, and electron interactions and energy deposition; the Boltzmann equation, elementary analytical solutions; deterministic computational methods, including spherical harmonics and discrete ordinates techniques; continuous slowing down and Fokker Planck approximations.

RADI.6060 Monte Carlo Simulation of Radiation Transport (Formerly 98.606) - Credits: 3

Radiation transport simulation by the Monte Carlo method: phase space tracking, dose response estimators, biasing methods; integral form of the Boltzmann equation; condensed history method for charged particles; neutron, photon, and electron transport calculations for medical physics and health physics applications.

RADI.6310L Professional Health Physics Internship
(Formerly 98.631) - Credits: 1-3

RADI.6650 Advanced Radiation Therapy Physics
(Formerly 98.665) - Credits: 3

The student will be introduced to the physics of advanced treatment techniques used in radiation therapy, which include external beam electron, proton, and photon therapy and internal brachytherapy. For these techniques, the principles of the techniques such as clinical applications, radiation delivery equipment, treatment planning methods, methods of dose calculations, determination of time of irradiation from dose prescription, dose measurements, and quality assurance will be studied. This knowledge will prepare the student for an introduction to the clinical practice of medical physics applied to complex treatment techniques used in radiation therapy. Also, this should help prepare the student for research in radiation therapy physics.

RADI.6710L Graduate Accelerator HP Internship
(Formerly 98.671) - Credits: 3

RADI.6720 Graduate Reactor HP Internship (Formerly 98.672) - Credits: 1-3

RADI.6730L Graduate Reactor HP Internship
(Formerly 98.673) - Credits: 3

RADI.6750L Graduate Medical HP Internship
(Formerly 98.675) - Credits: 3

RADI.6760L Graduate Medical Physics Internship
(Formerly 98.676) - Credits: 1-3

Clinical Rotation under the direction of clinical staff. This course provides the student with exposure to medical physics responsibilities in a radiation oncology department, including simulation, treatment planning and preparation, monitor unit calculations, dose measurements and calculations, treatment delivery techniques, quality assurance, and radiation safety.

RADI.6770L Graduate Medical Physics Internship
(Formerly 98.677) - Credits: 3

RADI.6780L Graduate HP Internship (Formerly 98.678) - Credits: 1-3
RADI.6790L Graduate HP Internship ( Formerly 98.679 ) - Credits: 1-3  
RADI.6830L Graduate HP Internship ( Formerly 98.683 ) - Credits: 3  
RADI.6850L Advanced Medical HP Internship ( Formerly 98.685 ) - Credits: 3  
RADI.6860L Advanced Medical Physics Internship ( Formerly 98.686 ) - Credits: 1-9  

Clinical Rotation under the direction of clinical staff. This course involves the student in one or more projects that require skill development, extended involvement, and project completion, which includes planning and delivery of advanced radiation therapy treatments.

RADI.6870L Advanced Medical Physics Internship ( Formerly 98.687 ) - Credits: 3  
RADI.6890L Advanced Graduate HP Internship ( Formerly 98.689 ) - Credits: 1  
RADI.6900L Advanced Graduate HP Internship ( Formerly 98.690 ) - Credits: 2  
RADI.6910L Advanced Graduate HP Internship ( Formerly 98.691 ) - Credits: 2  
RADI.6920L Advanced Graduate HP Internship ( Formerly 98.692 ) - Credits: 3  
RADI.6930L Advanced Graduate HP Internship ( Formerly 98.693 ) - Credits: 3  
RADI.6980 Medical Imaging II ( Formerly 98.599 ) - Credits: 3

Medical Imaging II is the second part of a two course sequence. Medical Imaging II focuses on the fundamental principles, instrumentation, image reconstruction and applications of computed tomography, radioactive tracer imaging, magnetic resonance imaging, ultrasound imaging, and new emerging imaging technologies.

RADI.7050 Supervised Teaching in Radiological Sciences ( Formerly 98.705 ) - Credits: 0  
RADI.7110 Graduate Seminar in Radiological Sciences ( Formerly 98.711 ) - Credits: 0-1  

"Variable credit course, student chooses appropriate amount of credits when registering."

RADI.7120 Graduate Seminar in Radiological Sciences ( Formerly 98.712 ) - Credits: 0-1  

"Variable credit course, student chooses appropriate amount of credits when registering."

RADI.7310L Advanced Project in Radiological Sciences I ( Formerly 98.731 ) - Credits: 3-6  
RADI.7320L Advanced Project in Radiological Sciences II ( Formerly 98.732 ) - Credits: 3  
RADI.7330 Graduate Project in Radiological Sciences and Protection ( Formerly 98.733 ) - Credits: 3-6  
RADI.7430 Master’s Thesis in Radiological Sciences and Protection ( Formerly 98.743 ) - Credits: 3  
RADI.7460 Master’s Thesis in Radiological Sciences and Protection ( Formerly 98.746 ) - Credits: 1-9  
RADI.7490 Master’s Thesis Research in Radiological Sciences ( Formerly 98.749 ) - Credits: 9  
RADI.7530L Doctoral Dissertation in Radiological Sciences and Protection ( Formerly 98.753 ) - Credits: 3  
RADI.7560 Doctoral Dissertation in Radiological Sciences and Protection ( Formerly 98.756 ) - Credits: 1-9  
RADI.7590L Doctoral Dissertation in Radiological Sciences and Protection ( Formerly 98.759 ) - Credits: 9  
RADI.7690 Continued Graduate Research ( Formerly 98.769 ) - Credits: 9
EDUC.5010 Teaching Diverse Populations (Formerly 01.501) - Credits: 3
Students examine, confront and learn to manage the challenge of successfully educating all children, regardless of racial, cultural, linguistic, gender or physical differences.

EDUC.5012 Mathematics for Elementary Teachers III: Basic Principles of Euclidean Geometry (Formerly 04.501) - Credits: 3
This course integrates the study of geometry and measurement and includes lines, angles, investigations of triangles, quadrilaterals, polygons, area and perimeter; congruency, similarity, and Pythagoras' Theorem. The students will explore mathematical explanation, argument, justification and how these processes connect to geometric proof. Also systems of units and concepts related to measurement will be investigated.

EDUC.5013 Introduction to Leading Professional Learning Communities (Formerly 05.501) - Credits: 1
This course introduces participants to strategies that will enable them to cultivate and lead school-based professional learning communities. During a week-long summer institute, students develop an action plan. In the fall, students will keep in contact (electronically) with peers and the instructor and will attend a final face-to-face session to support their efforts. The grade for the one credit course is awarded at the end of the fall semester.

EDUC.5020 Adolescent Development and Behavior (Formerly 01.502) - Credits: 3
This course provides an overview of adolescent development issues and classroom management practices. Adolescent development is examined through research into major theorists in developmental psychology: Piaget, Vygotsky, and Erikson etc. Classroom management strategies are explicitly taught through case study analyses, and examination of core beliefs, focusing on interpersonal relationships between students, teachers, parents, mentors and supervisors.

EDUC.5021 Issues, Mandates and Ethics in Special Education (Formerly 05.502) - Credits: 3
This course will examine special education laws and ethical practices in K-12 settings.

EDUC.5024 Student Development and Engagement - Credits: 3
This course will provide an understanding of theories of adolescent development, including both traditional and culturally relevant ways of learning. Participants will learn ways to engage students based on multiple theories of adolescent development.

EDUC.5030 Understanding Child Development in a Diverse Society (Formerly 01.503) - Credits: 3
Examines the major theoretical frameworks of child development and how cultural differences affect development and learning. Focus is on helping students make responsive and culturally relevant pedagogical decisions.

EDUC.5035 Directed Study - Credits: 3
Directed Study

EDUC.5040 Methods of Teaching Students with Moderate Disabilities (Formerly 01.504) - Credits: 3
Examines the methods of teaching students with moderate disabilities. Topics include curriculum (including the Massachusetts frameworks), IEPs, and instructional modifications appropriate for students with special needs.

EDUC.5043 Methods of Teaching Students with Moderate Disabilities-Secondary - Credits: 3
Examines the methods of teaching students with moderate disabilities at the secondary level. Topics include curriculum (including the Massachusetts frameworks), IEPs, and instructional modifications appropriate for students with special needs.

EDUC.5050 Children with Disabilities in the Classroom (Formerly 01.505) - Credits: 3
This course examines the nature of cognitive emotional, developmental, sensory, and physical disabilities that compromise student capacity to make adequate academic progress without special intervention. Legal and ethical responsibilities of the educator in inclusive classroom settings and as an active member of a multidisciplinary learning team are emphasized.

EDUC.5060 Oral Comm.for English Lang.Users I: Pronunciation for List. & Speaking (Formerly 02.506) - Credits: 0
This course offers graduate students the opportunity to increase and refine their understanding and ability to produce discrete sounds, sound combinations and the rhythm of spoken
English to add in their comprehension of spoken English and to aid in their personal communication skills. Class activities include pronunciation drills, short extended listening, short presentations, speaking tasks and group discussion. This is not a conversation class but student participants will be required to actively speak in each class. Priority given to TA’s/RA’s an later semester graduate students, but available to all graduate students.

EDUC.5062 Oral Communications for English Language Users II: Academic Oral English - Credits: 0

This course offers graduate students the opportunity to increase awareness of and to practice features of advanced spoken communication typical of academic environments: academic discussion/debate, conference/classroom/informal presentation, and question/answer sessions. Targeted skills include structure/organization, body language, intonation, dealing with nervousness, and awareness of cross-cultural communication patterns. As a workshop, this course requires active participation in a variety of speaking tasks, presentation preparation outside of class and feedback/discussion of peer communication. Priority given to and required for all TA’s. Some students may be required ot successfully complete 02.506/EDUC.5060 prior to enrollment in

EDUC.5070 Introduction to Academic Writing for English Second Language Users (Formerly 02.507) - Credits: 0

This course offers an introduction to the complex nature of academic language and academic writing, focusing on effective sentence, paragraph and text structures, purposeful and appropriate word choice, the writing process in writing contexts appropriate for graduate students early in their studies. Through attentive, details and critical reading of various materials, students will enhance their writing skills by applying effective planning, drafting, rewriting and editing strategies. As a workshop class, students are required to write (and write often), participate in a variety of oral/written tasks in class, and engage in constructive peer review. Recommended for graduate students early in their studies.

EDUC.5101 Foundations of Social Justice Education (Formerly 02.510) - Credits: 3

This course provides an introduction to the principles of social justice education, by examining and applying theories and methods of curriculum design, classroom teaching, and social emotional learning and development. This course will prepare educators to foster equity in classroom practice and pedagogy for racially, culturally, socioeconomically, and linguistically diverse learners.

EDUC.5102 Critical and Multicultural Literacies (Formerly 03.510) - Credits: 3

This course will address thinking, writing and talking about texts. It will examine the range of literacies including critical, print, technology, visual, media and informational. A special focus will be on anti-racist literature and texts of social justice.

EDUC.5110 Reading Theory & Instr. in Young Adult Literature (Formerly 06.511) - Credits: 3

The purpose of this course is to introduce graduate students who are preparing to teach to the reading theory and instruction appropriate for the teaching of young adult literature. There is an overview of theoretical views, a general study of what constitutes young adult literature, approaches to using the books, and finally developing the ability for critical analysis of this body of work. The course emphasizes the theme of identity in the development of young adults and the books that they read.

EDUC.5120 History for Teachers (Formerly 04.512) - Credits: 3

This course examines the major concepts, people and events of US and World history using the ten themes outlined by the NCSS (National Council for the Social Studies). These standards are grouped under the four strands for teaching social studies in the state of Massachusetts (history, economics, geography and civics) and guide the focus for teacher preparation and instruction.

EDUC.5130 Teaching World History (Formerly 04.513) - Credits: 3

In an increasingly globalized and diverse age, courses in world history have become a growing teaching field at the secondary level in the United States. The overarching purpose of this class is to help students prepare to teach classes in world history. This course will introduce the field and concepts of world history. It will familiarize students with available materials such as textbooks, readers, primary documents, academic books and articles, novels, films, websites, and podcasts. The class will introduce and align with the state, national, and AP standards in world history.

EDUC.5150 Practicum in English as a Second Language PreK-6 (Formerly 02.515) - Credits: 3

On-site field experience in an ESL classroom, under the supervision of a qualified ESL teacher and faculty of the Graduate School of Education.
EDUC.5160 Practicum in English as a Second Language 5-12 (Formerly 02.516) - Credits: 3
On-site field experience in an ESL classroom, under the supervision of a qualified ISL teacher and faculty of the Graduate School of Education.

EDUC.5170 Community Organization and Parental Partnership (Formerly 02.517) - Credits: 3
The aim is to prepare school personnel to work effectively with community groups and bilingual parent organization.

EDUC.5200 Teaching Reading and Writing in English (Formerly 02.520) - Credits: 3
This course examines the development of reading and writing necessary for the ESL child to learn to read and write in English. Students gain familiarity with the various perspectives and practices that have been found to be effective in the teaching of reading and writing to students whose first language is not English.

EDUC.5201 Curriculum Planning Perspectives (Formerly 01.520) - Credits: 3
This course introduces students to historical and contemporary curriculum perspectives and assists students in developing their own curriculum perspective, situated within the scholarship. The course also helps students develop skill in curriculum planning, grounded in relevant scholarship.

EDUC.5220 Young Adult Literature (06.522) - Credits: 3
The major emphasis of the course will be discussion and analysis of the goals of a literature curriculum and the exploration of various methods for achieving these goals. The characteristics of the different genres of literature will be discussed in detail.

EDUC.5240 Educational Assessments of Students with Moderate Disabilities (Formerly 02.524) - Credits: 3
A review of the various assessments and standardized tests that are used to identify students with moderate disabilities. The interpretation of assessment results and how to communicate them effectively to parents and school personnel will be examined.

EDUC.5250 Science for Secondary Science Teachers (Formerly 04.525) - Credits: 3
This course emphasizes content knowledge which includes the facts, concepts, laws, theories and organizing frameworks of science and syntactic knowledge which includes values, beliefs and assumptions that the science teacher has about the generation of scientific knowledge.

EDUC.5270 Language Acquisition (Formerly 06.527) - Credits: 3
This course will focus on the study of the acquisition of language and the relationship of language learning to the development of literacy. Students will examine both first and second language acquisition. Students will be expected to apply their knowledge of language acquisition to best teaching practices for enhancing first and second language development in the classroom and to the development of literacy.

EDUC.5280 Assessment of Reading and Language Disabilities (Formerly 06.528) - Credits: 3
This course examines the selection and use of procedures to make an adequate clinical and educational diagnosis. Includes the assessment of function and dysfunction in factors associated with language development; receptive, expressive, writing, reading; and the administration and interpretation of individual and group tests of perceptual, motor, and conceptual functioning in reading and language.

EDUC.5290 Treatment Reading and Language Disabilities (Formerly 06.529) - Credits: 3
This course will explore the specific practices in remedial teaching in grades K-12, using published materials, and developing new materials for small group, whole class, and tutoring settings. Students will develop and implement realistic corrective programs based on the interpretation of literacy assessments. These programs will include selecting strategies of instruction and materials, and establishing a framework of time and evaluation.

EDUC.5300 Interactions and Assessment in Science (Formerly 04.530) - Credits: 3
This course examines the ways in which students interact and learn in the science classroom. Construction of a Science, Technology, and Society (STS) unit plan, as well as the development of assessment tools that align to lesson and unit goals are key features of this course.

EDUC.5301 Reading and Thinking: Secondary School (Formerly 06.530) - Credits: 3
This course examines the relationships among reading, writing, and thinking in high school, particularly in diverse populations and with second language learners. Emphasis will be placed upon practical work in classrooms and the development and assessment of new teaching practices.

EDUC.5320 Inquiry and Interactions Seminar (Formerly 04.532) - Credits: 3

This course focuses on the PLTW approach to STEM teaching, utilizing a problem solving learning opportunities for students to investigate and participate in discourse about scientific ideas. The course will utilize the activity, project, problem-based (APB) instructional design that provides hands-on, real-world activities, projects, and problems. Activities help students build specific knowledge and skills. Projects provide students the opportunity to apply those skills and problems give student the change to develop their own solutions to real world problems. Successful completion of the applicable STEM focused PLTW core training course is required.

EDUC.5330 Mathematics for Elementary Teachers I: Basic Principles of Arithmetic (Formerly 04.533) - Credits: 3

Participants will be engaged in constructing solid conceptual understanding of the language and operations of arithmetic; topics include place value and the history of counting, inverse processes, a large repertoire of interpretations of operations with numbers, concepts of integers and rational numbers, multi-digit calculations, including standard algorithms and non-standard methods the reasoning behind the procedures.

EDUC.5340 Mathematics for Teachers I (Formerly 04.534) - Credits: 3

This course revisits the content related to the development of number and operation, proportions, ratios and percent; modeling operations with fractions, beginning algebra and geometry. The course emphasizes the meanings of operations and relationships among those operations; multiple representations of concepts and connections across different representations. It also examines basic Number Theory concepts, such as factors and multiples, as well as divisibility tests, at both concrete and abstract levels.

EDUC.5350 Mathematics for Teachers II (Formerly 04.535) - Credits: 3

This course revisits the mathematics content related to the grades 8-12. It examines in depth elementary functions, and different mathematical models such as linear, quadratic, exponential, logarithmic and trigonometric, to describe real life situations. The course includes some topics from Euclidean geometry. The course emphasizes multiple representations of concepts, connections across different representations, as well as different levels of representations form concrete to abstract.

EDUC.5390 Pre-Practicum: Alternate Route (Formerly 02.539) - Credits: 0

The pre-practicum occurs in the semester before the practicum. The course focuses on what it means to be a teacher by examining the content, dispositions and skills necessary to succeed in the profession. Students observe other teachers in their school and must spend one day observing in a district with different demographics. While there is no credit assigned to the pre-practicum, it is a required component of the program. Students complete a pre-practicum binder based on their observances.

EDUC.5400 Pre-Practicum (Formerly 02.540) - Credits: 0

The pre-practicum occurs in the semester before the practicum. The course focuses on what it means to be a teacher by examining the content, dispositions and skills necessary to succeed in the profession. Through a combination of site observations in schools of different demographics, personal/professional teaching opportunities and participation in professional seminars, elementary and secondary preservice teachers gain additional information and skills to prepare them for their practicum. While there is no credit assigned to the pre-practicum, it is a required component of the program. A fee is assessed.

EDUC.5402 Pre-Practicum - Credits: 3

the pre-practicum is a combination of coursework and field experiences and is a state requirement for both teachers of record and preservice teachers. It takes place in the semester before the practicum. Preservice teachers participate in either a full-day professional seminar, diverse field-based observations and experiences. The pre-practicum helps bridge theory into practice and provide opportunities for discussion and feedback in all coursework in the program. A portfolio addressing Massachusetts’ professional teacher standards (PSTs) and SMKs (Subject Matter Knowledge) is required at the end of the pre-practicum. After successful completion of the pre-practicum and with the approval of the graduate coordinator, students request a practicum placement.

EDUC.5410 Teaching Emergent Bilingual Students (Formerly 02.541 & UTL.441) - Credits: 3

The purpose of this course is to prepare new secondary teacher candidates with the knowledge and skills to effectively shelter their content instruction, so that the growing population of English learners (ELs) in PK-12 schools can achieve academic
success, and contribute their multilingual and multicultural resources. The course will provide aspiring teachers with practical research-based methods, strategies, and protocols to integrate subject area content, language, and literacy. Successful completion of this course provides SEI (Sheltered English Immersion) endorsement, which is required for teaching in the Commonwealth of Massachusetts. This is a service learning course.

EDUC.5413 Practitioner Action Research (Formerly 07.541) - Credits: 3

This course examines how action research helps educators to learn to explore pressing classroom and school issues in systematic ways. Action research provides educators with opportunities to deepen their knowledge and skills as reflective practitioners, allowing them to contribute to the achievement of students and the improvement of schools.

EDUC.5414 Teaching English Learners-Elementary - Credits: 3

This course will prepare elementary teacher candidates with the knowledge and skills to effectively shelter content instruction to ensure that the growing population of Massachusetts’ English Language Learners (ELLs) can access the curriculum, “achieve academic success and contribute their multilingual and multicultural resources as participants and future leaders in the 21st century global economy” (MA DESE, 2013). Successful completion of this course provides SEI (Sheltered English Immersion) endorsement, which is required for teaching in the Commonwealth of Massachusetts.

EDUC.5430 Classroom Management and Integrative Techniques (Formerly 02.543) - Credits: 3

This course prepares participants to create and maintain a safe and collaborative learning environment through the development of effective rituals, routines, and appropriate responses in the classroom. With attention to the development of Positive Behavioral Supports, participants will examine and apply basic behavioral theories, evidence-based principles, and relevant policies. Based in the Three Tiered Philosophy, the course learning progresses for Universal Design concepts to more prescriptive individualized interventions and incorporates the practices of personal reflection, professional collaboration and effective communication.

EDUC.5490 Theory and Research: Reading and Language (Formerly 06.549) - Credits: 3

A final course on the national and international research in reading and language and the pertinence and proposed implementation of research findings to instruction and the various roles of the reading supervisor or director.

EDUC.5500 Reading Specialist: Practicum I(Formerly 06.550) - Credits: 3

The Reading Specialist Practicum requires students to use the knowledge gained in their coursework to design, implement, and analyze a program for struggling readers in a clinical experience. The practicum meets both Massachusetts and IRA standards for Reading Specialist/Literacy Coach.

EDUC.5510 Elementary Math Methods (Formerly 02.551) - Credits: 3

New approaches in the curriculum and teaching of mathematics in the elementary school; analysis and use of current materials, national and state standards, multimedia approaches, and inductive and problem-solving techniques.

EDUC.5511 Literacy Coach: Practicum II (Formerly 06.551) - Credits: 3

This is the second of two clinical practicum experiences in the Reading and Language program. Candidates will design a professional development project in their school setting which will allow them to model lessons, observe and co-teach with peers, and provide feedback to teachers and paraprofessionals. The online seminar provides support for implementing the program. The practicum meets the guidelines for the International Reading Association.

EDUC.5530 Language Arts and Childrens Literature (Formerly 02.553) - Credits: 3

Approaches in the teaching and assessment of the language arts in the elementary school will be analyzed. Assorted genres of literature and the development of literature programs for children in multicultural environments will be studied.

EDUC.5531 Lowell and Industrial Revolution (Formerly 04.553) - Credits: 3

Participants in this National Endowment for the Humanities-sponsored Landmarks Workshop, offered through the Tsongas Industrial History Center, examine the causes and consequences of America’s Industrial Revolution, using Lowell as a case study. The course covers the nineteenth-century shift from an agrarian to an industrial society, with a focus on water-powered factory systems, textile production and corporations, the issue of slavery in a cotton textile city, labor and women’s history, environmental impacts, immigration, globalization, and literary responses. Limited to NEH participants only.
EDUC.5560 Reading and Reading Disabilities  
(Formerly 02.556) - Credits: 3
A critical analysis of fundamental issues and principles in the teaching of reading, including all phases of the elementary reading program. Analysis and remediation of reading disabilities which explores the use of critical diagnostic tools.

EDUC.5590 Introduction to Education Statistics  
Credits: 3
This course provides students with a foundational understanding of educational statistics. From variables, means, variance, distribution and measuring the central tendency to correlations, statistical/practical significance and group mean difference tests, students will explore the meaning and use of these essential social science tools. In tandem with technique, students will also explore the statistical issues behind topical concerns in education and become familiar with statistical sources of importance to educational researchers.

EDUC.5592 Teaching Founding Documents (Formerly 04.559) - Credits: 3
This course examines the founding documents and how these documents are relevant in the lives of middle school children.

EDUC.5593 Research and Evaluation Special Topics -  
Credits: 3
This course provides an opportunity to investigate emerging topics in the fields of research methodology or program evaluation education. Topics will vary by semester and the interest and expertise of the faculty. Discussion of theoretical and practical considerations of the topic under consideration will be integrated across the semester.

EDUC.5620 Elementary Social Studies  (Formerly 02.562) - Credits: 3
Examines teaching strategies and materials appropriate for the teaching of K-8 social studies. Examines national and state standards for the discipline.

EDUC.5630 Elementary Science Methods (Formerly 02.563) - Credits: 3
Models the teaching of science as guided discovery while exploring developmentally appropriate concepts in science. Examines national and state standards as well as nationally developed curriculum kit-based materials.

EDUC.5680 Internship in Moderate Disabilities 5-12  
(Formerly 02.568) - Credits: 3
Practicum in a special education setting under the supervision of qualified teachers, principal, and university faculty.

EDUC.5720 Curriculum and Teaching: English  
(Formerly 02.572) - Credits: 3
The purpose of this course is to prepare teacher candidates for the content-specific dimensions of their practicum. The course is designed to develop pedagogical skills, curriculum writing and also to encourage prospective English teachers to examine their own beliefs, expectations, and dispositions about the nature of the discipline, the practice of teaching, the process of learning, and the nature of the learners.

EDUC.5730 Curriculum and Teaching History (Formerly 02.573) - Credits: 3
Students analyze the content, methods, materials, and management techniques used in teaching History. Examination of national and state standards for the discipline. The course will include micro-teaching and self-evaluation, as well as school-based observation and participation in schools.

EDUC.5750 Curriculum and Teaching Math (Formerly 02.575) - Credits: 3
Students analyze the content, methods, materials, and management techniques used in teaching mathematics, and examine national and state standards for the discipline. The course includes micro-teaching, self-evaluation, school-based observation, and participation in schools.

EDUC.5760 Curriculum and Teaching Science (Formerly 02.576) - Credits: 3
Students analyze the content, methods, materials, and management techniques used in teaching science. Examination of national and state standards for the discipline. The course will include micro-teaching and self-evaluation, as well as school-based observation and participation in schools.

EDUC.5761 Promoting Healthy Lifestyles Among Students (Formerly 04.576) - Credits: 3
The focus of this course is on applying nutrition concepts relevant to elementary and middle school children and how these concepts can be integrated into the classroom at an age appropriate level. This course will address a broad range of issues including eating habits, disordered eating, sports nutrition, food allergies and school wellness policies.
EDUC.5780 Teaching Elementary Education and Seminar (Formerly 02.578) - Credits: 6

This full time practicum in the elementary school covers 12 weeks under the supervision of qualified teachers, principals, and faculty of the Graduate School of Education. Weekly seminar and portfolio development address the Massachusetts professional teaching standards. Matriculated students only. All coursework must be completed with a minimum 3.25 GPA. Before beginning the practicum.

EDUC.5790 Internship in Moderate Disabilities PreK - 8 (Formerly 02.579) - Credits: 3

Practicum in a special education setting under the supervision of qualified teachers, principal, and university faculty.

EDUC.5830 Teaching English and Seminar (Formerly 02.583) - Credits: 9

Full time practicum in the elementary, middle or secondary schools under the supervision of qualified classroom teachers and faculty of the Graduate School of Education. Weekly seminar and performance assessment addressing the Massachusetts Professional Standards for Teachers.

EDUC.5832 Teaching English and Seminar - Credits: 6

The practicum is a minimum of 12-weeks in a school setting and takes place after all coursework is completed. Practicum can take place in a middle or high school depending on the subject area of licensure. Massachusetts’ Department of Elementary and Secondary Education requires that a preservice teacher complete 300 hours of student teaching with 100 hours of full teaching responsibility in an approved school setting. Students are matched with experienced and licensed teachers who alongside a university supervisor evaluate the student’s performance, provide feedback, support and mentoring. Students return to campus biweekly to attend a practicum seminar that focuses on CAP (Candidate Assessment of Performance).

EDUC.5840 Teaching History and Seminar (Formerly 02.584) - Credits: 9

Full time practicum in the elementary, middle or secondary schools under the supervision of qualified classroom teachers and faculty of the Graduate School of Education. Weekly seminar and performance assessment addressing the Massachusetts Professional Standards for Teachers.

EDUC.5842 Teaching History and Seminar - Credits: 6

The practicum is a minimum of 12-weeks in a school setting and takes place after all coursework is completed. Practicum can take place in a middle of high school depending on the subject area of licensure. Massachusetts’ Department of Elementary and Secondary Education requires that a preservice teacher complete 300 hours of student teaching with 100 hours of full teaching responsibility in an approved school setting. Students are matched with experienced and licensed teachers who, alongside a university supervisor, evaluate the student’s performance, provide feedback, support and mentoring. Students return to campus biweekly to attend a practicum seminar that focuses on CAP (Candidate Assessment of Performance).

EDUC.5890 Teaching Mathematics and Seminar (Formerly 02.589) - Credits: 9

Full time practicum in the elementary, middle or secondary schools under the supervision of qualified classroom teachers and faculty of the Graduate School of Education. Weekly seminar and performance assessment addressing the Massachusetts Professional Standards for Teachers.

EDUC.5892 Teaching Mathematics and Seminar - Credits: 6

The practicum is a minimum of 12-weeks in a school setting and takes place after all coursework is completed. Practicum can take place in a middle of high school depending on the subject area of licensure. Massachusetts’ Department of Elementary and Secondary Education requires that a preservice teacher complete 300 hours of student teaching with 100 hours of full teaching responsibility in an approved school setting. Students are matched with experienced and licensed teachers who, alongside a university supervisor, evaluate the student’s performance, provide feedback, support and mentoring. Students return to campus biweekly to attend a practicum seminar that focuses on CAP (Candidate Assessment of Performance).

EDUC.5900 Teaching Biology and Seminar (Formerly 02.590) - Credits: 9

Full time practicum in the elementary, middle or secondary schools under the supervision of qualified classroom teachers and faculty of the Graduate School of Education. Weekly seminar and performance assessment addressing the Massachusetts Professional Standards for Teachers.

EDUC.5903 Teaching Biology and Seminar - Credits: 6

The practicum is a minimum of 12-weeks in a school setting and takes place after all coursework is completed. Practicum
can take place in the middle or high school depending on the subject area of licensure. Massachusetts’ Department of Elementary and Secondary Education requires that a preservice teacher complete 300 hours of student teaching with 100 hours of full teaching responsibility in an approved school setting. Students are matched with experienced and licensed teachers who alongside a university supervisor evaluate the students performance, provide feedback, support and mentoring. Students return to campus biweekly to attend a practicum seminar that focuses on CAP (Candidate Assessment of Performance).

EDUC.5910 Teaching Chemistry and Seminar (Formerly 02.591) - Credits: 9

Full time practicum in the elementary, middle or secondary schools under the supervision of qualified classroom teachers and faculty of the Graduate School of Education. Weekly seminar and performance assessment addressing the Massachusetts Professional Standards for Teachers.

EDUC.5913 Teaching Chemistry and Seminar - Credits: 6

The practicum is a minimum of 12-weeks in a school setting and takes place after all coursework is completed. Practicum can take place in a middle or high school depending on the subject area of licensure. Massachusetts’ Department of elementary and Secondary Education requires that a preservice teacher complete 300 hours of student teaching with 100 hours of full teaching responsibility in an approved school setting. Students are matched with experienced and licensed teachers who alongside a university supervisor evaluate the student’s performance, provide feedback, support and mentoring. Students return to campus biweekly to attend a practicum seminar that focuses on CAP (Candidate Assessment of Performance).

EDUC.5920 Teaching Earth Science and Seminar (Formerly 02.592) - Credits: 9

Full time practicum in the elementary, middle or secondary schools under the supervision of qualified classroom teachers and faculty of the Graduate School of Education. Weekly seminar and performance assessment addressing the Massachusetts Professional Standards for Teachers.

EDUC.5922 Principalship: Practicum I (Formerly 05.592) - Credits: 1-3

The first of two practicum experiences in which students assume a broad range of the responsibilities of a principal in order to demonstrate proficiency in meeting the Massachusetts Professional Standards and Indicators for Administrative Leadership. To enroll in the course, students must be employed in a Massachusetts Public School and have identified an administrator (principal or assistant principal) in the school who holds the appropriate Massachusetts Principal License and is willing to act as a mentor. Students must participate in the online course which accompanies the practicum, complete a practicum log, and meet periodically with the program supervisor to discuss their progress.

EDUC.5930 Teaching Physics and Seminar (Formerly 02.593) - Credits: 9

Full time practicum in the elementary, middle or secondary schools under the supervision of qualified classroom teachers and faculty of the Graduate School of Education. Weekly seminar and performance assessment addressing the Massachusetts Professional Standards for Teachers.

EDUC.5932 Principalship: Practicum II (Formerly 05.593) - Credits: 2-3

In order to enroll in Practicum 2, the student must have made satisfactory progress toward meeting the Massachusetts Professional Standards and indicators for Administrative Leadership in Practicum 1 and have logged sufficient hours as established by the program supervisor. In addition to the work required in the accompanying online course, students must complete the responsibilities identified with the mentor and program supervisor. The student’s work in Practicum 1 and 2 must meet the total of 500 hours of leadership activities required by the Massachusetts Department of Elementary and Secondary Education.

EDUC.5933 Teaching Physics and Seminar - Credits: 6

The practicum is a minimum of 12-weeks in a school setting and takes place after all coursework is completed. Practicum can take place in a middle or high school depending on the subject area of licensure. Massachusetts’ Department of Elementary and Secondary Education requires that a preservice teacher complete 300 hours of student teaching with 100 hours of full teaching responsibility in an approved school setting. Students are matched with experienced and licensed teachers who alongside a university supervisor evaluate the student’s performance, provide feedback, support and mentoring. Students return to campus biweekly to attend a practicum seminar that focuses on CAP (Candidate Assessment of Performance).

EDUC.5940 Teaching General Science and Seminar (Formerly 02.594) - Credits: 9

Full time practicum in the elementary, middle or secondary
EDUC.5942 Practicum I, Middle School Principal 5-8  
(Formerly 05.594) - Credits: 1

The practicum is a two-semester (1+2=3 credits) field-based experience in which the student engages in administrative responsibilities at the level of a school principal. These responsibilities are supervised by an on-site supervisor/mentor who holds certification in the appropriate area. A minimum of 300 hours must be completed during the course of the year. The responsibilities must be real and varied enough to allow the student to actively apply their knowledge and skills, thus demonstrating competence in the 'Standards for Advanced Programs in Educational Administration' of the ELCC (Educational Leadership Constituent Council). In addition to the field-based activities, candidates participate regularly in an on-line seminar with the university supervisor/instructor and meet for 3-4 face-to-face seminar sessions at the university. Students develop a practicum action plan, document their activities in a journal, participate in regular on-line discussions, complete several reflection assignments, and compile a final Practicum Portfolio. The basis of all work in the online seminar relates directly to the issues, experiences, and questions form the candidate's field-based activities. The Practicum aims to help all students achieve a fuller realization of their professional and personal resources as leaders and learners and strengthen their effectiveness as educational administrators now and into the future.

EDUC.5960 Practicum I, High School Principal 9-12  
(Formerly 05.596) - Credits: 1

The practicum is a two-semester (1+2=3 credits) field-based experience in which the student engages in administrative responsibilities at the level of a school principal. These responsibilities are supervised by an on-site supervisor/mentor who holds certification in the appropriate area. A minimum of 300 hours must be completed during the course of the year. The responsibilities must be real and varied enough to allow the student to actively apply their knowledge and skills, thus demonstrating competence in the 'Standards for Advanced Programs in Educational Administration' of the ELCC (Educational Leadership Constituent Council). In addition to the field-based activities, candidates participate regularly in an on-line seminar with the university supervisor/instructor and meet for 3-4 face-to-face seminar sessions at the university. Students develop a practicum action plan, document their activities in a journal, participate in regular on-line discussions, complete several reflection assignments, and compile a final Practicum Portfolio. The basis of all work in the online seminar relates directly to the issues, experiences, and questions form the candidate's field-based activities. The Practicum aims to help all students achieve a fuller realization of their professional and personal resources as leaders and learners and strengthen their effectiveness as educational administrators now and into the future.

EDUC.5950 Practicum II, Middle School Principal (5-8)  
(Formerly 05.595) - Credits: 2

The practicum is a two-semester (1+2=3 credits) field-based experience in which the student engages in administrative responsibilities at the level of a school principal. These responsibilities are supervised by an on-site supervisor/mentor who holds certification in the appropriate area. A minimum of 300 hours must be completed during the course of the year. The responsibilities must be real and varied enough to allow the student to actively apply their knowledge and skills, thus demonstrating competence in the 'Standards for Advanced Programs in Educational Administration' of the ELCC (Educational Leadership Constituent Council). In addition to the field-based activities, candidates participate regularly in an on-line seminar with the university supervisor/instructor and meet for 3-4 face-to-face seminar sessions at the university. Students develop a practicum action plan, document their activities in a journal, participate in regular on-line discussions, complete several reflection assignments, and compile a final Practicum Portfolio. The basis of all work in the online seminar relates directly to the issues, experiences, and questions form the candidate's field-based activities. The Practicum aims to help all students achieve a fuller realization of their professional and personal resources as leaders and learners and strengthen their effectiveness as educational administrators now and into the future.

EDUC.5970 Practicum II, High School Principal (9-12)  
(Formerly 05.597) - Credits: 2

The practicum is a two-semester (1+2=3 credits) field-based experience in which the student engages in administrative responsibilities at the level of a school principal. These responsibilities are supervised by an on-site supervisor/mentor who holds certification in the appropriate area. A minimum of 300 hours must be completed during the course of the year. The responsibilities must be real and varied enough to allow the student to actively apply their knowledge and skills, thus demonstrating competence in the 'Standards for Advanced Programs in Educational Administration' of the ELCC (Educational Leadership Constituent Council). In addition to the field-based activities, candidates participate regularly in an on-line seminar with the university supervisor/instructor and meet for 3-4 face-to-face seminar sessions at the university. Students develop a practicum action plan, document their activities in a journal, participate in regular on-line discussions, complete several reflection assignments, and compile a final Practicum Portfolio. The basis of all work in the online seminar relates directly to the issues, experiences, and questions form the candidate's field-based activities. The Practicum aims to help all students achieve a fuller realization of their professional and personal resources as leaders and learners and strengthen their effectiveness as educational administrators now and into the future.
help all students achieve a fuller realization of their professional and personal resources as leaders and learners and strengthen their effectiveness as educational administrators now and into the future.

EDUC.6003 Leadership in Schooling: Residency - Credits: 0

The residency is a required on-campus component of the Ed.D. in Leadership in Schooling. Held during the summer, students spend several full days working with their student cohort and selected faculty on program outcomes. Students establish study groups, conduct preliminary work for the portfolio (for comprehensive exam I) and qualifying paper (for comprehensive exam II), and participate in daily seminars. There is a fee associated with the residency.

EDUC.6010 Leadership, Law & Policy in Higher Education (Formerly 08.601) - Credits: 3

This course examines theory, research and practice that inform us about the problem of scholarship, teaching, change and innovation in higher education. Students study academic life in the larger context of the institutional structure.

EDUC.6011 Pilot Study Proposal (Formerly 05.601) - Credits: 1

Pilot Study Proposal one credit provides the student with a seminar experience for the development of a pilot study proposal. This course is intended for the student who anticipates taking one or two additional semesters to complete the pilot study proposal. Successful completion of a written pilot study proposal and oral defense are required for continued progress in the degree program.

EDUC.6012 Introduction to Linguistics (Formerly 02.601) - Credits: 3

All language teachers benefit from understanding of how language in general works. This course is designed to help students to understand and use in their language teaching the basic concepts, methods and approaches of linguistics. The following topics are covered in the course; phonetics (sounds/sound inventory of a language), phonology (how we understand and organize the sounds and patterns), morphology (word structure, morphemes; how smaller units of meaning make up words), syntax (sentence structure, how words make up sentences), semantics (how we understand and parse sentences, structural ambiguity, context within sentences), pragmatics (how context impacts meaning on a textual level), social aspects of language (dialects, sociolects, language change, etc.). Although most of the examples will involve English, for comparative and contrastive purposes other languages will be used (no need to understand them). Students will be encouraged to come up with as many of their own examples as possible.

EDUC.6020 Pilot Study Proposal (Formerly 05.602) - Credits: 2

Pilot Study Proposal two Credits provides the student with a seminar experience for the development of a pilot study proposal. This course is intended for the student who was previously enrolled in EDUC.6011 and anticipates completing the pilot study proposal by the end of the semester. Successful completion of a written pilot study proposal and oral defense are required for continued progress in the degree program.

EDUC.6030 Pilot Study Proposal (Formerly 05.603) - Credits: 1-3

Pilot Study Proposal Three Credits provides the student with a seminar experience for the completion of a pilot study proposal. This course is intended for the student who anticipates completing the pilot study proposal by the end of the semester, and who has not previously taken EDUC.6011 or 6020. Successful completion of a written pilot study proposal and oral defense are required for continued progress in the degree program.

EDUC.6040 Leadership of Community Engagement I (Formerly 05.604) - Credits: 2

The purpose of Leadership of Community Engagement I is to expose teacher leaders to the variety of issues associated with family and community engagement. Through critical examinations of theory, personal experiences and collective knowledge, teacher leaders will learn how to engage families and community members (i.e., business, health and service agencies and community-based organizations) and recognize the different forms of engagement. This course will highlight collaborative strategies that "shares power" with parents, families, and community organizations in schools.

EDUC.6070 The Adult Learner (Formerly 01.607) - Credits: 3

This course will focus on the learning and development of adolescent young adults, adults and older adults in both school-based and non-school based settings. Cognitive, emotional, social and professional learning will be addressed as well as differing and changing learning styles across the lifespan and different learning settings.

EDUC.6071 Advanced Academic Writing I (Formerly 02.607) - Credits: 3
This course will enable graduate level English language learners to become competent academic writers who can critically and creatively evaluate, analyze, construct and present their ideas and arguments. This is a student oriented, pro-active course where writing skills are connected to reading skills. Through attentive, detailed and critical reading of various materials students will further enhance their writing skills by applying effective planning, drafting, rewriting and editing strategies.

EDUC.6074 Methods of Sheltered Language Instruction (Formerly 06.607) - Credits: 3
Different approaches and teaching procedures in Second Language instruction will be discussed as well as the methodological models of English as a Second Language instruction.

EDUC.6075 Academic Writing for English Second Language Users - Credits: 0
This course engages students in forms of academic writing, particularly relevant to scientific areas of study, from proposal and responses to research articles. Topics include (but not limited to) the language necessary to convey specialized/technical content to a variety of audiences, information structure, extensive use of sources, analysis of and feedback on writing (published and in progress) and resources (corpora) available and their usage. Priority given to graduate students later in their studies.

EDUC.6076 Data Management and Visualization - Credits: 3
The use and analysis of data in all forms requires that educational researchers understand how to manage and visualize data, making creative use of this knowledge as they build robust findings well supported by evidence. In this class, students will be introduced to the underlying principles of data management and the ways different kinds of data and information can be visualized to support analysis and representation to curious audiences.

EDUC.6080 Student Development Theory (Formerly 01.608) - Credits: 3
The Student Development Theory course will provide students with a theoretical background in the developmental processes of college students. The course will cover pertinent models of student development pertaining to cognitive, moral, psycho/social, environmental, and identity development. Students will gain an understanding of each theory, and understand their practical application.

EDUC.6090 Seminar I: Professional Accomplishments (Formerly 05.609) - Credits: 1
Candidates are asked to document a limited number of verifiable accomplishments outside the classroom from both the professional and local communities. Candidates must explain how each accomplishment impacts student learning. Accomplishments are limited to the last five years. Later in the program, more recent accomplishments may be added to the entry. The portfolio entry is 20 pages in length.

EDUC.6100 Teaching Reading in Content Area (Formerly 06.610) - Credits: 3
This course presents the theoretical foundation and current best practices for content area reading, writing, and study skills. The focus is on motivation, cognition, memory, and verbal processing theories as they apply to methodology. Students learn to develop lessons and units that integrate reading and writing while covering concepts in the content areas.

EDUC.6101 Theories of Learning (Formerly 01.610) - Credits: 3
This course offers a detailed analysis of the major contemporary learning theories, both behavioral and cognitive.

EDUC.6104 Reading and writing Instruction for Middle and Secondary Teachers - Credits: 3
This course presents the theoretical foundation and current best practices for content area reading, writing, and study skills. The focus is on motivation, cognition, memory, and verbal processing theories as they apply to methodology. Students learn to develop lessons and units that integrate reading and writing while covering concepts in the content areas.

EDUC.6110 Introduction to Higher Education (Formerly 05.611) - Credits: 3
This course provides an overview of the post secondary education system in the United States. It offers an interdisciplinary examination of contemporary colleges and universities with special attention to purposes, institutions, governance, and stakeholders.

EDUC.6120 Topics in Language Arts and Literacy (Formerly 06.612) - Credits: 3
This is an elective course in the doctoral program that covers a range of topics in language arts and literacy.
EDUC.6125 Global Perspectives on Higher Education - Credits: 3

This course explores why higher education today is in the midst of a global revolution. We will examine trends in our current age of globalization and how these trends have impacted the college campus. We will also ask hard questions about why students, faculty, universities, and entire nations seek international exchanges, what they get out of all this movement, and how it relates to the expanding significance of global citizenship. Our goal is to move beyond the "food, flags, and festivals" view of global learning and toward meaningful research agendas about the role of higher education in an age of global opportunities and global challenges.

EDUC.6130 Leading the Professional Learning Community (Formerly 05.613) - Credits: 3

It is well documented that teachers who habitually examine their shared work based on inquiry, observation, analysis of data, dialogue, and experimentation tend to be more effective than those who are not reflective and work in isolation. How do we help all teachers become highly effective? How do we spread reflective practice from isolated pockets to all teachers in a school? The answer lies in the transformation of a school's professional staff from isolated practitioners into a professional learning community. A professional learning community is a work culture in which educators regularly learn with and from each other through collaborative inquiry. This course provides the practical know-how and deep understanding need for educators to introduce and lead collaborative inquiry within their school or district and transform the teaching staff into a professional learning community. Furthermore, this course introduces the idea of collaborative inquiry by transforming participants into a professional learning community during the course. Thus, participants focus collaborative inquiry on their shared practice, read and reflect on selected authors, and develop action plans to help them introduce or advance collaborative inquiry in their own work settings.

EDUC.6220 Managing Resources and Finances (Formerly 05.622) - Credits: 3

This course will provide students with an understanding of the financial principles and budget management in the operation of our public schools. We will analyze economic and demographic data, review local/state and federal education budgets, examine the legal principles of school finance, review local, state, and federal laws and policies on public education and evaluate case studies in the operation of public schools. Students will prepare budget documents, develop financial forecasts and prepare policy briefs on various topics related to school finance.

EDUC.6221 Science, Mathematics and the Educated Mind (Formerly 04.622) - Credits: 3

Examination of interaction of Science and Mathematics in the growth of knowledge, and current considerations of literacy.

EDUC.6225 Education Reform in Science, Technology, Engineering, & Mathematics - Credits: 3

This blended course explores the ongoing efforts to improve the equity and quality of Science, Technology, Engineering, and Mathematics (STEM) education. By examining a series of STEM education reform efforts form the local, state, and national levels, students will gain a practical and theoretical understanding of both the historical role policy plays in education and its chronic shortcomings. Students will investigate an example of a local example of STEM reform and report on it to the class from a reform perspective. Finally, the educator's role in implementing effective reform in is considered.

EDUC.6226 Leadership and Research in STEM Education - Credits: 3

Educators in this course will explore and analyze current research in STEM education, investigate how student performance data informs school and district program decision making, learn how to lead and empower teachers in the mapping of STEM curriculum across grade levels, and develop strategies to develop effective district-wide STEM professional development for K-12 educators.

EDUC.6227 Foundations of Student Learning in STEM fields - Credits: 3

This course examines key crosscutting issues that enable STEM teachers to understand how knowledge is obtained and verified. During the course you will explore the theoretical foundations and research that would help you to better understand the nature of cognitive processes, the development of STEM reasoning abilities, and applications for teaching.

EDUC.6230 School Policy and Law (Formerly 05.623) - Credits: 3

This course will provide students with an understanding of the law and legal basis for making decisions in our public schools. We will analyze court decisions, state and federal constitutional provisions and laws and public policies and regulations as they pertain to the operation of the public schools in the United States. With a solid understanding of the legal framework of governance at the federal, state and local level and the decisions derived though court cases, educators will be better equipped to respond to the numerous challenges and decisions they face throughout the school year.
EDUC.6231 Policy & Practice in Sci., Tech., Eng., & Mathematics Education (Formerly 04.623) - Credits: 3

This course explores the dynamic relationship between educational policy and classroom teaching. By comparing the similarities and differences for this relationship within each of these fields, students will gain a practical and theoretical understanding of both the historical role policy plays in education and its chronic shortcomings. Finally, the educator’s role in implementing effective change in these fields is considered.

EDUC.6240 Assessment of Learning (Formerly 04.624) - Credits: 3

Students examine various approaches to the formative and summative assessment of learning. This course examines the importance of assessment in planning curricula and individual lessons.

EDUC.6251 Teaching of Writing (Formerly 06.625) - Credits: 3

The Teaching of Writing examines theories and research in writing instruction at all levels. The course focuses, particularly, on teaching/learning strategies and activities that improve students' writing.

EDUC.6260 Developments of concepts in Science (Formerly 04.626) - Credits: 3

Students explore the historical development of selected science concepts and the emergence of the philosophy of science. Progress in science is examined together with views of the nature of science.

EDUC.6270 Second Language Acquisition and Assessment (Formerly 06.627) - Credits: 3

A Study of the general schools of thought that have formed the basis of teaching English as a Second Language. This course is designed to assist students in conceptualizing the foundations of second language acquisition. The course will also inform students about appropriate procedures for assessing the skill development of second language learners.

EDUC.6271 Development of Mathematics Concepts (Formerly 04.627) - Credits: 3

Participants will analyze the nature of mathematics content knowledge and the nature of mathematics process knowledge, as well as the nature and process of knowledge acquisition. A conceptual framework will emerge from the synthesis of existing information.

EDUC.6280 Reasoning and Problem Solving in Science (Formerly 04.628) - Credits: 0

An analysis of the development of procedural knowledge, with particular emphasis on reasoning and problem solving, as they are currently conceptualized in educational and psychological literature.

EDUC.6300 Educating Diverse Populations (Formerly 01.630) - Credits: 3

As the world becomes increasingly diverse, educators must be prepared to examine, confront, and manage the factors that affect the education of all children. This course addresses several central issues focusing on how teachers address the problems that confront students who differ from the majority population in language, ethnicity, culture, gender, and sexual orientation. Ensuring that their families and communities are actively involved in the educational process is also an important component of the course.

EDUC.6301 Reasoning and Problem Solving (Formerly 04.630) - Credits: 3

The course is designed to direct and encourage critical examination of the theory of problem solving. Students analyze current research literature relating to reasoning, problem solving and critical thinking. Synthesis of this literature serves as a foundation for examining curriculum decisions.

EDUC.6302 Education Policy and Law (Formerly 05.630) - Credits: 3

The course provides students in the Ph.D. in Leadership in Education the opportunity for in-depth consideration of fundamental questions, seminal research, and theoretical perspectives related to education policy at all levels. Students who successfully complete this course will be able to explain major theoretical and legal perspectives in education policy research; discuss contemporary trends in education policy and law at state and federal levels; and identify key social, political, and economic factor that influence education policy and law.

EDUC.6320 The Inclusive School (Formerly 01.632) - Credits: 3

School leaders must create environments that are welcoming to all students and their families and that capitalize on the strengths students bring to the learning environment as well as address the needs of students. As the population of students in
our schools has continued to become more diverse, building an inclusive environment in which all are valued and in which all student can succeed has become increasingly complex. Participants in this course will explore their values and beliefs as well as the dominant culture and prevailing belief systems present in the majority of today’s public schools. Participants will learn about ways in which many students, their families, and their communities may differ from this dominant culture, and the possible effects of this mismatch. Through readings and interactive discussions, participants will examine ways to build a school culture that is inclusive for all students and their families. Participants will develop detailed plans of action to actively and meaningfully involve parents and community members in all aspects of the school.

EDUC.6350 Dynamics of Curricular Change (Formerly 04.635) - Credits: 3
This course considers alternative perspectives of curriculum and explores issues and strategies involved in the process of changing the curricular visions and practices of schools.

EDUC.6360 Sociocultural Contexts of Educational Communities (Formerly 01.636) - Credits: 3
Examines the social, cultural and political forces that shape the educational environment and provide context for teaching and learning. The existing and desired relationships among schools, families, and communities will be discussed.

EDUC.6370 Historical and Contemporary Perspectives on Curriculum - Credits: 3
This course focuses on developing a knowledge base of historical and contemporary perspectives on curriculum and schooling as they evolved in American society. The first part of the course addresses three concepts as they relate to curriculum. They are: 1.) School, literacy and society. 2.) Movements in schooling and 3.) Dimensions of diversity. The second part of the course addresses an examination of conflicting views on selected issues, identifying related underlying problems, and then developing feasible resolutions. The assignments consist of textbook and library readings as well as the writing of 5 reflection papers during the 10 week course. Students’ final work will be submitted in a portfolio at the end of the semester for faculty evaluation and grading.

EDUC.6380 Curriculum Design K-12 (Formerly 04.638) - Credits: 3
A review of state mandates which, by law, shape the curriculum of the school. Examination of "new" curricula and their sources, as well as the development of a rationale for curriculum design and an evaluation of the personnel and techniques by which these curricula can be developed.

EDUC.6381 Planning, Technology and School Improvement (Formerly 05.638) - Credits: 3
This course helps educators develop a broad grasp of the educational possibilities and concerns the Internet raises, for K-12 educators as well as those in higher education. Through the course, students develop in-depth knowledge of Internet resources and problems related to a specific issue of professional interest.

EDUC.6410 Issues in Staff Development (Formerly 05.641) - Credits: 3
Includes understanding of how to work with adult learners who are peers, as well as techniques for assessing staff needs, design of programs to improve staff performance and strategies to ensure productive in-service education.

EDUC.6411 Fostering a Learning Organization in Higher Education (Formerly 01.641) - Credits: 3
This course will explore approaches to employee engagement and professional development. Organizational learning and adult learning theories will be introduced as mechanisms for delivering effective practices in the planning, design, and implementation of (1) employee knowledge, competency, and capacity-building practices and programs and (2) strategies for fostering a learning organization.

EDUC.6421 Principles of Supervision (Formerly 05.642) - Credits: 3
This course is designed to help current and aspiring supervisors explore the skills, knowledge and personal attributes central to instructional leadership and supervision. A paradigm shift away from an historical/traditional view of supervision towards a more collegial model is emphasized. Students will complete field work including two observations of a colleague and pre and post-lesson conferences.

EDUC.6423 Program Evaluation (Formerly 07.642) - Credits: 3
Evaluation tasks will be identified and the policy issues attendant to evaluation will be examined. Students will identify and discuss several models of program evaluation, understand what needs to be considered and addressed in needs assessment, and learn to identify an appropriate design for a new evaluation. Students will be expected to conduct program evaluation, present their ideas and illustrate how evaluation results can be useful for program decision making.
EDUC.6430 The Skillful Teacher (Formerly 04.643) - Credits: 3

This course is designed to help teachers and educational leaders view teaching from a reflective stance. Video material of teaching situations will be examined for the application of skills discussed in the course.

EDUC.6431 Principalship PK - 12 (Formerly 05.643) - Credits: 3

This course is designed to help aspiring principals explore the skills, knowledge and personal attributes central to effective leadership. The course aims to acquaint students with research, theories, and frameworks from the knowledge base on school leadership; explore the issues, daily experiences, and decisions of the principal within the action context of the school; assist students to think critically and systematically about leadership; help students become more conscious of their own values, assumptions and purposes as school leaders; further develop leadership skills, insight, and vision for schooling; assist students to think of themselves as educators for transformation.

EDUC.6440 Foundations for Practitioner Scholars (Formerly 01.644) - Credits: 3

This course will introduce students to seminal and recent work in the fields of philosophy, history, and psychology as they relate to education. Students will critically examine research and scholarly theory in these fields and their relationship to PK-12 Practice.

EDUC.6441 Models of Teaching (Formerly 04.644) - Credits: 3

This course will investigate researched-based instructional models that have been proven to facilitate learning in any academic content area. Each model addresses academic content as well as attainment of instructional goals and objectives. All models support the 21st learner by focusing on the needed skills for school, life and work. This course will benefit teachers who teach at any grade level.

EDUC.6450 Perspectives and Visions in Education I (Formerly 01.645) - Credits: 3

Open to matriculated doctoral candidates only. This foundational course provides new doctoral students with an understanding of differing perspectives on the purpose of public education in the United States during the last 150 years. The philosophical and political perspectives which influenced educational reform during this period will be examined. The course will culminate in reading and discussion of contemporary visions for schooling. This course must be taken before 01.646.

EDUC.6451 Directed Study Curriculum and Instruction (Formerly 04.645) - Credits: 3

EDUC.6460 Perspectives and Visions in Education II (Formerly 01.646) - Credits: 3

This course examines how psychology and education have been intertwined throughout the history of American education. Various psychological perspectives for educational practice will be considered. The role of research in education, including the use of psychological research methods will be considered as you begin preparing to conduct educational research. Visions of educational psychologists for utilizing psychological research findings in creating future educational practice and policies will also be explored.

EDUC.6490 Directed Study: Administration (Formerly 05.649) - Credits: 3

Through frequent consultation with the instructor, the student will investigate and define a problem for research and will present the findings in a significant paper. The directed study may not be substituted for a required course.

EDUC.6501 Capstone Project: Advanced Programs (Formerly 04.650) - Credits: 3

Students will have the opportunity to develop a teacher work sample consisting of work in six major areas: (1) contextual factors, (2) learning goals, (3) assessment plan, (4) design for instruction, (5) analysis of student learning, and (6) reflection.

EDUC.6502 Educational Reform (Formerly 05.650) - Credits: 3

Addresses the way in which an instructional leader initiates changes in organizations—whether curricular or in the systems which make organizations function.

EDUC.6510 Web-based Tech. in the Learning Environment: Teaching and Learning (Formerly 03.651) - Credits: 3

Students will research, discuss and examine web-based educational technologies and the pedagogical practices associated with them. We will also interrogate the way that these technologies and their requisite literacies have changed, are changing and will change the nature of institutional instruction. In addition, we will investigate the policy implications that arise from the existence of these technologies.
This course is taught online. It is suitable for students at the Masters, Ed.S or Doctoral level.

EDUC.6511 Transformative Leadership in Education (Formerly 05.651) - Credits: 3

This course considers ways in which school leaders can facilitate transformative change in all aspects of education. Focusing on theory, research, and pragmatic strategies, the course examines approaches to educational design and redesign for educational institutions undergoing significant change.

EDUC.6520 Change and Conflict in Higher Education (Formerly 05.652) - Credits: 3

Examines theories in the changing process, strategies for effective adoption and implementation of innovations and conflict resolution.

EDUC.6530 Capstone Alternative (Formerly 04.653) - Credits: 3

This Capstone Alternative is the culminating course for students who are not in regular PK-12 classroom settings, particularly those who are in the Autism Studies program. Candidates in this course will apply information that they have learned during their coursework to an action research project in a classroom or small group setting. In addition, candidates will develop a professional portfolio with products developed during coursework.

EDUC.6540 Student Development & Leadership in Higher Education (Formerly 08.654) - Credits: 3

This course will examine the role of higher education in creating leaders for a diverse and democratic society. Grounded in student development theory and practice, this course will engage participants in reflective and critical exploration of leadership theories, frameworks, concepts and skills that focus on social justice and purposeful change. The course is designed to provide foundational grounding in the study of leadership theory and research, with a focus on the leadership paradigms emphasizing transformation, collaboration and empowering group members in an effort to improve the world in which we live. During this course you will read current ideas about student development and the nature of leadership, you will engage in class activities and assignments which challenge you to think critically with multiple perspectives and frameworks and you will undertake a self-examination about who you are and what you believe as someone who will facilitate student development and leadership in student affairs and within higher education.

EDUC.6550 Directed Study Curriculum and Instruction (Formerly 04.655) - Credits: 3

Through frequent consultation with the instructor, the student will investigate and define a problem for research and will present the findings in a significant paper. The directed study may not be substituted for a required course.

EDUC.6560 Ed.S Seminar (Formerly 04.656) - Credits: 3

Candidates undertake an in-depth study of issues pertinent to PK-12 education and develop a product to address these issues. Candidates must complete 24 credits prior to registering for the Ed.S Seminar.

EDUC.6571 Readers Responses to Literature (Last Term 2009 Spring) (Formerly 06.657) - Credits: 3

An in-depth study of theory and research on the work in readers’ responses to literature. Attention is given to past findings and methodologies as well as to future research in this area.

EDUC.6580 Role of the Curriculum and Instructional Leader (Formerly 05.658) - Credits: 3

This course provides prospective leaders with the theoretical and empirical bases for understanding the instructional core and how to create the conditions needed for high quality teaching and learning to occur in their schools. Course participants will explore how to (i) establish a vision that promotes high standards for learning and is shared by all stakeholders; (ii) promote a positive school culture that is anchored in professional behavior and trust relationships; (iii) promote effective instructional programs and the application of best practices to student learning; (iv) make decisions grounded in reliable data integrity, fairness, and ethical conduct.

EDUC.6590 Strategies for Instruction in Higher Education (Formerly 08.659) - Credits: 3

A variety of theories, methods and multi-media techniques of teaching will be explored in order to familiarize students with the many options available to facilitate learning by adults.

EDUC.6600 Ethnographic Inquiry (Formerly 07.660) - Credits: 3

This course provides the theoretical underpinnings of the nature, principles and processes of ethnographic research which focuses on the understanding of human cultures. Students will study how an ethnographic research project is
developed and will conduct an aspect of a study during the semester. There will be particular emphasis on collecting and analyzing data in ethnographic research.

EDUC.6601 Diversity in Higher Education (08.660) - Credits: 3

Focuses on the preparation, admission, retention, and achievements of minorities in higher education, both past and present.

EDUC.6701 Practicum I: Higher Education Option (Formerly 08.670) - Credits: 3

The Practicum I: Higher Education is the first of two culminating requirements for those students striving to earn the M.Ed. in Education Administration: Higher Education Option. Practicum I and II require students to engage in a project that demonstrates the practical application of their knowledge and skills in real-life higher education leadership activities and responsibilities over the course of two semesters; both semesters involve significant leadership work in partnership with a supervisor/mentor in an appropriate higher education site. Selection of the focus and scope of the project will be tailored to students’ area of focus in the Higher Education Option and their current work responsibilities.

EDUC.6710 Practicum II: Higher Education (Formerly 08.671) - Credits: 3

Practicum II: Higher Education is the second in the series of two culminating requirements for those students striving to earn the M.Ed. in Education Administration: Higher Education Option. Similar to Practicum I (08.670), Practicum II (08.671) requires students to engage in the continuation of the project form Capstone I that demonstrates the practical application of their knowledge and skills in real-life higher education leadership activities and responsibilities over the course of the semester. Both Practicum semesters involve significant leadership work in partnership with a supervisor/mentor in an appropriate higher education site. Practicum II content will be tailored to students’ area of focus in the Higher Education Option and their current work responsibilities.

EDUC.6733 Ethics and Decision-Making in Higher Education - Credits: 3

This course will explore ethical theories and their application to higher education. The course will rely heavily on in class discussion and learning from all participants: faculty and students. A case study approach will be used in order for students to gain hands-on experience dealing with ethical issues that arise in the Higher Education setting.

EDUC.6740 Research into Learning in Science (Formerly 04.674) - Credits: 3

In this course, we shall be reading research articles and examining how the research was carried out. You will conduct an “action research” project. Those who engage in action research have a commitment to bring about change. In this case, you will be investigating something in your own classroom or school that concerns you and therefore the results of your research will help you to think about what might be done to change the situation. Through the collection and sorting of data we can gain insights into situations that were previously muddy. Teachers often have to make judgments based on experience, but this is not persuasive to outsiders. With data we can convince others that the course of action we choose is justified.

EDUC.6750 Leadership in Science Education (Formerly 04.675) - Credits: 3

There are many issues in science education that can be clarified as a result of reading current literature and engaging in discussion with other teachers. In this course, we will examine some of the most pressing issues that face us as science teachers e.g. What is science literacy? What role should inquiry play in a science curriculum? What is the role of technology in science education? Is ability grouping appropriate for learning in science? Each week we will examine a different issue and share our expertise, as we explore what it means to be a leader in science education. You will share your own science teaching expertise by developing an article to be submitted to an NSTA publication via a peer review process. Additionally, you will put your program learning into practice and will be assessed through written evidence captured in a professional portfolio.

EDUC.6751 History, Theory, & Contemporary Issues in Lang, Literacy & Culture (Formerly 06.675) - Credits: 3

The purpose of this course is to engage students in the complexities and debates regarding theoretical perspectives and research on language, literacy, and culture that have affected language and literacy learning. This course will begin with an introduction to the history of research done on concepts of language, literacy and culture. Students then look at the evolution of sociolinguistic and stenographic research language, literacy and culture as well as other modes of inquiry on language and literacies. Most of the course is spent closely examining studies for how they conceptualize the mutual construction of language, literacy, and culture, and for what they can tell us about the nature of literacy learning. In addition, students will explore the questions those studies raise such as cultural diversity, identity, learning, curriculum and instruction school-community relationships and social justice in literacy and language learning.
EDUC.6760 Exploring the Nature of Science
(Formerly 06.676) - Credits: 3
If you were asked to describe the characteristics of science what would you say and would you know whether professional scientists agree with you? National professional societies such as the NSTA and the AAAS, believe that if middle and high school students understand how science has been and is practiced, they will be more likely to question their own thinking, recognize the power of scientific theories and understand that there are no absolute truths. This course will take you on an exploration of some fascinating discoveries in the history of science, engage you in debate about controversial issues in science, and involve you in raising your own scientific questions.

EDUC.6761 History, Theory, and Research in the Teaching of Writing (Formerly 06.676) - Credits: 3
This course covers the history of the teaching of composition from the ancient Greeks to the present day, the development of both theory and pedagogy, and the current research into how writers learn, which teaching methods work best, and which issues continue to be of concern. Students will learn to critique writing pedagogy, to place programs and issues into historical perspective, and to analyze and design research into the teaching of writing.

EDUC.6770 Theories of Verbal Communication (Formerly 06.677) - Credits: 3
The course will examine various theories and models of verbal communication appropriate for study in the Language Arts and Literacy. The specific theories and models will be determined each semester.

EDUC.6780 History, Research and Contemporary Issues in Reading Instruction (Formerly 06.678) - Credits: 3
Students will trace the history of reading instruction in the United States from The New England Primer in the 1600s to the present with special attention to the ways in which those milestones may have impacted reading instruction today. Each of the key philosophical orientations to reading instruction will be explored from the point of view of the research that informs that instruction. Contemporary issues in reading instruction will be examined with ties to both the research and the history. Contemporary issues will be drawn from, but not limited to, politics, curriculum design, instructional materials, and instructional design.

EDUC.6910 Developing Inclusive School Contexts (Formerly 05.691) - Credits: 3
This course will introduce students to theory and research about structural inequities, barriers to education, and promising practices for addressing these barriers. Students will examine theory and research and implications for practice in PK-12 Leadership.

EDUC.6911 Applied Research Design (Formerly 07.691) - Credits: 3
This course is designed to provide PK-12 practitioners with an understanding of the principles of research design and the ethical responsibilities of conducting a research study. Participants will learn a broad range of research methodology approaches that can be applied to problems of practice. Participants will become skilled at reading, evaluating, and judging the trustworthiness of studies using different methodology approaches. They will design a practitioner-oriented research study.

EDUC.6920 Law, Policy, and Finance (Formerly 05.692) - Credits: 3
In this course students will examine scholarship and research in the areas of law, policy and finance as these affect educational practice. They will analyze law, policy and finance and its implications for leaders in PK-12 schools and school systems.

EDUC.6921 Quantitative Data Analysis for Practitioner Leaders (Formerly 07.692) - Credits: 3
The primary focus of this course is to prepare practitioner leaders to understand, interpret, and analyze quantitative data as it relates to their identified problem of practice.

EDUC.6922 Qualitative Research Methods Practitioner Leaders - Credits: 3
This is the first in a two-part sequence of courses that will introduce students to the scope of issues, techniques, and perspectives that compose qualitative research methodology. In this first course students will be introduced to historical, philosophical, and theoretical issues undergirding the approach, principles of research design, data collection techniques, and approaches for preliminary organization of the data. Students will also be introduced to literature and technologies of the field.

EDUC.6930 Organizational Learning (Formerly 05.693) - Credits: 3
This course will introduce students to research and theory in
the field of organizational learning and its application to PK-12 practice. Students will study the origins, evolution and contemporary findings of research in this field. Students will explore the practical implications of organizational learning for PK-12 leadership.

EDUC.6931 Data Analysis for Practitioner Leaders (Formerly 07.693) - Credits: 3

This course is designed to provide second year EdD students opportunities to learn how experts in the field are applying principles of improvement science to address educational problems—particularly those related to equity. At the end of the course, students are expected to demonstrate how they will apply improvement science methods to address a persistent educational problem in their own school or system contexts.

EDUC.6940 Systems Leadership I (Formerly 05.694) - Credits: 3

Drawing on organizational, management, and educational scholarship, this course introduces students to concepts and practices associated with strategic systems leadership. Students will apply their understandings of how to leverage both formal and informal sources of influence in their analysis of relevant teaching cases and the data they collect in an extensive field study project.

EDUC.6950 Systems Leadership II (Formerly 05.695) - Credits: 3

Building on the core concepts and practices introduced in Systems Leadership I, this course focuses specifically on how effective leaders use data to understand and address the challenges of their operation environment. Importantly, the course focuses on not only the technical knowledge and skills leaders need to use data as a lever for improvement at scale, but on the adaptive leadership skills required for meaningful systems change.

EDUC.6960 Strategic Partnering with Families and Communities (Formerly 05.696) - Credits: 3

This course will critically examine the variety of issues associated with partnering with parents, families and community organizations. Through analysis of theory, research and collective knowledge, doctoral students will learn how to strategically engage parents, families and community organizations and recognize the different forms of engagement. This course will emphasize collaborative strategies that "shares power" with key stakeholders in U.S. schools.

EDUC.6980 Research Seminar - Credits: 0

The goal of the Research and Program Evaluation program’s Research Seminar is to provide advisement, develop a sense of professional community among Ph.D. students and faculty in the program, and assist students to develop the “soft skills” of academia—including how to make professional presentations and deliver academic critique.

EDUC.6990 Doctoral Research Seminar (Formerly 07.699) - Credits: 0-1

This seminar, for all doctoral students and faculty in the Research and Program Evaluation Ph.D. program gives students the opportunity to learn about research and evaluation practice directly from faculty and other students speaking about their research and evaluation experiences. Students will learn how to: understand research and evaluation presentations; ask educated questions and make substantive suggestions and comments about research; and create and deliver a presentation of their research evaluation projects.

EDUC.6991 Reading and Applying Educational Research - Credits: 3

This course is designed to build student capacity for evidence-based decision making in K-12 schools. Specifically, it will advance student ability to locate educational research, evaluate it for quality, extract findings, and apply those findings to practice. Critically, the process of applying research to practice will consider local context and draw on stakeholder experiences, weaving them together with scholarship to develop school improvement plans.

EDUC.6999 Reading and Critiquing Educational Research - Credits: 3

This course, with its focus on educational leadership research, will help you locate different kinds of educational research, understand the basic format of various genres of research, read educational research, and efficiently extract findings and results. It will also help you critique educational research. This course will also prepare you to interpret methodological approaches, to examine the coherence of those approaches, to identify potential threats to validity, and to distinguish high-quality work from that which is merely competent.

EDUC.7000 Introduction to Research Design and Methods (Formerly 07.700) - Credits: 3

In this course students will be introduced to: Principles of research design in social sciences; Understanding how to plan for research using quantitative and/or qualitative data collection methods; Ethics of research conduct; Understanding and preparing for the Institutional Review board (IRB) process; Evaluating the trustworthiness of research; How to critically
review research; The historical and philosophical issues undergirding qualitative research; Paradigms; Sampling procedures; Types of measurement error; Methodologies appropriate for educational research; Recent developments in education research.

EDUC.7002 Conducting Research in Literacy Studies I
- Credits: 3

This course provides doctoral students prior to their dissertation research with an opportunity to develop a research proposal through an intensive literature review, writing and discussions. Based on a solid understanding of current research trends on literacy, culture and communication students will identify research questions and articulate theoretical perspectives that frame their research. Developing research design and analysis tools will also be a core element of this course as part of the students' research proposals. Students will go through IRB application using the proposal developed in this course to actually conduct their research in the next semester.

EDUC.7010 Cognitive & Info Processing Theories of Learning, Dev & Inst (Formerly 01.701) - Credits: 3

This course covers the fundamentals of human memory and cognition. In addition to modern memory theory, imagination, problem solving, invention, complex learning and complex skill performance will be explored.

EDUC.7011 Pilot Study (Formerly 05.701) - Credits: 1

Pilot Study One Credit provides the student with a seminar experience for the development of a pilot study. This course is intended for the student who anticipates completing the pilot study by the end of the semester. Successful completion of a written pilot study is required for continued progress in the degree program.

EDUC.7012 Data Analysis (Formerly 07.701) - Credits: 3

Prerequisite: A descriptive statistics or research methods course satisfactory to the Program Faculty. This course covers basic statistics used in the analysis of educational research.

EDUC.7014 Conducting Research in Literacy Studies II
- Credits: 3

This course will focus on the actual conduct of a research project. It may not be possible to complete a research project (data collection and analysis) in a single semester; however, some important aspects of a research project are expected, such as sample data collection using the research instruments developed in the previous semester, ongoing analysis and preliminary findings. Students are expected to receive approval from the IRB prior to the course and will begin data collection as soon as the semester begins.

EDUC.7020 Research Methods and Design (Formerly 07.702) - Credits: 3

Methods of data collection suitable for answering a variety of educational research questions. Considers both qualitative and quantitative strategies for research and evaluation needs. Prerequisite: 07.701 or acceptable substitute.

EDUC.7021 Pilot Study (Formerly 05.702) - Credits: 2

Pilot Study Two Credits provides the student with a seminar experience for the development of a pilot study. This course is intended for the student who was previously enrolled in EDUC.7011 and anticipates completing the pilot study by the end of the semester. Successful completion of a written pilot study is required for continued progress in the degree program.

EDUC.7030 Pilot Study (Formerly 05.703) - Credits: 1-3

Pilot Study Three Credits provides the student with a seminar experience for the completion of a pilot study. This course is intended for the student who anticipates completing the pilot study by the end of the semester and who has not previously enrolled in EDUC.7011 or 7021. Successful completion of a written pilot study is required for continued progress in the degree program.

EDUC.7040 Qualitative Research Methods (Formerly 07.704) - Credits: 3

This course concentrates on the use of qualitative methods for educational research. Strategies for conducting qualitative studies are described and techniques for analyzing and reporting findings are emphasized. Students will also examine strategies for the ethical conduct of qualitative research.

EDUC.7050 Survey Research (Formerly 07.705) - Credits: 3

Focusing on survey research methods, this course will familiarize students with the strategies, techniques, tactics, and issues in developing and administering questionnaires and interviews.

EDUC.7054 Introduction to Higher Education Research - Credits: 3

This course offers a critical examination of the research
EDUC.7060 Intermediate/Advanced Data Analysis (Formerly 07.706) - Credits: 3

Mixed methods research and evaluation uses both quantitative and qualitative data and information to answer research and evaluation questions. Mixed methods research and evaluation integrates these two general methodologies to design more complete and powerful scholarship and produce more informative answers to research, instructional, and educational questions of both the formative and the summative kind. These questions may be research hypotheses, instructional program effects, or educational program and policy evaluations. This course is designed to meet the needs and goals of the students who enroll in it and is conducted by a learning contract model. Advanced univariate and multivariate design and statistical techniques will be selectively covered, including: meta-analysis, instrument design and development. It includes various qualitative techniques and analytical models, such as development and use of protocols, interviewing, content and discourse as well as text analysis, analytic and observational scoring procedures and systems, document analysis, policy analysis. Scholarly text development such as histories, white papers, or professional literature reviews will be included.

EDUC.7070 Writing for Professional Publication (Formerly 07.707) - Credits: 3

In this course students will learn about the processes and the resources relevant to writing, publishing and presenting manuscripts for professional journals and conferences. There will be an emphasis on student-developed work based upon relevant topics in the students field of study. Instructor permission required.

EDUC.7082 Introduction to Discourse Analysis - Credits: 3

Discourse analysis has been increasingly used as a basic analytic tool of qualitative research. This research methods course focuses on the use of language in society at the level of multiple interlocutors and contexts. This course is by nature interdisciplinary, and the goal is to provide graduate level students in all disciplines with practical guidelines to doing discourse analysis in qualitative research and mixed methods research.

EDUC.7090 Measurement & Evaluation (Formerly 07.709) - Credits: 3

Basic measurement and evaluation theories and techniques are surveyed, including achievement, attitudes, opinions, abilities, personality, skills and trait variables. Emphasis is given to methods of establishing reliability and validity of various measures.

EDUC.7101 Qualitative Research: Advanced Topics in Analysis - Credits: 3

Students will examine selected cutting-edge topics in the field of qualitative research. They will become familiar with key journals in the field of qualitative research. Students are expected to research and write about a self-selected topic in the field of qualitative research methodology. The course stresses the skills of methodological literature review and professional academic writing.

EDUC.7110 Research Experience Research Experience - Credits: 3

The goals of Research Experience are to provide students in the Research and Evaluation in Education Program with mentored experience in a hands-on research project. Appropriate research experiences are those that allow the students opportunities to increase their skills, Knowledge, and experiences in the program goal areas. Students will work approximately 10 hours a week on the designated research project, meeting a minimum of 1 hour per week with the research mentor.

EDUC.7130 Research Writing Seminar - Credits: 3

This course provides participants with an opportunity to hone their writing skills in the humanities and social sciences, learn more about the process of academic publishing, and become familiar with the requirements of journals most relevant to their work. Students will develop a manuscript for publication, building general skills for academic writing across genres. In addition to being fully online, this course is individualized and flexible to meet students’ needs and goals. It is required for REE students and open to all other doc and master’s students at UMass Lowell.

EDUC.7290 Directed Study-Doctoral Education (Formerly 05.729) - Credits: 3

Participants will develop a focused line of investigation with the supervision of a faculty member in the college. Approval of advisor is required.

EDUC.7291 Directed Study: Language and Literature (Formerly 06.729) - Credits: 3

Students will work on individually designed projects in
language arts and literacy in close cooperation with a faculty member.

EDUC.7292 Directed Study: Mathematics and Science Education (Formerly 04.729) - Credits: 3

Participants will develop a focused line of investigation with the supervision of a faculty member in the college. Approval of advisor is required.

EDUC.7420 Foundations of Program Evaluation - Credits: 3

In this course the following topics will be considered: Fundamentals of Evaluation Theory; Evaluating Evaluation Approaches and Models: Explication and Application of Specific Models; Evaluation Design; Evaluation Ethics; Evaluation Procedures; Meta-evaluation.

EDUC.7430 Program Evaluation: Advanced Topics - Credits: 3

This course will further your knowledge of program evaluation by focusing on such topics as: Assessing the need for program evaluation; Working with stakeholders; Identifying, measuring and monitoring outcomes; Assessing impact; Social context of evaluation.

EDUC.7440 Program Evaluation and Public Policy - Credits: 3

The focus of this course includes: The relationship between evaluation and educational policies; Standards-Based evaluation; Responsive Evaluation; Evidence Based Evaluation; cost Benefits Analysis Evaluation; Large Scale Evaluations: Issues in Planning; Large Scale Evaluations: Analyses; Evaluation of Public Programs and Related Policy; Utilization of Findings in Policy.

EDUC.7501 Dissertation in Practice - Credits: 3

Ed.D. students will design their study, complete their proposal, conduct their study and defend their dissertation in practice, while enrolled in dissertation credit. This course is for Ed.D. cohort students only.

EDUC.7502 Dissertation in Practice: Data Collection and Analysis - Credits: 3

In this second course of the EdD dissertation course series, students will collect and analyze data with the support of the course instructor.

EDUC.7503 Dissertation in Practice: Dissertation Completion - Credits: 3

In this final course of the EdD program students formally report on their data in a written dissertation that they defend at the end of the semester.

EDUC.7530 Doctoral Dissertation/Education (Formerly 05.753) - Credits: 3

Doctoral candidates who have passed both the Pilot Study Proposal/Defense and the Pilot Study may register for this course. Candidates work with their chair and/or a committee member to advance their research. Permission of instructor is required.

EDUC.7531 Doctoral Dissertation/Education (Formerly 06.753) - Credits: 3

EDUC.7532 Doctoral Dissertation/Education (Formerly 04.753) - Credits: 3

EDUC.7560 Doctoral Dissertation/Education (Formerly 05.756) - Credits: 6

doctoral candidates who have passed both required doctoral examinations (comprehensive/Qualifying examinations) may register for dissertation credit. Candidates work with their chair and/or a committee member to advance their research. Part time candidates who wish to register for 6 credits of dissertation study in one semester must gain the permission of the instructor.

EDUC.7590 Doctoral Dissertation/Education (Formerly 05.759) - Credits: 9

Doctoral candidates who have passed both required doctoral examinations (comprehensive/Qualifying examinations) may register for dissertation credit. Candidates work with their chair of a committee member to advance their research. Only, full-time candidates, including TAs and RAs, and international students may register for 9 credits of dissertation study. Permission of Instructor is required.

EDUC.7600 Dissertation Research (Formerly 05.760) - Credits: 1

Doctoral candidates must be enrolled in this course if they have completed their required dissertation research and wish to defend their dissertation.

EDUC.7660 Continued Graduate Research (Formerly 05.766) - Credits: 6
Master of Science in Finance

The Finance Department at The Manning School of Business offers a graduate degree program in Master of Science in Finance (MSF) in addition to a finance options in the MBA and doctoral degree programs. All degree programs offered by the Finance Department, along with all programs offered by the MSB are accredited by the Association to Advance Collegiate Schools of Business (AACSB). This accreditation is the highest level of accreditation for a business school, and documents the commitment of the Finance Department, the Manning School of Business, and the University of Massachusetts Lowell to excellence in education and continuous improvement of programs to keep them rigorous and relevant.

Curriculum

For undergraduate business majors, the MSF curriculum consists of 10 courses (30 credits): five required courses in Finance and five electives (two of which are recommended to be in Finance). For applicants who earned an undergraduate degree in an area other than business, this program is preceded by three prerequisite courses (with grades of B- or better) representing key foundation material in Accounting, Economics, and Finance. These prerequisite course credits will not count toward the MSF degree. The curriculum plan for the MSF is as shown in the curriculum outline.

The courses in the Manning School of Business are currently offered in an accelerated 8-week format. Student are allowed to register for a maximum of two courses (6 credits) per 8-week term. In order to petition to take more than two courses per 8-week term, the student needs to submit a graduate academic petition to the Manning School Graduate Office.

Admission Requirements

1. Undergraduate Degree: Official transcripts. A minimum overall GPA of 3.0 is required.
2. GMAT (minimum 500): can be waived for UMass Lowell undergraduates with a GPA of 3.2 and above and upon receipt of a recommendation by an UMass Lowell faculty member; also can be waived if the undergraduate GPA is 3.5 and above at an AACSB accredited (or equivalent) university.
3. TOEFL for international students: (600+ paper-based, 250+ computer-based, or 100+ Internet-based).
4. Successful completion of all other Graduate Admissions Office requirements, including three letters of recommendation.

Curriculum Outline: Master of Science in Finance (MSF)

Prerequisite Course Requirements

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCT.5010</td>
<td>Financial Accounting</td>
<td>2 credits</td>
</tr>
<tr>
<td>FINA.5010</td>
<td>Business Financial Analysis</td>
<td>2 credits</td>
</tr>
<tr>
<td>ECON.2010</td>
<td>Microeconomics</td>
<td>3 credits</td>
</tr>
</tbody>
</table>

- Total Number of Courses required for the degree: 10
- Total credit hours required for the degree: 30

Academic and Graduation Requirements

Academic and graduation requirements are similar to those of the other graduate programs in the MSB. Specifically, no more than six (6) MSF course credits of grades below a B may be counted toward the MSF, and no graduate degree will be awarded to any student whose overall cumulative grade point average is below 3.0. Other policies, as contained in the UMass Lowell Graduate Catalog, will also apply as appropriate.

MSF Program Coordinator:

Prof. Ravi Jain
Phone: 978-934-2854
Email: MSF@uml.edu

Master of Science in Entrepreneurship Degree Program

- Program of Study
- Part-Time and Full-Time Study
- Admissions Process
- Course Descriptions

From a competitive perspective, the shift from a manufacturing base to a technology-innovation and knowledge-based economy requires new skills among organizational employees. In conversations with executive staff in major companies in the region we have been told repeatedly that the regions engineers and scientists need to be entrepreneurial. As competition and costs rise, research and development efforts must clearly
contribute to business growth and the company bottom line. Thus, companies are looking for technical professionals who can generate new ideas and new businesses.

The goal of the Master of Science in Entrepreneurship (MS E) is to provide all students (engineers, business, scientists, social, arts, etc.) with the skills and knowledge required to drive innovation in today’s collaborative, global workforce. Using a combination of class work, case work and real-world project activity, students will:

- Understand and leverage the business opportunities accompanying low- to high- technology innovation within established companies and through the launch of new ventures.
- Develop an understanding of technology innovation and entrepreneurship from both an academic and applied perspective.
- Learn how to appropriately value and finance technology innovations and new ventures.
- Develop the market research and sales skills necessary to position technology innovations to create competitive advantage.
- Develop the management skills required to identify, launch and execute innovative products, services and new ventures.
- Develop an applied understanding of the regulatory and property law issues accompanying the innovation and entrepreneurship processes.
- Develop the project management and interdisciplinary team skills required to manage in an open collaboration environment.

A graduate of the MS E program should be prepared to manage innovation in established firms, or to launch new technology-oriented ventures.

Program of Study

The MS E consists of ten courses (30 credits), including 4 core courses (12 credits), 4 elective courses (12 credits, 6 of which must be in Engineering and/or Science) and 2 course (6 credit) practicum. Each student will participate in the development and delivery of a team capstone project (through the 2 course practicum) which will be reviewed by an external professional panel.

The courses in the Manning School of Business are currently offered in an accelerated 8-week format. Student are allowed to register for a maximum of two courses (6 credits) per 8-week term. In order to petition to take more than two courses per 8-week term, the student needs to submit a graduate academic petition to the Manning School Graduate Office.

- MS in Entrepreneurship degree pathway (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

Part-Time and Full-Time Study

Students are admitted on either a part-time or full-time basis. Courses meet during the evening hours beginning at 6 p.m., with additional online and blended course options.

Part-time students are expected to graduate within two years. For an MS student, the full-time course load is nine credits. Degree requirements usually are completed in one year for students attending full-time.

Admissions Requirements

Target Audience

The Program will be offered to engineering, science and select business graduates as a fifth year program (the University’s Plus-One program) and to working professionals with an appropriate undergraduate degree in business, science, technology or engineering.

Working Professionals

Admissions to the program will be determined based on an overall review of the following applicant materials: undergraduate degree and performance in science, engineering or business (other areas will be considered if the applicant demonstrates significant work experience in a technical field), GMAT or GRE score, three letters of recommendation (professional and academic) and a letter describing the applicant’s professional goals and how earning a MS will assist in their professional development. For applicants from non-English speaking countries, a minimum score of the Test of English as a Foreign Language (TOEFL) or 600 (paper-based) or 100 (internet-based) must be obtained.

Plus-One Program (formerly the Accelerated Bachelor’s to Master’s Program)

The Plus-One Program option offered by the College of Management is an accelerated program offered to encourage outstanding undergraduate students in engineering, science and business to continue study at the graduate level. Undergraduate students in these majors (i.e., science, engineering, or business), who have a GPA of 3.00 or better at the end of their junior year must apply for this program before they complete their undergraduate graduation requirements. Students who plan to apply to this program must meet with the M»S> program
negotiation and exit strategies including mergers and venture capitalists, etc.; short-term and long-term financial internal sources and external sources such as angel investors. This course focuses on strategies for financing innovation and technology ventures both within a firm and on a stand-alone basis. Topics covered will include: different types of new technology ventures both within a firm and on a stand-alone basis. This course will enable students to understand the complexities involved in new innovation and technology-based product development. Through examples and exercises, students will be exposed to such topics as creative problem solving, customer/suppliers/partners involvements and inputs processes, integration among all functions, building and managing cross-functional teams, rapid prototyping and development, creating a learning organization and measurements.

**Course Descriptions:**

**ENTR.6500 Innovation and Emerging Technologies (3 credits)**

This course examines technological innovation and its relationship to value-creation and business strategy. Emphasis is placed on emerging scientific and technical innovations and the opportunities and challenges they present to both existing businesses and new venture entrepreneurs. The overall goal of this course is to help you to understand, appreciate and learn to manage the technology innovation process. Students examining innovation strategies, planning models, evaluation models, licensing and the commercialization process required to launch new businesses around innovative products and technologies.

**ENTR.6300 Market Research for Entrepreneurs (3 credits)**

In this course, students will learn and apply various marketing research techniques that will enable them to succeed as entrepreneurs. Some of the topics we will cover include: assessing customer needs, estimating market demand, determining the features of the proposed product/service and the price that would be most attractive to their target market, etc. The course will provide students with a overview of key marketing concepts, and understanding of the statistical methodology behind the market research techniques and practical application of the techniques via cases and projects.

**ENTR.6350 Financing Innovation and Technology Ventures (3 credits)**

This course focuses on strategies for financing innovation and new technology ventures both within a firm and on a stand-alone basis. Topics covered will include: different types of business organizations; different sources of funding including internal sources and external sources such as angel investors, venture capitalists, etc.; short-term and long-term financial planning and forecasting; business valuation; term sheet negotiation and exit strategies including mergers and acquisitions and IPOs. Each aspect of the course will be covered within the context of a business plan and venture lifecycle.

**ENTR.6400 New Venture Creation**

This course is designed to help students identify, evaluate, and obtain control over opportunities that can be exploited by starting new companies. It essentially focuses on entrepreneurship as a generic activity. It explores the opportunities and challenges faced by individuals starting up new ventures and the probable paths of career development for the students pursing entrepreneurship. Thus, for those who may be interested in starting or running a new business in their lives, this class will provide an essential foundation for the process, skills, and resources required as well as the opportunities available to the young entrepreneurs.

**ENTR.6450 New Product Development (3 credits)**

This course will focus on managing innovation and technology projects and the critical role that a project manager plays in successful execution. Topics included in the course are: project planning, deliverables, managing quality, change management, documentation, communication, risk management, project team, and human resource management approaches and creating and managing expectations.

**ENTR.6500 Corporate Entrepreneurship (3 credits)**

This course focuses on entrepreneurship in established companies. Corporate Entrepreneurship (CE) is a process by which companies adopt a conscious strategy to encourage creativity, innovation, outside-the-box thinking, experimentation, and risk taking. As a result, companies promoting and implementing CE strive for competitive advantages in rapidly changing global markets. The course will cover components of CE, developing and implementing CE strategies and managing CE.

**MGMT.6400 Building & Managing Entrepreneurial Teams (3 credits)**

**Course Descriptions:**

**ENTR.6400 New Venture Creation**

This course is designed to help students identify, evaluate, and obtain control over opportunities that can be exploited by starting new companies. It essentially focuses on entrepreneurship as a generic activity. It explores the opportunities and challenges faced by individuals starting up new ventures and the probable paths of career development for the students pursing entrepreneurship. Thus, for those who may be interested in starting or running a new business in their lives, this class will provide an essential foundation for the process, skills, and resources required as well as the opportunities available to the young entrepreneurs.

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**MGMT.6400 Building & Managing Entrepreneurial Teams (3 credits)**
A critical element of success in the launch of new products, services and companies is the composition and experience of the team members. This course examines the composition, development and lifecycle of entrepreneurial teams within the context of startups and existing corporations. Students will develop an understanding of the need for diverse experiences and skills among team members along with an understanding of how teams change as entrepreneurial processes progress. A particular emphasis will be placed on improving students communications and collaboration skills in a cross-functional team context. Students will also explore evolving open collaborative approaches employed by companies to accelerate innovation by using customers, suppliers, partner and other organizations outside the four walls of a company.

**ENTR.6880**
(Special Topics in Entrepreneurship & Innovation (3 credits))
Topics of current interest in Entrepreneurship. Innovation and Technology Management Subject matter to be announced in advance.

**PLAS.5370**
(Business Law for Engineers (3 credits))
Employment agreements, including ethical work considerations, non-compete provisions, trade secrets, assignment of rights to inventions; contracts including types, terms, warranties, risk of loss, remedies of breach; legal aspects of product design, prototyping and testing materials, product & equipment defects and liability intellectual property including patents, trade secrets, trademarks, copyright, accounting for intellectual property, licensing; business torts, damages & remedies including environmental pollution, conversion, breach of contract, injunctions.

**MECH.5760**
(Engineering Project Management (3 credits))
Skills are developed enabling engineers to be effective decision maker 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.

**PLAS.5900**
(Survey of Intellectual Property (3 credits))
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 patent protection and technology licensing.

**MECH.5750**
(Industrial Design of Experiments)
This course will familiarize the students with the concepts of Robust Design and statistical Design of Experiments (DOE) as applied in the design and manufacturing of new products. The course will discuss classical as well more current methodologies of DOE including Full Factorial, Fractional Factorial, Taguchi, Central Composite and D-Optimal Designs. The course will also provide for different methods for analysis of results including ANOVA, Signal to Noise, and Sampling techniques. Example experiments using industrial cases studies and the manufacturing laboratories at UML will be used.

**MIST.6300**
(E-Business)
This course provides a foundation on digital commerce and e-business for MBA students. It will cover both technological and managerial aspects of managing e-business operations in either a traditional or pure "dot.com" organization. Issues covered include interactive marketing and market-spaces, agent-based commerce and intelligent markets. electronic shopping carts, user interfaces, personalization an targeted communications, security, encryption, and payment systems, privacy and intellectual property.

**PUBH.6070**
(Healthcare Information Systems Credits)
This course provides health care professionals with a practical understanding of health care information systems sufficient to work effectively wit and support information systems design, development and implementation within a variety of health care setting. The course includes analysis and discussion of actual case examples. (Fall, Spring, Summer)

**MKTG.6010**
(Customers and Markets (pre-req MKTG.6300))
Pursues the development of comprehensive and integrated marketing plans using industry/competitor analysis, market value chains, and forecasting. And emphasis is given to business-to-business marketing situations which require an in-depth analysis of the firms’cs complex organizational behavior and evolving buyer-seller relationship.

**MIST.5650** (Cloud Computing)
This course starts with an overview of modern distributed models, exposing the design principles, systems architecture, and innovative applications of parallel, distributed, and cloud computing systems. The course will focus on the creation an maintenance of high-performance, scalable, reliable systems, providing comprehensive coverage of distributed and cloud computing, including: Facilitating management, debugging migration, and disaster recovery through virtualization. Clustered systems for research or ecommerce applications. Designing systems as web services Principles of cloud computing using examples from open-source and commercial applications.
ENTR.6700
Global Entrepreneurship
This course discusses state of global entrepreneurship and the opportunities for it. It will cover different forms of global entrepreneurship, influences of macro forces an factors for global entrepreneurs’ consideration. The course will offer a structured approach to thinking and creating entrepreneurship beyond domestic markets and operations. It will present entrepreneurship framework, case studies, group projects and connections with global entrepreneurs to understand ‘real-life global entrepreneurship”.

ENTR.5650
Technology Entrepreneurship
This course is designed to help master’s level students, often from fields outside of business, understand how technological and social innovations lead to new business and how those are created, funded, governed, and grown.

Capstone Experience

ENTR.6800
New Venture Planning Capstone I (3 credits)
ENTR.6810
New Venture Implementation Capstone II (3 credits)
These two capstone courses focus on technology commercialization, business planning and initial incubation of an early-stage business by project teams; and, development of an investment proposal to launch a new business. Students will be exploring, identifying and analyzing the path “from Idea to Market” for technology and research projects. They will evaluate selected technology and research projects for commercial applications, explore different options available to productize & introduce to market, and, where appropriate, complete a new venture business plan, and potentially launch or participate in launching a new business. The course will be offered as a continuous course over two consecutive semesters, requiring students to actually develop these commercialization projects. Each Team will be assigned to a faculty member who will instruct and guide them throughout the capstone experience.

Graduate Certificates in the Manning School of Business
The Manning School of Business offers graduate certificates in:

- Business Analytics
- Financial Management
- Foundations of Business
- Innovation & Entrepreneurship
- Supply Chain and Operations Management

Foundations of Business
Contact:
Manning School of Business Graduate Coordinators - phone: 978-934-2848, email: mba@uml.edu.
Graduate students in the certificate program who are subsequently accepted into the UMass Lowell AACSB accredited MBA program may apply certificate courses with grades of B or better to their MBA degree.

Required Core Courses:
12 Credit Hours - six courses at two credit hours each.

- ACCT.5010 (Financial Accounting)
- FINA.5010 (Business Financial Analysis)
- MKTG.5010 (Marketing Fundamentals)
- POMS.5010 (Operations Fundamentals)
- MGMT.5010 (Organizational Behavior)
- MGMT.5110 (Global Enterprise and Competition)

Foundations of Business Certificate Course Information
Students must hold an undergraduate degree for admission into a certificate program. A GMAT exam is not required for certificate programs. An undergraduate transcript must be supplied by student when applying.
Innovation and Entrepreneurship

Contact: Michael Ciuchta, Phone: 978-934-2993, Email: Michael_Ciuchta@uml.edu

Prerequisites: None (although certain course may contain prerequisites).

This certificate assists the aspiring entrepreneur, inventor and mid-career professional in understanding and applying the process associated with starting a new business or creating new business opportunities within established organizations. This program can be tailored to those interested in creating technology-based ventures or Main Street businesses or engaging in corporate entrepreneurship.

The program consists of two required courses (either New Venture Creation, or Corporate Entrepreneurship, AND either Technological Entrepreneurship or Innovation & Emerging Technology) and two electives (see below). Graduate students in the certificate program who are subsequently accepted into the UMass Lowell MS in Entrepreneurship or MBA program may apply applicable certificate courses with grades of B or better to their degree program.

**Required Courses**: (6 Credit hours, two 3 credit courses)

One of the following:

- ENTR.6400
  (https://www.uml.edu/catalog/courses/ENTR/6400)
  New Venture Creation
- ENTR.6550
  (https://www.uml.edu/catalog/courses/ENTR/6550)
  Corporate Entrepreneurship

One of the following:

- ENTR.6500
  (https://www.uml.edu/catalog/courses/ENTR/6500)
  Innovation & Emerging Technology
- ENTR.6510
  (https://www.uml.edu/catalog/courses/ENTR/6510)
  Technological Entrepreneurship

**Elective Courses** (6 Credit hours, two 3 credit courses chosen from the following):

- ENTR.6100
  (https://www.uml.edu/catalog/courses/ENTR/6100)
  Global Entrepreneurship & Innovation I**

**OR**

- ENTR.6110
  (https://www.uml.edu/catalog/courses/ENTR/6110)
  Global Entrepreneurship II**
- ENTR.6350
  (https://www.uml.edu/catalog/courses/ENTR/6350)
  Financing Innovation & Technology Ventures
- ENTR.6400
  (https://www.uml.edu/catalog/courses/ENTR/6400)
  New Venture Creation*
- ENTR.6450
  (https://www.uml.edu/catalog/courses/ENTR/6450)
  New Product Development
- ENTR.6500
  (https://www.uml.edu/catalog/courses/ENTR/6500)
  Innovation & Emerging Technology*
- ENTR.6510
  (https://www.uml.edu/catalog/courses/ENTR/6510)
  Technological Entrepreneurship*
- ENTR.6550
  (https://www.uml.edu/catalog/courses/ENTR/6550)
  Corporate Entrepreneurship*
- MKTG.6010
  (https://www.uml.edu/catalog/courses/MKTG/6010)
  Customer and Markets***
- MKTG.6300
  (https://www.uml.edu/catalog/courses/MKTG/6300)
  Market Research for Entrepreneurs

* If not used to satisfy required course
** Not offered online
*** Recommended elective if using as pathway to MBA

**Admissions Requirements**: Undergraduate degree. Related experience in science, engineering, technology or business preferred.

**Financial Management - Certificate**

Contact: Ravi Jain, Phone: 978-934-2854, email: Ravi_Jain@uml.edu

The Graduate Certificate in Financial Management is a 12 credit program (three two-credit courses and two three-credit courses) designed for non-financial mid-management
professionals in the private and public sectors who wish to advance to decision-making positions within their organizations.

Individuals with undergraduate degrees in fields other than business management with finance as the major who wish to acquire additional academic credentials to advance within their organization or who wish to change career paths and improve their competitive position in the job market will benefit from this program. Especially, for many employees working in the technical and scientific fields without any financial background, the Financial Management certificate will provide them with the knowledge needed for decision-making roles within their technical or scientific fields.

**Prerequisite:**

- ACCT.5010
  (https://www.uml.edu/catalog/courses/ACCT/5010)
  Financial Accounting and
- FINA.5010
  (https://www.uml.edu/catalog/courses/FINA/5010)
  Business Financial Analysis

**Required Courses: (9 credits)**

- FINA.6010
  (https://www.uml.edu/catalog/courses/FINA/6010)
  Corporate Finance
- FINA.6020
  (https://www.uml.edu/catalog/courses/FINA/6020)
  Advanced Corporate Finance
- FINA.6100
  (https://www.uml.edu/catalog/courses/FINA/6100)
  Global Financial Markets and Monetary Policy

**Elective (3 credits)**

One course from a list of approved courses, which may include courses such as:

- FINA.6750
  (https://www.uml.edu/catalog/courses/FINA/6750)
  Financial Derivatives
- FINA.6110
  (https://www.uml.edu/catalog/courses/FINA/6110)
  Financial Statement Analysis
- FINA.6880
  (https://www.uml.edu/catalog/courses/FINA/6880)
- Current Topics in Finance
  (https://www.uml.edu/catalog/courses/FINA/6770)
  Independent Study: Finance
- MIST.7060
  (https://www.uml.edu/catalog/courses/MIST/7060)
  Data Analytics
- ACCT.6010
  (https://www.uml.edu/catalog/courses/ACCT/6010)
  Accounting Information for Management Decisions

Graduate students in the certificate program are encouraged to extend their education further by applying for admission to the M.B.A. program may apply certificate courses with grades of B or better towards their M.B.A. degree requirements.

**Supply Chain and Operations Management**

Contact: Yao Chen, phone: 978-934-2764, email: Yao_Chen@uml.edu.

This certificate assists individuals who wish to acquire additional academic credentials to advance within their organization or who wish to change their career paths and improve their competitive position in the job market. Especially, for many employees working in the technical and scientific fields without an operations or industrial engineering background, the program will provide them with the knowledge needed for decision-making roles within their technical or scientific fields. The program is to meet the needs of those mid-career professionals in non-operations positions, who require a greater understanding of operations to advance towards decision-making positions in their organizations, to communicate effectively with operations managers, to pursue new careers in industrial engineering or operations management, or to demonstrate the contribution of their unit and/or ideas to the organizations value chain.

The certificate requires students to complete 12 hours of graduate study. This consists of four three-credit Supply Chain and Operations Management courses. Graduate students in the certificate program who are subsequently accepted into the UMass Lowell MBA program may apply certificate courses with grades of B or better to their MBA degree.

**Prerequisite Coursework** (prior to certificate coursework)

- ECON.2010
  (https://www.uml.edu/catalog/courses/ECON/2010)
  Microeconomics
- ECON.2110
Required: 3-credit courses

- POMS.6010 [Operations Fundamentals](https://www.uml.edu/catalog/courses/POMS/6010)
- POMS.6020 [Global Supply Chain Management](https://www.uml.edu/catalog/courses/POMS/6020)
- POMS.6030 [Service Management](https://www.uml.edu/catalog/courses/POMS/6030)
- MIST.6450 [Information Technology Project Management](https://www.uml.edu/catalog/courses/MIST/6450)

Admissions Requirements: Undergraduate degree and related experience in science, engineering, technology or business (other areas will be considered in consultation with the program coordinator).

Graduate Certificate in Business Analytics

Contact: Luvai Motiwalla, phone: 978-934-2754, email: Luvai_Motiwalla@uml.edu

The Graduate Certificate in Business Analytics is a 12-credit program designed for working professionals in various fields (e.g. business, engineering, health sciences, or computer science) who need to gain analytical skills to advance their educational and/or professional goals. Appropriate, successfully completed coursework taken as part of this graduate certificate program can later be applied and transferred either to the MBA degree program (as part of the Business Analytics option) or to the M.S. in Business Analytics degree program.

Admissions Requirements: Undergraduate degree and related experience in business, science, engineering, or technology is required. In addition, all students are required to have taken the following courses:

- Introductory Statistics, such as ECON.2110
- Statistics for Business and Economics I, MATH.2830
- Introduction to Statistics, or equivalent.
- Management Information Systems (MIS), such as MIST.2010
- Management Information Systems, MIST.2010
- Business Information Systems, or equivalent

All Applicants must submit an application, application fee, and official transcript to the Office of Graduate Admissions.

Graduate Certificate in Business Analytics Curriculum Outline

Required Elective Courses - Two from each group listed (total Courses required = 4)

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIST.6030 <a href="https://www.uml.edu/catalog/courses/MIST/6030">Database Management</a></td>
<td>POMS.6120 <a href="https://www.uml.edu/catalog/courses/POMS/6120">Statistics for Predictive Analytics</a></td>
</tr>
<tr>
<td>MIST.6060 <a href="https://www.uml.edu/catalog/courses/MIST/6060">Business Intelligence &amp; Data Mining</a></td>
<td>POMS.6220 <a href="https://www.uml.edu/catalog/courses/POMS/6220">Decision Analytics</a></td>
</tr>
<tr>
<td>MIST.6150 <a href="https://www.uml.edu/catalog/courses/MISR/6150">Data Engineering for Business Analytics</a></td>
<td>POMS.6240 <a href="https://www.uml.edu/catalog/courses/POMS/6240">Analytical Decision Making Tools</a></td>
</tr>
</tbody>
</table>

Total Credits Required: 12

Curriculum Summary

| Total Number of courses required for certificate | 4 |
| Total Credit Hours required for certificate     | 12 |

All courses listed above are currently offered on-campus; many of them are also offered on-line. The certificate can be earned through on-campus classes or a combination of on-campus and online classes.

Students who complete the certificate and choose to pursue an MBA degree or MS Business Analytics degree would need to...
apply for, and meet the requirements of, those respective programs.
Master of Science in Accounting

- Program of Study
- Admissions Requirements
- Curriculum

Program of Study

- General Option
- Business Analytics Option
- Corporate Accounting Leadership Option
- International Business Option

The Master of Science in Accounting (MSA) program in the Manning School of Business at UMass Lowell provides an economically affordable opportunity for qualified students to meet the licensing requirements to become Certified Public Accountants (CPAs) and prepare for success in a competitive environment and a respected profession, one whose members continue to be in high demand from public accounting firms, financial institutions, industry, government agencies, municipalities, schools, hospitals and charitable organizations. The Massachusetts Board of Public Accountancy has classified the MSA program at Manning School of Business as Level 1 and deemed the program to be substantially equivalent to AACSB standards. Any student who earns a graduate degree in accounting from a Level 1 program is judged to have satisfied the educational requirements to take the CPA exam. Students who earn degrees from non-Level 1 programs must demonstrate that they have satisfied such educational requirements. Therefore, our MSA program’s Level 1 status makes it easier for UMass Lowell accounting graduates to eventually become CPA’s.

The MSA program can be completed on a full-time or part-time basis and all courses are available online. Students must complete the general MS in Accounting or choose an option in Business Analytics, Corporate Accounting Leadership, or International Business. For a full-time student, the 10-course, 30-credit program can typically be completed in one calendar year (e.g., four courses in the fall, four in the spring, and two in the summer). Part-time students will, on average, complete the program in about three years. We accept students with undergraduate accounting, business and non-business degrees. Students without an accounting undergraduate degree from an accredited U.S. institution will have to complete a series of prerequisite courses prior to beginning the MSA program.

Admission Requirements

- GPA - Minimum undergraduate GPA of 3.0 (overall);
- GMAT (500+); can be waived if the undergraduate GPA is at least 3.5 at an AACSB-accredited school and upon receipt of a recommendation by a faculty member; GMAT can also be waived for students in the UMass Lowell Plus 1 Program with an undergraduate GPA of 3.0 or greater.
- Successful completion of all other University of Massachusetts Lowell Graduate Admissions requirements including three letters of recommendation and Master of Science in Accounting TOEFL minimums.
- Exceptions or modifications to the above will be considered on a case-by-case basis.
- An internship or other relevant employment in the field is strongly encouraged, either before or during the program.
- Students without an undergraduate accounting degree will need to complete the following courses prior to being considered for the MAS: Principles of Financial Accounting, Intermediate Accounting II, Cost Accounting, Federal Income Tax, and Auditing. These courses can be taken either at UMass Lowell, or at any other AACSB-accredited university. Additional coursework in business might also be necessary. Please contact MSA coordinator Stefanie Tate (mailto:stefanie_tate@uml.edu) for more information.

Curriculum

The Master of Science in Accounting requires 10 courses (30 credits). Students complete a core of 5 required courses (15 credits), two additional accounting courses (6 credits), and then complete three courses (9 credits) from business courses outside of accounting. Students can complete the general program or concentrate in a particular field by electives one of three options (Business Analytics, Corporate Accounting Leadership or International Business).

The courses in the Manning School of Business are currently offered in an accelerated 8-week format. Student are allowed to register for a maximum of two courses (6 credits) per 8 week term. In order to petition to take more than two courses per 8-week term, the student needs to submit a graduate academic petition to the Manning School Graduate Office.

Students without an accounting undergraduate degree granted by an accredited US institution will be required to complete a series of up to eight accounting prerequisite courses prior to
starting the MSA courses. For details on program prerequisites, please contact MSA Coordinator, Stefanie Tate (mailto:stefanie_tate@uml.edu).

Degree Pathways:

- General Option (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- Business Analytics Option (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- Corporate Accounting Leadership Option (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- International Business Option (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

Courses are generally selected from the UMass Lowell MBA program; other courses can be selected with the approval of the MSA Coordinator.

Students without an accounting undergraduate degree granted by an accredited US institution will be required to complete a series of up to eight accounting prerequisite courses prior to starting the MSA courses. Details on the prerequisites can be found online or by contacting the MSA Coordinator.

ACADEMIC AND GRADUATION REQUIREMENTS

- Academic and graduation requirements will be similar to those of the Manning School of Business MBA program.
- No more than six course credits of grades below a B may be counted toward the MSA.
- No graduate degree will be awarded to any student whose overall cumulative grade point average falls below 3.0.
- Other policies, as contained in the UMass Lowell graduate catalog, will also apply as appropriate.
- For a full-time student, the 10-course, 30-credit MSA program can typically be completed in one calendar year (e.g., four courses in the fall, four in the spring, and two in the summer).
- Part-time students will proceed at a slower and more varied pace (on average, about three years).
- The Manning School of Business will accept up to six graduate credits from other AACSB institutions on a case-by-case basis.

For more information about the Master of Science in
ACCT.5010 Financial Accounting (Formerly ACCT/60.501) - Credits: 2

An introduction to financial accounting within the context of business transactions and business decisions. This course is a broad introduction to using accounting information from the user’s perspective with little emphasis on traditional debits, credits, journal entries and ledgers. Emphasis is placed on preparing and understanding financial statements.

ACCT.6010 Accounting Information for Management Decisions (Formerly ACCT/60.601) - Credits: 3

Prerequisite: Student must be matriculated and must have completed foundation core courses. Focuses on the manager’s view as opposed to the accountant’s view of the decision process and related quantitative and qualitative information needs. The course material examines accounting information that will achieve faster, better, and cheaper operations. New strategic cost management models, such as ABC and target costing, are explored and contrasted with traditional cost approaches.

ACCT.6020 Advanced Management and Sustainability Accounting (Formerly ACCT/60.602) - Credits: 3

In the new environment of change, accountants are increasingly called on to support strategy through increasing efficiencies and reducing costs. This course will examine the different ways that accountants can add value through an understanding of value chain activities, use of technology, and extending value chain activities to develop a sustainability strategy.

ACCT.6050 Government and Non-Profit Accounting (Formerly ACCT/60.605) - Credits: 3

This course introduces students to financial accounting and reporting issues related to state and local government and non-profit organizations. Students will learn how to prepare, analyze, and interpret these entities financial statements.

ACCT.6120 Advanced Cost Management (Formerly ACCT/60.612) - Credits: 3

An examination of the cost data in ambiguous situations to assist managers in decision-making and strategy implementation. Emphasis is placed on advanced cost management for strategic planning, management control and, performance evaluation in multinational business entities.

ACCT.6220 Globalization and Accounting (Formerly ACCT/60.622) - Credits: 3

What role do accountants play in the globalizing business environment? This course will explore this topic, emphasizing global capital markets and financial reporting, the impact of global organizational structures and information systems on managerial accounting, and complex issues of audit and taxation that emerge in this global environment. To appreciate the impact of globalization, the course will consider such aspects as variations in the currencies, cultures, history, ethical issues and legal systems of different regions of the world, emphasizing how managers need to consider global opportunities and risks in their decision-making manage effectively.

ACCT.6230 Contemporary Accounting Issues (Formerly ACCT/60.623) - Credits: 3

Significant and rapid changes in accounting rules are impacting the financial reporting and analysis that management uses to make business decisions. This course will explore contemporary accounting topics that accounting professionals will face in the workplace and how the accompanying requirements are changing the way that companies and their business partners use, report, analyze, and interpret financial data. Subjects covered will vary as conditions change but may include International Financial Reporting Standards (IFRS), Fair Value Measurements, Post-Retirement Benefits, Revenue Recognition, or other current accounting topics.

ACCT.6300 Taxation of Business Entities (Formerly ACCT/60.630) - Credits: 3

This course provides coverage of gross income and business deductions, and provides a comprehensive overview of the taxation of corporations, partnerships, and sole proprietorships. This course will also cover the history of federal taxation, estate and gift taxes, and how the taxation of business entities fits into the entire tax system.

ACCT.6400 Financial Accounting Theory and Research (Formerly ACCT/60.640) - Credits: 3

A comprehensive exposure at an intermediate level to accounting theory and practice. Emphasis is placed on applying underlying accounting theory to complex accounting measurement problems. The effects of alternative methods are considered throughout the entire course.

ACCT.6450 Fraud Examination and Forensic Accounting (Formerly ACCT/60.645) - Credits: 3
This course introduces students to forensic accounting, with a significant focus on fraud examination, elements of fraud and the types of fraud schemes, including fraudulent financial statements, asset misappropriation, corruption, and money laundering. This course will focus on how professionals including business owners, executives, managers and accountants will benefit from understanding the causes, types and scope of fraud, fraud prevention, fraud detection, and fraud investigation. This course will cover management fraud, employee embezzlement and other types of fraud. The principles and methodology of fraud prevention, detection and investigation (e.g., forensic accounting) will be discussed. Students will develop skills in this course which will help them in multiple professions.

ACCT.6550 Advanced Auditing (Formerly ACCT/60.655) - Credits: 3

This course provides a more in-depth study of auditing topics including audit planning, evidence gathering and evaluation, professional standards and regulatory agencies, and a practical approach to accounting and auditing research. Applications will be drawn from public and private sector audits.

ACCT.6600 Accounting Data Analytics - Credits: 3

Topics to be covered in this course include managing and leaning data, building and evaluating models, visualizing the results of data analyses, and drawing conclusions from the analytics. A series of accounting topics with data analytics application will be discussed, such as fraud and earnings management detection, and financial statement analyses. Students should leave this course with skills necessary to understand data and manage data, to translate accounting and business problems into actionable proposals, and to present data/results to managers and data scientists.

ACCT.6770 Directed Study: Accounting (Formerly ACCT/60.677) - Credits: 3
ACCT.6990 Accounting Internship (Formerly ACCT/60.699) - Credits: 3
ACCT.7510 Accounting Research Methodology (Formerly ACCT/60.751) - Credits: 3

This course situates accounting and organization management research in the context of scientific inquiry generally, and social science in particular. In introduces students to the philosophical background of epistemological and metaphysical issues, the framing of scientific research, theory development, and the formulation of testable hypotheses. Operationalization, measurement and validity issues are studied, and a wide range of research paradigms and methodologies for accounting and organization management research are introduced and illustrated.

ACCT.7620 Empirical Financial Accounting Research II (Formerly ACCT/60.762) - Credits: 3

This is part II of a two part doctoral seminar in Empirical Financial Accounting Research. This course introduces and develops a broad understanding of empirical accounting research in financial reporting. The intent is to provide an overview of archival research and an in-dept analysis of current financial accounting research. This course will focus on the types of questions and innovative methods accounting academics are currently pursuing and developing.

ACCT.7720 Auditing and Corporate Governance Research (Formerly ACCT/60.772) - Credits: 3

This course is designed to expose doctoral students to major research areas in auditing and corporate governance research, with an emphasis on primarily archival research and secondarily judgment and decision making research. In line with Empirical Financial Accounting Research, emphasis will be placed on a significant number of research topics and methods by participating in active discussions about challenging research opportunities and auditing and corporate governance research.

ACCT.7960 Doctoral Dissertation (Formerly ACCT/60.796) - Credits: 1-9

Doctoral dissertation research.

ACCT.7970 Managerial Research Seminar (Formerly ACCT/60.797) - Credits: 0

The course will involve an on-going monthly presentation from across scholarly disciplines. Speakers will be drawn from local, national, and international universities. Attendance will be mandatory; PhD students should gain an appreciation for high level scholarship and corporate governance research.

ACCT.7990 Independent Study: Accounting - Credits: 3
BUSI.7010 Doctoral Curricular Practical Training
(Formerly BUSI 701) - Credits: 1

An internship, practicum or other type of employment that is either required by the student's academic program or an experience for which a student receives academic credit. To be eligible the student must be in legal F-1 status and have been enrolled full-time for one academic year. CPT work experience must be in the student's field of study and contain a curricular component.
FINA.5010 Business Financial Analysis (Formerly FINA/61.501) - Credits: 2

Introduces students to the finance function in a firm. Students are exposed to a variety of analytical techniques and to theory applied to financial decision making. Study will include effects of major financial decisions such as investment, financing and dividends on the value of a firm, in the light of their risk-return relationship under the assumption that the maximization of shareholder wealth is the goal of management. Pre-requisites: MBA or Certificate Programs or Permission of MBA Director.

FINA.6010 Corporate Finance (Formerly FINA/61.601) - Credits: 3

Relates working capital strategy, capital investment analysis, long-term financing, and capital structure decisions in a risk-return framework to the dynamics of the firm and the market in which it operates.

FINA.6020 Advanced Corporate Finance (Formerly FINA 602/61.621) - Credits: 3

This course covers advanced topics of financial decision-making concepts such as financial restructuring, mergers and acquisitions, different forms of debt and equity financing, leasing, and real options. The course includes techniques to incorporate uncertainty in financial analysis, to hedge corporate risk, and to restructure a firm through leveraged buyouts or under bankruptcy protection. It also includes advanced topics such as real options, theories of behavioral corporate finance, and the process to navigate extraordinary financial situations such as financial restructuring and liquidation.

FINA.6050 Mergers, Acquisitions, and Corporate Restructuring (Formerly FINA 605) - Credits: 3

This course examines the process by which takeovers and other corporate control transactions take place. Of particular interest will be the empirical evidence of capital market reactions to control transactions, to defensive measures by management against takeover bids and the valuation effects of these activities. We will also investigate restructuring activities that have significant effects on firm assets, liabilities, and equity claims, as well as their underlying economic motives. A Major focus will be the interaction of strategic planning, valuation, financial strategies, and investment decisions in the life cycle of the firm. This course is indispensable for those who plan to pursue careers in corporate finance, investment banking, private equity, and management consulting.

FINA.6100 Global Financial Markets and Monetary Policy (Formerly FINA 610/61.610) - Credits: 3

This course examines the interactions between changing perceptions of macroeconomic conditions and movements in the prices and yields on financial market instruments. The orientation of this course is heavily institutional with emphasis on helping students develop a "Wall Street" perspective on asset choice and the likely impact of macroeconomic conditions and policies on financial market prices. At the same time, the dependence of macroeconomic policy outcomes on global financial markets' expectations of future real growth in the US and in the world economy, expectations of inflation, sovereign default risk and of interest rates will be stressed.

FINA.6110 Financial Statement Analysis (Formerly FINA 611) - Credits: 3

This course introduces to students a comprehensive financial statement analysis and valuation framework that integrates financial reporting, financial analysis and valuation, and the application of this framework to fundamental analysis. This course provides students with hands-on experience in financial statement analysis. Students will be introduced to general tools of financial analysis, theoretical concepts, and practical valuation issues. By the end of the course, students should be comfortable with using firms financial statements to develop an understand of their performance and to establish a basis for making reasonable valuation estimates.

FINA.6210 Security Analysis and Portfolio Management (Formerly FINA 621/61.721) - Credits: 3

This course introduces the student to the main theories and practice of investments and portfolio management. The student will learn about various investment opportunities including real and financial assets; the investment environment including the money and capital markets; the investment process including identification of goals, data gathering and analysis etc.; and, decision making under a changing market environment. The material covered will include: selection of assets - with special emphasis on securities selection through technical analysis and fundamental analysis, computation of risk and return of individual assets, asset allocation and portfolio formation, computation of risk and return of portfolios, measurement of portfolio performance and rebalancing of portfolios. Also included in the material will be topics such as the "pyramid" approach, forecasting and the use of indicators and, market and industry indexes, models such as the CAPM, bond and stock valuation, mutual funds, domestic versus global investment etc.

FINA.6220 Advanced Portfolio Management (Formerly FINA 622/61.735) - Credits: 3

This course develops investment theory as applicable to
portfolio management and securities selection. Topics covered include identification of investor goals, identification of investment opportunities in real and financial assets under volatile capital market conditions as well as analysis and decision making under conditions of certainty and uncertainty. Related concepts include technical analysis and fundamental analysis, pyramid approach to investing, changing risk and return through asset allocation and portfolio formation, valuation of basic securities and rebalancing of portfolios.

FINA.6240 Fixed Income Securities (Formerly FINA/61.624) - Credits: 3

Financial securities whose valuation depends on interest rates, such as Treasury securities, municipal bonds, and corporate bonds are called Fixed Income Securities. In this course, students will learn how to value and manage the risk of these securities.

FINA.6530 Financial Institutions and Markets (Formerly FINA 653/61.732) - Credits: 3

Analysis of the theory and practice of financial intermediation by institutions in the financial markets, including debt, equity, and foreign exchange markets. Study of the role of financial intermediaries including commercial banks, investment banks, and brokers. Other topics include financial market policy making and regulation in financial markets with an aim to understanding the rationale and nature of such policies and regulations.

FINA.6550 Global Financial Regulation and Compliance - Credits: 3

This course will provide an in depth survey of some of the major regulatory regimes within which the global financial services industry operates. Participants will learn the principles and techniques required to establish and maintain an effective compliance regime consistent with a strong ethical corporate culture. The course will rely upon examination of real-world examples; and, students will participate in a significant case study, requiring them to design an effective compliance program for a hypothetical firm operating in multiple jurisdictions.

FINA.6610 Financial Risk Management (Formerly FINA 661) - Credits: 3

This course deals with the theoretical and practical approaches to effective financial risk management. It covers risk management techniques for corporations and for management of equity, bond, derivatives and investment portfolios. Topics include measurement of corporate risk exposure, portfolio risk exposure and value at risk (VAR) for financial institutions; risk diversification, modern portfolio theory, concentrated equity positions, portfolio benchmarking, the importance of asset allocations; market risk management, currency risk exposures, credit risk management, interest rate risks, and operational & integrated risk management; and computer applications.

FINA.6750 Financial Derivatives (Formerly FINA/61.675) - Credits: 3

The primary emphases in this course are the valuation and practical application of derivatives for both hedging and speculation. Topics include the characteristics of options, forward contracts, futures, and swaps; arbitrage and the valuation of derivatives; creating value and profit diagrams; and the structure of the derivatives markets. Ethical and economic issues associated with the use of derivatives as reported in the current financial press are also covered.

FINA.6770 Independent Study: Finance (Formerly FINA/61.677) - Credits: 3

Pre-Requisites: MBA Foundation Core and 61.601, or permission of MBA Coordinator.

FINA.6880 Current Topics in Finance (Formerly FINA/61.688) - Credits: 3

Topics of current interest in Finance. Subject matter to be announced in advance. For a current semester course title, please log on to ISIS, the Inter-Campus Student Information System.

FINA.6910 International Financial Management (Formerly FINA 691) - Credits: 3

The international dimension of the finance function of the firm. Financial constraints of the international environment and their effect on the standard concepts of financial management. The techniques of adapting risk analysis to the international situation. Study of international currency flows, monetary systems, forward cover and international banking policies.

FINA.7200 Financial Economics and Research (Formerly FINA 720) - Credits: 3

This doctoral-level course will introduce students to financial economics and the research methodology that supports advancement in the field. One major course objective is to provide the core theoretical foundations on which the various subfields, such as corporate finance and investments, rely upon. The second objective is to become familiar with financial data and the methodology to test the empirical evidence to validate theoretical arguments. Topics will include utility theory under
uncertainty, stochastic dominance, state preference theory, mean-variance portfolio theory, asset pricing, and contingent claims pricing. Topics that support corporate finance, such as information asymmetry and agency theory, will also be introduced.

FINA.7400 Corporate Finance Theory (Formerly FINA/61.740) - Credits: 3

This course covers topics in corporate finance including agency theory, theory of the firm, market for corporate control, financing policy, and dividend policy, among others.

FINA.7410 Investments Theory (Formerly FINA/61.741) - Credits: 3

This course covers topics in optimal portfolio choice and asset pricing including discrete-time and continuous time models for portfolio choice and security prices, Black-Scholes model of asset pricing, and general-equilibrium asset pricing models, among others.

FINA.7430 Seminar in Corporate Finance (Formerly FINA/61.743) - Credits: 3

This course is a doctoral level seminar covering both theoretical and empirical research in the area of corporate finance.

FINA.7440 Seminar in Investment Analysis (Formerly FINA/61.744) - Credits: 3

This course is a doctoral level seminar covering both theoretical and empirical research in the area of investments and asset pricing.

FINA.7840 Special Topics in Finance (Formerly FINA/61.784) - Credits: 3

This is a doctoral level course covering both theoretical and empirical research in an area of finance as determined by the instructor.

FINA.7960 Doctoral Dissertation (Formerly FINA 796) - Credits: 1-9

Doctoral dissertation research.

FINA.7970 Managerial Research Seminar (Formerly FINA 797) - Credits: 0

The course will involve an on-going monthly presentation from across scholarly disciplines. Speakers will be drawn from local, national, and international universities. Attendance will be mandatory; PhD students should gain an appreciation for high level scholarship. and corporate governance research.
American business is facing a very different internal and external environment today. This environment is characterized by rapid technological change, increased international competitiveness in manufacturing and other sectors, and a labor force which expects a higher quality of work life than did previous generations of employees. These changes directly affect the health and vitality of any region’s economy.

The UMass Lowell Master of Business Administration (MBA) program is designed primarily as a part-time evening program to serve middle level working professionals and others seeking management careers in business and industry. The program is designed to prepare students to manage effectively in rapidly changing regional, national, and global competitive environments. The MBA program not only requires a thorough understanding of the traditional functional areas of business, but also provides a detailed, integrated examination of issues faced by contemporary managers.

The unifying theme of industry analysis addresses the challenges posed by global competition, such as, accelerated change and complexity of technology, globalization of markets, increasing cultural diversity of human resources, ethical concerns, changing political processes, increasing role of governments in business, evolving organizational structures, and other similar issues. With this philosophical framework as its driving force, the MBA program at the University of Massachusetts Lowell prepares graduates to become leaders in a wide variety of commercial, industrial and governmental settings.

Additionally, three elective courses allow students to tailor their program to their specific professional needs. The awarding of the MBA degree signifies that the student has developed integrative skills in problem solving and decision making and can relate these skills to all functional areas of business. The development of this expertise entails an examination and application of advanced analytical tools.

Entrance Requirements

Application to the MBA program utilizes a rolling admissions policy and is open to students who have earned a 4-year baccalaureate degree. An aptitude for management decision-making and demonstrated academic ability are the most important qualifications for admissions. It is also required that applicants have an adequate mathematics background. Applicants should submit, along with their graduate school application, an official transcript of grades from their undergraduate institution(s), an official Graduate Management Admission Test (G.M.A.T.) score (the Graduate Record Examination is an acceptable alternative), three letters of recommendation, (letters of recommendation from work related sources are preferred), a resume, and a one-page written statement of academic and career goals. Students for whom English is not their national language must also submit an official score report for the Test of English as a Foreign Language (TOEFL).

Part-time and Full-time Study

MBA students may attend either full-time or part-time. On campus courses meet during the evening hours beginning at 6:30 PM. Most courses are currently also offered in an online format. Courses are offered in the fall, spring, and summer semesters. A minimum full-time course load is considered to be 9 credits. Part-time students usually complete their degree requirements in two years. Part-time students must complete their degree requirements within five years.

Admission to MBA Courses

MBA advanced core courses are open only to Manning School of Business graduate students who are fully matriculated degree candidates.

Residency Requirement

To be recommended for the MBA degree, students are required to complete a minimum of ten courses (30 credits) beyond the Foundations Core in the MBA program at the University of Massachusetts Lowell. Only under special circumstances, and with prior approval, are students permitted to complete courses at other institutions.

The courses in the Manning School of Business are currently offered in an accelerated 8-week format. Student are allowed to register for a maximum of two courses (6 credits) per 8 week term. In order to petition to take more than two courses per 8-week term, the student needs to submit a graduate academic petition to the Manning School Graduate Office.

Curriculum Requirements

The MBA program consists of twelve credit hours of foundation core courses which may be waived through previous undergraduate work, and thirty credit hours (10 courses) of advanced courses and electives, for a total of 42 credit hours.
Guidelines for Graduate Equivalency Credit of Foundation Core Courses:

The maximum number of courses that can be given equivalency credit is 12 credits. A student accepted to the UMass Lowell MBA program may request equivalency credit for any of the core courses listed above. These courses may be credited with exemption (meaning a replacement course is not required) if the equivalent undergraduate course work was completed with a grade of “B” or better within the past ten years. Additionally, up to two courses for 6 credits can be transferred in from an AACSB-accredited MBA program.

Degree Pathways for the Options

Students may choose General Business or concentrate in a particular field by taking three electives in a given area. To take electives, students must have completed the foundation core and be matriculated.

Degree Pathways for Options:

- Accounting
- Business Analytics
- Entrepreneurship
- Finance
- Healthcare
- Information Technology
- International Business
- Managerial Leadership
- Marketing

For more information about the Master of Business Administration, contact:
Manning School of Business Graduate Coordinators
Phone: 978-934-2848
Email: mba@uml.edu

Master of Science in Business Analytics (MSBA)

About MSBA

Business Analytics is the process of transforming raw data into business intelligence and insight. As companies generate more data at ever faster rates, the need for business analytics professionals is growing. The Master of Science in Business Analytics (MSBA) program will help you: Develop the ability to collect, manage and analyze data from a variety of sources; enhance your understanding of business processes and systems; develop the ability to understand and communicate insights gleaned from descriptive, predictive and prescriptive analytics.

Private and public firms in fields as diverse as health care, finance, logistics and marketing need business analysts to help them identify and solve problems related to forecasting, customer relationship management and revenue optimization - to name only a few. Experts predict that in the next 10 years hundreds of thousands of new jobs will be created in the domain of business analytics.

The MSBA program at UMass Lowell is a 30 credit program, which may be completed either full-time or part-time. The program integrates theory and practice, giving students a solid foundation of analytical skills that can be used to solve real-world problems.

Admissions Requirements

The following are general admissions requirements for MSBA. Exceptions will be considered on a case-by-case basis. To begin your application online, please go to the Graduate Admissions webpage and click the link for the online application at the bottom of the page.

1. The Graduate Admissions Application form and application fee.
2. Bachelor’s degree from an accredited college or university with a minimum overall GPA of 3.0. A CED foreign credential evaluation is required for degrees earned outside of the United States.
3. GMAT (minimum 500) or GRE (with equivalent minimum score). The GMAT/GRE may be waived based on certain criteria. To apply for a GMAT Waiver, please complete the GMAT Waiver Form and email it to msba@uml.edu.
4. Introductory-level business course prerequisites in the
following areas:
View Descriptions of Courses
(https://www.uml.edu/Catalog/Advance-search.aspx)
Note: Additional courses may be required for different tracks/concentrations. See below for track details.

5. Students must exhibit sufficient recent knowledge of statistics. Students, with a grade C or below, or have not taken a statistics course in the last 5 years prior to admission will be required to pass a competency exam in statistics.

6. Three letters of recommendation from instructors who have taught you, ideally in the field of study for which you are applying. Letters may also be from employers or supervisors who are in a position to compare your performance with that of your peers.

7. Statement of Purpose: Submit a 500 - 750 word statement indicating your immediate and long-range goals and any areas of specific interest or experience that may be relevant to the graduate program.

8. Resume or CV that lists your education and work experience.

9. Student for whom English is not their national language must also submit an official TOEFL score of 100 or higher or an IELTS score of 7.5 or higher. A waiver may be given to candidates who have completed at least two semesters of full-time college/university work in the United States by the date of submission of the application.

Curriculum
The Master of Science in Business Analytics requires 10 courses (30 credits). Students complete a core of 7 required courses (21 credits) and then complete three courses (9 credits) within one of four tracks (Accounting Analytics, Big Data, Managerial Decision Making, Marketing Analytics or Finance Analytics).

The courses in the Manning School of Business are currently offered in an accelerated 8-week format. Student are allowed to register for a maximum of two courses (6 credits) per 8 week term. In order to petition to take more than two courses per 8-week term, the student needs to submit a graduate academic petition to the Manning School Graduate Office.

Degree Pathway for:

- Accounting Analytics
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- Big Data Analytics
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- Managerial Decision Making
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- Marketing Analytics
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)
- Finance Analytics
  (https://www.uml.edu/catalog/pdf-pages/Graduate.pdf)

The Manning School of Business Website
(https://www.uml.edu/MSB/default.aspx) has more information on the Master of Science in Business Analytics.

For more information about the Master of Science in Business Analytics, contact:
MSBA Coordinator
Email: MSBA@uml.edu (mailto:MSBA@uml.edu)
MGMT.5010 Organizational Behavior (Formerly MGMT/66.501) - Credits: 2
Introduces students to management and organizational behavior. Its general purpose is to study and understand the behavior of individuals and groups in organizations. It is directed toward behavioral action components and emphasizes the close relationship between the study of organizational behavior and the practice of management. Pre-requisites: MBA or Certificate Programs, or Permission of MBA Director.

MGMT.5040 Curricular Practical Training (Formerly MGMT/66.504) - Credits: 1
An internship, practicum or other type of employment that is either required by the student's academic program or an experience for which a student receives academic credit. To be eligible the student must be in legal F-1 status and have been enrolled full-time for one academic year. CPT work experience must be in the student’s field of study and contain a curricular component. Contact the Manning School of Business Graduate Programs office for additional details.

MGMT.5110 Global Enterprise and Competition (Formerly MGMT/66.511) - Credits: 2
To be taken as last course in foundation core. Is an integrated investigation of global competitive issues to help students understand the processes of organization and technological innovation which permit businesses to achieve competitive advantages in a global environment. This course also deals with the nature and techniques of industry analysis necessary to the formulation of effective global strategy for the firm.

MGMT.5750 Business Fundamentals for Scientists and Engineers (Formerly PSM 575) - Credits: 3
Is designed for science and other non-business professionals seeking to excel as managers. This course will introduce core business principles. Starting with managing ourselves, and others, we will move through the functional business disciplines. There will be weekly, theme-based case studies and related articles that will provide ample opportunity to work individually and in teams. The goal of this course is to build your knowledge of business principles and develop the analytic and practical skills necessary to contribute in decision-making and operations.

MGMT.6010 Managing Organizational Change (Formerly MGMT/66.601) - Credits: 3
Examines how business enterprises are designed, managed and changed to operate efficiently and perform effectively within their competitive environments. It critically examines organizations that vary in terms of such characteristics as size, complexity, goals, and technology as they operate under different circumstances and at various stages of their life cycles. The role and impact of individual managers receive particular attention.

MGMT.6100 Managerial Leadership - Credits: 3
This course examines leadership theory and research with an emphasis on preparing students for the leadership challenges they face in their professional careers. Topic covered include: the difference between management and leadership; the role of experience; effective use of power and influence; leader traits and characteristics; and the situational factors leaders must assess in facilitating group effectiveness and teambuilding. Students will have the opportunity throughout the course to develop specific leadership skills and practice these skills through exercises, applied reading and class projects.

MGMT.6150 International Business - Credits: 3
This course addresses the issues involved in doing business overseas, and how it differs from purely domestic business. It surveys the changing international business landscape, focusing on the opportunities and challenges that company decision makers face in the global marketplace, and the factors that influence their decision to internationalize. Special attention is given to the broad concept of globalization - of markets and production - multinational enterprises include: governments, central banks, financial markets, regional and multilateral institutions (e.g., World Bank, IMF, WTO), and the role of individuals who shape the international environment.

MGMT.6250 Negotiations (Formerly MGMT/66.625) - Credits: 3
Pre-Requisite: MBA Foundation Core.

MGMT.6301 Management Consulting - Credits: 3
Management Consulting is a global industry with over 4200 billion in annual revenue. This course provides students with an in-depth conceptual and practical understanding of the consulting industry; how consulting firms are organized; project proposal writing; project life cycles; management of the consultant-client relationship; and consulting processes and tools relevant to the management and organizational issues many companies often face and that consultants often address. Upon completion of the course students will have a sufficient understanding of the consulting profession to explore this field as a potential career option.

MGMT.6400 Building and Managing Teams (Formerly MGMT/66.640) - Credits: 3
One critical determinant of success in an on-going corporate venture or launch of a new product, service or company is the performance of teams. This course examines the key roles of leader and follower in the development of project teams in both start startups and existing companies. It will address issues relating to team composition, team member capabilities, and team dynamics as teams develop and change over time. Emphasis is placed on acquiring the interpersonal, communication and collaboration skills necessary for effective team performance.

**MGMT.6450 Advanced Professional Communication**  
(Formerly MGMT/66.645)  - Credits: 3

Workforce analytics is the use of empirical data to improve the management of an organization’s human resources. The goal is for students to develop analytical literacy that will enable them to understand and apply fundamental analytic techniques, engage knowledgeablely with data scientists in the application of more complex forms of analysis, interpret the analytical reporting of others with greater sophistication, and apply empirical evidence to employee-related decisions. The course emphasizes the link between workforce analytics and strategic decision making at all levels of leadership that will guide strategic performance management, talent development, and optimal investment in human capital. It is thus a high value leadership tool central to the achievement of organizational goals.

**MGMT.6500 Workforce Analytics**  - Credits: 3

Automation, artificial intelligence, and other disruptive technologies are changing the fundamental nature and characteristics of work. This tidal wave of change is being referred to as the “future of work.” The purpose of this course is to help students understand these shifts to make them become better managers, entrepreneurs and strategists. Specifically, it will enable students to: 1) identify and understand the technological drivers that are changing the nature of work; 2) assess the industry implications of such changes; 3 examine how these larger changes are affecting how we organize and strategize; 4) understand the challenges of implementing new approaches to work; and 5) assess the ways in which individuals can adapt to the new work environment.

**MGMT.6520 Human Resources Management**  
(Formerly MGMT/66.652)  - Credits: 3

An introduction to the primary human resource functions-job design, recruitment, selection, training, managing workforce diversity, employee development, performance appraisal, compensation and benefits, with an emphasis on how these functions are affected by Equal Employment Opportunity requirements. 3 credits

**MGMT.6540 Managing Global and Workforce Diversity**  - Credits: 3

As business becomes increasingly global and U.S. demographics continue to change, leaders need specific knowledge and skills to navigate, manage, and develop a perspective that incorporates cross-cultural and demographic diversity. This course considers how employers respond to these new workforce realities, by examining the concepts, policies, and practices facing managers in a global, diverse workplace.

**MGMT.6550 Mid-Management Skills for the New Business Environment**  
(Formerly MGMT/66.655)  - Credits: 3

This course exposes students to managerial challenges in the digital economy with a focus on platform businesses such as Amazon, Uber, AirBnb, and others. Also addressed are the challenges faced by traditional firms in competing and interacting with platform firms. The course considers strategic and organizational issues, and explores subjects such as open and user innovation, crowdsourcing, ecosystem-based business models, and building and managing network effects. It is highly interactive case-based.
MGMT.6910 Strategy Formation and Implementation (Formerly MGMT/66.691) - Credits: 3
Reviews strategies for positioning a firm within its competitive environment. Fundamental concepts in strategic management; role of the CEO, levels and components of strategy, competitive analysis, and formulation and implementation of strategy are explored. Pre-Requisite: MBA Advanced Core.

MGMT.7300 Research Design I (Formerly MGMT/66.730) - Credits: 3
Seminar will address study design, including but not limited to methods, hypothesis development and testing, reliability, and validity.

MGMT.7330 Research Design Methods II (Formerly MGMT/66.733) - Credits: 3
Expanding beyond Research Design Methods I Student will begin the design of a research project which considers the range of research methodologies and the implications of their use.

MGMT.7440 Independent Study (Formerly MGMT/66.744) - Credits: 3
Students will be expected to establish a relationship with a faculty member and develop and submit a paper to a top academic conference within their first two years.

MGMT.7450 Seminar in Organization Theory (Formerly MGMT/66.745) - Credits: 3
This course focuses on how organizations form, interact, thrive and decline. Drawing on foundational and contemporary research literature, we study major schools of thought including classical management theory; behavioral theory of organizational decision making and learning; social construction processes (including sensemaking); organizational identity, culture and conflict; forms of organizing; interorganizational relationships and networks; population ecology; organizational economics; institutional theories (old and new); and organizational change processes. For each topic, we analyze theoretical and empirical research to consider how different theories benefit from various research methods and how specific methods are used to explore different theoretical perspectives.

MGMT.7460 Seminar in Organizational Behavior (Formerly MGMT/66.746) - Credits: 3
The doctoral seminar in organizational behavior focuses on theoretical perspectives that explain individual behavior and social processes in organizational settings. The course will draw on literature at the micro and meso levels of analysis. It will provide a broad exposure to the major research domains of this discipline such as motivation, organizational justice, decision making, leadership, power, and organizational change. Emphasis will be placed on critical evaluation of existing paradigms and emerging trends.

MGMT.7470 Leadership Theory and Concepts (Formerly MGMT/66.747) - Credits: 3
This doctoral seminar will provide an in-depth review of the theoretical and conceptual frameworks that characterize organizational leadership research, and provide an overview of the empirical research stemming from these frameworks. Students will develop a critical understanding of the literature and an ability to engage in the scholarly discourse surrounding leadership. The course will also help students develop their ideas regarding their own contribution to the field.

MGMT.7820 Business Policy & Strategy (Formerly MGMT/66.782) - Credits: 3
This course will focus on the various schools of thought for explaining firm performance variance, specifically industry structure, competitive advantage, and competitive position.

MGMT.7960 Doctoral Dissertation (Formerly MGMT 796) - Credits: 1-9
Doctoral dissertation research.

MGMT.7970 Managerial Research Seminar (Formerly MGMT 797) - Credits: 0
This course will involve mandatory attendance at on-going monthly presentations by invited scholars from local, national, and international universities. The goal of the course is to enhance PhD student appreciation for, and familiarity with, high quality research in various business-related disciplines.
ENTR.5910 Independent Study (Formerly ENTR 591) - Credits: 1

ENTR.6100 Global Entrepreneurship and Innovation I (Formerly ENTR /64.610) - Credits: 3

The Course is offered as a 2-week intensive experiential learning of Global Entrepreneurship and Innovation. It is designed to help students to understand the importance of entrepreneurship and innovation in today's global economy and to cultivate an entrepreneurial mind-set among the students in the UMass Lowell. Students will work in interdisciplinary, multi-cultural environments exploring problem solving techniques, opportunities identification, business concept development and venture planning using standard business model framework and bringing ideas to reality.

ENTR.6110 Global Entrepreneurship and Innovation II (Formerly ENTR /64.611) - Credits: 3

The Course is offered as a 2-week intensive experiential learning of Global Entrepreneurship and Innovation. It is designed to help students to understand the importance of entrepreneurship and innovation in today's global economy and to cultivate an entrepreneurial mind-set among the students in the UMass Lowell. Students will work in interdisciplinary, multi-cultural environments exploring problem solving techniques, opportunities identification, business concept development & Venture planning using standard business model framework and bringing ideas to reality.

ENTR.6350 Financing Innovation and Technology Ventures (Formerly ENTR /64.635) - Credits: 3

This course focuses on strategies for financing innovation and new technology ventures both within a firm and on a stand-alone basis. Topics covered will include: different types of business organizations; different sources of funding including internal sources and external sources such as angel investors, venture capitalists, etc.; short-term and long-term financial planning and forecasting; business valuation; term sheet negotiation and exit strategies including mergers and acquisitions and IPOs. Each aspect of the course will be covered within the context of a business plan and venture life-cycle.

ENTR.6400 New Venture Creation (Formerly ENTR/64.640) - Credits: 3

This course is designed for students who are interested in entrepreneurship. The focus is on entrepreneurship as generic activity. It explores the opportunities and challenges face by individuals who seek to start a new ventures and the probable career development paths that are available. For those who may be interested in starting or running a new business, the course will provide an essential foundation for this process, identify the skills and resources required, and explore the opportunities available to the young entrepreneur.

ENTR.6450 New Product Development (Formerly 66.630) - Credits: 3

This course will enable students to understand the complexities involved in new innovation and technology-based product development. Through examples and exercises, students will be exposed to such topics as creative problem solving, customers/suppliers/partners involvements and inputs processes, integration among all functions, building and managing cross functional teams, rapid prototyping and development, creating a learning organization and measurements.

ENTR.6500 Innovation and Emerging Technology (Formerly ENTR /64.650) - Credits: 3

This course examines technological innovation and its relationship to value-creation and business strategy. Emphasis is placed on emerging scientific and technical innovations and the opportunities and challenges they present to both existing businesses and new venture entrepreneurs. The overall goal of this course is to help you to understand, appreciate and learn to manage the technology innovation process. Students examine innovation strategies, planning models, evaluation models, licensing and the commercialization process required to launch new businesses around innovative products and technologies.

ENTR.6510 Technological Entrepreneurship (Formerly ENTR 565 and ENTR.5650) - Credits: 3

This course is designed to help master's level students, often from fields outside of business, understand how technological and social innovations lead to new businesses and how those are created, funded, governed, and grown.

ENTR.6550 Corporate Entrepreneurship (Formerly ENTR /64.655) - Credits: 3

This course is designed to help master's level students, often from fields outside of business, understand how technological and social innovations lead to new businesses and how those are created, funded, governed, and grown.
ENTR.6700 Global Entrepreneurship (Formerly ENTR /64.670) - Credits: 3

This course discusses state of global entrepreneurship and the opportunities for it. It will cover different forms of global entrepreneurship, influences of macro forces and factors for global entrepreneurs consideration. The course will offer a structured approach to thinking and creating entrepreneurship beyond domestic markets and operations. It will present entrepreneurship framework, case studies, group projects and connections with global entrepreneurs to understand real-life global entrepreneurship.

ENTR.6800 Capstone I - New Venture Planning (Formerly ENTR /64.680) - Credits: 3

Capstone I-New Venture Planning (64.680) and Capstone II-New venture Implementation (64.681) focus on technology commercialization, business planning and initial incubation of an early-stage business by project teams, and the development of an investment proposal to launch a new business. In Capstone I students will be exploring, identifying and analyzing the path "from Idea to Market" for technology and research projects. They will evaluate selected technology and research projects for commercial applications and explore different options available to productize and introduce these projects to market. Where appropriate, teams will complete a new venture business plan and launch a new business (Capstone II). These two courses together will comprise the M.S.I.T.E program Capstone experience and will require students to actually develop these commercialization projects. Each student team will be assigned to a faculty member(s) who will instruct and guide them throughout this process. Capstone II may only be taken by students in the M.S.I.T.E. program.

ENTR.6880 Current Topics in Entrepreneurship (Formerly ENTR /64.688) - Credits: 3

This course is designed for an entrepreneur or an intrapreneur that focuses on key marketing concepts, methods, and strategic issues relevant for start-up and early-stage entrepreneurs and new ventures within an established company. It will give students a broad and deep understanding of such topics; Entrepreneurship and marketing; Marketing Opportunities; Market Development; Distribution strategy; pricing Strategy; Customer Relationship Strategy; Communication Strategy; and Effective use of Social Media. Start-up entrepreneurs and intrapreneurs face the challenge of matching large resources of established companies and thus have to utilize different ("entrepreneurial") marketing methods to succeed.

ENTR.6990 Independent Study (Formerly ENTR /64.699) - Credits: 3

ENTR.7400 Seminar in Entrepreneurship Research (Formerly ENTR /64.740) - Credits: 3

This is a full-semester seminar devoted to the diverse field of entrepreneurship. During the semester, we will cover seminal articles as well as contemporary topics and debates. Our emphasis is on reading and discussing academic articles from various perspectives on entrepreneurship. Students are expected to actively participate and contribute to class discussions as well as prepare a research proposal.

ENTR.7420 Seminar in Corporate Entrepreneurship (Formerly ENTR /64.742) - Credits: 3

In this course, students will become familiar with and develop an in-depth understanding of the concepts, models, and paradigms that collectively form the foundation for corporate entrepreneurship. The purpose is to develop a keen awareness of major gaps that exist in the literature. Students will develop the ability to critically integrate findings from the literature and strengthen the skills needed to conduct original research in the related areas.

ENTR.7430 Seminar in Innovation and New Product Development (Formerly ENTR /64.743) - Credits: 3

This seminar is on the progress of the scholarly research on innovation and new product development. Topics include: types, drivers, and outcomes of innovation; new product development processes, how innovations and new products can help an organization develop a sustainable competitive
advantage.

ENTR.7440 Current Topics in Innovation and Entrepreneurship (Formerly ENTR 64.744) - Credits: 3

This course examines current topics facing entrepreneurs and companies in strategic marketing of their innovative products and services. The specific issues covered include customers risk and value perceptions, buyer-seller relations, customer lifetime value, international

ENTR.7960 Doctoral Dissertation (Formerly ENTR 64.796) - Credits: 1-9

Doctoral dissertation research.

ENTR.7970 Managerial Research Seminar (Formerly ENTR 64.797) - Credits: 0

The course will involve an on-going monthly presentation from across scholarly disciplines. Speakers will be drawn from local, national, and international universities. Attendance will be mandatory; PhD students should gain an appreciation for high level scholarship and corporate governance research.

MKTG.5010 Marketing Fundamentals (Formerly MKTG 501, 62.501) - Credits: 2

Describes how marketing strategies and plans of a competitive enterprise are formulated, implemented, and adjusted over time. Behavioral and quantitative aspects are covered, as well as analysis of the environmental forces affecting marketing decisions. Pre-requisites: MBA or Certificate Programs, or Permission of MBA Director.

MKTG.5450 Professional and Scientific Communication (Formerly PSM 545) - Credits: 3

This course will help you improve your professional communication. A science professional who can communicate quickly, clearly and effectively will be most successful in the workplace. In this course, you will gain a fuller understanding of the communication process, and will practice the application of effective communication skills. You will develop both written and oral communication within the context of your professional area. Students will prepare and present a variety of short to moderate length presentations and written assignments. These assignments simulate those encountered in the "real-world" including persuasive presentations, oral and written reports, media interviews, memoranda, and crisis situations. This class will also display the impact of newer technologies such as e-mail and presentational software and the opportunities they present and constraints they place on effective communication. Supplemental course reading and materials included as appropriate.

MKTG.6010 Customers and Markets (Formerly MKTG 615/62.615) - Credits: 3

Prerequisite: Student must be matriculated and have finished foundation core. Pursues the development of comprehensive and integrated marketing plans using industry/competitor analysis, market value chains, and forecasting. An emphasis is given to business-to-business marketing situations which require an in-depth analysis of the firms’ complex organizational behavior and evolving buyer-seller relationship.

MKTG.6150 Sustainable Marketing (Formerly MKTG 615/62.615) - Credits: 3

MKTG.6200 Sales Management (Formerly MKTG.620) - Credits: 3

This course offers students the opportunity to understand how sales management is conducted in small entrepreneurial organizations and large established enterprises. Topics include aligning the sales function with overall organizational objectives, integrating sales into the value delivery process, recruiting a talented sales team and meeting enterprise goals through target setting, compensation schemes, effective use of sales automation systems, and the importance of the Internet and other emerging technologies in the sales discipline. The course will explore the range of sales skills from the consultative selling of complex deals to transactional account management, as well as structural options such as product specialization, customer segment focus and territory alignment.

MKTG.6250 Digital Marketing (Formerly MKTG 625/62.625) - Credits: 3

This course combines a strategic view of digital marketing and its challenges and opportunities with a tactical approach whereby through case studies, interactive sessions, class exercises, and client projects, students learn about the latest research and best practices in the industry. Topics to be covered include digital marketing strategy, digital marketing and business model innovation, social media marketing, search engine optimization, mobile marketing, video marketing, web analytics and measurement, legal and security issues, and multichannel integration. Students will leave the course with a working knowledge of the tools and processes for creating, managing, and executing digital marketing plans.

MKTG.6300 Market Research (Formerly 62.630) - Credits: 3
In this course students will learn and apply various marketing research techniques that will enable them to make soundly based decisions about new products or services in either an existing firm or new venture. Some of the topics covered include: assessing customer needs, estimating market demand, deciding the features of a proposed product/service and the price that would be most attractive in its target market. The course will provide students with an overview of key marketing concepts, and understanding of the statistical methodology behind market research techniques and practical application of these techniques through cases and projects.

**MKTG.6700 International Marketing (Formerly MKTG 670/62.670)** - Credits: 3

This course gives students a comprehensive view of marketing planning activity related to foreign markets. It is aimed at developing your understanding of the various dimensions in a business enterprise that are influenced by marketing. Marketing is a leading, integrated activity that influences the enterprise as a whole. Understanding of key trends in the global context and how they might affect a firm’s marketing activity is fundamental for all employees, particularly marketers, executive management and the leadership team including the CEO, and managers at all levels in various functions of the company. This course provides a comprehensive introduction to this fascinating subject in business management.

**MKTG.6770 Independent Study: Marketing (Formerly MKTG 677/62.677)** - Credits: 3

Pre-Requisite: MBA Foundation Core and 62.601 or permission of MBA Coordinator.

**MKTG.6880 Current Topics in Marketing (Formerly MKTG 688/62.688)** - Credits: 3

Topics of current interest in Marketing. Subject matter to be announced in advance. For a current semester course title, please log on to ISIS, the Inter-Campus Student Information System.

**MKTG.7100 Seminar in Marketing and Innovation Strategy - Credits: 3**

This seminar aims to build the foundation for scholarly research in marketing on strategy-related phenomena. The seminar involves in-depth discussions of seminal and cutting-edge ideas and methodologies on some important topics in marketing and innovation strategy research. Discussion topics include, but are not limited to, branding, new product/service development, and competitive dynamics.

**MKTG.7200 Seminar in Consumer Behavior - Credits: 3**

This seminar aims to build the foundation for scholarly research on phenomena related to consumer judgement and decision-making. The seminar involves in-depth discussions of seminal and cutting-edge ideas and methodologies on some important topics in consumer behavior research. Discussion topics include, prospect theory, rational choice, framing, task effects, and biases.

**MKTG.7300 Seminar in Business-to-Business Marketing - Credits: 3**

This Seminar aims to build the foundation for scholarly research on phenomena related to business-to-business marketing. The seminar involves in-depth discussions of seminal and cutting-edge ideas and methodologies on some important topics. Discussion topics include but are not limited to, account management, transaction cost economics, agency theory, resource dependence, networks and alliances.

**MKTG.7960 Doctoral Dissertation - Credits: 1-9**

Doctoral dissertation research.
MIST.6010 Management Information Systems
(Formerly 63.601, MIST 601) - Credits: 3
Examines computer technologies, database management, and data communications as vehicle to improve and/or restructure business processes and decision making effectiveness to create competitive advantage.

MIST.6030 Database Management (Formerly 63.730: Advanced Data Management, MIST 603) - Credits: 3
This course provides students with in-depth knowledge for modeling, designing, implementing, and managing database systems for operational and decision support purposes. Topics covered include relational database model, entity-relationship modeling, normalization, SQL language, data warehousing, data quality and integration, data and database administration, and object-oriented database.

MIST.6060 Business Intelligence and Data Mining (Formerly MIST 606) - Credits: 3
This Course introduces the concepts and technologies of business intelligence and data mining. The course studies how data-oriented business intelligence techniques can be used by organizations to gain competitive advantages, as well as how to design and develop these techniques. Topics include classification, clustering, association analysis, prediction, and text and web mining. Data-mining related ethical issues will also be discussed.

MIST.6070 Electronic Business (Formerly 63.630: E-business, MIST 607) - Credits: 3
This course provides a foundation on digital commerce and e-business for MBA students. It will cover both technological and managerial aspects of managing e-business operations in either a traditional or pure "dot.com" organization. Issues covered include interactive marketing and market-spaces, agent-based commerce and intelligent markets, electronic shopping carts, user interface issues, EDI transaction via Extrane, database interfaces, personalization and targeted communications, security, encryption, and payment systems, privacy and intellectual property.

MIST.6080 Enterprise System Management
(Formerly 63.640, MIST 608) - Credits: 3
This course, an MBA elective, will focus on Enterprise Resource Planning (ERP) systems that integrate information spanning the functional boundaries within an organization. ERP systems include like SAP/R3, PeopleSoft, Oracle, and Customer Relationship Management (CRM) like Seibel, Tariva, etc. The goals of the course are to help students understand ERP systems and their underlying components and technologies, the implications of implementing ERP in organizations. Course will cover management and technical issues during the pre-implementation, installation, and post-installation stages of the ERP and/or CRM software in organizations. This course will cover topics such as: ES planning, business process re-engineering, selection of ES software and vendors, role of outside consultants, budgeting and resource planning, systems conversion, testing, user training, stabilization, role of top management, IT staff, consultants, design teams, and employee, and other topics.

MIST.6100 Information Technology Infrastructure (Formerly 63.610, MIST 610) - Credits: 3
This course examines in detail, the two major technologies for establishing the Information Technology (IT) architecture &Infrastructure in an organization. Topics include Multi-user Database environments, review of IT architectures, the migration of legacy systems, network (WAN, LAN) design, deployment, and management, and role of the Internet, Extranet, and Intranet.

MIST.6140 Social and Economic Networks (Formerly 63.745: Electronic Commerce. MIST 614) - Credits: 3
This course introduces the concepts and technologies of social network analysis. The course studies how social media analytics can be used by organizations to gain competitive advantages, as well as how to develop and implement the techniques of network analysis. We cover graph theory, graph database, social influence, community detection, information diffusion, and applications of network analysis of recommendation and feature selections. Upon successful completion of this course, students will possess a working knowledge of many concepts of social media analytics and associated techniques and will be able to solve real-world data-driven decision problems at strategic, tactical, and operational levels.

MIST.6150 Data Quality for Business Analytics
(Formerly 63.760 Enterprise Information Systems, MIST 615) - Credits: 3
This course provides students with knowledge and skills to process data for business analytics. Topics include data quality requirement and data preparation for business analytics, impact of data quality on analytics, and methods for assessing and improving data quality in the context of business analytics.

MIST.6160 Advanced Data Mining (Formerly 63.798: Independent Study in Management Information, MIST
MIST.6160 Advanced Data Mining - Credits: 3
The course will cover advanced data mining techniques with applications in different business domains. Students will be introduced to advanced analytic solutions aimed at addressing issues related to big data including volume, variety, and velocity. Topics will focus on performing descriptive and predictive analytics through programmatic analytic platforms as well as text analytics techniques for unstructured or semi-structured data. Concepts will be introduced through a hands-on approach using state-of-the-art analytic platforms and tools.

MIST.6170 Advanced Machine Learning - Credits: 3
This is an advanced course on machine learning and data science for business. In this course, students learn how to analyze, design and develop machine learning techniques and tools for business analytics. Applications to both strategic and operational problems in today’s data-driven ecosystem will be discussed. Topics include supervised learning, unsupervised learning, statistical learning, ensemble learning, model and performance evaluation, text feature learning, text analytics, artificial neural networks, deep neural networks, deep learning, and machine-learning and AI related privacy and ethical issues. The course will be taught using Python programing language.

MIST.6350 Project Management (Formerly MIST/MGMT 635) - Credits: 3
This course will focus on managing innovation and technology projects and the critical role that a project manager plays in successful execution. Topics included in the course are: project planning, deliverables, managing quality, change management, documentation, communication, risks management, project team and human resource management approaches and creating and managing expectations.

MIST.6450 Information Technology Project Management (Formerly 63.620, MIST 645) - Credits: 3
Application and integration of the project management body of knowledge (PMBOK) areas to managing information technology (IT) projects. Focuses on project management tools and techniques for defining and managing the project’s goal, scope, schedule, and budget. Other topics include quality management, risk management, change management, and knowledge management as they are related to IT projects.

MIST.6490 Business Analytics Capstone Project - Credits: 3
Students will be guided through the process of developing and delivering a business analytics project to support decision making in organizations. In this culminating project, students draw on the breadth and depth of the curriculum to address an industry supplied problem in small teams. The capstone project will involve application of industry accepted methodologies and analytical tools to solve real-world problems in R&D marketing, supply chain, healthcare, finance and/or other disciplines.

MIST.6880 Current Topics in Management Information Systems (Formerly 63.688, MIST 688) - Credits: 3
Selected topics having current and future impact in the field of MIS. Subject matter to be announced in advance.

MIST.7060 Data Analytics (Formerly 63.706, MIST 706) - Credits: 3
This course introduces the concepts and technologies of data analytics and data mining for transforming data into insight and business intelligence. The course studies how the data-driven analytics technologies can be used by organizations to gain competitive advantages, and how to design and develop these technologies. Topics include data integration, data transformation, prediction, classification, clustering, association, text mining, optimization, model and performance evaluation, and data-mining related privacy and ethical issues.

MIST.7070 Electronic Commerce (Formerly 63.707, MIST 707) - Credits: 3
This course provides a foundation on digital commerce and e-business research for PhD. students. It will cover both technological and managerial aspects of managing e-business operations in either a pure (Dot.Com) organization or traditional organization (bricks-and-click). Issues covered include interactive marketing and market-spaces, agent-based commerce and intelligent markets, electronic shopping carts, user interface issues, EDI transaction via Extranets, database interfaces, personalization and targeted communications, security, encryption, and payment systems, privacy and intellectual property. Students will be conducting literature review in each of these key e-business areas and identify potential future research directions.

MIST.7080 Enterprise Systems (Formerly 63.708, MIST 708) - Credits: 3
The course will focus on implementation issues with Enterprise Systems (also called Enterprise Resource planning -- ERP) which integrate the informational and functional boundaries within organization. The goals of the course are to help students understand the underlying ERP components and technologies, change management, and process integration in
organization. Conceptual models will be analyzed on topics such as business process management, customer relationship management, supply chain management, privacy and security, and outsourcing issues as related to the implementation of enterprise systems. Students will be assessed through case analysis, exams, and research paper proposals.

MIST.7090 Independent Study in Management Information Systems (Formerly 63.709, MIST 709) - Credits: 1-3
An opportunity for the student to carry out individualized study relating to the field of Management Information Systems under the supervision of a member of the faculty. Prerequisites: MBA Foundation Core and Permission of MBA Coordinator

MIST.7370 Multivariate Statistical Methods (Formerly 63.737, MIST 737) - Credits: 3
This course introduces statistical methods and techniques for multivariate data analysis. The course studies basic ideas underlying multivariate statistical methods and covers various applications of multivariate statistical analysis. The course discusses the design of a multivariate study, the choice of a multivariate method, the procedure of multivariate statistical analysis, and the interpretation of the analysis results. Topics include multivariate normal distribution, multivariate analysis of variance and covariance (MANOVA and MACOVA), principal components, factor analysis, structure equation modeling, canonical correlation, discriminant analysis, and cluster analysis.

MIST.7500 Seminar in Information Systems Research (Formerly 63.750, MIST 750) - Credits: 3
This course focuses on the contemporary topics in information systems research. The materials discussed in this course will be selected from leading IS research publications. Subject areas may be organizational, social, or technological in nature. Research methodologies may be empirical, computational or economics oriented. This course will normally be taught by multiple faculty members jointly.

MIST.7880 Current Topics in Management Information Systems (Formerly MIST 788) - Credits: 3
This course addresses one or more topics having current or future impact on the research fields of Information Systems. Topics change at each course offering. Typically, the course will focus on emerging research streams in Management Information Systems, exploring new techniques and methodologies used in the literature that yield high-impact research results.

MIST.7900 Doctoral Dissertation (Formerly MIST 790) - Credits: 1-9
Doctoral dissertation research.

MIST.7970 Managerial Research Seminar (Formerly MIST 797) - Credits: 0-1
The course will involve an on-going monthly presentation from across scholarly disciplines. Speakers will be drawn from local, national, and international universities. Attendance will be mandatory; PhD students should gain an appreciation for high level scholarship and corporate governance research. "Variable credit course, student chooses appropriate amount of credits when registering."

MIST.CAPSTO Non-Credit Capstone Review - Credits: 0
POMS.5010 Operations Fundamentals (Formerly 63.501/POMS 501) - Credits: 2
Provides students with an introduction to operations management and operations analysis. The latter furnishes the student with a set of quantitative tools which are useful in designing and operating the former. These techniques are also generally applicable to other functional areas/courses within the MBA Program. Prerequisites: MBA or Certificate Programs, or Permission of MBA Director.

POMS.5CO-OP Curricular Practical Training - Credits: 0-1
Curricular Practical Training. "Variable credit course, student chooses appropriate amount of credits when registering."

POMS.6010 Operations Management (Formerly 63.671/POMS 601) - Credits: 3
Examines the strategic and tactical operations processes of manufacturing and service firms that foster global competitiveness. This course focuses on traditional and newer approaches including just-in-time, total quality management, MRP, flexible manufacturing systems, and capacity and management that lead to an integrated operations strategy. Cost reductions, flexibility, and market responsiveness are also considered.

POMS.6020 Global Supply Chain Management (Formerly POMS 602) - Credits: 3
Supply chain management has become a crucial factor in the success of many leading organizations, including for-profit and not-for-profit companies, government agencies, and humanitarian relief efforts. This course will start with principles and concepts of supply chain management, tracing the flows of materials, funds, and information required to develop and deliver products and services around the globe. Topics covered include sourcing, logistics, demand planning, and inventory management, along with the use of quality tools and lean methodologies to improve supply chain operations and develop supplier relationships. This course will also discuss the challenges, key issues, and trends in global supply chain management, such as sustainability, disruptions, security, and innovation.

POMS.6030 Service Management (Formerly 63.673/POMS 603) - Credits: 3

This course is intended to provide students with the necessary tools and understanding to manage service operations. Service firms represent the fastest-growing sector of the economy. This course will focus on the various aspects involved in the management of service operations. The service operations are managed differently to their intangibility, time-sensitivity, high levels of customer involvement and lack of engineering standards. This course will explore topics such the measurement of productivity and quality, managing capacity and demand, management of waiting line, management of technology, and the most used service analytic tool - Data envelopment Management.

POMS.6040 Managerial Quality Control (Formerly 63.690/POMS 604) - Credits: 3

POMS.6120 Statistics for Predictive Analytics - Credits: 3

This course introduces statistical methods and techniques for predictive analytics. This is part of the business-analytics umbrella of courses. The main focus of this course is on regression, a powerful and widely used predictive method. Topics covered include simple linear regression, multiple regression, variable selection, model diagnostics, and systems of regression equations. The course also covers classification techniques using statistical methods such as linear discriminant function and logistic regression. Spreadsheet software, such as MS Excel, and statistical software, such as SAS and R, will be heavily utilized.

POMS.6210 Advanced Statistics for Business Analytics - Credits: 3

This course introduces important statistical techniques in business analytics such as time series analyses, multivariate analyses, and fundamental concepts in casual inferences. This course is practice-oriented with a focus on business contexts such as housing finance, e-commerce and online marketing.

POMS.6220 Decision Analytics - Credits: 3

This course covers the three main facets of business analytics: descriptive, predictive, and prescriptive analytics. Students will gain the knowledge of managerial decision-making (commonly referred to as data analytics, decision support systems-DSS, data mining). Some of the business analytic topics covered include neural networks, decision trees, support vector machines, k-means, association rule mining, Analytical Hierarchy Process, Data Envelopment Analysis, expert systems, optimization, and simulation.

POMS.6240 Analytical Decision Making Tools - Credits: 3

This course covers principles and techniques of applied mathematical modeling for managerial decision making. Emphasis is on the methods of prescriptive analytics, including optimization models, decision analysis, simulation modeling, and risk analysis. Problems studied will include applications in finance, health care, marketing, operations, and management. Cases studies will be used extensively to demonstrate the practical use of models to improve managerial decision making. In addition to developing and applying models, emphasis will be placed on explaining the models and interpreting their results.

POMS.7090 Independent Study: Operations Management (Formerly 63.779/POMS 709) - Credits: 3

Pre-requisites: MBA Foundation Core and Permission of MBA Coordinator

POMS.7100 Predictive Modeling & Causal Analytics - Credits: 3

This class first builds the fundamentals for the advanced predictive modeling techniques in various domains of business. It also covers the methods to combine forecasts from various prediction models. then it explores the integration methods of structural equation modeling (covariance-based and partial least squares-based) along with the prediction modeling approaches, all of which are encompassed within the term of causal analytics.

POMS.7200 Non-parametric Modeling - Credits: 3

Benchmarking and performance evaluation are used to improve an organization's products and processes. This course focuses on linear programming models used in benchmarking and
performance evaluation. The technique is called data envelopment analysis (DEA). DEA has been proven to yield exceptional insights and substantial results in practice. Our emphasis is on basic concepts, mathematical formulas, and their applications. This is a spreadsheet-based modeling course. The mathematical models will be established and solved by using Excel and Excel Solver. Some Visual Basic for application (VBA) coding is required.

POMS.7300 Prescriptive Analytics: Optimization & Simulation - Credits: 3

In this course, fundamental prescriptive analytics methodologies i.e. optimization and simulation are covered. This course provides an overview of optimization and simulation frameworks to solve wide range of issues in management science and also their applications are studied.

POMS.7900 Doctoral Dissertation - Credits: 1-9

Doctoral dissertation research.