Francis College of Engineering

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

On this page you will find:

- Graduate Programs Offered
- Common Admission Requirements
- Common Doctoral Degree Requirements
- Dissertation Proposal
- Nontechnical/Management Courses for Doctor of Engineering
- Other Doctoral Programs
- Links to department catalog section
- Engineering College-Wide Courses
- Faculty in the College of Engineering (pdf)

Graduate Programs Offered

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

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

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

- Environmental Studies

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

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

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

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

The intent of the Doctor of Engineering/Doctor of Philosophy (D.Eng./Ph.D.) programs is to prepare engineers for leadership and research positions in industry, academia and government. The doctoral programs include advanced graduate course work in engineering and allied subjects and research culminating in a doctoral dissertation. The Ph.D. degree is oriented more towards academic research, while the D.Eng. degree is oriented more toward industry.
A total of 63 credit hours of graduate level courses are required for both the Ph.D. and D.Eng. degrees. These credits are composed of the following components:

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

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

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

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

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

Options are offered in the following areas:

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

Rules and requirements vary slightly with the administering department.

**Common Admission Requirements**

Admission to the program will be based on review by Graduate Admissions and by the Admissions Committee of each administering Department. Applicants are required to submit the following items to Graduate Admissions:

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

Doctoral programs in the College of Engineering may also require a BS or MS in Engineering or a closely related field. Depending on the option selected, students may be required to make up prerequisites which they lack in comparison to the equivalent Engineering curriculum at the University of Massachusetts Lowell.

**Transfer Credits**

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

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.

**Common Doctoral Degree Requirements**

In addition to 63 semester hours of approved graduate credits and thesis:

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

Doctoral Qualifying Examination

1. The doctoral qualifying examination is administered on a declared schedule, usually twice each year. The timing and format of the doctoral qualifying examination may vary by department.
2. The student is permitted two attempts at passing the doctoral qualifying examination.
3. If this first attempt at the doctoral qualifying examination is unsatisfactory, a second and final attempt at passing the exam must occur at the next offering of the qualifying exam. Failure to schedule or to participate in the qualifying exam process as outlined will be considered a failed attempt.
4. Students failing the doctoral exam twice will automatically be dismissed from the doctoral program.
5. Students who do not take the examination at the prescribed time may lose all their financial support, if any, and may be dismissed from the doctoral program.
6. The decision of each administering Department regarding whether a student has passed the qualifying exam is final.

Doctoral Dissertation Proposal

Each student is required to submit and defend a dissertation proposal before a Department Doctoral Committee. This committee shall be comprised of the departmental faculty advisor and at least two other faculty members. This committee may or may be the same as the dissertation research committee for the student. Upon approval by this Department Doctoral Committee, the doctoral graduate coordinator for the department will notify the Vice Provost for Graduate Education and the Associate Dean for Graduate Studies in the College of Engineering that the student is now formally a candidate for the Doctor of Engineering/Doctor of Philosophy degree. Admission to candidacy status does not guarantee awarding of the doctoral degree.

Dissertation

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

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


Nontechnical/Management Courses for Doctor of Engineering

D.Eng. students are required to take a minimum of 9 credits of graduate nontechnical/management courses from a list of approved courses offered within the College of Engineering or College of Management.


Other Doctoral Programs

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

- [Applied Mechanics](#)
- [Energy Engineering](#)
- [Radiological Sciences](#)

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

- [Biochemistry](#)
- [Environmental Studies](#)
- [Polymer Science/Plastics Eng. Option](#)

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

The Francis College of Engineering seeks to prepare men and women to be successful in engineering or their chosen profession.

The faculty and staff of the Francis College of Engineering are strongly committed to providing our students with a high quality education relevant to the needs of society and industry. We will do this in a cooperative atmosphere that facilitates learning and cares about the needs of our students.

Programs are available in several engineering disciplines to accommodate varied interests. In addition, within each discipline students may prepare for various careers such as research, development, design, production, construction, teaching, and management. A faculty advisor is assigned to each student to provide experienced guidance in selecting programs and courses and in career planning.

Each student is encouraged to develop his or her full potential as an engineer with a high degree of awareness of the technological needs of society, the nation, and particularly those of Massachusetts industry, government, and educational institutions.

The College stresses professional needs by continuously updating courses and options in the standard engineering and selected specialty programs. The departments use all available resources to advance the level of excellence of their programs. All undergraduate engineering programs are accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. Departments adhere to the standards of the National Society of Professional Engineers. The college also follows the careers of successful graduates, and solicits their views on making programs more relevant and effective.

In each discipline, the College of Engineering offers graduate research programs that not only serve as a source of updating the undergraduate course offerings, but also ensure that faculty are on the cutting edge of their particular disciplines. These programs advance the general level of information and knowledge that is so essential in fast-moving technological fields, while providing the highly specialized research required by industry. By functioning as an educational resource to the engineering profession and industry of the Commonwealth through instruction, consulting services, and research, the College of Engineering at the University of Massachusetts Lowell provides its students with an ever-current view of the working world for which they must prepare.

The College also offers associate and baccalaureate degree programs in Engineering Technology in the evenings through Online & Continuing Education.

Minor in Business Administration for Engineers

The minor in business administration for engineers is offered by the College of Management (CoM) in conjunction with the College of Engineering.

Courses in the Minor in Business Administration for Engineers

Required courses:

- 49.201 Economics I (may count as Gen Ed course)
- 60.201 Accounting/Financial
- 61.301 Business Finance
- 62.201 Marketing Principles
- 66.301 Organizational Behavior

Elective courses:

Two courses from a selected list which is approved by the Engineering department and College of Management or 63.301 Management Information Systems plus one additional course from a selected list which is approved by the Engineering department and CoM.

For Civil & Environmental Engineering, these two additional courses are:

- 14.372 Civil Engineering Systems (already core in CEE)
Courses marked with * and 66.301 Organizational Behavior may be used as Technical Electives in CEE.

For Plastics Engineering, these two additional courses are:

- 26.537 Business Law for Engineers (†)
- And one from the following list:
  - 26.507 Plastics Industry Organization (*)
  - 26.540 Commercial Development of Polymeric Systems (*)
  - 26.590 Survey of Intellectual Property (*)
  - 22.576 Engineering Project Management (*)

† Course 26.542 counts as a Design elective, and courses marked with * count as a Technical Elective in Plastics. In addition, Plastics students not taking 22.576 are encouraged to take 60.202 Accounting/Managerial or 14.470 Engineering Economics or 10.409 Economics & Process Analysis.

For Chemical Engineering, these two additional courses are:

- 10.409 Economics and Process Analysis
- and one from the following list:
  - 14.372 Civil Engineering Systems (*)
  - 63.210 Operations Analysis Techniques
  - 22.576 Engineering Project Management (*)
  - 26.542 Business Law for Engineers (*)
  - 26.590 Survey of Intellectual Property (*)

Courses marked with * may count as a Technical Elective in ChE.

For Mechanical Engineering, these two additional courses are:

- 22.576 Engineering Project Management (*)
- 22.575 Industrial Design of Experiments (*)
- 14.372 Civil Engineering Systems or 63.210 Operations Analysis Techniques
- 14.470 Engineering Economics (*) or 10.409 Economics & Process Analysis (*)
- 26.542 Business Law for Engineers (*)

Courses marked with * may count as a Technical Elective in ME.

For Electrical and Computer Engineering, these two additional courses may be:

- 14.372 Civil Engineering Systems or 63.210 Operations Analysis Techniques
- 14.470 Engineering Economics or 10.409 Economics and Process Analysis
- 22.576 Engineering Project Management
- 26.542 Business Law for Engineers
- 26.590 Survey of Intellectual Property

Additional courses may be added by each Engineering Department to their list of elective courses, with the approval of the College of Management.

Energy Engineering Minor

Courses for a Minor in Energy Engineering

Required Courses: Fifteen credits of core courses are required in the following subject areas.

Subject Area/Satisfying Courses (one required for each subject area):

**Thermodynamics**

- 10.311 Chemical Engineering Thermodynamics (Credits: 3)
- 10.347 Elements of Thermodynamics and Heat Transfer (Credits: 3)
- 22.242 Thermodynamics (Credits: 3)
- 26.247 Thermodynamics (Credits: 3)

**Electrical Circuits**

- 10.205 Fundamentals of Electricity (Credits: 3)
- 16.201 Circuit Theory I (Credits: 3)
- 16.211 Fundamentals of Electricity I (Credits: 3)
• 16.213 Fundamentals of Electricity I (Credits: 3)

**Engineering Economics**

• 10.409 Engineering Economics (Credits: 3)
• 14.470 Engineering Economics (Credits: 3)
• 23.414 Engineering Economics (Credits: 3)

**Energy Policy**

• 18.3xx Energy, Policy, and Society (Credits: 3)
• 18.572 Energy and Environment (Credits: 3)

**Energy Conversion Systems**

• 16.428 Alternative Energy Sources (Credits: 3)
• 22.3xx Energy Conversion Systems (Credits: 3)

**Elective Courses**: At least 6 credits of upper division elective courses are required; students must meet all course pre-requisites or obtain permission of the instructor. While not mandatory, it is recommended that the courses be chosen to develop depth within one of the following Energy Engineering tracks.

**Track/Suggested Courses**

**Alternative Energy**

• 16.428 Alternative Energy Sources
• 16.444 Power Distribution System
• 22.426 Green Energy Engineering

**Electric Vehicles**

• 16.429 Electric Vehicle Technology
• 16.515 Power Electronics

**Energy Conservation**

• 14.579 Green and Sustainable Civil Engineering
• 14.581 Engineering Systems Analysis
• 22.545 Advanced Industrial Heat/Mass Transfer

**Nuclear Engineering**

• 10/24.331 Introduction to Nuclear Engineering I
• 10/24.434 Introduction to Nuclear Engineering II
• 24.507 Reactor Engineering and Safety

**Solar Engineering**

• 22.521 Solar Fundamentals
• 22.527 Solar Energy Engineering
• 22.528 Photovoltaics Manufacturing

**Wind Engineering**

• 22.426 Green Energy Engineering
• 22.558 Aero/Wind Engineering

Additional courses may be added by the College of Engineering to the list of elective courses.

**Minor in Biomedical Engineering & Biotechnology (BMEBT)**

**Courses for a Minor in Biomedical Engineering & Biotechnology**

**Requires Courses:**
Fourteen credits of core courses are required in the following subject areas. Recommended courses are indicated with an asterisk (*) but alternate courses may be substituted as appropriate.
Subject-Area/Suggested Courses

**Biology**

*81.210 Biology for Engineers (3 credits)
*81.212 Biology for Engineers Lab (1 credit)

or

81.111 Principles of Biology I (3 credits)
81.117 Experimental Biology I (1 credit)

**Physiology & Anatomy**

*83.102 Life Science II (3 credits)
*83.104 Life Science II Lab (1 credit)

or

35.102 Human Anatomy and Physiology II (3 credits)
35.104 Human Anatomy and Physiology II Lab (1 credit)

or

81.252 Physiology (3 credits)
81.254 Physiology Lab (1 credit)

**Statistics**

*92.386 Probability and Statistics I (3 credits)

or

14.286 Probability and Statistics for Engineers (3 credits)

or

92.283 Introduction to Statistics (3 credits)

or

92.385 Applied Statistics (3 credits)

or

22.361 Math Methods for Mechanical Engineers (3 credits)

or

19.575 Introduction Biostatistics and Epidemiology (3 credits)

**Biomedical Engineering**

*IB.400 Intro to Biomedical Engg & Biotechnology (3 credits)

**Elective Courses:**

Two courses from a selected list which is approved by the College of Engineering, College of Sciences and College of Health Sciences. This can be chosen based on the specialization, or track.

**Assistive Technology**

16.441 Introduction to Biosensors
34.510 Models and Measurement in Disability
26.554 Medical Device Design

**Biochemistry**

36.350 Human Biochemistry
81.419 Biochemistry I
81.420 Biochemistry II
84.570 Protein Chemistry

**Biomaterials**

10.506 Colloidal, Interfacial and Nanomaterials Science
10.533 Macromolecular Colloidal Science and Engineering
26.542 Colloidal Nanoscience and Engineering
26.575 Biomaterials I
26.675 Biomaterials II
26.579 Problems in Biomaterials
84.672 Surface and Colloid Chemistry
97.503 Polymer Science I
97.504 Polymer Science II
Biomechanics
19.530/531 Ergonomics and Work/Lab
19.632 Advanced Biomechanics
19.638 Methods in Work Analysis

Bioprocessing
10.548 Process Analytical Technology and Quality by Design for Biopharmaceuticals
10.535 Cell and Microbe Cultivation
10.538 Advanced Separations in

Biotechnology
10.545 Isolation and Purification
10.555 Biopharmaceutical GMP
81.586 Biotechnology Process Project Laboratory

Forensics
84.303 Forensic Science I
84.304 Forensic Science II

Genetics
35.435 Medical and Clinical Genetics
81.335 Principles of Genetics
81.405 Bioinformatics
81.460 Stem Cell Biology

Immunology
36.331 Immunology
81.482 Cancer Biology
81.493 Immunology

Medical Devices
16.441 Introduction to Biosensors
26.553 Polymers in Medicine
26.554 Medical Device Design

Medical Imaging
16.411 Medical Diagnostic Imaging
16.460 Biomedical Instrumentation
95.498 Introduction to Medical Imaging
95.477 Electronic and Optoelectronic Devices

Molecular Biotechnology
81.421 Biochemistry Techniques
81.476 Cell Culture

Toxicology
19.503 Toxicology and Health
19.514 Aerosol Science
19.621 Nanomaterials: Exposure, Health and Safety

Additional courses may be added by each College to their list of elective courses.

10.501 Paper Industry Processes
Course ID: 2897
Course Details: Processes of fiber separation from raw materials, fiber purification and mechanical processing of fiber and sheet
Chemical engineering theory is applied to the analysis of these operations.

Max Credits: 3
Min Credits: 3

**10.502 Principles of Chemical Engineering**

Course ID: 34592

Course Details: Introduction to the field of chemical engineering and solution of problems involving units and dimensions, mass balances, flow sheets and gas relationships.

Max Credits: 3
Min Credits: 3

**10.506 Colloidal, Interfacial and Nanomaterials Science and Engineering**

Course ID: 35692

Course Details: 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.

Max Credits: 3
Min Credits: 3

**10.508 Material Science and Engineering**

Course ID: 2900

Course Details: 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.

Max Credits: 3
Min Credits: 3

**10.510 Advanced Separation Processes**

Course ID: 2902

Course Details: 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.

Max Credits: 3
Min Credits: 3

**10.512 Industrial Chemistry**

Course ID: 36645

Course Details: 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.

Max Credits: 3
Min Credits: 3

**10.518 Microprocessor Control**

Course ID: 2906

Course Details: Single board computers and single chip controllers and how they are used in chemical process control. Programming
methods for using minicomputers as process controllers; interfacing requirements and communications. Laboratory projects include both software and hardware.

Max Credits: 3
Min Credits: 3

10.520 Advanced Thermodynamics

Course ID: 2907

Course Details: 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.

Max Credits: 3
Min Credits: 3

10.522 Chemical Process Design

Course ID: 2909

Course Details: 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.

Max Credits: 3
Min Credits: 3

10.523 Nanodevices and Electronics Materials Processing

Course ID: 2910

Course Details: Materials processing methods in electronics and related industries; crystal contamination control, growth, diffusion, etching, epitaxy, ion implantation, lithography, and other topics.

Max Credits: 3
Min Credits: 3

10.524 Self Assembly and Nanotechnology

Course ID: 2911

Course Details: 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.

Max Credits: 3
Min Credits: 3

10.526 Advanced Kinetics and Reactor Design

Course ID: 38511

Course Details: 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.

Max Credits: 3
Min Credits: 3

10.528 Advanced Transport Phenomena

Course ID: 2914

Course Details: 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.

Max Credits: 3
Min Credits: 3

10.529 Recent Advances in Nanotechnology and Green Chemistry

Course ID: 2915

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

Max Credits: 3
Min Credits: 3

10.530 Advanced Control Strategies

Course ID: 2916

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

Max Credits: 3
Min Credits: 3

10.532 Principles of Chemical Engineering II

Course ID: 2918

Course Details: 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.

Max Credits: 3
Min Credits: 3

10.533 Macromolecular Colloidal Science and Engineering

Course ID: 2919

Course Details: 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.

Max Credits: 3
Min Credits: 3

10.535 Cell and Microbe Cultivation

Course ID: 2921

Course Details: 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.

Max Credits: 3
Min Credits: 3

10.538 Advanced Separations in Biotechnology

Course ID: 30314
Course Details: This course provides in depth analysis of the two methods used most often in Bioseparations, filtration and chromatography. For both techniques, basic concepts are reviewed. Membrane, depth, sterile and tangential flow filtration, as well as ion exchange, hydrophobic interaction, and hydroxyapatite chromatography are considered. The emphasis for both methods is on specific applications, scale-up, validation and cleaning.

Max Credits: 3  
Min Credits: 3

10.539 Mathematical Methods for Engineers

Course Details: 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).

Max Credits: 3  
Min Credits: 3

10.542 Colloidal Nanoscience and Nanoscale Engineering

Course Details: 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.

Max Credits: 3  
Min Credits: 3

10.544 Formulation of Biotherapeutics

Course Details: 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.

Max Credits: 3  
Min Credits: 3

10.545 Isolation and Purification

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

Max Credits: 3  
Min Credits: 3

10.548 Engineering Process Analytics

Course Details: 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.
10.550 Biomedical Applications of Nanotechnology

Course ID: 38427

Course Details: 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.

Max Credits: 3
Min Credits: 3

10.552 Directed Study: Chemical Engineering

Course ID: 2927

Course Details:

Max Credits: 3
Min Credits: 3

10.555 Biopharmaceutical Regulatory Compliance

Course ID: 2928

Course Details: 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.

Max Credits: 3
Min Credits: 3

10.556 Materials for Aerospace and Energy Applications

Course ID: 38515

Course Details: 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.

Max Credits: 3
Min Credits: 3

10.586 Biotechnology Processing Projects Laboratory

Course ID: 2929

Course Details: 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.

Max Credits: 3
Min Credits: 3

10.593 Cooperative Education

Course ID: 2931

Course Details:
10.601 Seminar
Course ID: 2932
Course Details: Required for all graduate students.
Max Credits: 0
Min Credits: 0

10.602 Graduate Seminar
Course ID: 2933
Course Details: Required for all graduate students.
Max Credits: 0
Min Credits: 0

10.650 Nanoscale Transport Phenomena for Manufacturing Nanodevices
Course ID: 38291
Course Details: 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.
Max Credits: 3
Min Credits: 3

10.720 Special Projects in Chemical Engineering
Course ID: 2942
Course Details: Special projects undertaken by a student to expand his/her knowledge in specific fields related to his/her master's project.
Max Credits: 3
Min Credits: 3

10.733 Graduate Project - Chemical Engineering
Course ID: 2945
Course Details: 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.
Max Credits: 3
Min Credits: 3

10.736 Graduate Project - Chemical Engineering
Course ID: 2946
Course Details:
Max Credits: 6
Min Credits: 6

10.741 Thesis Review
Course ID: 35264
Course Details:
Max Credits: 1
Min Credits: 1

10.743 Master's Thesis - Chemical Engineering
Course ID: 2948
Course Details: 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.
Max Credits: 3
Min Credits: 3

10.746 Master's Thesis - Chemical Engineering
Course ID: 2949
Course Details:
Max Credits: 6
Min Credits: 6

11.512 Adv Fiber Processing
Course ID: 2958
Course Details:
Max Credits: 3
Min Credits: 3

11.563 Calculus II
Course ID: 2959
Course Details:
Max Credits: 4
Min Credits: 4

14.503 Computer Based Analysis of Structures
Course ID: 38785
Course Details: 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.
Max Credits: 3
Min Credits: 3

14.504 Advanced Strength Of Material
Course ID: 3012
Course Details: 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.
Max Credits: 3
Min Credits: 3

14.505 Concrete Materials

Course ID: 3013
Course Details: 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.
Max Credits: 3
Min Credits: 3

14.508 Practice of Structural Engineering

Course ID: 36644
Course Details: 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.
Max Credits: 3
Min Credits: 3

14.511 Inspection and Monitoring of Civil Infrastructure

Course ID: 35284
Course Details: 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, acoustical/ultrasonic, thermal, magenetic/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.
Max Credits: 3
Min Credits: 3

14.512 Structural Stability

Course ID: 35733
Course Details: 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.
Max Credits: 3
Min Credits: 3

14.521 Reliability Analysis

Course ID: 3018
Course Details: 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.
14.527 Geotechnical and Environmental Site Characterization

Course ID: 3020

Course Details: 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

Max Credits: 3
Min Credits: 3

14.528 Drilled Deep Foundations

Course ID: 37401

Course Details: Design and analyses of drilled deep foundations including: Deep foundations classification and historical perspective. Cost analysis of foundations. Construction methods and monitoring techniques. Static capacity and displacement analyses of a single drilled foundation and a group under vertical and lateral loads. Traditional and alternative load test methods - standards, construction, interpretation, and simulation. Integrity testing methods. Reliability based design using the Load and Resistance Factor design (LRFD) methodology application for drilled deep foundations.

Max Credits: 3
Min Credits: 3

14.529 Engineering with Geosynthetics

Course ID: 3021

Course Details: 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.

Max Credits: 3
Min Credits: 3

14.530 Driven Deep Foundations

Course ID: 3022

Course Details: 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.

Max Credits: 3
Min Credits: 3

14.531 Advanced Soil Mechanics

Course ID: 3023

Course Details: 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,
Max Credits: 3
Min Credits: 3

14.533 Advanced Foundation Engineering

Course ID: 3025
Course Details: 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.

Max Credits: 3
Min Credits: 3

14.534 Soil Dynamics and Earthquake Engineering

Course ID: 3026

Max Credits: 3
Min Credits: 3

14.536 Soil Engineering

Course ID: 3027
Course Details: 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.

Max Credits: 3
Min Credits: 3

14.537 Experimental Soil Mechanics

Course ID: 3028
Course Details: 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.

Max Credits: 3
Min Credits: 3

14.539 Ground Improvement

Course ID: 3030
Course Details: 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.

Max Credits: 3
Min Credits: 3

14.540 Urban Transportation Planning

Course ID: 3031
Course Details: 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.
14.541 Traffic Engineering

Course ID: 3032

Course Details: 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.

Max Credits: 3
Min Credits: 3

14.542 Transportation Network Analysis

Course ID: 3033

Course Details: 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.

Max Credits: 3
Min Credits: 3

14.543 Traffic Principles for Intelligent Transportation Systems

Course ID: 3034

Course Details: 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.

Max Credits: 3
Min Credits: 3

14.544 Transportation Economics and Project Evaluation

Course ID: 3035

Course Details: 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.

Max Credits: 3
Min Credits: 3

14.545 Public Transit Plan and Design

Course ID: 3036

Course Details: 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.

Max Credits: 3
Min Credits: 3
14.546 Pavement Design
Course ID: 3037
Course Details: 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.
Max Credits: 3
Min Credits: 3

14.547 Airport Planning and Design
Course ID: 3038
Course Details: 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.
Max Credits: 3
Min Credits: 3

14.548 Traffic Management and Control
Course ID: 3039
Course Details: 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.
Max Credits: 3
Min Credits: 3

14.549 Traffic Flow Theory
Course ID: 3040
Course Details: Traffic flow theory seeks to describe through precise mathematical models (a) the interactions between the vehicle and the roadway system and (b) the interactions among vehicles. Such theories forms the basis of all the models and procedures used in design and operational analysis of streets and highways. The course examines the fundamental traffic flow characteristics: time headway, flow, time-space trajectories, speed, distance headway and density. In depth treatment of related analytical techniques including traffic stream modeling at both microscopic and macroscopic levels, supply and demand analysis, shock wave analysis, queuing analysis and simulation modeling of traffic systems.
Max Credits: 3
Min Credits: 3

14.550 Behavior of Structures
Course ID: 3041
Course Details: 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.
Max Credits: 3
Min Credits: 3

14.551 Advanced Steel Design
Course ID: 3042
Course Details: 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.

Max Credits: 3
Min Credits: 3

14.552 Behavior - Concrete Structure

Course ID: 3043

Course Details: 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.

Max Credits: 3
Min Credits: 3

14.553 Wood Structures

Course ID: 3044

Course Details: 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.

Max Credits: 3
Min Credits: 3

14.557 Structural Dynamics

Course ID: 3048

Course Details: Analysis of typical structures subjected to dynamic force or ground excitation using direct integration of equations of motion, modal analysis and approximate methods.

Max Credits: 3
Min Credits: 3

14.558 Bridge Design

Course ID: 3049

Course Details: 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.

Max Credits: 3
Min Credits: 3

14.561 Physical Chemical Treatment Processes

Course ID: 3051

Course Details: 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, settlings, activated carbon adsorption, ion exchange, and filtration.

Max Credits: 3
Min Credits: 3

14.562 Physical and Chemical Hydrology Geology

Course ID: 3052
Course Details: 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.

Max Credits: 3
Min Credits: 3

14.564 Hydrology & Hydraulics

Course ID: 3054

Course Details: This course utilizes engineering principles to quantitatively describe the movement of water in natural and manmade environmental systems. Topics include: hydrologic cycle, stream 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.

Max Credits: 3
Min Credits: 3

14.567 Environmental Aquatic Chemistry

Course ID: 3056

Course Details: 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.

Max Credits: 3
Min Credits: 3

14.568 Environmental Fate and Transport

Course ID: 3057

Course Details: 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.

Max Credits: 3
Min Credits: 3

14.570 Wastewater Treatment and Storm Water Management Systems

Course ID: 3058

Course Details: 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.

Max Credits: 3
Min Credits: 3

14.571 Surface Water Quality Modeling

Course ID: 3059

Course Details: 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.

Max Credits: 3
14.572 Marine and Coastal Processes

Course ID: 3060

Course Details: 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.

Max Credits: 3  
Min Credits: 3

14.573 Solid Waste Engineering

Course ID: 3061

Course Details: 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.

Max Credits: 3  
Min Credits: 3

14.575 Groundwater Modeling

Course ID: 3063

Course Details: 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.

Max Credits: 3  
Min Credits: 3

14.576 GIS Applications in Civil and Environmental Engineering

Course ID: 3064

Course Details: 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.

Max Credits: 3  
Min Credits: 3

14.578 Biological Wastewater Treatment

Course ID: 3066

Course Details: Course covers the theoretical and practical aspects of biological wastewater treatment operations. Topics include kinetics of biological growth and substrate utilization, materials balance in chemostats and plug flow reactors, activated sludge process analysis and design, sedimentation and thickening, nitrification and denitrification, phosphorus removal, fixed-film processes analysis and design, anaerobic processes analysis and design, aerated lagoons and stabilization ponds, and natural treatment systems.

Max Credits: 3  
Min Credits: 3
14.579 Green and Sustainable Civil Engineering

Course ID: 35734

Course Details: 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.

Max Credits: 3
Min Credits: 3

14.580 Construction Law

Course ID: 34708

Course Details: An introduction to contract, statutory and tort law governing the relationships between the multitude of parties involved in the construction process. The purpose of this course is to give students an understanding of how the law interacts with the construction industry. Course introduces students to the obligations, rights and risks of architects, engineers, general contractors, subcontractors, sureties and insurers throughout the construction process.

Max Credits: 3
Min Credits: 3

14.581 Engineering Systems Analysis

Course ID: 3067

Course Details: 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, queueing 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.

Max Credits: 3
Min Credits: 3

14.585 Transportation Safety

Course ID: 30816

Course Details: 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.

Max Credits: 3
Min Credits: 3

14.591 Capstone Practicum

Course ID: 33229

Course Details: The course will include: directed study regarding the technical and also social, political and financial aspects of a project; and on-site project review and assessment and culminate with preparation of a professional project report and presentations. Not-for-profit domestic and international projects may be studied. Course will be open to those having completed preparatory work. Project availability will be by agreement of faculty advisor and project sponsors prior to enrollment. (Offered only upon availability of suitable projects and adequate outside financial support.)

Max Credits: 3
Min Credits: 3

14.595 Hazardous Waste Site Remediation
Course ID: 3074
Course Details: 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, phyto remediation, and in situ oxidation, will be addressed. A term paper and professional presentation in class regarding a relevant topic is required.
Max Credits: 3
Min Credits: 3

14.596 Grad Industrial Exposure
Course ID: 3075
Course Details:
Max Credits: 0
Min Credits: 0

14.651 Special Topics in Civil Engineering
Course ID: 3078
Course Details: Course content and credits to be arranged with instructor who agrees to direct the student.
Max Credits: 3
Min Credits: 3

14.653 Special Topics
Course ID: 3079
Course Details:
Max Credits: 3
Min Credits: 3

14.693 Civil Engineering Individual Project
Course ID: 3082
Course Details:
Max Credits: 3
Min Credits: 3

14.705 Supervised Teaching in Civil Engineering
Course ID: 3084
Course Details:
Max Credits: 0
Min Credits: 0

14.733 Masters Project in Civil Engineering
Course ID: 3085
Course Details:
Max Credits: 3
Min Credits: 3

14.736 Masters Project in Civil Engineering
Course ID: 34790
Course Details:
Max Credits: 6
Min Credits: 6

14.741 Master's Thesis-Civil Engineering
Course ID: 30315
Course Details:
Max Credits: 1
Min Credits: 1

14.743 Master's Thesis - Civil Engineering
Course ID: 3086
Course Details:
Max Credits: 3
Min Credits: 3

14.746 Master's Thesis - Civil Engineering
Course ID: 3087
Course Details:
Max Credits: 6
Min Credits: 6

14.749 Master's Thesis - Civil Engineering
Course ID: 3088
Course Details:
Max Credits: 9
Min Credits: 9

14.752 Independent Study in Civil Engineering
Course ID: 3089
Course Details:
Max Credits: 3
Min Credits: 3

14.753 Doctoral Dissertation
Course ID: 3090
Course Details:
Max Credits: 3
Min Credits: 3
14.757 Doctoral Dissertation
Course ID: 33069
Course Details:
Max Credits: 7
Min Credits: 7

14.759 Doctoral Dissertation
Course ID: 3092
Course Details:
Max Credits: 9
Min Credits: 9

14.763 Continued Graduate Research
Course ID: 3093
Course Details:
Max Credits: 3
Min Credits: 3

14.766 Continued Graduate Research
Course ID: 3094
Course Details:
Max Credits: 6
Min Credits: 6

14.769 Continued Graduate Research
Course ID: 3095
Course Details:
Max Credits: 9
Min Credits: 9

16.502 VLSI Design
Course ID: 1268
Course Details: Introduction to CMOS circuits including transmission gate, inverter, NAND, NOR gates, MUXEs, latches and registers. MOS transistor theory including threshold voltage and design equations. CMOS inverter's DC and AC characteristics along with noise margins. Circuit characterization and performance estimation including resistance, capacitance, routing capacitance, multiple conductor capacitance, distributed RC capacitance, multiple conductor capacitance, distributed RC capacitance, switching characteristics incorporating analytic delay models, transistor sizing and power dissipation. CMOS circuit and logic design including fan-in, fan-out, gate delays, logic gate layout incorporating standard cell design, gate array layout, and single as well as two-phase clocking. CMOS test methodologies including stuck-at-0, stuck-at-1, fault models, fault coverage, ATPG, fault grading and simulation including scan-based and self test techniques with signature analysis. A project of modest complexity would be designed to be fabricated at MOSIS.
Max Credits: 3
Min Credits: 3

16.504 VLSI Fabrication
Course ID: 3260

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

Max Credits: 3
Min Credits: 3

16.505 Microwave Electronics

Course ID: 3261

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.506 Antenna Theory and Design

Course ID: 3262


Max Credits: 3
Min Credits: 3

16.507 Electromagnetic Materials and Waves

Course ID: 3263

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.508 Quantum Electronics for Engineers

Course ID: 3264

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

Max Credits: 3
Min Credits: 3

16.509 Linear Systems Analysis

Course ID: 3265

Max Credits: 3
Min Credits: 3

16.510 Digital Signal Processing

Course ID: 3266


Max Credits: 3
Min Credits: 3

16.511 Medical Diagnostic Imaging

Course ID: 3267

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

Max Credits: 3
Min Credits: 3

16.512 Mixed-Signal VLSI Design

Course ID: 36394

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.513 Control Systems

Course ID: 3268

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.514 Integrated Power Systems

Course ID: 3227
Course Details: 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.

Max Credits: 3
Min Credits: 3

16.515 Power Electronics

Course ID: 1267

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

Max Credits: 3
Min Credits: 3

16.517 MMIC Design and Fabrication

Course ID: 3271

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

Max Credits: 3
Min Credits: 3

16.519 Engineering of Submicron Machines

Course ID: 3273

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.520 Computer Aided Engineering Analysis

Course ID: 3274

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.521 Real Time Digital Signal Processing

Course ID: 3275

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.523 Introduction to Solid State Electronics

Course ID: 3277


Max Credits: 3
Min Credits: 3

16.524 Computational Methods for Power System Analysis

Course ID: 3278

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.525 Power Distribution Systems

Course ID: 3279

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.526 Power Systems Stability and Control

Course ID: 3213


Max Credits: 3
Min Credits: 3

16.527 Advanced VLSI Design Techniques

Course ID: 33544

Course Details: 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.
16.528 Alternate Energy Sources

Course ID: 3280

Course Details: 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.

16.529 Electric Vehicle Technology

Course ID: 3281

Course Details: Electric vehicle VS internal combustion engine vehicle. Electric vehicle (EV) saves the environment. EV design, EV motors, EV batteries, EV battery chargers and charging algorithms, EV instrumentation and EV wiring diagram. Hybrid electric vehicles. Fuel cells. Fuel cell electric vehicles. The course includes independent work.

16.531 RF Design

Course ID: 3282

Course Details: 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.

16.532 Computational Electromagnetics

Course ID: 3283


16.533 Microwave Engineering

Course ID: 3284

Course Details: 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 Chebyshhev 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.

16.541 Introduction to Biosensors
Course ID: 33545

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.543 Theory of Communication

Course ID: 3288

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.546 Communication Networks

Course ID: 3291

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.548 Coding and Information Theory

Course ID: 3293

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.550 Advanced Digital System Design

Course ID: 30320

Course Details: Design of logic machines. Finite state machines, gate array designs, ALU and 4 bit CPU unit designs, micro-programmed systems. Hardware design of advanced digital circuits using XILINX. Application of probability and statistics for hardware performance, and upgrading hardware systems. Laboratories incorporate specification, top-down design, modeling, implementation and testing of actual advanced digital design systems hardware. Laboratories also include simulation of circuits using VHDL before actual hardware implementation and PLDs programming. Prerequisites: 16.202, 16.207, 16.265, 92.260, 16.216.

Max Credits: 3
Min Credits: 3

16.551 Advanced Robotics Automation and Machine Intelligence
**Course ID:** 36395

**Course Details:** Covers advanced foundations and principles of robotic manipulation; includes the study of advanced robot motion planning, task level programming and architectures for building perception and systems for intelligent robots. Autonomous robot navigation and obstacle avoidance are addressed. Topics include computational models of objects and motion, the mechanics of robotic manipulators, the structure of manipulator control systems, planning and programming of robot actions. Components of mobile robots, perception, mechanism, planning, and architecture; detailed case studies of existing systems. Pre-Req: Permission of Instructor.

Max Credits: 3  
Min Credits: 3

**16.552 Microprocessor Systems II & Embedded Systems**

**Course ID:** 3295

**Course Details:** Continuation of 16.317. CPU architecture, memory interfaces and management, coprocessor interfaces, bus concepts, bus arbitration techniques, serial I/O devices, DMA, interrupt control devices. Including Design, construction, and testing of dedicated microprocessor systems (static and real-time). Hardware limitations of the single-chip system. Includes micro-controllers, programming for small systems, interfacing, communications, validating hardware and software, microprogramming of controller chips, design methods and testing of embedded systems.

Max Credits: 3  
Min Credits: 3

**16.553 Software Engineering**

**Course ID:** 3296

**Course Details:** 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.

Max Credits: 3  
Min Credits: 3

**16.556 Robotics**

**Course ID:** 3298

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

Max Credits: 3  
Min Credits: 3

**16.559 Introduction to Nanoelectronics**

**Course ID:** 37745

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

Max Credits: 3  
Min Credits: 3

**16.560 Biomedical Instrumentation**

**Course ID:** 30817

**Course Details:** Analysis and design of Biomedical Instrumentation systems that acquire and process biophysical signals. Properties of
Biopotential signals and electrodes; Biopotential Amplifiers and Signal Processing; Basic Sensors and Principles; Medical Imaging Systems; Electrical Safety.

Max Credits: 3
Min Credits: 3

16.561 Computer Architecture and Design

Course ID: 3301


Max Credits: 3
Min Credits: 3

16.565 Analog Devices and Techniques

Course ID: 1266

Course Details: A survey of analog devices and techniques, concentrating on operational amplifier design and applications. Operational amplifier design is studied to reveal the limitations of real opamps, and to develop a basis for interpreting their specifications. Representative applications are covered, including: simple amplifiers, differential and instrumentation amplifiers, summers, integrators, active filters, nonlinear circuits, and waveform generation circuits. A design project is required.

Max Credits: 3
Min Credits: 3

16.568 Electro Optic Systems

Course ID: 3305

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.571 Radar Systems

Course ID: 3307


Max Credits: 3
Min Credits: 3

16.572 Embedded Real Time Systems

Course ID: 3308

Course Details: 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.

Max Credits: 3
Min Credits: 3
16.573 Operating Systems

Course ID: 3309

Course Details: Covers the components, design, implementation, and internal operations of computer operating systems. Topics include basic structure of operating systems, Kernel, user interface, IO device management, device drivers, process environment, concurrent processes and synchronization, inter-process communication, process scheduling, memory management, deadlock management and resolution, and file system structures. laboratories include examples of components design of a real operating systems.

Max Credits: 3
Min Credits: 3

16.574 Advanced Logic Design

Course ID: 3310


Max Credits: 3
Min Credits: 3

16.575 Field Programmable Gate Arrays Logic Design Techniques

Course ID: 3311

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.576 Principles of Solid State Devices

Course ID: 3312

Course Details:

Max Credits: 3
Min Credits: 3

16.577 Verification of Digital Systems

Course ID: 3313

Course Details:

Max Credits: 3
Min Credits: 3

16.580 Robotics, Automation and Machine Intelligence

Course ID: 35618

Course Details: 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.
Max Credits: 3
Min Credits: 3

16.581 Computer Vision and Digital Image Processing

Course ID: 3315

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.582 Wireless Communications

Course ID: 3316

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.583 Network Design: Principles, Protocols and Applications

Course ID: 3317

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.584 Probability and Random Processes

Course ID: 3318


Max Credits: 3
Min Credits: 3

16.590 Fiber Optic Communication

Course ID: 3322

Course Details: Optical fiber; waveguide modes, multimode vs single mode; bandwidth and data rates; fiber losses; splices, couplers, connectors, taps and gratings; optical transmitters; optical receivers; high speed optoelectronic devices; optical link design; broadband switching; single wavelength systems (FDDI, SONET, ATM); coherent transmission; wavelength division multiplexing and CDMA; fiber amplifiers.

Max Credits: 3
Min Credits: 3

16.593 Industrial Experience

Course ID: 3324

Course Details:

Max Credits: 1

Min Credits: 1

16.595 Solid State Electronics

Course ID: 32955

Course Details: Topics included are physical limits of microminiaturization, metal semiconductor junctions, p-n junctions diodes, rectifiers, varactors, tunnel diodes and photodetectors and solar cells; bipolar junction transistors, field effect transistors (junction FET, MESHFET, MOSFET); heterojunction devices and high speed devices; quantum dots, wires and two dimensional quantum well devices; light emitting devices; flat panels, liquid crystals and hot electron eitters. Prerequisite: 16.523 or Permission of Instructor.

Max Credits: 3

Min Credits: 3

16.598 Seminar for Teaching Assistants

Course ID: 37927

Course Details: This course will meet once per week and attendance in mandatory for all TAs. The course will cover an overview of laboratories for the following week.

Max Credits: 0

Min Credits: 0

16.601 Graduate Seminar

Course ID: 3326

Course Details: 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 fall semester.

Max Credits: 0

Min Credits: 0

16.602 Graduate Seminar

Course ID: 3327

Course Details: There will be a series of seminars by distinguished researchers from academia and industry, in addition to UML faculty. Moreover, there will be seminars dedicated to instructional sessions in library services, introduction to Department and Faculty research, and information of thesis requirements and professional ethics. Attendance is mandatory for doctoral and MS students with thesis option. The students are required to write short reports summarizing the talk after each seminar. This course is offered in the spring semester.

Max Credits: 0

Min Credits: 0

16.612 Converged Voice and Data Network

Course ID: 33547

Course Details: Covers the technologies and protocols used to transport voice and data traffic over a common communication network, with emphasis on voice over IP (VoIP). The specific topics covered include voice communication network fundamentals, data networking
fundamentals, voice packet processing, voice over packet networking, ITU-T VoIP architecture, IETF VoIP architecture, VoIP over WLAN, access networks for converged services: xDSL and HFC networks, and IP TV service.

Max Credits: 3
Min Credits: 3

16.616 Computational Power Systems Analysis

Course ID: 3339
Course Details: Power system matrices, power flow studies, fault studies, state estimation, optimal power dispatch, and stability studies.

Max Credits: 3
Min Credits: 3

16.617 Modelling Of Communication Networks

Course ID: 3340
Course Details: 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 band-width approaches, simulation modeling, discrete event simulation of transport and multiplexing protocols using OPNET software, statistical techniques for validation and sensitivity analysis.

Max Credits: 3
Min Credits: 3

16.650 Advanced Computing Systems Hardware Architecture

Course ID: 33546
Course Details: 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.

Max Credits: 3
Min Credits: 3

16.652 Parallel & Mp Architect

Course ID: 3346
Course Details:

Max Credits: 3
Min Credits: 3

16.653 AI and Machine Learning

Course ID: 3347
Course Details:

Max Credits: 3
Min Credits: 3

16.656 Fault Tolerant System Design

Course ID: 3349
Course Details:

Max Credits: 3
16.658 Computer Network Security

Course ID: 3351

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

Max Credits: 3
Min Credits: 3

16.659 Distributed Systems

Course ID: 3352

Course Details:
Max Credits: 3
Min Credits: 3

16.660 Mobile Communication Networks

Course ID: 3353

Course Details:
Max Credits: 3
Min Credits: 3

16.666 Storage Area Networks

Course ID: 3359

Course Details:
Max Credits: 3
Min Credits: 3

16.669 Opto Electronic Devices

Course ID: 30326

Course Details:
Max Credits: 3
Min Credits: 3

16.688 Theoretical Acoustics

Course ID: 3369

Course Details:
Max Credits: 3
Min Credits: 3

16.710 Selected Topics
Course ID: 3376
Course Details: Topics of current interest in electrical Engineering. Subject matter to be announced in advance.
Max Credits: 3
Min Credits: 3

16.711 Special Topics

Course ID: 3377
Course Details: Topics of current interest in Electrical Engineering. Subject matter to be announced in advance.
Max Credits: 3
Min Credits: 3

16.712 Special Topics in Electrical Engineering

Course ID: 3378
Course Details:
Max Credits: 3
Min Credits: 3

16.715 Special Topics

Course ID: 3381
Course Details:
Max Credits: 3
Min Credits: 3

16.729 Selected Topics in Electrical Engineering

Course ID: 3394
Course Details: Advanced topics in various areas of Electrical Engineering and related fields. Prerequisite: specified a the time of offering.
Max Credits: 3
Min Credits: 3

16.730 Thesis - Electrical Engineering

Course ID: 3395
Course Details:
Max Credits: 6
Min Credits: 6

16.732 Systems Engineering Thesis

Course ID: 30819
Course Details:
Max Credits: 3
Min Credits: 3

16.733 Advance Graduate Project
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.

Max Credits: 3  
Min Credits: 3

16.736 Graduate Project - Electrical Engineering

Course Details:

Max Credits: 6  
Min Credits: 6

16.739 Graduate Project - Electrical Engineering

Course Details:

Max Credits: 9  
Min Credits: 9

16.740 Advanced Project in Electrical Engineering

Course Details:

Max Credits: 3  
Min Credits: 3

16.743 Master's Thesis in Electrical Engineering

Course Details: Master's Thesis Research

Max Credits: 3  
Min Credits: 3

16.746 Master's Thesis in Electrical Engineering

Course Details: 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 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.

Max Credits: 6  
Min Credits: 6

16.749 Master's Thesis - Electrical Engineering

Course Details:

Max Credits: 6  
Min Credits: 6
Course Details:
Max Credits: 9
Min Credits: 9

16.751 Doctoral Thesis
Course ID: 30327

16.752 PhD Thesis
Course ID: 30328

16.754 Doctoral Thesis - Electrical Engineering
Course ID: 30329

16.755 Doctoral Dissertation
Course ID: 29831

16.757 Doctoral Dissertation
Course ID: 29830

16.766 Continued Grad Research
Course ID: 3407

16.771 Eng Sys Analysis I
Course ID: 3409
Course Details: 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.

Max Credits: 3
Min Credits: 3

16.772 Eng Sys Analysis II

Course ID: 3410

Course Details: 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.

Max Credits: 3
Min Credits: 3

16.773 Eng Sys Analysis III

Course ID: 3411

Course Details: 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.

Max Credits: 3
Min Credits: 3

18.502 Limnology

Course ID: 3490

Course Details: Limnology is a lecture course which covers the basic elements of limnology, which has been described as the study of the functional relationships and productivity of non-marine (i.e., freshwater and estuarine) communities as they are affected by the physical, chemical, and biological components of the environment. Starting with the origins of lake basins in the landscape, the course presents key concepts for understanding how lakes work and are affected by man. These concepts (e.g., heat budgets, lake circulation patterns, nutrient budgets) are incorporated with the lake biota (e.g., phytoplankton, zooplankton, fish) and synthesized to provide perspective on ecosystem structure and function. While the emphasis is on lakes and ponds, the course also examines the stream environment and its function. Finally, the course considers man-made stresses for lake and stream systems and provides the tools to diagnosis and restore aquatic resources.

Max Credits: 3
Min Credits: 3

18.510 Water Resource System Assessment

Course ID: 3495

Course Details: The course is designed to build understanding of the technologies and methods of analysis of water resource management issues and of the interdependence they have to each other when real problems must be evaluated. It presumes no prior background in any water related technology. The emphasis is upon building understanding of fundamental concepts in order to apply them to the management of water resources. Management in this case implies resolution of conflicts in technology utilization of a resource because of scarcity or incompatibility of competing possible uses. Hypothetical cases are resolved to aid in converting concepts into reasonable applications to problems. Prerequisites: Students must only meet the general one year of calculus and of chemistry requirements for matriculation into the Environmental Studies M.S. program. Students whose first language is not English are urged to gain facility in understanding spoken technical English and in having easy facility with formal written English prior to enrolling. 92.131 Calculus I and 92.132 Calculus II.

Max Credits: 3
**18.531 Sustainable Water Infrastructure**

Course ID: 36536

Course Details: Drinking water and wastewater managers across the country are facing the same challenges of rising costs, aging infrastructure, and increased rates of population growth. In order to address these concerns effectively, utility leaders must look beyond the limited operational and financial goals that are usually considered, and take into account other aspects of effective utility management, including: long-term planning and resiliency; community sustainability; employee leadership and development; and stakeholder engagement, understand and support. This course will explore a full variety of considerations in maintaining sustainable water infrastructure using real-world examples and tools of the trade to engage students and prepare them for future careers in the water sector.

Max Credits: 3
Min Credits: 3

**18.572 Energy and Environment**

Course ID: 3514

Course Details: Laws that govern the conversion of energy from one form to another. Flow of energy in our present industrial society from extraction through transport and conversion to end use. Electricity: generation from fossil fuel, nuclear, hydro, solar and other sources; its distribution and end use. Air, water and soil pollution from all sources of energy on a local, regional and global scale. Amelioration of environmental effects by emission control, fuel switching, renewable energy and conservation.

Max Credits: 3
Min Credits: 3

**18.581 Understanding Massachusetts Contingency Plan**

Course ID: 3523

Course Details: 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 by nature. Prerequisites: None. Though not required, some familiarity with relevant environmental science and/or engineering principles is desirable.

Max Credits: 3
Min Credits: 3

**18.626 Advanced Graduate HP Internship**

Course ID: 3526

Course Details:

Max Credits: 3
Min Credits: 3

**18.693 Master's Project in Environment**

Course ID: 3528

Course Details:

Max Credits: 3
Min Credits: 3

**18.733 Graduate Project - Environmental Studies**

Course ID: 3531

Course Details:
Max Credits: 3
Min Credits: 3

**18.743 Master's Thesis - Environmental Studies**

Course ID: 3534

Course Details:

Max Credits: 3
Min Credits: 3

**18.749 Master's Thesis - Environmental Studies**

Course ID: 3536

Course Details:

Max Credits: 9
Min Credits: 9

**19.510 Fundamentals of Occupational Health**

Course ID: 3549

Course Details: 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, radiation and extreme environments. The course provides an in-depth understanding of indoor air quality problems that may result in health risks as well as prevention and remediation options. Students will understand the health risks from blood borne pathogens, as well as the regulations and methods of prevention. They will also gain knowledge of hazard communication regulations, material safety data sheets and how to research chemical hazards.

Max Credits: 3
Min Credits: 3

**19.703 Independent Study: Ergonomics**

Course ID: 3640

Course Details: Advanced topics in biomechanics, work physiology, occupational safety or human factors not covered in the regular curriculum. Content may vary from year to year.

Max Credits: 3
Min Credits: 3

**20.535 Microprocessor Application**

Course ID: 3761

Course Details:

Max Credits: 3
Min Credits: 3

**22.504 Energy Engineering Workshop**

Course ID: 3869

Course Details: 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, and presentation.

Max Credits: 3
22.505 Directed Studies - ME
Course ID: 31917
Course Details:
Max Credits: 3
Min Credits: 3

22.510 Dynamics and Diagnostics of Rotating Machinery
Course ID: 38784
Course Details: 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.
Max Credits: 3
Min Credits: 3

22.512 Applied Finite Elements
Course ID: 3871
Course Details: 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.
Max Credits: 3
Min Credits: 3

22.513 Finite Element Analysis I
Course ID: 3872
Course Details: 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.
Max Credits: 3
Min Credits: 3

22.514 Finite Element Analysis of Composites
Course ID: 3873
Course Details:
Max Credits: 3
Min Credits: 3

22.515 Modal Analysis
Course ID: 3874
Course Details: Review of single and multiple degree of freedom system using classical and Laplace formulations. Finite element methods for dynamic systems. Model reduction/expansion formulations. Modal participation and mode activation concepts. Linear
algebra review, matrix formulations, matrix eigenanalysis, generalized inverses, spectral and singular valued decomposition techniques. Models developed using MATLAB.

Max Credits: 3
Min Credits: 3

22.516 Experimental Modal Analysis

Course ID: 3875

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.518 Signal Proc Techniques

Course ID: 3877

Course Details:

Max Credits: 3
Min Credits: 3

22.520 Numerical Methods for Partial Differential Equations

Course ID: 36063

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.521 Solar Fundamentals

Course ID: 3879

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.524 Fund of Acoustics

Course ID: 31881

Course Details:

Max Credits: 3
Min Credits: 3
22.525 Grid-Connected Solar Electric Systems

Course ID: 38510

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.526 Transport Processes in Energy Systems

Course ID: 38509

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.527 Solar Energy Engineering

Course ID: 3881

Course Details: Systems engineering, stochastic modeling, design, and life-cycle cost analysis of several solar systems: photovoltaics, passive heating, solar cooling, and daylighting; Web Based.

Max Credits: 3
Min Credits: 3

22.528 Photovoltaics Manufacturing

Course ID: 34725

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.530 Autonomous Robotic Systems

Course ID: 38577

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.531 Math Methods In Mechanical Engineering

Course ID: 3883
Course Details:
Max Credits: 3
Min Credits: 3

**22.545 Advanced Industrial Heat and Mass Transfer**

Course ID: 32792

Course Details: 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.

Max Credits: 3
Min Credits: 3

**22.549 Cooling of Electronic Equipment**

Course ID: 3894

Course Details: 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

Max Credits: 3
Min Credits: 3

**22.550 Vibrations**

Course ID: 3895

Course Details:
Max Credits: 3
Min Credits: 3

**22.553 MEMS & Microsystems**

Course ID: 32791

Course Details: 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.

Max Credits: 3
Min Credits: 3

**22.554 Dynamic Systems and Controls**

Course ID: 3898

Course Details: 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.

Max Credits: 3
Min Credits: 3
22.557 Microsystem Design

Course ID: 34605

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.559 Multi-Scale Computational Fluid Dynamics I

Course ID: 37600

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.560 Multi-Scale Computational Fluid Dynamics II

Course ID: 37601

Course Details: Applications of CFD methods to the solution of multi-phase problems such as: heat pipes, fuel cells, nanofluidics, material processing and manufacturing, etc.

Max Credits: 3
Min Credits: 3

22.562 Solid Mechanics I

Course ID: 3901

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.569 Fracture Mechanics

Course ID: 38881

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.570 Polymer Nanocomposites

Course ID: 34581

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.571 Collaborative Engineering

Course ID: 3907

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.574 Design For Reliability Engineering

Course ID: 3910

Course Details: (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.

Max Credits: 3
Min Credits: 3

22.575 Industrial Design of Experiment

Course ID: 3911

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.576 Engineering Project Management

Course ID: 3912

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.579 Robotics

Course ID: 3914

Course Details: Common robotics joints and robotics classification. Planes of motion and fold lines. Robotics capability. Forward and
inverse kinematics and the RobSim software package. Trajectory planning and elementary obstacle avoidance. Robotics dynamics and feasible trajectory evaluation. Design of the control system for the non-linear robotics problem. Classroom studies are followed by hands-on applications in the Automated Manufacturing Assembly and Robotics Laboratory.

Max Credits: 3
Min Credits: 3

**22.580 Adv Grad Res Dev Proj**

Course ID: 3915

Course Details:

Max Credits: 3
Min Credits: 3

**22.581 Advanced Fluid Mechanics**

Course ID: 3916

Course Details: 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.

Max Credits: 3
Min Credits: 3

**22.583 Advanced Aerodynamics**

Course ID: 3918


Max Credits: 3
Min Credits: 3

**22.584 Ocean Engineering**

Course ID: 3919

Course Details: 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.

Max Credits: 3
Min Credits: 3

**22.589 Finite Element in Thermofluids**

Course ID: 3923

Course Details: 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.

Max Credits: 3
Min Credits: 3

**22.591 Mechanical Behavior of Materials**

Course ID: 3925
Course Details: 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 polymers. Topics include: elastic behavior, dislocations, crystal plasticity, strengthening mechanisms, composite materials, glassy materials, creep and creep fracture, tensile fracture, and fatigue.

Max Credits: 3
Min Credits: 3

22.593 Graduate Co-op Education

Course ID: 3927

Course Details: 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.

Max Credits: 0
Min Credits: 0

22.595 Graduate Co-op II

Course ID: 3929

Course Details:

Max Credits: 0
Min Credits: 0

22.596 Composite Materials

Course ID: 3930

Course Details: Analysis of anisotropic lamina and laminated composites. Methods of fabrication and testing of composites. Other topics include environmental effects, joining and machining.

Max Credits: 3
Min Credits: 3

22.597 Processing of Composites

Course ID: 3931

Course Details: 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

Max Credits: 3
Min Credits: 3

22.602 Special Topic: Thermo-Fluids

Course ID: 3934

Course Details: Study of advanced topics in thermo-fluid energy systems and processes not covered in the regular curriculum. Contents may vary from year to year.

Max Credits: 3
Min Credits: 3

22.603 Special Topic: Vibration Dynamics

Course ID: 3935
Course Details: Study of advanced topics in vibrations/dynamics not covered in the regular curriculum. Contents may vary from year to year.

Max Credits: 3
Min Credits: 3

22.611 Matrix Methods
Course ID: 3940
Course Details: 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.

Max Credits: 3
Min Credits: 3

22.614 Finite Element Analysis II
Course ID: 3942
Course Details: Nonlinear finite element methods as applied to large deformation and nonlinear material behavior and contact problems 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.

Max Credits: 3
Min Credits: 3

22.622 Family Violence
Course ID: 3944
Course Details:
Max Credits: 3
Min Credits: 3

22.650 Nano. Transport Phen. for Manufacturing Nanodevice
Course ID: 38883
Course Details: 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.

Max Credits: 3
Min Credits: 3

22.741 Master's Thesis - Mechanical Engineering
Course ID: 3959
Course Details:
Max Credits: 1
Min Credits: 1

22.742 Master's Thesis - Mechanical Engineering
Course ID: 3960
Course Details:
Max Credits: 2
Min Credits: 2

*22.743 Master's Thesis - ME*

Course ID: 3961
Course Details: MS Thesis Research
Max Credits: 3
Min Credits: 3

*22.746 Master's Thesis - ME*

Course ID: 3962
Course Details: MS Thesis Research
Max Credits: 6
Min Credits: 6

*22.749 Master's Thesis - Mechanical Engineering*

Course ID: 3963
Course Details: MS Thesis Research
Max Credits: 9
Min Credits: 9

*22.751 Adv Projects In Mechanical Engineering*

Course ID: 3964
Course Details:
Max Credits: 3
Min Credits: 1

*22.761 Continued Grad Research*

Course ID: 38491
Course Details: Continued Grad Research
Max Credits: 1
Min Credits: 1

*22.763 Continued Graduate Research*

Course ID: 3968
Course Details: Continuing Graduate Research
Max Credits: 3
Min Credits: 3

*22.766 Continued Graduate Research*

Course ID: 3969
22.769 Continued Graduate Research

Course ID: 3970

Course Details: Continuing Graduate Research

Max Credits: 6
Min Credits: 6

22.771 Systems Analysis I

Course ID: 3971

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.772 Systems Analysis II

Course ID: 3972

Course Details: 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.

Max Credits: 3
Min Credits: 3

22.773 Systems Analysis III

Course ID: 3973

Course Details: 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.

Max Credits: 3
Min Credits: 3

24.504 Energy Engineering Workshop

Course ID: 4057

Course Details: 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.

Max Credits: 3
Min Credits: 3
24.505 Reactor Physics

Course ID: 4058

Course Details: 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.

Max Credits: 3
Min Credits: 3

24.507 Reactor Engineering and Safety

Course ID: 4060

Course Details: 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.

Max Credits: 3
Min Credits: 3

24.509 Dynamic Systems Analysis

Course ID: 4062

Course Details: 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.

Max Credits: 3
Min Credits: 3

24.510 Nuclear Fuel Cycle

Course ID: 4063

Course Details: 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.

Max Credits: 3
Min Credits: 3

24.514 Chemical and Nuclear Waste

Course ID: 4066

Course Details: 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.

Max Credits: 3
Min Credits: 3

24.516 Radiation Shielding and Protection

Course ID: 38017

Course Details: 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 materials. 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.

Max Credits: 3
Min Credits: 3

**24.519 Reactor Operator Training**

Course ID: 4067

Course Details: Training, including in-reactor experience and topical lectures, as given to Reactor Operator Trainees who will undergo Federal testing for a Reactor Operator License.

Max Credits: 3
Min Credits: 3

**24.520 Reactor Operator Training**

Course ID: 4068

Course Details: 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.

Max Credits: 3
Min Credits: 3

**24.531 Selected Topics in Engineering**

Course ID: 4077

Course Details: Special problems in nuclear science and engineering assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

Max Credits: 3
Min Credits: 3

**24.532 Selected Topics: Energy Science**

Course ID: 4078

Course Details: Special problems in nuclear science and engineering assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

Max Credits: 3
Min Credits: 3

**24.536 Reactor Experiments**

Course ID: 38016

Course Details: 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.

Max Credits: 3
Min Credits: 3
24.539 Mathematical Methods for Engineers

Course ID: 1261
Course Details: 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).

Max Credits: 3
Min Credits: 3

24.601 Graduate Research Seminar

Course ID: 4086
Course Details:

Max Credits: 0
Min Credits: 0

24.651 Selected Topics in Energy Engineering

Course ID: 4088
Course Details:

Max Credits: 3
Min Credits: 3

24.705 Supervised Tchg - Nuclear Engineering

Course ID: 4092
Course Details:

Max Credits: 0
Min Credits: 0

24.733 Graduate Project - Energy Engineering

Course ID: 4094
Course Details:

Max Credits: 3
Min Credits: 3

24.739 Graduate Project - Energy Engineering

Course ID: 4096
Course Details:

Max Credits: 9
Min Credits: 9

24.741 Thesis Review

Course ID: 35265
Course Details:

Max Credits: 1
**24.743 Master's Thesis - Nuclear Engineering**

Course ID: 4098  
Course Details:  
Max Credits: 3  
Min Credits: 3

**24.746 Master's Thesis - Energy Engineering**

Course ID: 4099  
Course Details:  
Max Credits: 6  
Min Credits: 6

**24.749 Master's Thesis - Energy Engineering**

Course ID: 4100  
Course Details:  
Max Credits: 9  
Min Credits: 9

**24.766 Continued Graduate Research**

Course ID: 4106  
Course Details:  
Max Credits: 6  
Min Credits: 6

**24.769 Continued Graduate Research**

Course ID: 4107  
Course Details:  
Max Credits: 9  
Min Credits: 9

**25.550 Introduction to Nanotechnology**

Course ID: 30852  
Course Details: 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.  
Max Credits: 3  
Min Credits: 3

**25.570 Selected Issues in Nanomanufacturing**

Course ID: 30850
Course Details: 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.

Max Credits: 0
Min Credits: 0

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26.500 Advanced Project In Plastics I
Course Details: A laboratory course for advanced projects in the areas of plastics materials, design, processing, elastomers, coatings, adhesives, or medical plastics.

26.501 Advanced Project In Plastics II
Course Details: Continuation of 26.500.

26.503 Mechanical Behavior of Polymers
Course Details: Topics covered in this course include linear viscoelasticity, creep, stress relaxation, dynamic behavior, hysteresis, stress-strain response phenomena, principles of time-temperature superposition, rubber elasticity, failure and fracture mechanisms for polymers, and the effect of additives on mechanical behavior. Real life design examples are used to demonstrate the topics and concepts as much as possible.

26.506 Polymer Structure Properties & Applications
Course Details: Relationships between polymer structure (chemical composition, molecular weight and flexibility, intermolecular order and bonding, supermolecular structure) and practical properties (processability, mechanical, acoustic, thermal, electrical, optical, and chemical) and applications.

26.509 Plastics Processing Theory I
Course Details: 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.

26.510 Plastics Processing Theory II
Course Details: A continuation of Theory I using the transport phenomena approach to analyze and describe plastics conversion processes, including roll processing blown film extrusion, injection molding, and mixing.
26.511 Polymer Blends

Course ID: 4215

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.512 Porous Polymers

Course ID: 4216

Course Details: Preparation, structure, and properties of porous polymers. Includes both practical systems in development and production and novel techniques of more fundamental interest and/or aimed at more specialized applications. Existing and potential applications for these materials will also be discussed, and related back to their structure and properties.

Max Credits: 3
Min Credits: 3

26.513 New Plastics Materials

Course ID: 4217

Course Details: Critical examination of the new plastics appearing in the research literature and being field-tested for commercialization in the plastics industry.

Max Credits: 3
Min Credits: 3

26.514 Statistics for Six Sigma

Course ID: 4218

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.515 Lean Plastics Manufacturing

Course ID: 30849

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.518 Plastics Product Design

Course ID: 4221

Course Details: 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.

Max Credits: 3
26.522 Advanced Project in Plastics IV

Course ID: 4225

Course Details: 

Max Credits: 3

Min Credits: 3

26.524 Process Analysis Instrument and Control

Course ID: 4227


Max Credits: 3

Min Credits: 3

26.528 Plastics Information Data Bases

Course ID: 4230

Course Details: Review of procedures for literature searching, databases, etc.

Max Credits: 1

Min Credits: 1

26.530 Selected Topics

Course ID: 4232

Course Details: 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.

Max Credits: 3

Min Credits: 1

26.532 Adhesives and Adhesion

Course ID: 4234

Course Details: 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.

Max Credits: 3

Min Credits: 3

26.533 Coatings Science and Technology I

Course ID: 4235

Course Details: This course reviews the basic principles of design and formulation of waterborne, high-solids, powder resins used for the development of solvent-less "green" coatings and the use of bio-derived resins, mostly based on soybean oil and other renewable raw materials. The mechanisms and methods of curing and of polymerization for polymers used as coatings will also be covered.

Max Credits: 3

Min Credits: 3

26.534 Coatings Science and Technology II
Course ID: 4236

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.535 Rubber Technology

Course ID: 4237

Course Details: Polymerization and compounding of the commercial elastomers. Properties and test methods. Leading applications and methods of processing.

Max Credits: 3
Min Credits: 3

26.537 Business Law for Engineers

Course ID: 30847

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.540 Commercial Development of Plastics

Course ID: 4241

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.541 Computer Applications in Plastics

Course ID: 4242

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.542 Colloidal Nanoscience and Nanoscale Engineering

Course ID: 1259

Course Details: 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.

Max Credits: 3
Min Credits: 3
26.544 Advanced Plastics Materials

Course ID: 4243

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.545 Additives for Polymer Materials

Course ID: 4244

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.547 Materials for Renewable Energy and Sustainability

Course ID: 4246

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.548 Analytical and Numerical Methods in Plastics Processing

Course ID: 4247

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.549 Product Design for Elastomers

Course ID: 4248

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.550 Processing with Elastomers

Course ID: 4249

Course Details: This course covers the basics of elastomer processing. Topics include mixing, Rheology, extrusion, injection molding,
compressing molding, and curing as it applies to elastomers.

Max Credits: 3
Min Credits: 3

26.551 Extrusion Die Design

Course ID: 4250

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.552 Machine Design

Course ID: 4251

Course Details: Hydraulics, machine logic, drives, pumps, motors, heaters, barrel and screw combinations, mechanical design. Hydraulic and electrical control circuits development. A semester project is required.

Max Credits: 3
Min Credits: 3

26.553 Medical Device Design I

Course ID: 4252

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.554 Medical Device Design II

Course ID: 4253

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.563 Current Topics in Plastics Materials I

Course ID: 4262

Course Details: Individual research and presentation in the field of plastics materials.

Max Credits: 1
Min Credits: 1

26.564 Current Topics in Plastics Materials II

Course ID: 4263

Course Details: Individual research and presentation in the field of plastics materials.
Max Credits: 1
Min Credits: 1

26.565 Thermosets

Course ID: 31944

Course Details: Provides an in-depth review of the major families of engineering thermosetting resins: phenolics, aminos, polyesters, epoxies, silicones, and various polyurethanes systems. Emphasis is on the basic chemistry, inherent physical properties and processability, and the effect of polymer modifiers (additives) on the functional properties of molding compounds. Typical market sectors served and related processing/fabrication technologies used in reinforced plastics/composites are reviewed.

Max Credits: 3
Min Credits: 3

26.566 Polymer Materials Systems Solution

Course ID: 4264

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.568 Dynamic Mechanical Properties II

Course ID: 4266

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.569 Current Topics in Plastics Design I

Course ID: 4267

Course Details: Individual research and presentation in the field of plastics design.

Max Credits: 1
Min Credits: 1

26.570 Current Topics in Plastics Processing I

Course ID: 4268

Course Details: Individual research and presentation in the field of plastics processing.

Max Credits: 1
Min Credits: 1

26.572 Advanced Plastics Processing Engineering Laboratory

Course ID: 4270

Course Details:

Max Credits: 1
Min Credits: 1
26.574 Advance Physical Properties Lab

Course ID: 4272

Course Details: Measurement of mechanical properties in tension, compression, shear, and flexure; dielectric constant and dissipation factor; thermal behavior under stress; melt rheology.

Max Credits: 1
Min Credits: 1

26.575 Biomaterials I

Course ID: 4273

Course Details: A comprehensive study of the history, current and future trends 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.

Max Credits: 3
Min Credits: 3

26.576 Advanced Mold Design

Course ID: 4274

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.577 Plastics Process Engineering I

Course ID: 1256

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.578 Advanced Plastics Processing

Course ID: 4275

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.582 Current Topics in Plastics Design II

Course ID: 4279

Course Details: Individual research and presentation in the field of plastics product or tooling design.
26.583 Advanced Research Methodology

Course ID: 4280

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.585 Computer Aided Engineering I

Course ID: 4282

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.589 Polymer Nanocomposites

Course ID: 34581

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.590 Survey of Intellectual Property

Course ID: 4285

Course Details: 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)

Max Credits: 3
Min Credits: 3

26.591 Industrial Thesis Development I

Course ID: 4286

Course Details: 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.

Max Credits: 9
Min Credits: 1

26.593 Cooperative Education

Course ID: 4288
Course Details: Enables graduate students to work full time to gain practical industrial experience for one semester while on reduced course load.

Max Credits: 1
Min Credits: 1

26.595 Thermoplastic Elastomers

Course ID: 4290

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.596 Plastics, Elastomers and Additives from Renewable Resources

Course ID: 33604

Course Details: This course will provide an introduction to plastics, elastomers and additives obtained from renewable resources. Processes that involve conversion (chemically/enzymatically) of naturally occurring precursors (monomers) obtained from renewable resources to plastics and elastomers will be reviewed. Brief discussion of processing, degradation and recycling of these materials will also be included.

Max Credits: 3
Min Credits: 3

26.601 Graduate Industrial Coop Education I

Course ID: 4295

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

Max Credits: 3
Min Credits: 1

26.606 Plastics Manufacturing Systems Engineering

Course ID: 35172

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.607 Supply Chain Management for Engineers

Course ID: 37379

Course Details: 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.

Max Credits: 3
Min Credits: 3
26.610 Plastics Industry Development

Course ID: 35816

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.618 Structural Product Design

Course ID: 37683

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.650 Nanoscale Transport Phenomena for Manufacturing Nanodevices

Course ID: 4300

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

Max Credits: 3
Min Credits: 3

26.675 Biomaterials II

Course ID: 34943

Course Details: 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.

Max Credits: 3
Min Credits: 3

26.741 Master's Thesis - Plastics Engineering

Course ID: 4333

Course Details:

Max Credits: 1
Min Credits: 1

26.743 Masters Thesis Plastics Engineering

Course ID: 4334

Course Details: Individual research projects in plastics.

Max Credits: 3
Min Credits: 3

26.746 Master's Thesis - Plastics Engineering
Course ID: 4336
Course Details: Individual research projects in plastics.
Max Credits: 6
Min Credits: 6

26.749 M S Grad Res Plastics
Course ID: 4337
Course Details: Individual research projects in plastics.
Max Credits: 9
Min Credits: 9

26.751 Doctoral Thesis Research
Course ID: 4338
Course Details:
Max Credits: 1
Min Credits: 1

26.763 Continued Graduate Research
Course ID: 4346
Course Details: Individual research projects in plastics.
Max Credits: 3
Min Credits: 3

26.766 Continued Graduate Research
Course ID: 4347
Course Details: Individual research projects in plastics.
Max Credits: 6
Min Credits: 6

26.769 Continued Graduate Research
Course ID: 4349
Course Details: Individual research projects in plastics.
Max Credits: 9
Min Credits: 9

29.759 Doctoral Research - Plastics Engineering
Course ID: 4438
Course Details:
Max Credits: 3
**IB.500 Introduction to Biomedical Engineering & Biotechnology**

Course ID: 20110

Course Details: Team-taught introductory course that emphasizes a multidisciplinary approach to current topics in the range of academic disciplines and gives students their first exposure to faculty research areas. The course, as much as possible, will involve faculty from within Biomedical Engineering and Biotechnology. The course, as much as possible, involves faculty from all participating campuses. Speakers from industry are also invited to present topics of contemporary importance.

Max Credits: 3

**IB.510 Digital Signal Processing**

Course ID: 3266


Max Credits: 3

**IB.511 Medical Diagnostic Imaging**

Course ID: 3267

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

Max Credits: 3

**IB.512 Medical Image Processing**

Course ID: 37007

Course Details: 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].

Max Credits: 3

**IB.513 Biomedical Imaging Informatics**

Course ID: 38346

Course Details: The focus of this course will be on Medical Imaging Informatics (MII), Which is the application of the technologies that enable the complex environment needed for modern medical imaging information systems. These MII systems are increasingly pushing the limits of computing, networking and storage capabilities. The study of MII would be instructive for someone interested in generally examining instances of complex information systems are for someone who is interested in the specifics of Picture Archiving and communications Systems (PACS) and radiologic Information Systems (RIS).

Max Credits: 3
**IB.516 Basic Principles of Nuclear Magnetic Resonance Imaging**

Course ID: 37008

Course Details: 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.

Max Credits: 3
Min Credits: 3

**IB.517 Embedded System Design in Medical Systems**

Course ID: 37006

Course Details: 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.

Max Credits: 3
Min Credits: 3

**IB.520 Ethical Iss. Biomedical**

Course ID: 20111

Course Details:

Max Credits: 1
Min Credits: 1

**IB.521 Real Time Digital Signal Processing**

Course ID: 3275

Course Details: 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.

Max Credits: 3
Min Credits: 3

**IB.525 Introduction to Translational Science**

Course ID: 38639

Course Details: 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.

Max Credits: 3
Min Credits: 3

**IB.550 BMBT Laboratory Experience**
IB.560 Biomedical Instrumentation

Course ID: 30817

Course Details: Analysis and design of Biomedical Instrumentation systems that acquire and process biophysical signals. Properties of Biopotential signals and electrodes; Biopotential Amplifiers and Signal Processing; Basic Sensors and Principles; Medical Imaging Systems; Electrical Safety.

Max Credits: 3

Min Credits: 3

IB.575 Quantitative Physiology

Course ID: 32058

Course Details: 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.

Max Credits: 3

Min Credits: 3

IB.600 Capstone Project

Course ID: 20112

Course Details:

Max Credits: 3

Min Credits: 3

IB.601 Sem: Biomedical Engineering & Biotechnology

Course ID: 20113

Course Details: 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.

Max Credits: 3

Min Credits: 3

IB.710 Directed Study

Course ID: 30401

Course Details:

Max Credits: 3

Min Credits: 3

IB.711 Directed Studies

Course ID: 35005
Course Details:
Max Credits: 1
Min Credits: 1

**IB.712 Directed Studies**
Course ID: 30402

Course Details:
Max Credits: 2
Min Credits: 2

**IB.720 Independent Study**
Course ID: 30403

Course Details:
Max Credits: 3
Min Credits: 3

**IB.721 Independent Study**
Course ID: 30404

Course Details:
Max Credits: 1
Min Credits: 1

**IB.722 Independent Study**
Course ID: 35006

Course Details:
Max Credits: 2
Min Credits: 2

**IB.756 Doctoral Dissertation**
Course ID: 29832

Course Details:
Max Credits: 6
Min Credits: 6

**IB.759 Dissertation Research**
Course ID: 30405

Course Details:
Max Credits: 9
Min Credits: 1

**IB.771 CPT-Co-op Training**
Course ID: 35698
Course Details: Course required to perform CPT
Max Credits: 1
Min Credits: 0

IB.780 Thesis Review
Course ID: 36528
Course Details: Thesis Review
Max Credits: 1
Min Credits: 1

Change of Program

Students who wish to change their declarations of program within the College of Engineering are required to follow the procedure stipulated under . It should be noted that College of Engineering students who change their programs within the College of Engineering after the first semester of the sophomore year should expect to have to take semester credits beyond the minimum degree requirement, and thus extend the normal four-year period of study.

Students who wish to change from engineering to a major that is offered by another college within the University of Massachusetts Lowell must apply for an intercollegiate transfer. These procedures are described under .

Qualified students from other colleges in the University of Massachusetts Lowell may transfer into degree programs of the College of Engineering using the same procedure. However, these students may expect to extend their period of study beyond the normal four-year period, particularly if they transfer after the first semester of the sophomore year.

Declaration of a Second Major

Candidates for degrees in the College of Engineering may be permitted to elect additional majors offered in other colleges of the University, provided that all curriculum requirements in engineering are satisfied.

Engineering students who wish to take on a second major that is offered by the College of Engineering or by another college must formalize this intent by the start of the junior year. At that time the student is also required to submit for approval his or her intended program of study to the advisor in the department offering the second major. It should be noted that in most cases, the election of an additional major will extend the normal four-year period of undergraduate study. Students who elect to take a second academic major in another college are candidates for one degree in the College of Engineering only. A student who pursues an academic major in the College of Engineering and another college or two majors in the College of Engineering is subject to all degree requirements of the College of Engineering and is subject only to major course requirements specified by the department of the secondary major. For a complete statement of University Policy on double majors, refer to .

Degree Requirements

Each candidate for the undergraduate degree must satisfy the general requirements of the University of Massachusetts Lowell in order to graduate. The student must also meet the specific academic requirements of the College of Engineering as indicated in this section, as well as complete all credits and courses required by the department in which the student majors. The number of credits required for the completion of each College of Engineering program is established by the department offering the program.

Courses taken by freshmen entering any engineering discipline are for the most part similar and include calculus, physics, chemistry, college writing, and engineering design.

Introduction to Engineering I (25.107) introduces first-year students to the engineering design process for solving open-ended problems. Introduction to Engineering II (25.108) is department-specific and continues with computer tools and applications to department-specific problems.

Students who have completed their freshman programs with a grade-point average of 2.50 or better automatically qualify for admission to the sophomore program of their choice. Students who fail to achieve that required average will be admitted to the sophomore year of engineering programs only upon the recommendation of appropriate departmental committees.

Please refer to the university grade-point average policy for satisfying retention and graduation requirements.

Individuals who are not granted continued matriculation in the College of Engineering but who satisfy university retention requirements may file for intercollegiate transfer within the university. Students who are dismissed from the College of Engineering and who are ineligible to file for intercollegiate transfer, or who are denied admission to another college following application for intercollegiate transfer, are dismissed from the university.

Transfer Policies
General Policies

It is the policy of the College of Engineering to accept transfer students from other institutions as well as from other colleges within the University of Massachusetts Lowell. Such students may expect recognition of previously completed courses if these are equivalent to those that are specified by the curricula of the College of Engineering. Transfer students are required to have at least a 2.5 grade-point average in order to be admitted to the College of Engineering.

Transfer from Other Institutions

UMass Lowell participates in the Joint Admissions Program of the Massachusetts Community Colleges and the University of Massachusetts. According to this program, a student from one of these community colleges is guaranteed admission to UMass Lowell provided the student is enrolled in a designated transfer program and earns an associate degree with a 2.5 or higher cumulative grade point average.

Courses that are transferred from other institutions are initially evaluated by the Office of Admissions in terms of general University of Massachusetts Lowell requirements. Professional courses are subsequently evaluated by the departments in which the student has been accepted. Credit is given for completed courses where the grade is C (2.00 on a 4.00 scale) or better.

The University of Massachusetts Lowell also subscribes to the Commonwealth Transfer Compact. Under this compact, the holder of an associate degree from a compact institution receives up to 66 credits for this work toward a Bachelor of Science in engineering or technology. Courses which are transferred to the University of Massachusetts Lowell under the provisions of the Commonwealth Transfer Compact, but which do not meet the credit requirements of the College of Engineering, or which are not acceptable as unrestricted elective courses, will be listed on the student's transcript, but will not apply to the minimum degree requirements.

In the event that a student has first transferred to some other college in the University of Massachusetts Lowell under the Commonwealth Transfer Compact and subsequently makes a transfer to the College of Engineering, all previously completed courses, including transferred courses from other compact institutions, will be re-evaluated in terms of their applicability toward degree requirements of the College of Engineering.

The policies of each of the colleges in the university determine the applicability of grades received in transfer to the grade-point average of the student’s major at the University of Massachusetts Lowell. It is the policy of the College of Engineering not to count such grades for the purpose of determining the student's grade-point average in his or her professional area.

2 + 2 and 2 + 3 Transfer Programs

The College of Engineering has been a leader in the development and implementation of 2 + 2 and 2 + 3 Programs in the Commonwealth of Massachusetts. More and more students who are interested in earning a Bachelor of Science degree in one of the engineering disciplines pursue their first two years of the curriculum at selected community and state colleges and complete the degree requirements during two to three final years at the University of Massachusetts Lowell. The program is ideal from the standpoint of the student who is not ready to enter a four-year college, allowing the participant to ease into college life while still remaining close to home and within the environment of a smaller college.

The contractual agreements among participating schools require an on-going review of coursework normally offered in the first two years. Curricula and other requirements are carefully established and examined by faculty at both institutions.

Transfer agreements vary with each institution participating in the 2 + 2 or 2 + 3 programs. Some participating colleges offer programs that prepare students for transfer to mechanical and electrical engineering; programs in other schools lead to entry into chemical, civil or plastics engineering. High school students who are considering this program should consult the office of admissions at the University of Massachusetts Lowell for information about available programs in participating institutions.

Repetition of Transferred Courses

A student who has been granted transfer credit from another institution, and on this basis has been assigned to advanced courses for which the transferred course is a prerequisite, may be subsequently advised to repeat such transferred work at the University of Massachusetts Lowell. Such cases arise when preparation of the student is demonstrably inadequate to allow successful performance.

To repeat a transferred course a student must file an academic petition with the Dean of the College. Since credit may not be granted more than once for the completion of any course, a condition for filing such a petition is the simultaneous filing of a request to revoke recognition statement to dispose of the previously transferred course credit.

Intercollegiate Transfer to the College of Engineering

Students wishing to transfer to the College of Engineering from another college within the University of Massachusetts Lowell, or from a baccalaureate (degree granting) Division of Continuing Education program, must file a form for change of major together with a transcript, with the Dean of the College of Engineering and with the appropriate engineering department head. Petitions for transfer must be filed no later than November 1 in order to transfer in the spring semester, and no later than April 1 in order to transfer in the fall semester.
Any student who wishes to transfer from another college in the University to the College of Engineering must have a minimum grade-point average of 2.500. Irrespective of the grade received, all courses that may not be applied to the College of Engineering program requirements will be deleted from the student’s cumulative grade-point average.

For further procedural details about the university’s policies concerning intercollegiate transfers, students are referred to .

**Policies**

Please review the following policies:

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