COURSE DESCRIPTIONS

Explanation of course descriptions
On the following pages are brief outlines of the courses prescribed for students in the Faculty of Applied Science and Engineering, listed in alphabetical order of the prefixes. The suffix following the course number indicates the session in which the course is given; the second line of the description shows the program and year for which the course is prescribed, the number of hours of lectures, laboratory and tutorial work per week, and the weight units assigned to the course.

Sample

ECE461H1 S
Internetworking
IV- AECPEBASCC; IV - AECPEBASC, AEESCBASEC (elective) 3/1.5/-/0.50

ECE: Department of Electrical and Computer Engineering

461: Course number

H1: Half course, St George Campus

S: A second-session (winter) course.

F would indicate a first-session or fall course;

F/S would indicate that the course given in the first session is repeated in the second session (a student may take one or the other, but not both);
Y would indicate a course that continues
over both sessions, i.e., a year-long course.

For determination as to whether a course is considered core or a technical elective for your program, consult your program curriculum outline in Chapter 7.

3: three hours lectures/week

1.5: equivalent of 1BD hours of laboratory per week (normally delivered as 3hrs of lab on alternating weeks

-: no tutorial

0.50: equals one half credit

In addition to the 100-, 200-, 300- and 400-series courses, this Calendar also lists courses in the 500- and 1000-series. The 500-series courses are undergraduate courses that are also intended for graduate students; 1000-series are graduate courses that are open to undergraduate students by permission.

Many course descriptions include a statement of exclusions, prerequisites and co-requisites. The absence of such a statement does not imply that the course does not have such conditions. In these statements, the oblique symbol (“/”) means “OR”, and the comma (“,”) means “AND”.

Any recommendation for textbooks should be considered as tentative only, and is subject to change. Students should therefore not purchase textbooks until they have been in attendance in the course, unless informed otherwise by their department.

Note: For all Arts and Science courses, please refer to the Arts and Science 2010-2011 Academic Calendar for updated course descriptions.

Actuarial Science

ACT370H1 S
Financial Principles for Actuarial Science II
III - AEESCBASEF 3/-/-/0.50

Mathematical theory of financial derivatives, discrete and continuous option pricing models, hedging strategies and exotic option valuation.

Aerospace Science and Engineering

AER201H1 S
Engineering Design
II - AEESCBASE 1/5/-/0.50

Design of integrated, multidisciplinary systems is introduced through a major course project. Project selection and definition of functions and performance objectives for the open-ended design problem will take place early on by teams of students, while learning practical subjects of engineering in lectures and workshops. This process will lead to the preparation of project proposals consisting of identification of design objectives and constraints, generation and evaluation of potential approaches, selection of the most promising design concept, identification of product subsystems, and assignment of responsibilities to team members. Following project approval, the design process will comprise preliminary design, followed by detailed design, prototype construction and testing, and preparation of a final design report. Progress is evaluated weekly, culminating in a prototype demonstration and design review.

AER210H1 F
Vector Calculus & Fluid Mechanics
II - AEESCBASE 3/0.50/2/0.50

The first part of this course covers multiple integrals and vector calculus. Topics covered include: double and triple integrals, derivatives of definite integrals, surface area, cylindrical and spherical coordinates, general coordinate transformations (Jacobians), Taylor series in two variables, line and surface integrals, parametric surfaces, Green's theorem, the divergence and gradient theorems, Stokes's theorem. The second part of the course provides a general introduction to the principles of continuum fluid mechanics. The basic conservation laws are derived in both differential and integral form, and the link between the two is demonstrated. Applications covered include hydrostatics, incompressible and compressible frictionless flow, the speed of sound, the momentum theorem, viscous flows, and selected examples of real fluid flows.

AER301H1 F
Dynamics
III - AEESCBASEA 3/-/1/0.50

Reference frames in relative translation and rotation, vector and matrix formulations. Dynamics of a single particle and of systems of particles. Lagrange's equations. D'Alembert's and Hamilton's principle. Orbital dynamics. Rigid body kinematics and dynamics, Lagrangian approach to vibrations of complex systems. Model analysis. Primary Reference: class notes. Reference Books: Greenwood, Principles of Dynamics; Goldstein, Classical Mechanics.

AER302H1 S
Aircraft Flight
III - AEESCBASEA 3/-/1/0.50

Basics of aircraft performance with an introduction to static stability and control. Topics covered include: Equations of Motion; Characteristics of the Atmosphere; Airspeed Measurement; Drag (induced drag, total airplane drag); Thurst and Power (piston engine characteristics, gas turbine performance); Climb (range payload); Tunrs; Pull-up; Takeoff; Landing (airborne distance, ground roll); Flight envelope (maneuvering envelope, gust load factors); Longitudinal and lateral static stability and control; Introduction to dynamic stability.

AER303H1 F
Aerospace Laboratory I
III - AEESCBASEA -/1/-/0.15

Students will perform a number of experiments in the subject areas associated with the Aerospace Option curriculum, and prepare formal laboratory reports.

AER304H1 S
Aerospace Laboratory II
III - AEESCBASEA -/1/-/0.15

Students will perform a number of experiments in the subject areas associated with the Aerospace Option curriculum, and prepare formal laboratory reports.

AER307H1 F
Aerodynamics
III - AEESCBASEA, IV - AEMECBASC 3/-/1/0.50

Review of fundamentals of fluid dynamics, potential-flow, Euler, and Navier-Stokes equations; incompressible flow over airfoils, incompressible flow over finite wings; compressibility effects; subsonic compressible flow over airfoils; supersonic flow; viscous flow; laminar layers and turbulent boundary layers and unsteady aerodynamics. Textbook: Anderson, J.D., Fundamentals of Aerodynamics, 3rd Edition, McGraw Hill, 2001.

AER310H1 S
Gasdynamics
III - AEESCBASEA 3/-/1/0.50

Basic introduction to compressible gasdynamics. Includes some fundamental thermodynamics, thermal and caloric equations of state, derivation of Euler's equations by control volume approach. Also, includes the theory of steady flows in ducts with area changes, adiabatic frictional flows, duct flows with heat transfer, normal and oblique shock waves, Prandtl-Meyer expansion wave, moving shock and rarefaction waves, shock tubes, and wind tunnels. The lectures are supplemented by problem sets. Reference book: Anderson, J.D., Modern Compressible Flow with Historical Perspective.
Prerequisite: AER202H1 S "Fluid Mechanics", or equivalent.)

AER315H1 F
Combustion Processes
III - AEESCBASEA 3/-/1/0.50

Scope and history of combustion, and fossil fuels; thermodynamics and kinetics of combustion including heats of formation and reaction, adiabatic flame temperature, elementary and global reactions, equilibrium calculations of combustion products, and kinetics of pollutant formation mechanisms; propagation of laminar premixed flames and detonations, flammability limits, ignition and quenching; gaseous diffusion flames and droplet burning; introduction to combustion in practical devices such as rockets, gas turbines,

reciprocating engines, and furnaces; environmental aspects of combustion.
Prerequisite: CHE219H1 Engineering Thermodynamics, or equivalent

AER334H1 F
Numerical Methods I
III - AEMECBASC 3/-/1.50/0.50

This introductory course to numerical methods includes the following topics: polynomial interpolation, numerical integration, solution of linear systems of equations, least squares fitting, solution of nonlinear equations, numerical differentiation, solution of ordinary differential equations, and solution of partial differential equations. Tutorial assignments using the C programming language focus on engineering applications relevant to the background of students taking the course.

AER336H1 S
Scientific Computing
III - AEESCBASEA, IV - AEESCBASER 3/-/1/0.50

An introduction is provided to numerical methods for scientific computation which are relevant to the solution of a wide range of engineering problems. Topics addressed include interpolation, integration, linear systems, least-squares fitting, nonlinear equations and optimization, initial value problems, partial differential equations, and relaxation methods. The assignments make extensive use of MATLAB. Assignments also require knowledge of Fortran or C.

AER372H1 S
Control Systems
III - AEESCBASEA, III - AEESCBASEJ 3/1.50/1/0.50

An introduction to dynamic systems and control. Models of physical systems. Stability and feedback control theory. Analysis and synthesis of linear feedback systems by “classical” and state space techniques. Introduction to nonlinear and optimal control systems. Digital computer control. Multivariable feedback system design.

AER373H1 S
Mechanics of Solids and Structures
III - AEESCBASEA, III - AEESCBASEI 3/-/1/0.50

An Introduction to Solid and Structural Mechanics. Continuum Mechanics: Stress, strain and constitutive relations for continuous systems, Equilibrium equations, Force and Flexibility methods, Introduction to Cartesian Tensors. Variational Principles: Virtual Work, Complementary Virtual Work, Strain Energy and Work, Principle of Stationary Value of the Total Potential Energy, Complementary Potential Energy, Reissner’s Principle, Calculus of Variations, Hamilton’s Principle. Beam and Plate theory. Dynamics of discrete and continuous systems. Text: Shames & Dym, Energy and Finite Element Methods in Structural Mechanics.

AER406H1 S
Aircraft Design
IV - AEESCBASEA -/-/3/0.50

This course involves the detailed preliminary design of an airplane. Performance and mission specifications are given, as well as the engine’s characteristics. The class is divided into teams of three to four students who are guided to develop an airplane that can meet these specifications. Individual team members will specialize in areas such as “performance”, “structure”, “systems”, etc., although all team members should be conversant with each other’s results and methodology. Each week, a representative of each team presents a progress lecture on that team’s efforts, which is discussed and critiqued by the class. Also, the teams meet one-on-one with the professor and tutors to discuss specific design questions. At the end of the course each team will present a verbal and written report of sufficient detail to provide a compelling case for the feasibility of their proposed airplane. Text: Raymer, Daniel P., Aircraft Design: A Conceptual Approach, published by the AIAA.

AER407H1 F
Space Systems Design
IV - AEESCBASEA -/3/-/0.50

Introduction to the conceptual and preliminary design phases for a space system currently of interest in the Aerospace industry. A team of visiting engineers provide material on typical space systems design methodology and share their experiences working on current space initiatives through workshops and mock design reviews. Aspects of operations, systems, electrical, mechanical, software, and controls are covered. The class is divided into project teams to design a space system in response to a Request for Proposals (RFP) formulated by the industrial team. Emphasis is placed on standard top-down design practices and the tradeoffs which occur during the design process. Past projects include satellites such as Radarsat, interplanetary probes such as a solar sailer to Mars, a Mars surface rover and dextrous space robotic systems.
Prerequisite: AER372/MIE404

AER501H1 F
Advanced Mechanics of Structures
IV - AEESCBASEA 3/-/1/0.50

Introduction to the Finite Element Method and Structural Optimization. Review of linear elasticity: stress, strain and material constitutive laws, Variational Principles. The Finite Element technique: problem formulation - methods of Ritz and Galerkin, element properties - C0 and C1 formulations, static and dynamic problems: applications to bar, beam, membrane and plate problems. Structural Optimization: Overview of problems, Optimal Design problem formulation, solution strategies - gradient search techniques, Sensitivity analysis for static and dynamic problems, Optimization problems using commercial finite element codes. Text: Shames & Dym, Energy and Finite Element Methods in Structural Mechanics.

AER503H1 S
Aeroelasticity
IV - AEESCBASEA 3/-/1/0.50

Static aeroelastic phenomena are studied, including divergence of slender wings and control reversal. Various methods of solution are considered such as closed form, matrix format iteration and the Rayleigh-Ritz approach. A Study of vibration and flutter of wings and control surfaces is presented with particular emphasis on those parameters which affect flutter speed.

AER506H1 F
Spacecraft Dynamics and Control
IV - AEESCBASEA 3/-/1/0.50

Planar “central force” motion; elliptical orbits; energy and the major diameter; speed in terms of position; angular momentum and the conic parameter; Kepler’s laws. Applications to the solar system; applications to Earth satellites. Launch sequence; attaining orbit; plane changes; reaching final orbit; simple theory of satellite lifetime. Simple (planar) theory of atmospheric entry. Geostationary satellite; adjustment of perigee and apogee; east-west stationkeeping. Attitude motion equations for a torque-free rigid body; simple spins and their stability; effect of internal energy dissipation; axisymmetric spinning bodies. Spin-stabilized satellites; long-term effects; sample flight data.

Dual-spin satellites; basic stability criteria; example-CTS. “active” attitude control; reaction wheels; momentum wheels; controlmoment gyros; simple attitude control systems.

AER507H1 F
Introduction to Fusion Energy
IV - AEESCBASEA, IV - AEESCBASEJ, IV - AEESCBASEP, IV - AEESCBASER, I - AEMINENR 3/-/1/0.50

Nuclear reactions between light elements provide the energy source for the sun and stars. On earth, such reactions could form the basis of an essentially inexhaustible energy resource. In order for the fusion reactions to proceed at a rate suitable for the generation of electricity, the fuels (usually hydrogen) must be heated to temperatures near 100 million Kelvin. At these temperatures, the fuel will exist in the plasma state. This course will cover: (i) the basic physics of fusion, including reaction cross-sections, particle energy distributions, Lawson criterion and radiation balance, (ii) plasma properties including plasma waves, plasma transport, heating and stability, and (iii) fusion plasma confinement methods (magnetic and inertial). Topics will be related to current experimental research in the field.

AER510H1 S
Aerospace Propulsion
IV - AEESCBASEA 3/-/1/0.50

Scope and history of jet and rocket propulsion; fundamentals of air-breathing and rocket propulsion; fluid mechanics and thermodynamics of propulsion including boundary layer mechanics and combustion; principles of aircraft jet engines, engine components and performance; principles of rocket propulsion, rocket performance, and chemical rockets; environmental impact of aircraft jet engines.
Prerequisite: AER310H1 Gasdynamics

AER525H1 F
Robotics
IV - AEESCBASEA, IV - AEESCBASEM, IV - AEESCBASER, IV - AEMECBASC 3/1.50/1/0.50

The course addresses fundamentals of analytical robotics as well as design and control of industrial robots and their instrumentation. Topics include forward, inverse, and differential kinematics, screw representation, statics, inverse and forward dynamics, motion and force control of robot manipulators, actuation schemes, task-based and workspace design, mobile manipulation, and sensors and instrumentation in robotic systems. A series of experiments in the Robotics Laboratory will illustrate the course subjects.

Applied Mathematics

APM384H1 F
Partial Differential Equations
III - AECPEBASC, III - AEELEBASC, III - AEESCBASEA, III - AEESCBASEB, III - AEESCBASEF, III - AEESCBASEO, III - AEESCBASEP, IV - AEESCBASER 3/-/1/0.50

Boundary value problems and Sturm-Liouville theory for ordinary differential equations. Partial differential equations of first order, characteristics,Hamilton-Jacobi theory. Diffusion equations; Laplace transform methods. Harmonic functions, Green’s functions for Laplace’s equation, surface and volume distributions; Fourier transforms. Wave equation, characteristics; Green’s functions for the wave equation; Huygens principle.

APM446H1 F
Applied Nonlinear Equations
IV - AEESCBASEA 3/-/-/0.50

Nonlinear partial differential equations and their physical origin. Fourier transform; Green’s function; variational methods; symmetries and conservation laws. Special solutions (steady states, solitary waves, travelling waves, self-similar solutions). Calculus of maps; bifurcations; stability, dynamics near equilibrium. Propagation of nonlinear waves; dispersion, modulation, optical bistability. Global behaviour solutions; asymptotics and blow-up.

Applied Science and Engineering (Interdepartmental)

APS104H1 S
Introduction to Materials and Chemistry
I - AECPEBASC, I - AEELEBASC, I - AEENGBASC 3/-/1/0.50

This is an introductory course in materials science and physical chemistry. Topics include: fundamentals of atomic, structure, the nature of bonding, crystal structure and defects, the laws of chemical thermodynamics (including a discussion of enthalpy and entropy), reaction equilibrium, and phase equilibria. These basic principles provide the foundation for an exploration of structure-property relationships in metals, ceramics, and polymers, with emphasis on mechanical properties.

APS105H1 F
Computer Fundamentals
I - AECPEBASC, I - AEELEBASC, I - AEENGBASC 3/2/1/0.50

An introduction to computer systems and problem solving using computers. Topics include: the representation of information, programming techniques, programming style, basic loop structures, functions, arrays, strings, pointer-based data structures and searching and sorting algorithms. The laboratories reinforce the lecture topics and develops essential programming skills.

APS106H1 S
Fundamentals of Computer Programming
I - AECHEBASC, I - AECIVBASC, I - AEINDBASC, I - AELMEBASC, I - AEMECBASC, I - AEMMSBASC 3/2/1/0.50

An introduction to computer systems and software. Topics include the representation of information, algorithms, programming languages, operating systems and software engineering. Emphasis is on the design of algorithms and their implementation in software. Students will develop a competency in the C programming language and will be introduced to the C++ programming language. Laboratory exercises will explore the concepts of both Structure-based and Object-Oriented programming using examples drawn from mathematics and engineering applications.

APS111H1 F
Engineering Strategies & Practice I
I - AECHEBASC, I - AECIVBASC, I - AECPEBASC, I - AEELEBASC, I - AEENGBASC, I - AEINDBASC, I - AELMEBASC, I - AEMECBASC, I - AEMMSBASC 3/1/1/0.50

This course introduces and provides a framework for the design process. Students are introduced to communication as an integral

component of engineering practice. The course is a vehicle for understanding problem solving and developing communications skills. This first course in the two Engineering Strategies and Practice course sequence introduces students to the process of engineering design, to strategies for successful team work, and to design for human factors, society and the environment. Students write team and individual technical reports and give presentations within a discussion group.

APS112H1 S
Engineering Strategies & Practice II
I - AECHEBASC, I - AECIVBASC, I - AECPEBASC, I - AEELEBASC, I - AEENGBASC, I - AEINDBASC, I - AELMEBASC, I - AEMECBASC, I - AEMMSBASC — 3/2/-/0.50

This course introduces and provides a framework for the design process, problem solving and project management. Students are introduced to communication as an integral component of engineering practice. The course is a vehicle for practicing team skills and developing communications skills. Building on the first course, this second course in the two Engineering Strategies and Practice course sequence introduces students to project management and to the design process in greater depth. Students work in teams on a term length design project. Students will write a series of technical reports and give a team based design project presentation.

APS150H1 F
Ethics in Engineering
I - AECHEBASC, I - AECIVBASC, I - AECPEBASC, I - AEELEBASC, I - AEENGBASC, I - AEINDBASC, I - AELMEBASC, I - AEMECBASC, I - AEMMSBASC — -/-/1/0.05

An introduction to professional ethics and the Academic Code of Conduct. Topics include: the theory of ethics, professional code of ethics, ethics in the profession, proper use of intellectual property in the professional and in academic settings, plagiarism, the Academic Code of Conduct, and application of ethics in practice.

APS191H1 S
Introduction to Engineering
I - AEENGBASC — 1/-/-/0.15

This is a seminar series that will preview the core fields in Engineering. Each seminar will highlight one of the major areas of Engineering. The format will vary and may include application examples, challenges, case studies, career opportunities, etc. The purpose of the seminar series is to provide first year students with some understanding of the various options within the Faculty to enable them to make educated choices for second year. This course will be offered on a credit/no credit basis.

APS234H1 F
Entrepreneurship and Small Business
4/-/1/0.50

Part 1 of the 2 Part Entrepreneurship Program

The age of enterprise has arrived. Strategic use of technology in all sorts of businesses makes the difference between success and failure for these firms. Wealth creation is a real option for many and the business atmosphere is ready for you! Increasingly, people are seeing the advantages of doing their own thing, in their own way, in their own time. Entrepreneurs can control their own lives, structure their own progress and be accountable for their own success - they can fail, but they can not be fired! After all, engineers are the most capable people to be in the forefront of this drive to the business life of the next century. This course is the first of a series of two dealing with entrepreneurship and management of a small company. It is intended that the student would continue to take the follow up course APS432 as s/he progresses toward the engineering degree. Therefore, it is advisable that the descriptions of both courses be studied prior to deciding to take this one. This is a limited enrolment course. If the number of students electing to take the course exceeds the class size limit, selection of the final group will be made on the basis of the "Entrepreneur's Test". There will be a certificate awarded upon the successful completion of both courses attesting to the fact that the student has passed this Entrepreneurial Course Series at the University of Toronto. The course is based on real life issues, not theoretical developments or untried options. Topics covered include: Who is an entrepreneur; Canadian business environment; Acquisitions; Different business types (retail, wholesale, manufacturing, and services); Franchising; Human resources, Leadership, Business law; and many others. Several visitors are invited to provide the student with the opportunity to meet real entrepreneurs. There will be several assignments and a session project. It should be noted that the 5 hours per week would all be used for whatever is needed at the time, so tutorials will not normally happen as the calendar indicates them.

Exclusion: CHE488H1/CIV488H1/ECE488H1/MIE488H1/MSE488H1

APS301H1 F
Technology in Society and the Biosphere I
II - AECIVBASC, IV - AEESCBASEI, I - AEMINENR, I - AEMINENV — 3/-/1/0.50

Humanities and Social Science Elective

Core Course in the Environmental Engineering Minor

This course teaches future engineers to look beyond their specialized domains of expertise in order to understand how technology functions within human life, society and the biosphere. By providing this context for design and decision-making, students will be enabled to do more than achieve the desired results by also preventing or significantly reducing undesired consequences. A more preventively-oriented mode of practicing engineering will be developed in four areas of application: materials and production, energy, work and cities. The emphasis within these topics will reflect the interests of the class.

APS302H1 S
Technology in Society and the Biosphere II
I - AEMINENV — 3/-/1/0.50

Humanities and Social Science Elective

This course examines the interactions between advanced technology and human life, society and the biosphere. Topics include: industrialization and the birth of rationality and technique; the computer and information revolution as symptom of a deeper socio-cultural transformation; other "post-industrial" phenomena; the transition from experience to information; technique as social force, life-milieu and system; and living with complex socio-technical systems.

Prerequisite: APS301H1/APS203H1/APS103H1

APS304H1 S
Preventive Engineering and Social Development
I - AEMINENV — 3/-/1/0.50

Humanities and Social Science Elective

The present intellectual and professional division of labour makes it next to impossible for specialists to deal with the consequences of their decisions that fall beyond their domains of expertise, thus institutionalizing an end-of-pipe approach to the many problems created by contemporary civilization. To turn this situation around, preventive approaches have been developed that use the

understanding of how technology interacts with human life, society and the biosphere to adjust decision-making in order to achieve the desired results while at the same time preventing or reducing undesired effects. These preventive approaches can transform our materials and production systems, energy systems, workplaces and urban habitats to make contemporary ways of life more economically sound, socially viable and environmentally sustainable.
Prerequisite: APS301H1/APS203H1/APS103H1, APS302H1

APS305H1 S
Energy Policy
III - AEESCBASEJ, I - AEMINENR 3/-/1/0.50

Complimentary Studies Elective
Core Course in the Sustainable Energy Minor
Introduction to public policy including the role and interaction of technology and regulation, policy reinforcing/feedback cycles; procedures for legislation and policy setting at the municipal, provincial and federal levels; dimensions of energy policy; energy planning and forecasting including demand management and conservation incentives; policy institution, analysis, implementation, evaluation and evolution; Critical analyses of case studies of energy and associated environmental policies with respect to conservation and demand management for various utilities and sectors; policy derivatives for varied economic and social settings, developing countries and associated impacts.

APS320H1 F
Representing Science on Stage
2/-/2/0.50

Humanities and Social Science Elective
An examination of representations of science/scientists in theatre. Reading and/or viewing of works by contemporary playwrights and related materials on science and culture. Critical essays; in-class discussion and scene study.

APS321H1 F
Representing Science and Technology in Popular Media
2/-/2/0.50

Humanities and Social Science Elective
Analytical approach to writing and style; representations of current scientific research and developments in technology in the popular media; books by scientists aimed at non technical readers, reporting (including new media) on developments in science and technology. Rhetorical strategies for delivering technical information to non technical readers, inlcuding misrepresentations, analogy and metaphor. Focus on the popular media's (mis)representations of climate science, nanotechnology, and bioengineering.
Prerequisite: CHE397H1/ECE297H1/ECE299H1/ESC201H1/MSE390H1

APS322H1 S
Language and Power
2/-/2/0.50

Humanities and Social Science Elective
Analytical approach to writing and style. Study of persuasion in political, scientific and ethical contexts. Development of critical thinking skills. History of rhetoric viewing major contributors in context: Aristotle, Cicero, Medieval rhetoric, modern rhetoricians. Analysis of major scientific and political writing and speech.
Prerequisite: CHE397H1/ECE297H1/ECE299H1/ESC201H1/MSE390H1

APS432H1 S
Entrepreneurship and Business Management
4/-/1/0.50

Part 2 of the 2 Part Entrepreneurship Program
This is part two of the Entrepreneurship course series. The student considering taking this course would typically plan to pursue a career in small business started by him/herself, or in a family enterprise. The skills acquired, however, are very useful in any business where a graduate might end up in his/her career, without the need for actually being an entrepreneur. Our approach to teaching is based on real-life business experiences and many years of successful practice of "what we preach". The course contains very little theoretical work or academic approaches. It is designed to familiarise you with the kinds of opportunities (problems) likely to be encountered in an entrepreneurial career. If you really want this lifestyle and are prepared to work hard, we will provide you with the practical knowledge and technical skills required to pursue this kind of career. Topics covered in this course include: Marketing and Sales; Legal issues; Financing the business; Human Resources challenges, the Business Plan and many other issues. Note that the course material may be adjusted between the two courses as required. We recognize the value of communication skills in both the classroom and in project reports. In fact, we require that you learn how to present yourself in a business-like manner. As and when appropriate, outside visitors from the business community will join in and contribute to the class discussions. The course deals with practical concepts, actual past and current events and is presented from the point of view of someone who has "done it all". This means that what you hear is the real stuff. There will be several assignments and the preparation of a full Business Plan as the session project. It should be noted that the 5 hours per week would all be used for whatever is needed at the time, so tutorials will not normally happen as the calendar indicates them.
Prerequisite: APS234 - Entrepreneurship and Small Business
Exclusion: CHE488H1/CIV488H1/ECE488H1/MIE488H1/MSE488H1

APS501H1 F
Leadership and Leading for Groups and Organizations
3/-/-/0.50

Complementary Studies Elective
This course will examine leadership in relation to technology and the engineering profession. Topics will include: leadership theories, historic and current leaders, ethical leadership, teaming and networking, productivity and innovation, thinking frameworks, business leadership, and influencing people. Through this course students will explore their own leadership abilities and develop or strengthen their competencies in areas such as managing conflict, team dynamics, running effective meetings, developing others, and creation of vision and mission statements. The course will be delivered through lectures, workshops, readings, and guest speakers.

APS510H1 F
Technologies and Organizations in Global Energy Systems
I - AEMINENR 3/-/1/0.50

Complementary Studies Elective
This course presents and discusses a broad range of global energy systems (including electricity generation, electricity end use, transportation and infrastructure) that are emerging based on two key trends: (a) the increasing ability to deploy technologies and engineering systems globally, and (b) innovative organizations, many driven by entrepreneurship (for profit and social) and entrepreneurial finance techniques. The course considers these types of innovations in the context of developed economies, rapidly developing economies such as India and China, and the developing world. The course will

interweave a mix of industry examples and more in-depth case studies. The result will be a matrix (not necessarily completely filled in) along the three dimensions of type of technologies, types of organizational structure, and development level of the country or region. The examples and cases are examined with various engineering, business and environmental sustainability analysis perspectives.

Biomaterials and Biomedical Engineering

BME105H1 S
Systems Biology
I - AEESCBASE 2/1.25/1/0.50

Using a quantitative, problem solving approach, this course will introduce basic concepts in cell biology and physiology. Various engineering modeling tools will be used to investigate aspects of cell growth and metabolism, transport across cell membranes, protein structure, homeostasis, nerve conduction. Problem based learning approach will demonstrate the utility of the engineering approach to solve biotechnological problems.

BME340H1 S
Biomedical Engineering Instrumentation and Technology
III - AEESCBASEB 2/4/-/0.50

An introduction to the principles and operation of selected biomedical devices used in clinical and laboratory settings. Topics will be drawn from the following list: ECG/EMG/EEG measurements, electrocautery, electrosurgery, blood pressure measurement, defibrillators, design of surgical hardware, RT-PCR, microscopy, protein/DNA/mRNA extraction, protein assays, colorometric assays of enzymatic activity and clinical laboratory testing. Design and problem-solving skills will be developed by design, construction and characterization of a piece of hardware. Laboratory work will be the main focus on the course and will stress practical applications of material covered in lecture.

BME350H1 S
Physiological Control Systems
III - AEESCBASEB 3/0.25/1/0.50

An introduction to physiological concepts and selected physiological control systems. This course will focus on selected systems such as the neuromuscular, cardiovascular, and endocrine control systems. An introduction to the structures and mechanisms responsible for proper functioning of these systems will be given. This course will combine linear control theory, physiology, and neuroscience with the objective of explaining how these complex systems operate in the healthy and diseased human body.

BME395H1 S
Cellular Molecular Bioengineering I
III - AEESCBASEB, IV - AEESCBASEO 3/-/2/0.50

This course focuses on the molecular biology of cells, building on BME105, and their integration into tissues and organs. It covers integrating cells into tissues; molecular genetic techniques; signalling at the cell surface and signalling pathways that control gene activity; integration of signals and gene controls, the eukaryotic cell cycle, cell birth, lineage and death; inflammation, wound healing and immunology. The course will be centered around the problems of tissue engineering and of other medical devices or therapeutic options. There will be considerable emphasis on learning to read the research literature.

BME440H1 F
Bioengineering Instrumentation and Technology
IV - AECHEBASC, III - AEELEBASC, I - AEMINBIO 2/4/-/0.50

This course has a progression of laboratory experiments that start with directed experimentation and leads to open-ended design projects. In this course, the application of a basic science concept learned in other complementary courses will be examined in detail by experimentation. The application of the basic science is evident in their use for laboratory experimentation by introducing the principles and operation of selected biomedical devices used in clinical and laboratory settings. Topics will be drawn from the following list: PCR, microscopy, cellular simulation, protein/DNA/mRNA extraction, protein assays, drug delivery, colorimetric assays of enzymatic activity, industrial and commercial enzyme applications and clinical laboratory testing (see description below for experiments). Design and problem-solving skills will be developed by a design project based on material from the course. Laboratory work will be the main focus on the course and will stress practical applications of material covered in lecture.
Prerequisite: CHE353H1F, Engineering Biology

BME455H1 F
Cellular and Molecular Bioengineering II
IV - AECHEBASC, III - AECPEBASC, III - AEELEBASC, I - AEMINBIO 3/1.50/1/0.50

Quantitative approach to understanding cellular behaviour. Using engineering tools (especially derived from transport phenomena and chemical kinetics) to integrate and enhance what is known about mammalian cell behaviour at the molecular level. The course combines mathematical modeling with biology and includes numerical methods, factorial design, statistics, empirical models, mechanistic models and mass transfer. Specific topics include: receptor-ligand interactions, cell adhesion and migration, signal transduction, cell growth and differentiation. Examples from gene therapy, and cellular and tissue engineering are used.
Prerequisite: CHE353H1 and CHE354H1

BME496H1 F
Cellular Molecular Bioengineering II
IV - AEESCBASEB 3/3/1/0.50

A quantitative approach to understanding cellular behaviour. Using engineering tools (especially derived from transport phenomena and chemical kinetics) to integrate and enhance what is known about mammalian cell behaviour at the molecular level. Specific topics include: receptor-ligand interactions, cell adhesion and migration, signal transduction, cell growth and differentiation. Examples from gene therapy, and cellular and tissue engineering are used.
Prerequisite: BME395H1

BME510H1 S
Regenerative Medicine
IV - AEESCBASEB 4/-/-/0.50

This course integrates relevant aspects of physiology, pathology, developmental biology, disease treatment, tissue engineering, and biomedical devices. The first part of the course will stress basic principles in each of these disciplines. The second portion of the course will integrate these disciplines in the context of specific organ systems. For example, the physiology of the cardiovascular system, the development of the system, cardiovascular disease, the relationship between developmental defects and adult disease,

current disease treatment, cardiovascular devices, and the current progress in cardiovascular tissue engineering will be presented. The teaching material will be gathered from various textbooks and scientific journals. Whenever possible, experts in the relevant field will teach guest lectures. This integrative approach will be reflected by a problem-based learning approach to testing and a written report.

BME595H1 S
Medical Imaging
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASEB, IV - AEESCBASER, I - AEMINBIO 2/1.50/1/0.50

This is a first course in medical imaging. It is designed as a final year course for engineers. It has a physical and mathematical approach emphasizing engineering concepts and design. It describes magnetic resonance and ultrasound and X ray imaging in detail. These topics allow engineers to apply principles learned in the first two years in: computer fundamentals, dynamics, calculus, basic EM theory, algebra and differential equations, signals systems. It is a depth course complementing the kernels: communication systems (modulation), fields and waves (wave propagation) and on probability and random processes (Poisson and Gaussian noise). It will introduce students to the concept of measurement as an “inverse problem”. The laboratory will involve hands on NMR and Ultrasound measurements as well as image analysis of MRI data.

Chemical Engineering and Applied Chemistry

CHE112H1 F/S
Physical Chemistry
I - AECHEBASC, I - AECIVBASC, I - AELMEBASC, I - AEMMSBASC 3/1/1/0.50

A course in physical chemistry. Topics discussed include systems and their states, stoichiometry, the properties of gases, the laws of chemical thermodynamics (calculations involving internal energy, enthalpy, free energy, and entropy), phase equilibrium, chemical equilibrium, ionic equilibrium, acids and bases, solutions, colligative properties, electrochemistry, and corrosion.

CHE113H1 S
Concepts in Chemical Engineering
I - AECHEBASC 3/1/3/0.50

Chemical engineers are employed in extremely diverse fields ranging from medicine to plastics manufacture to the financial industry. This course introduces students to the core chemical engineering competencies of process principles, transport processes, informatics, and chemical engineering science. The competencies are presented in the context of the Department of Chemical Engineering and Applied Chemistry's clustered research areas of biomolecular and biomedical engineering, bioprocess engineering, engineering informatics, environmental science and engineering, advanced inorganic molecular systems, pulp and paper, surface and interface engineering, polymers and polymer processing and sustainable energy. Laboratories will reinforce the core chemical engineering concepts.

CHE204H1 Y
Applied Chemistry III - Laboratory
II - AECHEBASC -/6/-/0.50

This full year laboratory course will survey aspects of inorganic, organic and analytical chemistry from a practical point of view in a comprehensive laboratory experience. Theory, where applicable, will be interwoven within the laboratories or given as self-taught modules. Topics to be covered are inorganic and organic synthesis and analysis and will include elements of process and industrial chemistry and practice (including Green Chemistry).
Corequisite: CHE200H1F, CHE203H1S

CHE208H1 F
Process Engineering
II - AECHEBASC 3/-/2/0.50

An introduction to mass and energy (heat) balances in open systems. A quantitative treatment of selected processes of fundamental industrial and environmental significance involving phase equilibria, reaction and transport phenomena under both steady state and unsteady state conditions. Examples will be drawn from the chemical and materials processing industries, the energy and resource industries and environmental remediation and waste management.
Prerequisite: MAT188H1F

CHE210H1 S
Heat and Mass Transfer
II - AECHEBASC 3/-/2/0.50

Fundamentals of heat and transfer, including conduction, convective heat transfer, natural convection, design of heat exchangers, Fick’s law of diffusion, analysis of mass transfer problems using Fick’s law and mass balances, and effect of chemical reactions on mass transfer. Particular attention is focused on convective heat and mass transfer coefficients as obtained in laminar flow, or from turbulent heat transfer correlations and analogies.
Prerequisite: CHE221H1F

CHE211H1 F
Fluid Mechanics
II - AECHEBASC 3/-/2/0.50

Fundamentals of fluid mechanics including hydrostatics, manometry, Bernoulli’s equation, integral mass, linear momentum and energy balances, engineering energy equation, Moody chart, pipe flow calculations, flow measurement instruments and pumps, dimensional analysis, differential analysis of laminar viscous flow, and brief introductions to particle systems, turbulent 1low, non-Newtonian fluids and flow in porous systems.

CHE213H1 S
Applied Chemistry II - Organic Chemistry
II - AECHEBASC 3/-/1/0.50

Topics include the structure, bonding and characteristic reactions of organic compounds including additions, eliminations, oxidations, reductions, radical reactions, condensation/hydrolysis and rearrangements. The chemical relationships and reactivities of simple functional groups are discussed with an emphasis placed on reaction mechanisms involving the formation of organic intermediates, chemicals and polymers. An introduction will be given on biologically relevant compounds such as carbohydrates, proteins, lipids and nucleic acids. Examples will be discussed which outline the usefulness of these reactions and chemicals within the broader chemical industry.
Corequisite: CHE204H1Y

CHE220H1 F
Applied Chemistry I - Inorganic Chemistry
II - AECHEBASC 3/-/2/0.50

The Chemistry and physical properties of inorganic compounds are discussed in terms of atomic structure and molecular orbital treatment of bonding. Topics include acid-base and donor-acceptor chemistry, crystalline solid state, chemistry of main group elements and an introduction to coordination chemistry. Emphasis is placed on second row and transition metal elements.
Corequisite: CHE20H1Y

CHE221H1 F
Calculus and Numerical Methods
II - AECHEBASC 3/2/2/0.50

Fundamentals of fluid mechanics including hydrostatics, manometry, Bernoulli's equation, integral mass, linear momentum and energy balances, engineering energy equation, Moody chart, pipe flow calculations, flow measurement instruments and pumps, dimensional analysis, differential analysis of laminar viscous flow, and brief introductions to particle systems, turbulent flow, non-Newtonian fluids and flow in porous systems.

CHE222H1 S
Applied Differential Equations
II - AECHEBASC 3/-/2/0.50

Solution of differential equations using the D-operator, Laplace transform methods and vector-matrix techniques. Application of these techniques to problems of chemical engineering interest. Considerable emphasis will be placed on the formulation of the relevant differential equations and the identification of the appropriate boundary conditions.
Prerequisite: MAT186H1F, MAT187H1S

CHE223H1 S
Statistics and Experimental Design
II - AECHEBASC 3/-/2/0.50

Analysis of data using statistics and design of experiments. Topics include probability, properties of the normal distribution, confidence intervals, hypothesis testing, fitting equations to data, analysis of variance and design of experiments. The tutorial involves, in part, the application of commercial software to interpret experimental data, as obtained in Chemical Engineering laboratories.
Prerequisite: MAT186H1F, MAT187H1S

CHE230H1 S
Environmental Chemistry
II - AECHEBASC, III - AECPEBASC, III - AEELEBASC, I - AEMINENV 3/-/2/0.50

The chemical phenomena occurring in environmental systems are examined based on fundamental principles of organic, inorganic and physical chemistry. The course is divided into sections describing the chemistry of the atmosphere, natural waters and soils. The principles applied in the course include reaction kinetics and mechanisms, complex formation, pH and solubility equilibria and adsorption phenomena. Molecules of biochemical importance and instrumental methods of analysis relevant to environmental systems are also addressed. (formerly EDC230H1S)

CHE249H1 F
Engineering Economic Analysis
II - AECHEBASC 3/-/1/0.50

Engineering analysis and design are not ends in themselves, but they are a means for satisfying human wants. Thus, engineering concerns itself with the materials used and forces and laws of nature, and the needs of people. Because of scarcity of resources and constraints at all levels, engineering must be closely associated with economics. It is essential that engineering proposals be evaluated in terms of worth and cost before they are undertaken. In this course we emphasize that an essential prerequisite of a successful engineering application is economic feasibility. Hence, investment proposals are evaluated in terms of economic cost concepts, including break even analysis, cost estimation and time value of money. Effective interest rates, inflation and deflation, depreciation and income tax all affect the viability of an investment. Successful engineering projects are chosen from valid alternatives considering such issues as buy or lease, make or buy, cost and benefits and financing alternatives. Both public sector and for-profit examples are used to illustrate the applicability of these rules and approaches.

CHE260H1 F
Thermodynamics and Heat Transfer
II - AEESCBASE 3/0.50/1/0.50

Classical thermodynamics and its applications to engineering processes. Concepts of energy, heat, work and entropy. First and second laws of thermodynamics. Properties of pure substances and mixtures. Phase equilibrium, and chemical equilibrium.

CHE297Y1 Y
Seminar Course: Communications Portfolio I
II - AECHEBASC -/-/0.25/0.00

Each student will develop a portfolio of communication assignments completed in other university courses. Contents of the portfolio will demonstrate among them a range of skills: individual and group work, written and oral communications; expository, persuasive and research-based writings, and iterative composition. Students will generate a critical reflection on the items included in the portfolio. Those whose communication work is not up to standard will be provided with opportunity for remedial work. The course will allow for integration of communication work across the curriculum. The course will be offered on a credit/no credit basis. Students who receive no credit for this course must retake it in year 3.

CHE298H1 F
Communication
II - AECHEBASC -/-/2/0.25

Each student will make a large number of very short speeches developing skills for speaking to large and small groups. Many elements of public speaking are explored: voice, body language, timing, word selection, speech preparation, speech structure, audience and surroundings. Students will prepare and present overheads. Extemporaneous speeches. Questions and answers. Interviewing.

CHE308H1 F
Chemical Processes for Energy Generation and Storage
III - AEESCBASEJ 3/-/1/0.50

The chemistry and chemical engineering involved in various forms of power generation and storage: alternative liquid fuels, nuclear power, fuel cells, solar cells/photovoltaics. A team-taught course with instruction from leading experts within the Faculty. Lectures will be focused around the presentation and analysis of recent published

accounts or a review of the state of the art, while providing the necessary background within each field to enable the students to make objective critiques of the topics discussed. Where applicable, the design of facilities and devices for the forms of generation or storage will be discussed.

CHE311H1 S
Separation Processes
III - AECHEBASC 3/4/2/0.75

Staged equilibrium and rate governed separation processes for gases and liquids. Topics include equilibrium stage calculations, cascade separation, binary distillation, gas absorption and stripping, liquid-liquid extraction, membrane processes, adsorption and ion exchange. Experiments in fluid mechanics, heat transfer and related unit operations.

CHE322H1 S
Process Dynamics and Control
III - AECHEBASC 3/0.25/2/0.50

The major goals of this course are to teach students how to model chemical processes and how to design control strategies for these processes. The first part of the course focuses on the types of interconnections encountered in chemical engineering, namely feedback, parallel and series connections, and their effect on the process dynamics. The second part of the course looks at the design of feedback, feedforward, cascade and multivariable control strategies for these processes and interprets these types of “engineered” interconnections in terms of the effect they have on the performance of the overall system. This course will make extensive use of interactive learning through computer simulation based on the Matlab software package and its associated Simulink block diagram simulation environment.

CHE323H1 F
Engineering Thermodynamics
III - AECHEBASC, I - AEMINENR 3/4/2/0.50

Classical thermodynamics and its applications to engineering processes are introduced. Topics include: the concepts of energy, work and entropy; the first and second laws of thermodynamics; properties of pure substances and mixtures; the concepts of thermal equilibrium, phase equilibrium and chemical equilibrium; and heat engines and refrigeration cycles.

CHE324H1 F
Process Design
III - AECHEBASC 3/4/2/0.75

This course presents the philosophy and typical procedures of chemical engineering design projects. The course begins at the design concept phase. Material and energy balances are reviewed along with the design of single unit operations and equipment specification sheets. The impact of recycles on equipment sizing is covered. Safety, health and environmental regulations are presented. These lead to the development of safe operating procedures. The systems for developing Piping and Instrumentation diagrams are presented. Process safety studies such as HAZOPS are introduced. Typical utility systems such as steam, air and vacuum are discussed. Project economics calculations are reviewed.

CHE326H1 F
Thermodynamics and Kinetics Laboratory
III - AECHEBASC -/4/-/0.25

This one term laboratory course involves experiments investigating thermodynamics and kinetics, complimenting two courses this term. Thermodynamic experiments include phase equilibrium and calorimetry, and kinetics experiment include ivestigations of rate constants and Arrhenius behvaiour.

CHE332H1 F
Reaction Kinetics
III - AECHEBASC 3/-/2/0.50

The rates of chemical processes. Topics include: measurement of reaction rates, reaction orders and activation energies; theories of reaction rates; reaction mechanisms and networks; development of the rate law for simple and complex kinetic schemes; approach to equilibrium; homogeneous and heterogeneous catalysis. Performance of simple chemical reactor types.

CHE333H1 S
Chemical Reaction Engineering
III - AECHEBASC, III - AEESCBASEB 3/-/2/0.50

Covers the basics of simple reactor design and performance, with emphasis on unifying the concepts in kinetics, thermodynamics and transport phenomena. Topics include flow and residence time distributions in various reactor types as well as the influence of transport properties (bulk and interphase) on kinetics and reactor performance. The interplay of these facets of reaction engineering is illustrated by use of appropriate computer simulations.

CHE334H1 S
Team Strategies for Engineering Design
III - AECHEBASC 1/-/2/0.25

In this course, team strategies including how teams work, how to lead and manage teams, and decision making methodologies for successful teams will be taught in the context of engineering design. The development of problem solving and design steps will be undertaken. This course will be taught with an emphasis on team development and problem solving as it relates to the practice of process safety management in engineering and engineering design. The teams will develop a PFD and P&ID’s, as well as an operating procedure for a portion of the process. Thus, environmental and occupational health and safety becomes the vehicle through which the teamwork is performed.

CHE341H1 F
Engineering Materials
IV - AECHEBASC 3/-/1/0.50

This course advances the understanding of the use of materials in engineering design, with special emphasis on corrosion and the effect of chemical environment on long term failure modes. Students will learn how to apply material property data to specify materials for load bearing applications, thermal and other non-structural applications, and chemical containment and transport. Topics will include strength of materials concepts, an introduction to computerized materials databases, material failure modes and criteria, principles of corrosion, and practical applications of corrosion prediction and mitigation. Students are required to design a component of their choice and do a detailed materials selection as a major design project.

CHE353H1 F
Engineering Biology
IV - AECHEBASC, IV - AECIVBASC, III - AECPEBASC, III - AEELEBASC, III - AEINDBASC, III - AEMECBASC, I - AEMINBIO, IV - AEMMSBASC — 3/-/1/0.50

Using a quantitative, problem solving approach, this course will introduce basic concepts in cell biology and physiology. Various engineering modelling tools will be used to investigate aspects of cell growth and metabolism, transport across cell membranes, protein structure, homeostasis, nerve conduction and mechanical forces in biology.
Exclusion: BME105H1

CHE354H1 S
Cellular and Molecular Biology
IV - AECHEBASC, IV - AECIVBASC, III - AECPEBASC, III - AEELEBASC, III - AEINDBASC, III - AEMECBASC, I - AEMINBIO, IV - AEMMSBASC — 3/0.50/2/0.50

This course will cover the principles of molecular and cellular biology as they apply to both prokaryotic and eukaryotic cells. Topics will include: metabolic conversion of carbohydrates, proteins, and lipids; nucleic acids; enzymology; structure and function relationships within cells; and motility and growth. Genetic analysis, immunohistochemistry, hybridomis, cloning, recombinant DNA and biotechnology will also be covered. This course will appeal to students interested in environmental microbiology, biomaterials and tissue engineering, and bioprocesses. Prerequisite: CHE353H1F

CHE374H1 F
Economic Analysis and Decision Making
III - AEESCBASEA, III - AEESCBASEB, III - AEESCBASEF, III - AEESCBASEI, III - AEESCBASEJ, III - AEESCBASEO, III - AEESCBASEP, III - AEESCBASER — 3/-/1/0.50

Economic evaluation and justification of engineering projects and investment proposals. Cost estimation; financial and cost accounting; depreciation; inflation; equity, bond and loan financing; after tax cash flow; measures of economic merit in the private and public sectors; sensitivity and risk analysis; single and multi-attribute decisions. Introduction to micro-economic. Applications: retirement and replacement analysis; make-buy and buy-lease decisions; economic life of assets; capital budgeting; selection from alternative engineering proposals; production planning; investment selection.

CHE375H1 S
Engineering Finance and Economics
III - AEESCBASEF — 3/-/1/0.50

This course consists of three modules: 1) managerial accounting, 2) corporate finance and 3) macro economics. The first module, managerial accounting, will consist of an introduction to financial statements and double entry recordkeeping, then delve deeper into aspects of revenue, expenses, assets, debt and equity.The second module, corporate finance, will introduce the concept of risk and return, and the Capital Asset Pricing Model, and then delve deeper into capital budgeting, corporate financing, financial statement analysis and financial valuation. The third model, macro economics, will introduce global aspects of business, including economic, political, societal and technological, then discuss factors such as GDP, inflation, unemployment, interest rates, foreign exchange rates, fiscal debt/surplus and balance of payments, and their impact on the financials of a given country.

CHE390H1 F
Physical and Inorganic Chemistry
III - AEESCBASEB, III - AEESCBASEO — 3/-/1/0.50

The objective of this course is to introduce fundamental chemistry required in order to understand environmental systems. The chemistry of inorganic compounds will be introduced in terms of atomic orbitals, molecular structure, periodic trends and coordination chemistry. The impact of pH, oxidation potential and complexation on chemical speciation will be described and related to chemistry in natural waters. Intermediate level concepts relevant to chemical kinetics such as rate laws and mechanisms will be presented and applied to photochemistry and atmospheric chemistry. Partitioning in multiphase systems will be discussed with emphasis on adsorption and chemistry in water/soil systems.

CHE391H1 F
Organic Chemistry and Biochemistry
III - AEESCBASEB, III - AEESCBASEO — 3/1/1/0.50

This course examines the sources, structures, properties and reactions of organic chemicals with reference to their interactions with the environment. Industrial organic chemistry, biochemical compounds and relevant biochemical reactions will be discussed.

CHE393H1 F
Biotransport Phenomena
III - AEESCBASEB — 3/1/1/0.50

Fundamentals of momentum, heat and mass transfer. Topics include mass, linear momentum and energy balances: Differential analysis of laminar viscous flow, heat conduction and diffusion, and convective transport. Examples from environmental and biomedical systems will be discussed.

CHE397Y1 Y
Seminar Course: Communications Portfolio II
III - AECHEBASC — -/-/0.25/0.00

This course builds on the work begun in CHE297Y. Each student will develop a portfolio of communication assignments completed in other university courses. Contents of the portfolio will demonstrate among them a range of skills: individual and group work, written and oral communications; expository, persuasive and research-based writings, and iterative composition. Students will generate a critical reflection on the items included in the portfolio. Those whose communication work is not up to standard will be provided with opportunity for remedial work. The course will allow for integration of communication work across the curriculum. Students who complete this course will be prepared to make presentations which are a part of the capstone course, CHE430Y Chemical Plant Design. The course will be offered on a credit/no credit basis. Students who receive no credit for this course must retake it in year 4.

CHE403H1 S
Professional Practice
IV - AECHEBASC — 2/-/-/0.25

In this course, lectures and seminars will be given by practicing engineers who will cover the legal and ethical responsibility an engineer owes to an employer, a client and the public with particular emphasis on environmental issues.

CHE412H1 S
Advanced Reactor Design
IV - AECHEBASC, IV - AEESCBASEJ 3/-/1/0.50

Heterogeneous reactors. Mass and heat transport effects including intraparticle transport effects (Thiele modulus). Stability for various rate laws, transport regimes. Time dependent issues - deactivation/regeneration strategies. Emerging processes.

CHE430Y1 F
Chemical Plant Design
IV - AECHEBASC 2/-/6/1.00

Students work in teams to design plants for the chemical and process industries and examine their economic viability. Lectures concern the details of process equipment and design.
Prerequisite: CHE249H1F, CHE324H1F, and two of CHE311H1S, CHE322H1S, CHE333H1S or equivalent)

CHE451H1 F
Petroleum Processing
IV - AECHEBASC, IV - AEESCBASEJ, I - AEMINENR 3/-/1/0.50

This course is aimed at surveying the oil industry practices from the perspective of a block flow diagram. Oil refineries today involve the large scale processing of fluids through primary separation techniques, secondary treating plus the introduction of catalyst for molecular reforming in order to meet the product demands of industry and the public. Crude oil is being shipped in increasing quantities from many parts of the world and refiners must be aware of the properties and specifications of both the crude and product slates to ensure that the crude is a viable source and that the product slate meets quality and quantity demands thus assuring a profitable operation. The course content will examine refinery oil and gas operations from feed, through to products, touching on processing steps necessary to meet consumer demands. In both course readings and written assignments, students will be asked to consider refinery operations from a broad perspective and not through detailed analysis and problem solving.
Exclusion: CHE470H1/CHE472H1 if the topic was Petroleum Processing

CHE460H1 S
Environmental Pathways and Impact Assessment
IV - AECHEBASC, I - AEMINENV 3/-/2/0.50

Review of the nature, properties and elementary toxicology of metallic and organic contaminants. Partitioning between environmental media (air, aerosols, water, particulate matter, soils, sediments and biota) including bioaccumulation. Degradation processes, multimedia transport and mass balance models. Regulatory approaches for assessing possible effects on human health and ecosystems.

CHE461H1 S
Chemical Properties of Polymers
IV - AECHEBASC, IV - AEESCBASEB, I - AEMINBIO, IV - AEMMSBASC 3/0.25/1/0.50

Several methods of polymer synthesis and characterization are discussed. This includes a discussion on the mechanism of step polymerization and chain polymerization by radical or ionic techniques. Further detail is provided on emulsion vs. Solution vs. Bulk polymerization methods and the associated kinetics of polymerization. Several polymer characterization techniques are introduced, including gel permeation chromatography, differential scanning calorimetry, thermal gravimetric analysis, among others.
Exclusion: MSE330H1S , CHM325H1S

CHE462H1 S
Food Engineering
IV - AECHEBASC, I - AEMINBIO 3/0.50/1/0.50

The quantitative application of chemical engineering principles to the large-scale production of food. Food processing at the molecular and unit operation levels. The chemistry and kinetics of specific food processes. The application of chemical engineering unit operations (distillation, extraction, drying) and food specific unit operations such as extrusion, thermal processing refrigeration/freezing.

CHE463H1 S
Polymer Science & Engineering
IV - AECHEBASC 3/-/1/0.50

This course provides an introduction to polymer science and engineering. The fundamentals of polymer properties and how they are affected by processing are first broadly presented and then illustrated using a case study approach. Polymer molecular and physical properties as well as flow and mechanical properties are examined. Specific examples include: the polymerization of methyl methacrylate, the reactive extrusion of polyethylene, the blending of polyethylene with polypropylene and microencapsulation by spray drying. Consequences of the need to recycle waste plastic are considered throughout.

CHE466H1 F
Bioprocess Engineering
IV - AECHEBASC, IV - AEESCBASEB, I - AEMINBIO, I - AEMINENV 3/0.66/1/0.50

An introduction to the biological and engineering principles relevant to the processing of biological materials and to processing using biological agents, such as cells, enzymes or antibodies. Topics to be covered include elementary microbiology, enzyme kinetics, immobilization of biocatalysts, bioreactor design/analysis and bioseparation processes.
Prerequisite: CHE353H1F

CHE467H1 F
Environmental Engineering
IV - AECHEBASC, IV - AEESCBASEO, I - AEMINENR, I - AEMINENV 3/-/1/0.50

Core Course in the Environmental Engineering Minor A course which treats environmental engineering from a broad based but quantitative perspective and covers the driving forces for engineering activities as well as engineering principles. Models which are used for environmental impact, risk analysis, health impact, pollutant dispersion, and energy system analysis are covered.
Exclusion: ECV360H1/CIV440H1

CHE469H1 S
Fuel Cells and Electrochemical Conversion Devices
IV - AECHEBASC, IV - AEESCBASEJ, I - AEMINENR 3/-/1/0.50

The objective of this course is to provide a foundation for understanding the field of electrochemical conversion devices with particular emphasis on fuel cells. The topics will proceed from the fundamental thermodynamic in-system electodics and ionic interaction limitations to mass transfer and heat balance effects,t o the externalities such as economics and system integration challenges. Guest lecturers from the fuel cell industry will be invited to procide an industrial perspective. Participants will complete a paper and in-class presentation.
Exclusion: MIE517H1

CHE470H1 F/S
Special Topics in Chemical Engineering
IV - AECHEBASC 3/-/1/0.50

A course covering selected topics in Chemical Engineering, not covered in other electives. Different topics may be covered each year depending on the interest of the Staff and students. May not be offered every year. Limited enrolment: permission of the Department required.

CHE471H1 F
Modelling in Chemical Engineering
IV - AECHEBASC, IV - AEESCBASEJ 3/-/1/0.50

This course outlines the methodology for the modelling of physical systems and its applications. Topics will include a review of physical laws, selection of balance space, compartmental versus distributed models, and applications of the conservation laws including force, and energy balances for both discrete and continuous systems at the level of algebraic and ordinary differential equations. The course covers a wide range of applications including environmental issues, biochemical processes, biomedical systems, material science, transport phenomena, and unit operations.

CHE488H1 S
Entrepreneurship and Business for Engineers
3/-/2/0.50

A complete introduction to small business formation, management and wealth creation. Topics include: the nature of the Entrepreneur and the Canadian business environment; business idea search and Business Plan construction; Buying a business, franchising, taking over a family business; Market research and sources of data; Marketing strategies promotion, pricing, advertising, electronic channels and costing; The sales process and management, distribution channels and global marketing; Accounting, financing and analysis, sources of funding, and financial controls; The people dimension: management styles, recruiting and hiring, legal issues in employment and Human Resources; Legal forms of organization and business formation, taxation, intellectual property protection; the e-Business world and how businesses participate; Managing the business: location and equipping the business, suppliers and purchasing, credit, ethical dealing; Exiting the business and succession, selling out. A full Business Plan will be developed by each student and the top submissions will be entered into a Business Plan competition with significant cash prices for the winners. Examples will be drawn from real business situations including practicing entrepreneurs making presentations and class visits during the term. (Identical courses are offered: ECE488H1F, MIE488H1F, MSE488H1F and CIV488H1S.)

*Complementary Studies Elective
Exclusion: APS234H1, APS432H1

CHE499Y1 Y
Thesis
IV - AECHEBASC -/7/-/1.00

The course consists of a research project conducted under the supervision of a senior staff member. The project may have an experimental, theoretical or design emphasis. Each thesis will contain a minimum 60% combined Engineering Science and Engineering Design (with a minimum of 10% in each component). This course is open to students with permission of the Department and research project supervisor.

CHE507H1 S
Data-based Modelling for Prediction and Control
IV - AECHEBASC, IV - AEESCBASEB 3/-/1/0.50

This course will teach students how to build mathematical models of dynamic systems and how to use these models for prediction and control purposes. The course will deal primarily with a system identification approach to modelling (using observations from the system to build a model). Both continuous time and discrete time representations will be treated along with deterministic and stochastic models. This course will make extensive use of interactive learning by having students use computer based tools available in the Matlab software package (e.g. the System Identification Toolbox and the Model Predictive Control Toolbox).

CHE553H1 F
Electrochemistry
IV - AECHEBASC, IV - AEESCBASEJ, I - AEMINENR 3/-/1/0.50

This course provides a working knowledge of modern electrochemistry. The topics dealt with include, the physical chemistry of electrolyte solutions, ion transport in solution, ionic conductivity, electrode equilibrium, reference electrodes, electrode kinetics, heat effects in electrochemical cells, electrochemical energy conversion (fuel cells and batteries), and industrial electrochemical processes. Numerous problems are provided to clarify the concepts.

CHE561H1 S
Risk Based Safety Management
IV - AECHEBASC 3/-/1/0.50

This course provides an introduction to Process Safety Management. The historical drivers to improve safety performance are reviewed and the difference between safety management and occupational health and safety is discussed. National and international standards for PSM are reviewed. Risk analysis is introduced along with techniques for process hazard analysis and quantification. Consequence and frequency modelling is introduced. Rsik based decision making is introduced, and the course concludes with a discussio of the key management systems required for a successful PSM system.
Exclusion: CHE470H1/CHE472H1 if the topic was Risk Based Safety Management

CHE564H1 S
Pulp and Paper Processes
IV - AECHEBASC, I - AEMINBIO, I - AEMINENV 3/-/1/0.50

The processes of pulping, bleaching and papermaking are used to illustrate and integrate chemical engineering principles. Chemical reactions, phase changes and heat, mass and momentum transfer are discussed. Processes are examined on four scales: molecular, diffusional, unit operations and mill. In the tutorial each student makes several brief presentations on selected topics and entertains discussion.

CHE565H1 F
Aqueous Process Engineering
IV - AECHEBASC, IV - AEESCBASEJ, I - AEMINENV, IV - AEMMSBASC 3/-/1/0.50

Application of aqueous chemical processing to mineral, environmental and industrial engineering. The course involves an introduction to the theory of electrolyte solutions, mineral-water interfaces, dissolution and crystallization processes, metal ion separations, and electrochemical processes in aqueous reactive systems. Applications and practice of (1) metal recovery from primary (i.e. ores) and secondary (i.e. recycled) sources by hydrometallurgical means, (2)

treatment of aqueous waste streams for environmental protection, and (3) production of high-value-added inorganic materials.

CHE568H1 S
Nuclear Engineering
IV - AECHEBASC, IV - AEESCBASEJ, IV - AEESCBASEP, I - AEMINENR 3/-/1/0.50

Fundamental and applied aspects of nuclear engineering. The structure of the nucleus; nuclear stability and radioactive decay; the interaction of radiation with matter including radiological health hazards; the interaction of neutrons including cross-sections, flux, moderation, fission, neutron diffusion and criticality. Poison buildup and their effects on criticality. Nuclear engineering of reactors, reactor accidents, and safety issues.
Exclusion: MIE414H1

CHE575H1 F
Mechanical Properties of Bio-Composites and Biomaterials
IV - AECHEBASC, IV - AEESCBASEB, I - AEMINBIO 3/-/1/0.50

The course provides an overview on mechanical properties of biological materials, biomaterials for biomedical applications, and bio-fibre reinforced composites based on renewable resources with a focus on their viscoelastic and dynamic behaviour. General principles related to elasticity, linear viscoelasticity, and composite reinforcement theory will be introduced. Some testing and measurement techniques for these properties will be also discussed.

Chemistry

CHM325H1 F/S
Introduction to Inorganic and Polymer Materials Chemistry
III - AEESCBASEO 2/-/-/0.50

Fashioned to illustrate how inorganic and polymer materials chemistry can be rationally used to synthesize superconductors, metals, semiconductors, ceramics, elastomers, thermoplastics, thermosets and polymer liquid crystals, with properties that can be tailored for applications in a range of advanced technologies. Coverage is fairly broad and is organized to crosscut many aspects of the field.
Prerequisite: CHM220H1/CHM225Y1, CHM238Y1, CHM247H1/CHM249H1

CHM410H1 F
Analytical Environmental Chemistry
I - AEMINENV 3/3/-/0.50

An analytical theory, instrumental, and methodology course focused on the measurement of pollutants in soil, water, air, and biological tissues and the determination of physical/chemical properties including vapour pressure, degradation rates, partitioning. Lab experiments involve application of theory.
Prerequisite: CHM310H1
Recommended Preparation: CHM317H1

CHM415H1 F/S
Atmospheric Chemistry
IV - AECHEBASC, I - AEMINENV 3/-/-/1.00

This course considers the chemistry occurring in the Earth's atmosphere, with emphasis on developing molecular-level understanding of the photochemistry, free-radical kinetics, and heterogeneous chemistry that occurs. Topics include stratospheric ozone depletion, trace gas oxidation, urban air pollution, acid rain, and the connections between aerosols and climate.
Prerequisite: CHM220H1/CHM225Y1/CHM310H1
Recommended Preparation: MAT135Y1/MAT137Y1; PHY138Y1/140Y1/(PHY131H1, PHY132H1)/(PHY151H1, PHY152H1)

CHM426H1 S
Polymer Chemistry
IV - AEESCBASEO 2/-/-/0.50

Scope of polymer chemistry. Classification of polymers. Synthesis and characterization. Polymers in solution. Thermodynamics of polymer solutions and blends, Flory-Huggins theory. Polymers in the solid state. Crystalline and amorphous polymers. Glass transition and melting temperature. Mechanical properties. Polymers as advanced materials.
Prerequisite: CHM325H1, CHM328H1, CHM348H1

CHM434H1 F
Advanced Materials Chemistry
IV - AEESCBASEO 2/-/-/0.50

A comprehensive investigation of synthetic methods for preparing diverse classes of inorganic materials with properties intentionally tailored for a particular use. Begins with a primer on solid-state materials and electronic band description of solids followed by a survey of archetypical solids that have had a dramatic influence on the materials world, some new developments in materials chemistry and a look at perceived future developments in materials research and technology. Strategies for synthesizing many different classes of materials with intentionally designed structures and compositions, textures and morphologies are then explored in detail emphasizing how to control the relations between structure and property of materials and ultimately function and utility. A number of contemporary issues in materials research are critically evaluated to appreciate recent highlights in the field of materials chemistry - an emerging sub-discipline of chemistry.
Prerequisite: CHM325H1, CHM338H1

CHM446H1 F
Organic Materials Chemistry
IV - AEESCBASEO 2/-/-/0.50

This course covers design, synthesis, characterization and application of organic materials. Emphasis is placed on classic examples of organic materials including semiconducting polymers, molecular devices, self-assembled systems, and bioconjugates, as well as recent advances from the literature.

Civil Engineering

CIV100H1 F
Mechanics
I - AECHEBASC, I - AECIVBASC, I - AECPEBASC, I - AEELEBASC, I - AEENGBASC, I - AEINDBASC, I - AELMEBASC, I - AEMECBASC, I - AEMMSBASC 3/-/2/0.50

The principles of statics are applied to composition and resolution of forces, moments and couples. The equilibrium states of structures are examined. Throughout, the free body diagram concept is emphasized. Vector algebra is used where it is most useful, and stress blocks are introduced. Shear force diagrams, bending moment diagrams and stress-strain relationships for materials are discussed. Stress and deformation in axially loaded members and flexural members (beams) are also covered.

CIV102H1 F
Structures and Materials - An Introduction to Engineering Design
I - AEESCBASE 3/-/2/0.50

An introduction to the art and science of designing structures; material bodies that sustain or resist forces. Force, work, energy, stress, strain. The properties of engineering materials: strength, stiffness, ductility. Simple structural elements. Engineering beam theory. Stability of columns. The practical problems which constrain the design of structures such as bridges, towers, pressure vessels, dams, ships, aircraft, bicycles, birds, and trees are described. Design methods aimed at producing safe, functional, efficient and elegant structures are introduced.

CIV201H1 F
Introduction to Civil Engineering
II - AECIVBASC -/-/-/0.20

A field-based course introducing students to current and historical civil engineering works in the urban and natural environments, highlighting the role of the Civil Engineer in developing sustainable solutions. It will run the Tuesday through Thursday immediately following Labour Day, with follow-up assignments coordinated with the course CIV282 Engineering Communications I. Students must have their own personal protective equipment (PPE). One night will be spent at the University of Toronto Survey Camp near Minden, Ontario.

CIV209H1 S
Civil Engineering Materials
II - AECIVBASC 3/2/2/0.50

Deals with the basic principles necessary for the use and selection of materials used in Civil Engineering and points out the significance of these in practice. Fundamentals which provide a common basis for the properties of various materials are stressed. The laboratory time is devoted to demonstrations illustrating the fundamentals covered in lectures.
Prerequisite: CME210H1.

CIV214H1 S
Structural Analysis I
II - AECIVBASC 3/-/2/0.50

This course provides an introduction to the nature of loads and restraints and types of structural elements, and then reviews the analysis of statically determinate structures. Shear and moment diagrams for beams and frames are considered, along with influence lines, cantilever structures, three-pin arches, cables and fatigue. Virtual work principles are viewed and applied to various structural systems. An introduction to the analysis of indeterminate structures is made, and the Portal method is applied to the analysis of building frames under lateral loads. Displacement methods of an analysis including moment distribution are also studied.
Prerequisite: MAT188H1 F, CIV210H1/CME210H1

CIV220H1 F
Urban Engineering Ecology
II - AECIVBASC, III - AECPEBASC, III - AEELEBASC, III - AEINDBASC, III - AEMECBASC, I - AEMINENV 3/-/1/0.50

Core Course in the Environmental Engineering Minor Basic concepts of ecology within the context of urban environments. Response of organisms, populations, dynamic predator-prey and competition processes, and ecosystems to human activities. Thermodynamic basis for food chains, energy flow, biodiversity and ecosystem stability. Biogeochemical cycles, habitat fragmentation and bioaccumulation. Introduction to industrial ecology and life cycle assessment principles. Urban metabolism and material flow analysis of cities. Response of receiving waters to pollution and introduction to waste water treatment. Emphasis is on identifying the environment/engineering interface and minimizing environmental impacts.
Prerequisite: CHE112H1.
Exclusion: EDV220H1

CIV235H1 S
Civil Engineering Graphics
II - AECIVBASC 2/2/2/0.50

Fluency in graphical communication skills as part of the civil engineering design process is emphasized. Drawings are prepared making use of freehand sketching, drafting equipment and commercially available computer drafting programs. Topics in descriptive geometry are covered to develop spatial visualization skills. Drawing procedures and standards relevant to Civil Engineering projects to be covered include layout and development of multiple orthographic views, sectional views, dimensioning, and pictorial views. Class projects, assignments and lecture examples demonstrate how graphical skills fit into the overall design process.

CIV250H1 S
Hydraulics and Hydrology
IV - AECHEBASC, II - AECIVBASC, IV - AELMEBASC 3/1.50/1/0.50

The hydrologic processes of precipitation and snowmelt, evapotranspiration, ground water movement, and surface and subsurface runoff are examined. Water resources sustainability issues are discussed, including water usage and water shortages, climate change impacts, land use impacts, and source water protection. Conceptual models of runoff and basics of hydrologic modelling are developed, including runoff hydrographs, the unit hydrograph method and the Rational method. Methods for statistical analysis of hydrologic data, concepts of risk and design, and hydrological consequences of climate change for design are introduced. Principles of open channel hydraulics are applied to design of lined and unlined channels. Energy and momentum principles are studied with application to channel transitions, critical flow, choked flow, hydraulic jumps, and gradually varied flow. Methods for natural channel design and channel restoration are examined.
Exclusion: EDV250H1.

CIV280H1 F
Management of Construction
II - AECIVBASC, IV - AEESCBASEI, IV - AELMEBASC 3/-/2/0.50

An introduction to the management of construction projects including: the nature of the industry, project delivery alternatives, legal and ethical considerations, the Safety Act and construction regulations, labour relations, construction contracts, risk distribution, project planning and scheduling, estimating and bidding, controlling of time, cost and quality, accounting leading to financial statements, dispute resolution, as well as new and evolving concepts in managing construction.
Exclusion: CIV320H1.

CIV282H1 F
Engineering Communications I
II - AECIVBASC 1/-/1/0.20

This course develops students' communications skills focusing on the specific skills required for work in foundational civil engineering. Target communication areas include: Oral Presentation; Logical Argument; Document Development; Sentence and Discourse Control; and Visual Design. The course will build capacity in support of specific assignments delivered in other courses in the same term.

CIV300H1 F
Terrestrial Energy Systems
IV - AECHEBASC, IV - AECIVBASC, III - AECPEBASC, III - AEELEBASC, III - AEINDBASC, III - AEMECBASC, I - AEMINENR, I - AEMINENV 3/-/2/0.50

Core Course in the Sustainable Energy Minor Various earth systems for energy transformation, storage and transport are explored. Geological, hydrological, biological, cosmological and oceanographic energy systems are considered in the context of the Earth as a dynamic system, including the variation of solar energy received by the planet and the redistribution of this energy through various radiative, latent and sensible heat transfer mechanisms. It considers the energy redistribution role of large scale atmospheric systems, of warm and cold ocean currents, the role of the polar regions, and the functioning of various hydrological systems. The contribution and influence of tectonic systems on the surface systems is briefly introduced, as well the important role of energy storage processes in physical and biological systems, including the accumulation of fossil fuel reserves.
Exclusion: EDV300H1.

CIV301H1 S
Design of Hydro and Wind Electric Plants
III - AEESCBASEJ 3/-/2/0.50

Introduction to the applications of turbo-machinery. Description of typical wind and hydroelectric plants; different types of turbo-machines. Fundamental fluid mechanics equations, efficiency coefficients, velocity triangles, characteristic curves, similarity laws, specific speed, vibration, cavitation of hydraulic turbines, pump/turbines; variable speed machines. Estimation of main dimensions of machine units, machine house, waterways, electrical and civil structure; transients and stability. Layout of electric and storage plants. Major and auxiliary equipments and systems. Small and mini plants. Case studies.
Exclusion: EDV301H1.

CIV312H1 F
Steel and Timber Design
III - AECIVBASC 3/-/2/0.50

An introduction to structural engineering design. Topics discussed include safety and reliability, load and resistance, probability of failure, performance factors, and material properties. A study of basic steel design examines tension members, compression members, beams, framing concepts and connections. Plasticity and composite action in steel structural systems are also discussed. Timber design aspects include beams, compression members and connections.
Prerequisite: CIV214H1, CIV235H1.

CIV313H1 S
Reinforced Concrete I
III - AECIVBASC 3/-/2/0.50

An introduction to the design of reinforced concrete structures. Concrete technology, properties of concrete and reinforcing steel, construction practice, and general code requirements are discussed. Analysis and design of members under axial load, flexure, shear, and restraint force are examined in detail. Other aspects of design covered include control of cracks, minimum and maximum reinforcement ratios, fire resistance, durability, distress and failure, and design of formwork and shoring.
Prerequisite: CIV214H1, [CIV312H1 or CIV314H1].

CIV324H1 S
Geotechnical Engineering II
III - AECIVBASC, IV - AELMEBASC 3/1/1/0.50

Building on CME321, more complex aspects of geotechnical analysis and design are considered. Soil identification and classification and laboratory- and field-based soil index tests; correlations of index test results to engineering properties. Coupled shear and volume change, soil deformations; serviceability limit state design of shallow and deep foundations, shored excavations. Soil-structure interaction; tie backs and reinforced earth. Laboratories for soil identification and classification, confined triaxial compression (drained and undrained tests), and reinforced earth model.
Prerequisite: CIV321H1 or CME321H1.

CIV331H1 F
Transport I - Introduction to Urban Transportation Systems
III - AECIVBASC 3/-/1/0.50

This course introduces the fundamentals of transportation systems and the application of engineering, mathematical and economic concepts and principles to address a variety of transportation issues in Canada. Several major aspects of transportation engineering will be addressed, including transportation planning, public transit, traffic engineering, geometric design, pavement design and the economic, social and environmental impacts of transportation. The course focuses on urban transportation engineering problems. (not offered 2009/2010)

CIV332H1 S
Transport II - Performance
III - AECIVBASC 3/-/1/0.50

This course focuses on the fundamental techniques of transportation systems performance analysis with emphasis on congested traffic networks. Topics include transportation demand, supply and equilibrium, traffic assignment, network equilibrium, and system optimality, traffic flow theory, shockwaves, highway capacity analysis, introduction to deterministic and stochastic queuing analyses, intersection signal control types and related timing methods, and

traffic simulation. The course also provides an introduction to basic elements of Intelligent Transportation Systems (ITS).

CIV340H1 S
Municipal Engineering
III - AECIVBASC 3/-/2/0.50

Municipal service systems for water supply and wastewater disposal, land development, population forecasting, and demand analysis. Water supply: source development, transmission, storage, pumping, and distribution networks. Sewerage and drainage, sewer and culvert hydraulics, collection networks, and storm water management. Maintenance and rehabilitation of water and wastewater systems, and optimization of network design. Design projects.
Prerequisite: EDV250H1 or CIV250H1.
Exclusion: CIV540H1.

CIV342H1 F
Water and Wastewater Treatment Processes
IV - AECHEBASC, III - AECIVBASC, I - AEMINBIO, I - AEMINENV 3/1/-/0.50

Principles involved in the design and operation of water and wastewater treatment facilities are covered, including physical, chemical and biological unit operations, advanced treatment and sludge processing.

CIV352H1 F
Structural Design 1
III - AEESCBASEI 3/-/2/0.50

The course covers the analysis of determinate and indeterminate structures, with application of the principles to the design of steel bridges. The nature of loads and structural safety is considered, with reference to the Canadian Highway Bridge Design Code. Shear and bending moment diagrams for beams and frames are reviewed, as is the deflection of beams (by various methods) and the deflection of trusses. Classical bridge types, such as arches, trusses and suspension bridges are analyzed. Analysis tools studied include: Influence Lines, virtual work, fatigue, displacement methods for the analysis of indeterminate structures (including moment distribution for continuous beams), plus solution by computer frame analysis programs. The behaviour and design of basic steel members covers: tension members, compression members, beams, beam-columns and simple connections. Plastic analysis is introduced and applied to continuous beams. The expertise gained in structural analysis and steel design is then applied in a steel bridge design project.
Prerequisite: CIV102H1 or equivalent.

CIV355H1 F
Urban Operations Research
III - AEESCBASEI 3/-/2/0.50

This course focuses on quantitative methods and techniques for the analysis and modelling of urban transportation systems. Major topics include probabilistic modelling, queuing models of transport operations, network models, and simulation of transportation systems. The application of these methods to modelling various components of the transportation system (including road, transit and pedestrian facilities) is emphasized in this course.

CIV357H1 S
Structural Design 2
III - AEESCBASEI 3/-/2/0.50

Building on the "Structural Design I" course, further analysis tools for indeterminate structural systems are studied with generalized flexibility and stiffness methods. Loadings due to force, support displacement, temperature change and member prestrain are covered. Timber design aspects include material properties, beams, compression members and simple connections. The behaviour and design of basic reinforced concrete elements covers concrete properties and members under axial load, shear and bending. Other practical aspects of design incorporated are crack control, minimum and maximum reinforcement ratios, durability, formwork and shoring. The aptitude for structural analysis and concrete design is then tested in a low-rise, reinforced concrete building design project.
Prerequisite: CIV352H1 F

CIV359H1 S
Intelligent Transportation Systems
III - AEESCBASEI 3/-/1/0.50

This course focuses on modern techniques to optimize the performance of a transportation system with emphasis on traffic networks in congested urban areas. The course introduces the broad components of Intelligent Transportation Systems then moves into more in-depth analysis of advanced traffic management and information systems as a core component of ITS. The course covers both basic fundamentals as well as advanced techniques. Topics include history of ITS, ITS user services and subsystems, ITS interoperability and system architecture, enabling technologies for ITS, introduction to telecommunication technologies for ITS, introduction to control theory for transportation systems, traffic flow modeling, static and dynamic transportation network analysis, incident detection, freeway control, and surface street network control. Some advanced topics such as the use of artificial intelligence in ITS will also be introduced.

CIV375H1 F
Building Science
IV - AECHEBASC, III - AECIVBASC, I - AEMINENR, I - AEMINENV 3/1/2/0.50

The fundamentals of the science of heat transfer, moisture diffusion, and air movement are presented. Using these fundamentals, the principles of more sustainable building enclosure design, including the design of walls and roofs are examined. Selected case studies together with laboratory investigations are used to illustrate how the required indoor temperature and moisture conditions can be maintained using more durable and more sustainable designs.

CIV380H1 S
Sustainable Energy Systems
III - AECIVBASC, IV - AEESCBASEI 3/-/1/0.50

This course will provide students with knowledge of energy demand and supply from local to national scales. Topics include energy demands throughout the economy, major energy technologies, how these technologies work, how they are evaluated quantitatively, their economics and their impacts on the environment. In addition, the ever changing context in which these technologies (and emerging technologies) are being implemented will be outlined. Systems approaches including life cycle assessment, will be refined and applied to evaluate energy systems. A particular focus will be placed on analysis of energy alternatives within a carbon constrained economy.
Prerequisite: CME368H1, CIV375H1, CIV220H1.
Corequisite: CIV382H1.

CIV382H1 S
Engineering Communication II
III - AECIVBASC 1/-/1/0.20

Engineering Communication II builds students' communication skills with particular emphasis on professional delivery of information through document design, visual rhetoric and professional presentation. The course will build capacity in support of specific assignments delivered in other courses in the same term.

CIV416H1 F
Reinforced Concrete II
IV - AECIVBASC, IV - AEESCBASEI 3/-/2/0.50

This course covers the behaviour and ultimate strength of reinforced concrete structures. Members subjected to flexure, axial load, shear and torsion are treated. Detailing of reinforcement, the design of floor systems and the design of shear walls are covered. An introduction to the seismic design of reinforced concrete structures is made. Emphasis is given to the relationship between recent research results and current building codes. A brief treatment of the behaviour and design of masonry walls is included.
Prerequisite: CIV313H1.

CIV420H1 F
Construction Engineering
IV - AECIVBASC 3/-/2/0.50

This course considers the engineering aspects of construction including earthmoving, equipment productivity, fleet balancing, formwork design, shoring, hoisting, aggregate production, equipment operating costs, and modular construction. Several construction projects will be reviewed to demonstrate methods and processes. Students will be expected to visit construction sites, so safety boots and hard hats are required.

CIV440H1 S
Environmental Impact and Risk Assessment
IV - AECHEBASC, IV - AECIVBASC, IV - AEESCBASEJ, IV - AELMEBASC, I - AEMECBASC, I - AEMINENR, I - AEMINENV 3/-/1/0.50

Core Course in the Environmental Engineering Minor. The process and techniques for assessing and managing the impacts on and risks to humans and the ecosystem associated with engineered facilities, processes and products. Both biophysical and social impacts are addressed. Topics include: environmental assessment processes; environmental legislation; techniques for assessing impacts; engineering risk analysis; health risk assessment; risk management and communication; social impact assessment; cumulative impacts; environmental management systems; the process of considering alternative methods for preventing and controlling impacts; and stakeholder involvement and public participation. Examples are drawn from various engineering activities and facilities such as energy production, chemical production, treatment plants, highways and landfills.
Exclusion: EDV360H1.

CIV456H1 S
Collaborative Design Project
IV - AEESCBASEI 1/3/-/0.50

Major design project involving both structural and transportation design elements. Students work in small teams. Emphasis is on an integrated design process from conceptual design through to a constructable plan which addresses the functional, economic, aesthetic and environmental aspects of the problem.

CIV460H1 F
Engineering Project Finance and Management
IV - AEESCBASEI 3/-/1/0.50

This course deals with the structuring, valuing, managing and financing of infrastructure projects. The financing portion builds on material covered in Engineering Economics. Key topics include; structuring projects, valuing projects, the rationale for project financing (types of funds and financing), project viability and financial modeling, risk analysis, externalities and social cost benefit analyses. Financing of large scale projects by the public and private sectors as well as through public/private partnerships is treated in detail. Project management concepts, issues, and procedures are introduced. A series of case studies analyzing both successful and unsuccessful projects are examined.
Enrolment Limits: Civil Engineering students may take this course with prior permission from the Division of Engineering Science and the Department of Civil Engineering.

CIV477H1 F/S
Special Studies in Civil Engineering
IV - AECIVBASC 3/-/1/0.50

A course covering selected topics in Civil Engineering not covered in other electives. The topics, which may be different every year, are selected by Staff. Course may not be offered every year and there may be limited enrolment in particular years.
Enrolment Limits: Permission of the Department of Civil Engineering is required.

CIV488H1 S
Entrepreneurship and Business for Engineers
3/-/2/0.50

A complete introduction to small business formation, management and wealth creation. Topics include: the nature of the Entrepreneur and the Canadian business environment; business idea search and Business Plan construction; Buying a business, franchising, taking over a family business; Market research and sources of data; Marketing strategies promotion, pricing, advertising, electronic channels and costing; The sales process and management, distribution channels and global marketing; Accounting, financing and analysis, sources of funding, and financial controls; The people dimension: management styles, recruiting and hiring, legal issues in employment and Human Resources; Legal forms of organization and business formation, taxation, intellectual property protection; the e-Business world and how businesses participate; Managing the business: location and equipping the business, suppliers and purchasing, credit, ethical dealing; Exiting the business and succession, selling out. A full Business Plan will be developed by each student and the top submissions will be entered into a Business Plan competition with significant cash prices for the winners. Examples will be drawn from real business situations including practicing entrepreneurs making presentations and class visits during the term. (Identical courses are offered in other Departments: MSE488H1, MIE488H1, ECE488H1 and CHE488H1.)
Exclusion: APS234H1, APS432H1.

CIV497H1 F
Engineering Design and Professional Practice
IV - AECIVBASC 3/-/1/0.50

The relationship between engineering design, engineering knowledge, and professional ethics is examined. A range of topics related to engineering design are covered including: the engineering design process, design skills, engineering innovations, teamwork skills, writing and communication skills (proposal writing, presentations, poster design), the role of drawing and prototype models in design,

sustainable design and social responsibility (ethical and social dimensions), engineering failures and engineering ethics, macro and micro ethics, and professional practice. Historical and current civil engineering design projects will be presented by industry professionals, illustrated through case histories as documented in the popular media, and researched by students using the technical literature. This course is a prerequisite to CIV498H1 - Group Design Project, and the course assignments and project serve to provide a transition to the subsequent course. The range of design modules that will be available in CIV498H1 will be presented in this course and the students will be divided into their respective design groups.

CIV498H1 S
Group Design Project
IV - AECIVBASC -/-/3/0.50

The Group Design Project is a significant design experience that integrates the mathematics, basic sciences, engineering sciences, complementary studies, and detailed design aspects of the different civil engineering sub-disciplines.
Prerequisite: CIV497H1.

CIV499H1 F/S
Individual Project
IV - AECIVBASC -/-/3/0.50

Individual Projects are arranged between the student and a supervising faculty member. The individual project can have either a design project focus or a research focus. If the focus is on design then the design project can be either motivated by the CIV498H1 Group Design Project experience, or it can be entirely new. The student's work must culminate in a final design report or a thesis, as well as an oral presentation. The grading of both the final written submission as well as the oral presentation is carried out by the supervising faculty member. The Individual Project may be undertaken in either the Fall (F) or Winter (S) Session, but not both (i.e., the Individual Project carries a maximum weight of 0.5; it cannot be made into a full year course)

CIV510H1 S
Solid Mechanics II
IV - AECIVBASC, IV - AEESCBASEI 3/-/2/0.50

This course provides a continuing study of the mechanics of deformable solids. Stress and equilibrium conditions, strain and compatibility conditions, stress-strain relations and yield/failure criteria are considered in the context of civil engineering materials. Two-and three-dimensional elasticity theory is developed, with an introduction to the use of tensor notation. Advanced topics in bending, shear and torsion of beams are also covered, as is elementary plate bending theory. The course concludes with a further development and application of energy methods including virtual work, potential energy, strain energy, and related approaches.
Prerequisite: CIV210H1.

CIV513H1 S
Collaborative Engineering and Architectural Design Studio
IV - AECIVBASC 1/5/-/0.50

Engineering and Architecture students are paired to form a design team for a specified building design project. Lectures are given on design development, aspects of structural system design, the relationship of structure to program and function, modeling and drawing, digital modeling, as well as topics related to the specific term design project. Studio design experience to familiarize students with both the synergistic and divergent goals of the engineering and architectural design and to develop collaboration skills for optimizing the outcome of the interdisciplinary professional interaction. Architecture students in this joint studio are enrolled in ARC3016Y S.
Prerequisite: [CIV313H1 or CIV352H1], CIV357H1.
Enrolment Limits: Enrolment will be limited to students enrolled in the Yolles Design section of CIV498H. Graduate students may take this course by application only.

CIV514H1 F
Concrete Technology
IV - AECIVBASC, IV - AEESCBASEI 3/-/2/0.50

Material aspects of concrete production will be dealt with in the context of various performance criteria with emphasis on durability. The process of material selection, proportioning, mixing, transporting, placing and curing concrete will be the framework within which topics such as: the use of admixtures, choice of cements, environmental influences, methods of consolidation and testing techniques will be studied.

CIV516H1 S
Public Transit Operations and Planning
IV - AECIVBASC, III - AEESCBASEI 3/-/1/0.50

The objective of this course is to introduce the fundamentals of urban transit operations and planning. The course will cover several topics, including history and role of transit in urban areas, classification of transit modes, fundamentals of transit performance and operational analysis, capacity analysis, scheduling, line and network design, transit economics, systems planning and mode selection.

CIV517H1 F
Prestressed Concrete
IV - AECIVBASC, IV - AEESCBASEI 3/-/-/0.50

An introduction to procedures for predicting the load-deformation response of prestressed concrete elements and structures with emphasis on how these procedures can be used in the design of new structures and in the evaluation of existing structures. Topics include: prestressing technology; control of cracking; response to axial load and flexure; response to shear and torsion; disturbed regions; restraint of deformations; design codes.
Prerequisite: CIV313H1 or CIV375H1 or equivalent.

CIV518H1 S
Behaviour and Design of Steel Structures
IV - AECIVBASC, IV - AEESCBASEI 3/-/2/0.50

The behaviour and design of trusses, frames, members and connections in steel building and bridge structures is presented and design methods are developed. Ultimate strength, stability, and postbuckling are emphasized in topical examples including: plate girders, composite steel/concrete girders, second-order frame behaviour, high-strength bolted and welded framing connections. Design applications considering metal fatigue and brittle fracture, and methods of plastic analysis are also introduced. Canadian design standards and the Limit States Design concepts are used.

CIV519H1 F
Structural Analysis II
IV - AECIVBASC 3/-/2/0.50

The general flexibility and stiffness methods of analysis; multispan beams, trusses, frames and grids; loadings due to force, support displacement, temperature change and member prestrain; axial and flexural stability; basic plasticity. Topics in this course represent the basis for the finite element method of analysis.
Prerequisite: CIV214H1.

CIV521H1 F
Rock Mechanics
IV - AECIVBASC 3/1/-/0.50

This course provides general analytical tools and experimental methods that are used in rock mechanics. The lectures are complemented with laboratory experiments. Theoretical topics include: stress and strain, linear elasticity, failure modes and models of rocks, fracture of rocks, inelastic behavior of rock, seismic waves in rocks.
Experiments include: preparation of rock samples, uniaxial compressive strength measurements, Brazilian disc tests for rock tensile strength, fracture toughness measurements with core-based rock samples.
Prerequisite: CIV210H1/CME210H1

CIV523H1 S
Urban Excavations
IV - AECIVBASC, IV - AEESCBASEI, IV - AELMEBASC 3/-/1/0.50

This course considers some advanced topics in Geotechnical Design including: unsaturated groundwater flow, and slope stability analysis incorporating the vadose zone; design of well systems for dewatering construction projects; soft ground tunneling systems and deep excavation systems for controlling excavation-induced displacements in built-up urban environments.Case histories, many from the Greater Toronto Area, are used to illustrate the concepts and motivate the class assignments.
Prerequisite: CIV321H1 F/CME321H1 F; equivalent or permission of instructor

CIV529H1 S
Rock Engineering
IV - AECIVBASC, IV - AEESCBASEI 3/-/1/0.50

This course uses case studies to cover the practical aspects of rock engineering. Topics include: rock mass classification, shear strength of discontinuities, structurally controlled instability in tunnels, slope stability, factor of safety and probability of failure, analysis of rockfall hazards, in situ and induced stresses, rock mass properties, tunnels in weak rock, large powerhouse caverns in weak rock, rockbolts and cables, shotcrete support and blasting damage in rock.
Exclusion: MIN429H1.

CIV531H1 F
Transport Planning
IV - AECIVBASC, III - AEESCBASEI, I - AEMINENV 3/-/1/0.50

This course is intended to provide the student with the following: the ability to design and execute an urban transportation planning study; a working knowledge of transportation planning analysis skills including introductions to travel demand modelling, analysis of environmental impacts, modelling transportation - land use interactions and transportation project evaluation; an understanding of current transportation planning issues and policies; and an understanding of the overall process of transportation planning and its role within the wider context of transportation decision-making and the planning and design of urban areas. Person-based travel in urban regions is the focus of this course, but a brief introduction to freight and intercity passenger transportation is also provided. A “systems” approach to transportation planning and analysis is introduced and maintained throughout the course. Emphasis is placed throughout on designing transportation systems for long-run environmental, social, and economic sustainability.
Prerequisite: CIV368H1.

CIV549H1 F
Groundwater Flow and Contamination
IV - AECHEBASC, IV - AECIVBASC, IV - AELMEBASC, I - AEMINENV 3/-/1/0.50

Mechanics of saturated and unsaturated fluid flow in porous media. Confined and unconfined flow. Flow to wells. Analytical and numerical solutions of groundwater flow equations. Non-reactive and reactive contaminant transport on groundwater systems. Analytical and numerical solutions of contaminant transport equations. Flow and solute transport in fractured porous media. Assessment of environmental impacts of waste disposal operations. Remediation of contaminated groundwater.
Prerequisite: JVM270H1/CIV270H1/CME270H1, CIV250H1/EDV250H1 S or equivalent

CIV550H1 F
Water Resources Engineering
IV - AECHEBASC, IV - AECIVBASC, I - AEMINENV 3/-/2/0.50

Global and national water problems, law and legislation. Hydraulic structures. Reservoir analysis. Urban drainage and runoff control: meteorologic data analysis, deterministic and stochastic modelling techniques. Flood control: structural and nonstructural alternatives. Power generation: hydro and thermal power generation. Low flow augmentation. Economics and decision making.
Prerequisite: CIV250H1/EDV250H1, CIV340H1 S or equivalent

CIV575H1 F
Building Science
IV - AEESCBASEI, IV - AEESCBASEJ 3/1/2/0.50

The fundamentals of the science of heat transfer, moisture diffusion, and air movement are presented. Using these fundamentals, the principles of more sustainable building enclosure design, including the design of walls and roofs are examined. Selected case studies together with laboratory investigations are used to illustrate how the required indoor temperature and moisture conditions can be maintained using more durable and more sustainable designs.
Exclusion: CIV375H1 This is the last year the course will be offered as CIV575H1, in future years it will be offered as CIV375H1 only

CIV576H1 S
Sustainable Buildings
IV - AECIVBASC, IV - AEESCBASEI, I - AEMINENR, I - AEMINENV 3/-/1/0.50

Building systems including the thermal envelope, heating and cooling systems, as well as water and lighting systems are examined with a view to reducing the net energy consumed within the building. Life-cycle economic and assessment methods are applied to the evaluation of various design options including considerations of embodied energy and carbon sequestration. Green building strategies including natural ventilation, passive solar, photovoltaics, solar water heaters, green roofs and geothermal energy piles are introduced. Following the application of these methods, students are introduced to efficient designs including LEED designs that lessen the impact of buildings on the environment. Exemplary building designs will be presented and analyzed.
Prerequisite: CIV375H1/CIV575H1 or equivalent.

CIV577H1 S
Infrastructure for Sustainable Cities
IV - AECIVBASC, IV - AEESCBASEI, I - AEMINENR, I - AEMINENV 3/-/1/0.50

Developing infrastructure for sustainable cities entails understanding the connection between urban morphology and physiology. This course uses a systems approach to analyzing anthropogenic material flow and other components of urban metabolism, linking them to the design of urban infrastructure. Elements of sustainable transportation, green buildings, urban climatology, urban vegetation, water systems and local energy supply are integrated in the design of sustainable urban neighbourhoods.
Prerequisite: CIV340H1, [CIV375H1/CIV575H1], CIV531H1.

CIV1171H S
Structural Dynamics
IV - AEESCBASEI 3/-/-/0.50

The response of civil engineering structures to various time-dependent disturbances is studied. Multi-degree of freedom structures are examined with a view to the simplification of their analyses by reduction to as few degrees of freedom as is warranted. Response into the inelastic range of material resistance is considered. Matrix optimisation of analysis is used whenever advantageous and typical problems are solved with the aid of electronic computers.
Enrolment Limits: This course may be taken by Civil Engineering students with prior permission of the Division of Engineering Science and the Department of Civil Engineering.

CIV1174H S
Finite Element Methods in Structural Mechanics
IV - AEESCBASEI 3/-/-/0.50

Review of required mathematical concepts. Thorough development of the displacement rnethod of finite element analysis. Derivation of the element matrices for planes stress and strain, three dimensional, axisymmetric and plate bending elements. Introduction to nonlinear analysis. Application to structures using existing computer capabilities.
Prerequisite: CIV519H1 or equivalent.
Enrolment Limits: This course may be taken by Civil Engineering students with prior permission of the Division of Engineering Science and the Department of Civil Engineering.

Civil and Mineral Engineering

CME185H1 S
Earth Systems Science
I - AECIVBASC, I - AELMEBASC 3/2/1/0.50

This course introduces students to the basic earth sciences with an emphasis on understanding the impact of humans on the natural earth systems. Beginning with a study of the lithosphere, principles of physical geology will be examined including the evolution and internal structure of the earth, dynamic processes that affect the earth, formation of minerals and rocks and soil, ore bodies and fossil-energy sources. Next, the biosphere will be studied, including the basic concepts of ecology including systems ecology and biogeochemical cycles. The influence of humans and the built environment on these natural systems will also be examined with a view to identifying more sustainable engineering practices. Finally, students will study the oceans and the atmosphere and the physical, chemical and thermodynamic processes involved in climate change.

CME210H1 F
Solid Mechanics I
II - AECIVBASC, II - AELMEBASC 3/1.50/1.50/0.50

An introduction to the mechanics of deformable bodies. General biaxial and triaxial stress conditions in continua are studied, as are elastic stress, strain and deformation relations for members subjected to axial load, bending and shear. Properties of plane sections, moment-area theorems for calculating deflection, and Mohr's circle representation of stress and of moment of inertia are examined, followed by a look at stability.
Prerequisite: CIV100H1/CIV101H1, MAT186H1 F, MAT187H1 S
Exclusion: CIV210H1

CME261H1 F
Engineering Mathematics I
II - AECIVBASC, II - AELMEBASC 3/1/1/0.50

This course deals with both numerical methods for engineering analysis (solution of linear and non-linear equations, interpolation, numerical integration) and advanced topics in analytical calculus (multiple integrals and vector analysis). Within the numerical methods portion of the course emphasis is placed on problem formulation, solution algorithm design and programming applications. Within the analytical calculus portion emphasis is placed on the mathematical foundations of engineering practice and the interrelationship between analytical and numerical solution methods.
Prerequisite: MAT188H1 F, MAT187H1 S
Exclusion: CIV261H1

CME263H1 S
Probability Theory for Civil and Mineral Engineers
II - AECIVBASC, II - AELMEBASC 3/-/2/0.50

Probability theory as the study of random phenomena in Civil and Mineral Engineering systems, including the definition of probability, conditional probability, Bayes' theorem in discrete and continuous sample spaces. Common single and multivariate distributions. Mathematical expectation including mean and variance. Independence. An introduction to realizations of probability models and parameter estimation.
Exclusion: CIV263H1

CME270H1 F
Fluid Mechanics I
II - AECIVBASC, II - AELMEBASC 3/1.50/1/0.50

Fluid and flow characteristics, applications, dimensions and units. Fluid statics. One-dimensional flow including conservation of mass, energy and momentum. Introduction to dimensional analysis and similitude, laminar and turbulent flow, boundary layer concept, and flow about immersed objects. Calculation of flow in closed conduits and open channels.
Exclusion: CIV270H1

CME321H1 F
Geotechnical Engineering I
III - AECIVBASC, III - AEESCBASEI, III - AELMEBASC 3/1.50/1/0.50

An introduction to elements of geotechnical analysis and design. Shear strength at constant volume; ultimate limit state design of retaining walls, shored excavations, soil slopes, rafts, strip and spread footings, and piles and caissons. Compaction of granular soil; engineered fills for earth dams, roads, and backfills. Consolidation of fine grained soil; construction preloads and ultimate settlement predictions. Permeability, seepage analysis, and internal stability of granular soil; internal hydraulic design of coffer dams and zoned earth dams; construction dewatering. Site investigation and monitoring

techniques in support of geotechnical design. Laboratories for unconfined compression, direct shear, compaction, consolidation, and seepage models.
Prerequisite: CIV270H1/CME270H1, CIV210 H1/CME210H1F
Exclusion: CIV321H1

CME358H1 F
Survey Camp
III - AECIVBASC, III - AELMEBASC -/-/-/0.50

At Survey Camp, students obtain extensive hands-on experience in the use of land surveying instruments and in the essentials of survey practice. Measurements of distances and angles, survey calculations, sources of error, and corrections and adjustments are introduced. Application exercises include route surveys, topographic mapping, and construction surveying. Concepts of higher order survey techniques and global positioning systems are reviewed and illustrated. Students attend Survey Camp split into two week camps prior to the start of Third Year Fall Session.
Exclusion: CIV358H1

CME362H1 F
Engineering Mathematics II
III - AECIVBASC, III - AELMEBASC 3/-/2/0.50

This course continues the study of numerical and analytical methods for civil engineering analysis. Analytical and numerical methods for solving ordinary differential equations are treated in some detail, followed by numerical solution methods for partial differential equations. The final major topic of the course deals with an introduction to optimization. Emphasis is placed throughout the course on problem formulation, solution algorithm design and programming applications.
Exclusion: CIV362H1

CME368H1 S
Engineering Economics and Decision Making
III - AECIVBASC, III - AELMEBASC 3/-/1/0.50

The incorporation of economic and non-monetary considerations for making decision about public and private sector engineering systems in urban and other contexts. Topics include rational decision making; cost concepts; time value of money and engineering economics; microeconomic concepts; treatment of risk and uncertainty; and public project evaluation techniques incorporating social and environmental impacts including benefit cost analysis and multi-objective analysis.
Exclusion: CIV368H1

Computer Science

CSC180H1 F
Introduction to Computer Programming
I - AEESCBASE 3/2/1/0.50

The first of two problem-based courses that introduces students to programming and computational thinking, and prepares them for additional study across a breadth of programming fields. Students will design and implement computational solutions to problems drawn from their 1F courses, with specific focus on problem decomposition and the use of programming paradigms appropriate to the problems being solved. Computational thinking is introduced as a means to solve problems through a focus on algorithm, data, and models of computation.

CSC190H1 S
Computer Algorithms, Data Structures and Languages
I - AEESCBASE 3/3/-/0.50

The second of two problem-based courses that introduces students to programming and computational thinking, and prepares them for additional study across a breadth of programming fields. Students will design and implement computational solutions to problems drawn from their 1S courses, and will explore new programming paradigms appropriate to these challenges. More advanced forms of computational thinking suitable for understanding and solving a wider variety of problems are introduced.

CSC192H1 F
Computer Programming, Algorithms, Data Structures and Languages
I - AEESCBASE 3/2/1/0.50

An accelerated and combined version of CSC180H1 F and CSC190H1 S intended for students who have some previous programming experience (e.g. one year programming in Turing, Pascal, Java, C or similar languages.) Students will focus on problem decomposition and the use of programming paradigms appropriate to the problems being solved. Computational thinking is introduced as a means to solve problems through a focus on algorithm, data, and models of computation. Students will design and implement computational solutions to problems drawn from their 1F courses, and will explore new programming paradigms appropriate to these challenges. More advanced forms of computational thinking suitable for understanding and solving a wider variety of problems are introduced.

CSC309H1 F/S
Programming on the Web
IV - AEESCBASER 2/-/1/0.50

An introduction to software development on the web. Concepts underlying the development of programs that operate on the web; survey of technological alternatives; greater depth on some technologies. Operational concepts of the internet and the web, static client content, dynamic client content, dynamically served content, n-tiered architectures, web development processes, and security on the web. Assignments involve increasingly more complex web-based programs. Guest lecturers from leading e-commerce firms will describe the architecture and operation of their web sites.

CSC318H1 F/S
The Design of Interactive Computational Media
IV - AEESCBASER -/-/-/0.50

User-centred design of interactive systems; methodologies, principles, and metaphors; task analysis. Interdisciplinary design; the role of graphic design, industrial design, and the behavioural sciences. Interactive hardware and software; concepts from computer graphics. Typography, layout, colour, sound, video, gesture, and usability enhancements. Classes of interactive graphical media; direct manipulation systems, extensible systems, rapid prototyping tools. Students work on projects in interdisciplinary teams. Enrolment limited, but non-computer scientists welcome.

CSC326H1 F
Programming Languages
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 2/-/1/0.50

Study of programming styles and paradigms. Included are object-oriented scripting functional and logic-based approaches. Languages that support these programming styles will be introduced. Languages treated include Python, Lisp or Scheme and Prolog.

Exclusion: CSC324H1 F

CSC343H1 F/S
Introduction to Databases
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 2/-/1/0.50

Introduction to database management systems. The relational data model. Relational algebra. Querying and updating databases: the query language SQL. Application programming with SQL. Integrity constraints, normal forms, and database design. Elements of database system technology: query processing, transaction management.
Prerequisite: ECE345H1 F/S or CSC190H1 S or CSC192H1 F
Exclusion: CSC434H1.

CSC384H1 F/S
Introduction to Artificial Intelligence
IV - AEESCBASER 2/-/1/0.50

Theories and algorithms that capture (or approximate) some of the core elements of computational intelligence. Topics include: search; logical representations and reasoning, classical automated planning, representing and reasoning with uncertainty, learning, decision making (planning) under uncertainty. Assignments provide practical experience, both theory and programming, of the core topics.

CSC401H1 S
Natural Language Computing
IV - AEESCBASER 2/-/1/0.50

Introduction to techniques involving natural language and speech in applications such as information retrieval, extraction, and filtering; intelligent Web searching; spelling and grammar checking; speech recognition and synthesis; and multi-lingual systems including machine translation. N-grams, POS-tagging, semantic distance metrics, indexing, on-line lexicons and thesauri, markup languages, collections of on-line documents, corpus analysis. PERL and other software.

CSC411H1 F
Machine Learning and Data Mining
IV - AEESCBASER 2/-/1/0.50

An introduction to methods for automated learning of relationships on the basis of empirical data. Classification and regression using nearest neighbour methods, decision trees, linear models, and neural networks. Clustering algorithms. Problems of overfitting and of assessing accuracy. Problems with handling large databases.

CSC418H1 F/S
Computer Graphics
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 2/-/1/0.50

Identification and characterization of the objects manipulated in computer graphics, the operations possible on these objects, efficient algorithms to perform these operations, and interfaces to transform one type of object to another. Display devices, display data structures and procedures, graphical input, object modeling, transformations, illumination models, primary and secondary lighting effects; graphics packages and systems. Students, individuals or in teams, implement graphical algorithms or entire graphics systems.
Prerequisite: CSC190H1 S; ECE243H1 S/ECE352H1 F; ECE345H1 F; Proficiency in C Limited Enrolment

CSC428H1 F/S
Human-Computer Interaction
IV - AEESCBASER 2/-/1/0.50

Understanding human behaviour as it applies to user interfaces: work activity analysis, observational techniques, questionnaire administration and unobtrusive measures. Operating parameters of the human cognitive system, task analysis and cognitive modelling techniques and their application to designing interfaces. Interface representations and prototyping tools. Cognitive walkthroughs, usability studies and verbal protocol analysis. Case studies of specific user interfaces.

CSC443H1 F/S
Database System Technology
IV - AEESCBASER 2/-/1/0.50

Implementation of database management systems. Storage management, indexing, query processing, concurrency control, transaction management. Database systems on parallel and distributed architectures. Modern database applications: data mining, data warehousing, OLAP, data on the web. Object-oriented and object-relational databases.

CSC444H1 F
Software Engineering I
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 2/-/1/0.50

The software development process. Software requirements and specifications. Software design techniques. Techniques for developing large software systems; CASE tools and software development environments. Software testing, documentation and maintenance.
Prerequisite: ECE344H1 F/S or ECE353H1 S

CSC467H1 F
Compilers and Interpreters
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 2/-/1/0.50

Compiler organization, compiler writing tools, use of regular expressions, finite automata and context-free grammars, scanning and parsing, runtime organization, semantic analysis, implementing the runtime model, storage allocation, code generation.
Prerequisite: ECE352H1F

CSC487H1 F
Foundations of Computer Vision
IV - AEESCBASER 2/-/1/0.50

Introduction to vision, visual processes, and image understanding. Brief biological motivation for computational vision. Camera system geometry and image acquisition, basic visual processes for recognition of edges, regions, lines, surfaces. Processing colour, stereo images, and motion in image sequences. Active vision methods such as visual attention and interpretation-guided imaging system geometry changes. Object recognition. Applications of visual systems.

Electrical and Computer Engineering

ECE101H1 F
Seminar Course: Introduction to Electrical and Computer Engineering
I - AECPEBASC, I - AEELEBASC 1/-/-/0.15

This is a seminar series that will introduce first year students to the wealth of subjects within the field of Electrical and Computer Engineering. Instructors will be drawn from the various research groups within the Department. This course will be offered on a credit/no-credit basis. Credit will not be given to students who attend fewer than 70% of the seminars. Students who receive no credit for the course must re-take it in their 2F session. Students who have not received credit for this course at the end of their 2F session will not be permitted to register in session 2S.

ECE110H1 S
Electrical Fundamentals
I - AECPEBASC, I - AEELEBASC, I - AEENGBASC, I - AEINDBASC, I - AEMECBASC, I - AEMMSBASC 3/2/1/0.50

A simplified overview of the physics of electricity and magnetism: Coulomb's law, Gauss' law, Ampere's law, Faraday's law. Physics of capacitors, resistors, and inductors. An introduction to circuit analysis: resistive circuits, nodal and mesh analysis, network theorems. Natural and forced response of RL and RC circuits. Sinusoidal steady-state analysis and power in AC circuits.

ECE159H1 S
Fundamentals of Electric Circuits
I - AEESCBASE 3/1.50/1/0.50

DC linear circuit elements. DC linear circuit analysis; Kirchhoff's Laws, superposition, Thevenin and Norton equivalents, nodal analysis. Operational amplifier. Transient response of linear circuits. Sinusoidal steady state analysis; phasors, power in AC circuits. Frequency response; resonance phenomena.

ECE212H1 F
Circuit Analysis
II - AECPEBASC, II - AEELEBASC 3/1.50/2/0.50

Nodal and loop analysis and network theorems. Natural and forced response of RL, RC, and RLC circuits. Sinusoidal steady-state analysis. Frequency response; resonance phenomena; poles and zeros; applications of the Laplace transform.

ECE216H1 S
Signals and Systems
II - AECPEBASC, II - AEELEBASC 3/-/2/0.50

Fundamental discrete- and continuous-time signals, definition and properties of systems, linearity and time invariance, convolution, impulse response, differential and difference equations, Fourier analysis, sampling and aliasing, applications in communications.

ECE221H1 S
Electric and Magnetic Fields
II - AECPEBASC, II - AEELEBASC 3/1/1/0.50

The fundamental laws of electromagnetics are covered, including Coulomb's law, Gauss' law, Poisson's and Laplace's equations, the Biot-Savart law, Ampere's law, Faraday's law, and Maxwell's equations. Vector calculus is applied to determine the relationship between the electric and magnetic fields and their sources (charges and currents). The interaction of the fields with material media will be discussed, including resistance, polarization in dielectrics, magnetization in magnetic materials, properties of magnetic materials and boundary conditions. Other topics include: electric and magnetic forces, the electric potential, capacitance and inductance, electric and magnetic energy, magnetic circuits, and boundary-value problems.

ECE231H1 S
Introductory Electronics
II - AECPEBASC, II - AEELEBASC 3/1/1/0.50

An introduction to electronic circuits using operational amplifiers, diodes, bipolar junction transistors and field-effect transistors.

ECE241H1 F
Digital Systems
II - AECPEBASC, II - AEELEBASC 3/3/-/0.50

Digital logic circuit design with substantial hands-on laboratory work. Algebraic and truth table representation of logic functions and variables. Optimizations of combinational logic, using “don’t cares”. Multi-level logic optimization. Transistor-level design of logic gates; propagation delay and timing of gates and circuits. The Verilog hardware description language. Memory in digital circuits, including latches, clocked flip-flops, and Static Random Access Memory. Set-up and hold times of sequential logic. Finite state machines - design and implementation. Binary number representation, hardware addition and multiplication. Tri-state gates, and multiplexors. There is a major lab component using Complex Programmable Logic Devices (CPLDs) and Field-Programmable Gate Arrays (FPGAs) and associated computer-aided design software.

ECE243H1 S
Computer Organization
II - AECPEBASC, II - AEELEBASC 3/3/-/0.50

Basic computer structure. Design of central processing unit. Hardwired and microprogrammed control. Input-output and the use of interrupts. Arithmetic circuits. Assembly language programming. Main memory organization. Peripherals and interfacing. Microprocessors. System design considerations. The laboratory will consist of experiments involving logic systems and microprocessors. Design activity constitutes a major portion of laboratory work.

ECE244H1 F
Programming Fundamentals
II - AECPEBASC, II - AEELEBASC 3/2/1/0.50

Provides a foundation in programming using an object-oriented programming language. Topics include: classes and objects, inheritance, exception handling, basic data structures (lists, tree, etc.), big-O complexity analysis, and testing and debugging. The laboratory assignments emphasize the use of object-oriented programming constructs in the design and implementation of reasonably large programs.

ECE253H1 F
Digital and Computer Systems
II - AEESCBASE 3/3/-/0.50

Digital system design principles. Logic circuits, logic synthesis. Registers, arithmetic circuits, counters, finite state machines, and programmable logic devices. Verilog hardware description language. Computer structure, machine language instruction execution and sequencing, addressing techniques. Processors, input/output techniques, and memory hierarchy. The laboratory work consists of exercises involving the design of logic circuits, and microprocessor systems. Modern computer-aided design tools and FPGA technology are used. Design aspects constitute a major portion of laboratory work.
Exclusion: ECE341H1 F and ECE370H1 S

ECE259H1 S
Electromagnetism
II - AEESCBASE 3/-/1/0.50

Field theory of electromagnetic phenomena based on vector analytical formulation of fundamental observations, and application thereof to electrostatic, magnetostatic and electromagnetic effects. Topics: conservation of charge, electric field intensity and flux density vectors, Gauss' law, Coulomb's law, electric potential, Poisson's and Laplace's equations; magnetic flux density and field intensity vectors, Ampere's law, non-existence of magnetic charges, vector potential, Biot-Savart's formula, Faraday's induction law; displacement current, electromagnetic waves, special relativity and Lorentz transformation.

ECE297H1 S
Communication and Design
II - AECPEBASC, II - AEELEBASC 1.50/3/2/0.50

An introduction to electrical and computer engineering design processes illustrated by the design and implementation of software systems. Creative development with appropriate organizational and reporting and recording activities, both oral and written, is emphasized. The general design cycle and pragmatic strategies used in the creation of small designs and larger systems are presented. These methods are implemented in practical lab work done in teams. Oral skills are developed in seminars and team discussions, by learning to handle questions, and by making formal presentations. Written skills are developed in reports related to the lecture and lab activities.

ECE302H1 F/S
Probability and Random Processes
III - AECPEBASC, III - AEELEBASC 3/-/2/0.50

Basic principles and properties of probability. Random variables, distribution and density functions. Expectation, moments, characteristic function, correlation coefficient. Functions of random variables. Bernoulli trials, Binomial, Poisson and Gaussian distributions. Introduction to random processes. Applications will be chosen from reliability theory, estimation and hypothesis testing, linear models for data, noise in devices, random number generation and simulation.
Prerequisite: MAT290H1 F and MAT291H1 F and ECE216H1 S
Exclusion: STA286H1 S

ECE311H1 S
Dynamic Systems and Control
III - AECPEBASC, III - AEELEBASC 3/0.60/1/0.50

An introduction to dynamic systems and their control. Differential equation models of mechanical, electrical, and electromechanical systems. State variable form. Linearization of nonlinear models and transfer functions. Use of Laplace transform to solve ordinary differential equations. Conversion of models from state variable form to transfer function representation and vice versa. Block diagrams and their manipulation. Time response: transient analysis and performance measures. Properties of feedback control systems. Steady state tracking: the notion of system type. The concept of stability of feedback systems, Routh-Hurwitz stability criterion. Frequency response and stability in the frequency domain. Root locus. Bode and Nyquist plots and their use in feedback control design.
Prerequisite: MAT290H1 F and MAT291H1 F and ECE216H1S

ECE314H1 F
Fundamentals of Electrical Energy Systems
III - AECPEBASC, III - AEELEBASC, I - AEMINENR 3/1.50/1/0.50

Introduction to 3-phase systems, single line diagrams and complex power flow. Energy conversion via switch-mode power electronic circuits: DC/DC converters, DC/AC converters. Energy conversions via magnetic devices: Faraday's law for time varying fields, characterization of hysteresis and eddy current losses in magnetic materials, modelling of magnetic circuits, transformer and inductor modelling and design. Introduction to electromechanical energy conversion: Lorentz Force, concepts of energy, co-energy, forces between ferromagnetic materials carrying flux, simple magnetic actuators.
Prerequisite: ECE212H1 F and ECE221H1S and ECE231H1 S

ECE316H1 F/S
Communication Systems
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASEB, IV - AEESCBASER 3/1.50/1/0.50

An introductory course in analog and digital communication systems. Analog and digital signals. Signal representation and Fourier transforms; energy and power spectral densities; bandwidth. Distortionless analog communication; amplitude, frequency and phase modulation systems; frequency division multiplexing. Sampling, quantization and pulse code modulation (PCM). Baseband digital communication; intersymbol interference (ISI); Nyquist's ISI criterion; eye diagrams. Passband digital communications; amplitude-, phase- and frequency-shift keying; signal constellations. Performance analysis of analog modulation schemes in the presence of noise. Performance analysis of PCM in noise.
Prerequisite: MAT290H1 F and ECE216H1 S

ECE318H1 S
Fundamentals of Optics
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASEB, IV - AEESCBASEO, III - AEESCBASEP, IV - AEESCBASER 3/1.50/1/0.50

Geometric Optics: Spherical surfaces, lenses and mirrors, optical imaging systems, matrix method, and aberrations. Polarization: Polarizer and polarizations, anisotropic materials, dichroism, birefringence, index ellipsoid, waveplates, optical activity, Faraday effect. Interference: superposition of waves, longitudinal and transverse coherence, Young's double-slit experiment, Michelson and Fabry-Perot interferometer, thin-films. Diffraction and Fourier Optics: diffraction theory, single and double slits, diffraction gratings, spatial filtering, basic optical signal processing. (Background preparation in ECE320H1 F - Fields and Waves, or ECE357H1 S - Electromagnetic Fields, is strongly recommended.)
Prerequisite: ECE221H1 S

ECE320H1 F
Fields and Waves
III - AECPEBASC, III - AEELEBASC 3/1.50/1/0.50

Voltage and current waves on a general transmission line, reflections from the load and source, transients on the line, and Smith's chart. Maxwell's equations, time retarded scalar and vector potentials, electric and magnetic fields wave equations, boundary conditions, plane wave propagation, reflection and transmission at boundaries, constitutive relations, dispersion, polarization; and Poynting vector.
Prerequisite: ECE221H1 S

ECE330H1 S
Semiconductor and Device Physics
III - AECPEBASC, III - AEELEBASC 3/-/2/0.50

Wave and quantum mechanics, the Schrodinger equation, quantum wells and density of states. Quantum statistics, solid-state bonding and crystal structure. Electron waves, dispersion relation inside periodic media, Fermi level and energy bands. Physical understanding of semiconductors at equilibrium, intrinsic and extrinsic semiconductors and excess carriers.
Prerequisite: ECE221H1 S and ECE231H1 S. (Backround preparation in ECE320H1 F - Fields and Waves is strongly recommended).

ECE331H1 F/S
Analog Electronics
III - AECPEBASC, III - AEELEBASC 3/1.50/0.75/0.50

Transistor amplifiers, including: differential and multistage amplifiers, integrated circuit biasing techniques, output stage design and IC amplifier building blocks. Frequency response of amplifiers at low, medium and high frequencies. Feedback amplifier analysis. Stability and compensation techniques for amplifiers using negative feedback.
Prerequisite: ECE212H1 F and ECE231H1 S

ECE334H1 F/S
Digital Electronics
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 3/1.50/1/0.50

Digital design techniques for integrated circuits. The emphasis will be on the design of logic gates at the transistor level. A number of different logic families will be described, but CMOS will be emphasized. Review of: device modeling, IC processing, and Spice simulation, simplified layout rules, inverter noise margins, transient response, and power dissipation, traditional CMOS logic design, transmission gates, RC timing approximations, input-output circuits, latches and flipflops, counters and adders, decoders and muxes, dynamic gates, SRAMs, DRAMs, and EEPROMs.
Prerequisite: ECE241H1 F and ECE231H1 S or ECE253H1 F and ECE360H1 F

ECE335H1 F
Introduction to Electronic Devices
III - AECPEBASC, III - AEELEBASC 3/-/2/0.50

Electrical behaviour of semiconductor structures and devices. Metal-semiconductor contacts; pn junctions, diodes, photodetectors, LED's; bipolar junction transistors, Ebers-Moll and hybrid-pi models; field effect transistors, MOSFET, JFET/MESFET structures and models; thyristors and semiconductor lasers.
Prerequisite: MAT291H1 F and ECE221H1 S and ECE231H1 S

ECE342H1 S
Computer Hardware
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASEP 3/3/-/0.50

Arithmetic circuits, cubical representation of logic functions, digital system design, timing analysis, design of asynchronous circuits, testing of logic circuits.
Prerequisite: ECE241H1 F and ECE243H1 S

ECE344H1 F/S
Operating Systems
III - AECPEBASC, III - AEELEBASC, I - AEMECBASC 3/3/-/0.50

Operating system structures, concurrency, synchronization, deadlock, CPU scheduling, memory management, file systems. The laboratory exercises will require implementation of part of an operating system.
Prerequisite: ECE244H1 F and ECE243H1 S
Exclusion: ECE353H1 S

ECE345H1 F/S
Algorithms and Data Structures
III - AECPEBASC, III - AEELEBASC 3/-/2/0.50

Design and analysis of algorithms and data structures that are essential to engineers in every aspect of the computer hardware and software industry. Review of background material (recurrences, asymptotics, summations, trees and graphs). Sorting, search trees and balanced search trees, amortized analysis, hash functions, dynamic programming, greedy algorithms, basic graph algorithms, minimum spanning trees, shortest paths, introduction to NP completeness.
Prerequisite: ECE244H1 F

ECE349H1 F
Introduction to Energy Systems
III - AEESCBASER 3/1.50/1/0.50

Established and emerging sources of electrical energy: hydroelectric, thermal, wind, and solar. Three-phase AC systems and complex power. Mechanisms for electrical-electrical energy conversion: power electronic systems for DC-DC conversion, single-phase DC-AC and three-phase DC-AC conversion, transformers for single-phase and three-phase AC-AC conversion. Electro-mechanical energy conversion via the synchronous machine. Fundamentals of AC electrical energy networks: frequency regulation, voltage regulation, and protection.

ECE350H1 S
Physical Electronics
III - AEESCBASEO, III - AEESCBASEP, IV - AEESCBASER 3/1.50/1/0.50

The crystal lattice and basis; real and reciprocal space; diffraction experiments. Electronic theory of semiconductors: energy bands, crystal momentum, effective mass, holes. Semiconductors in equilibrium: Fermi-Dirac statistics, electron and hole densities, donors and acceptors. Carrier transport. Excess carriers, generation and recombination, lifetime, ambipolar diffusion. Semiconductor diodes: the ideal p-n junction, non-idealities, small signal and transient response, photodiode, LED, semiconductor laser; metal semiconductor contact; heterojunctions. MOS capacitor, MOST. BJT: carrier distribution, currents, the Ebers-Moll model, small signal parameters, switching, secondary effects.

ECE352H1 F
Computer Organization
III - AEESCBASER 3/3/-/0.50

A continuation of some of the topics introduced in ECE253F, Digital and Computer Systems. Synchronous and asynchronous sequential circuits, pipelining, integer and floating-point arithmetic, RISC processors.

ECE353H1 S
Systems Software
III - AEESCBASER 3/3/-/0.50

Operating system structure, processes, threads, synchronization, CPU scheduling, memory management, file systems, input/output, multiple processor systems, virtualization, protection, and security. The laboratory exercises will require implementation of part of an operating system.

ECE354H1 S
Electronic Circuits
IV - AEESCBASEA, III - AEESCBASEB, IV - AEESCBASER 3/1.50/0.50/0.50

A course on analog and digital electronic circuits. Topics include single-stage amplifiers, current mirrors, cascode amplifiers and differential pairs. Amplifier frequencey response, feedback and stability are also covered. Digital CMOS logic circuits are introduced.

ECE355H1 F
Signal Analysis and Communication
III - AEESCBASEB, IV - AEESCBASEM, III - AEESCBASER 3/-/2/0.50

An introduction to continuous-time and discrete-time signals and systems. Topics include characterization of linear time-invariant systems, Fourier analysis, linear filtering, sampling of continuous-time signals, and modulation techniques for communication systems.

ECE356H1 S
Linear Systems and Control
III - AEESCBASEB, IV - AEESCBASEO, III - AEESCBASER 3/1.50/1/0.50

An introduction to dynamic systems and their control. Differential equation models of physical systems using transfer functions and state space models. Linearization. Initial and input response. Stability theory. Principle of feedback. Internal Model Principle. Frequencey response. Nyquist stability. Loop shaping theory. Computer aided design using MATLAB and Simulink.
Prerequisite: ECE355H1 F

ECE357H1 S
Electromagnetic Fields
IV - AEESCBASEA, III - AEESCBASEP, III - AEESCBASER 3/1.50/1/0.50

An introduction to transmission line theory: voltage and current waves, characteristic impedance, reflections from the load and source, transients on the line, Smith's chart, impedance matching. Fundamentals of electromagnetic theory: Maxwell's equations, Helmholtz's theorem, time retarded scalar and vector potentials, gauges, boundary conditions, electric and magnetic fields wave equations and their solutions in lossless and lossy medium. Plane wave propagation, reflection and transmission at boundaries. Constitutive relations and dispersion. Radiating dipole and waveguides.

ECE358H1 S
Foundations of Computing
IV - AEESCBASER 3/-/1/0.50

Fundamentals of algorithm design and computational complexity, including: analysis of algorithms, graph algorithms, greedy algorithms, divide-and-conquer, dynamic programming, network flow, approximation algorithms, the theory of NP-completeness, and various NP-complete problems.

ECE359H1 F
Energy Conversion
III - AEESCBASEJ 3/1.50/1/0.50

Introduction to power processing, linear regulators, switch-mode power concepts, DC-DC converters, Voltage and current source inverters, coupled magnetic circuit concepts (properties of magnetic materials, Faraday's Law for time varying fields, characterization and modeling of hysterisis and eddy current losses in magnetic materials, magnetic circuit model, topological dual principle), inductor circuit model, multi-winding transformer circuit model, multiwinding switch mode converters; flyback, forward and push-pull converters. Laboratories cover electrical energy conversion, magnetic devices, complex power flow and introduce appropriate measurement techniques.

ECE360H1 F
Electronics
IV - AEESCBASEA, III - AEESCBASEB, III - AEESCBASEP, III - AEESCBASER 3/1.50/1/0.50

An introduction to electronics. Basic electronic circuits: introductory frequency analysis, operational amplifiers, diodes, bipolar junction transistors, field-effect transistors, small-signal analysis, frequency response of single-stage circuits.

ECE361H1 F/S
Computer Networks I
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 3/1.50/0.50/0.50

Layered network architectures; overview of TCP/IP protocol suite. Introduction to sockets; introduction to application layer protocols. Peer-to-Peer Protocols: ARQ; TCP reliable stream service; flow control. Data Link Controls: Framing; PPP; HDLC. Medium access control and LANs: Aloha; Ethernet; Wireless LANs; Bridges. Packet Switching: Datagram and virtual circuit switching; Shortest path algorithms; Distance vector and link state algorithms.
Prerequisite: STA286H1 S or ECE302H1 F/S
Corequisite: ECE302H1 F/S. (Students must take the co-requisite, ECE302H1 F/S in the same term as ECE361H1 F/S, OR in a term before taking ECE361H1 F/S.)

ECE362H1 S
Digital Signal Processing
IV - AEESCBASEB, IV - AEESCBASEP, III - AEESCBASER 3/1.50/1/0.50

Review of sampling and discrete-time signals in one or more dimensions; linear shift-invariant systems; the Z-transform; the discrete-time Fourier transform; the discrete Fourier transform and computationally efficient implementations (fast Fourier transforms); general orthogonal representations; wavelet bases; discrete-time filters: finite and infinite impulse response filters; fixed-point implementations and finite word-length effects; multidimensional filters and multidimensional signal processing. Illustrative applications are drawn from audio and biomedical signal processing, communication systems, and image and video signal processing.
Exclusion: ECE431H1

ECE410H1 F
Control Systems
III - AECPEBASC, III - AEELEBASC 3/1.50/1/0.50

State space analysis of linear systems, the matrix exponential, linearization of nonlinear systems. Structural properties of linear systems: stability, controllability, observability, stabilizability, and detectability. Pole assignment using state feedback, state estimation using observers, full-order and reduced-order observer design, design

of feedback compensators using the separation principle, control design for tracking. Control design based on optimization, linear quadratic optimal control, the algebraic Riccati equation. Laboratory experiments include computer-aided design using MATLAB and the control of an inverted pendulum on a cart.
Prerequisite: ECE311H1 S
Exclusion: ECE557H1 F

ECE411H1 S
Real-Time Computer Control
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASEB, IV - AEESCBASER — 3/1.50/-/0.50

Digital Control analysis and design by state-space methods. Introduction to scheduling of control tasks using fixed-priority protocols. Labs include control design using MATLAB and Simulink, and computer control of the inverted pendulum using a PC with real-time software.
Prerequisite: ECE311H1 S or ECE356H1 S

ECE413H1 S
Energy Systems and Distributed Generation
III - AECPEBASC, III - AEELEBASC, III - AEESCBASEJ, IV - AEESCBASER, I - AEMINENR — 3/1.50/1/0.50

Three-phase systems; steady-state transmission line model; symmetrical three-phase faults; power system stability; symmetrical components; unsymmetrical faults and fault current calculation; distribution network; equivalent steady-state model of voltage-sourced converter; distributed energy resources (DR); distributed energy storage; interface between DR and power system.
Prerequisite: ECE314H1 F or ECE315H1 F or ECE349H1F or ECE359H1 F

ECE417H1 S
Digital Communication
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER — 3/1.50/1/0.50

Basic concepts of digital communication. Baseband data transmission, intersymbol interference, Nyquist pulse shaping, equalization, line coding, multi-path fading, diversity. Binary and M-ary modulation schemes, synchronization. Signal space concepts, optimum receivers, coherent and noncoherent detectors. Information theory, source encoding, error control coding, block and convolutional codes.
Prerequisite: ECE302H1 F/S and ECE316H1 F/S.

ECE419H1 S
Distributed Systems
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER — 3/1.50/-/0.50

Design issues in distributed systems: heterogeneity, security, transparency, concurrency, fault-tolerance; networking principles; request-reply protocol; remote procedure calls; distributed objects; middleware architectures; CORBA; security and authentication protocols; distributed file systems; name services; global states in distributed systems; coordination and agreement; transactions and concurrency control; distributed transactions; replication.
Prerequisite: ECE344H1 F/S or ECE353H1 S

ECE422H1 S
Radio and Microwave Wireless Systems
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER — 3/1.50/1/0.50

Analysis and design of systems employing radio waves, covering both the underlying electromagnetics and the overall system performance aspects such as signal-to-noise ratios. Transmission/reception phenomena include: electromagnetic wave radiation and polarization; elementary and linear dipoles; directivity, gain, efficiency; integrated, phased-array and aperture antennas; beam-steering; Friis transmission formulas. Propagation phenomena include: diffraction and wave propagation over obstacles; multipath propagation in urban environments; atmospheric and ionospheric effects. Receiver design aspects include: receiver figures of merit, noise in cascaded systems, noise figure, and noise temperature. System examples are: fixed wireless access; mobile and personal communication systems; wireless cellular concepts; satellite communications; radar; radiometric receivers; GPS.
Prerequisite: ECE320H1 F or ECE357H1 S

ECE431H1 F/S
Digital Signal Processing
III - AECPEBASC, III - AEELEBASC — 3/1.50/1/0.50

An introductory course in digital filtering and applications. Introduction to real-world signal processing. Review of sampling and quantization of signals. Introduction to the discrete Fourier transform and its properties. The fast Fourier transform. Fourier analysis of signals using the discrete Fourier transform. Structures for discrete-time systems. Design and realization of digital filters: finite and infinite impulse response filters. DSP applications to communications: decimators and interpolators, estimation, equalization. DSP applications to multimedia: DCT and video coding.

ECE442H1 F
Introduction to Micro- and Nano-Fabrication Technologies
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASEO, IV - AEESCBASER — 3/2/1/0.50

An introduction to the fundamentals of micro- and nano-fabrication processes with emphasis on cleanroom practices. The physical principles of optical lithography, electron-beam lithography, alternative nanolithography techniques, and thin film deposition and metrology methods. The physical and chemical processes of wet and dry etching. Cleanroom concepts and safety protocols. Sequential micro-fabrication processes involved in the manufacture of microelectronic and photonic devices. Imaging and characterization of micro- and nano-structures. Examples of practical existing and emerging micro- and nano-devices. Limited enrollment.
Prerequisite: ECE335H1 or ECE350H1

ECE445H1 F
Neural Bioelectricity
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASEB, IV - AEESCBASEO, IV - AEESCBASER, I - AEMINBIO — 3/1.50/1/0.50

This course deals with generation, transmission and significance of bioelectricity in neural networks. Topics covered include: (i) Basic features of neural systems. (ii) Ionic transport mechanisms in neural membranes. (iii) Nonlinear circuit models of neuronal membranes. (iv) Propagation of electricity in neural cables. (v) Extracellular electric fields of cellular moving current sources. (vi) Biological neural networks. (vii) Artificial neural networks. (viii) Learning and memory in artificial neural networks. Laboratory topics include: (a) Measurement of surface potentials on human torsos. (b) Generation of cellular electricity in computer models of nonlinear circuits. (c) Propagation of

bioelectricity in computer models of nonlinear neural cables. (d) Investigation of a computer model of a periform cortex network.

ECE446H1 F
Sensory Communication
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASEB, IV - AEESCBASER, I - AEMINBIO 3/1.50/-/0.50

Physical acoustics, acoustic measurements, electroacoustic transducers, and physiological acoustics. Speech processing, speech recognition algorithms and signal processing by the auditory system. Engineering aspects of acoustic design. Electrical models of acoustic systems. Noise, noise-induced hearing loss, and noise control. Introduction to vision and other modalities. Musical and psychoacoustics.

ECE448H1 F
Biocomputation
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASEB, I - AEMINBIO 3/-/2/0.50

New technologies in molecular and cellular biology have allowed the collection of unprecedented amounts of biological data ranging from sequences to protein structures to gene expression. The need to synthesize knowledge from this abundant data is driving the convergence of the biological and computer sciences. This course will introduce the fundamental concepts and challenges in molecular biology and the computational and statistical approaches applied to model and address them. Course topics include basic concepts in molecular and structural biology, sequence-based algorithms (such as pairwise and multiple sequence alignment, statistical models), structure-based algorithms (such as energy models, homology modeling, threading), and systems biology algorithms (such as hierarchal and neural network clustering).
Prerequisite: CHE353H1 F

ECE450H1 S
Software Engineering II
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 3/1.50/1/0.50

A continuation of the material introduced in Software Engineering I, focusing on pragmatic structuring principles and design methodologies. Formal specification and validation of software systems. Object-oriented design and design patterns. Testing, metrics and maintenance of software systems. Reverse engineering. Safety-critical and real-time software systems. Emphasis is given to the design and development of large, complex software systems. A session project is normally required.
Prerequisite: CSC444H1 F

ECE451H1 S
VLSI Systems and Design
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 2/3/2/0.50

An introduction to the design, verification and layout of VLSI circuits for complex digital systems. The focus is on CMOS technology, using custom and standard cell-based design flows, and covering both design and computer-aided design techniques. Topics covered include deep sub-micron design, clocking techniques, physical design, sub-system design, power, testing, simulation, placement/routing, synthesis, and test generation. The course has a major project component in which students design and produce a layout for a small microprocessor chip.

ECE452H1 F
Computer Architecture
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 3/-/1/0.50

Performance analysis and metrics and cost. Instruction set architectures. Instruction-level parallelism: pipelining, superscalar, dynamic scheduling, VLIW processors. Data-level prallelism: vector processors, GPUs. Thread-level parallelism: multiprocessors, multi-core, coherence, simultaneous multi-threading. Memory hierarchies: caches and virtual memory support. Simulation tools and methods. Limited Enrollment.
Prerequisite: ECE243H1 S or ECE352H1 F

ECE454H1 F
Computer Systems Programming
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 3/3/-/0.50

This course teaches fundamental techniques for programming computer systems, with an emphasis on obtaining good performance. The course will focus on system behaviour and operation, covering important concepts such as finite precision number representations, manipulation of bits and bytes at a low level, program operation at the machine level, memory allocation and management, the use of memory hierarchy for good performance, measuring and optimizing program performance. The course will also cover other selected advanced topics in programming techniques. Students will gain hands-on experience in a variety of topics and programming environments, and a deeper understanding of how to program computer systems for high performance and efficiency.

ECE461H1 F
Internetworking
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 3/1.50/0.50/0.50

This course will cover the fundamentals of protocols for packet switching networks with emphasis on Internet type of networks including the following topics: the Internetworking concept and architectural model; data link layer (Ethernet and PPP); service interface; Internet addresses; address resolution protocol; Internet protocol (connectionless datagram delivery); routing IP datagrams; Internet control message protocol (error and control messages); subnet and supernet address extensions; ping program; traceroute program; user datagram protocol; reliable stream transport service (TCP); the socket interface; routing (GGP, EGP, IP, OSPF, HELLO); Internet multicasting; domain name system; applications such as HTTP, electronic mail, and SNMP; Internet security and firewall design; Ipv6, RSVP, flows, and ISIP.
Prerequisite: ECE361H1 F/S

ECE462H1 S
Multimedia Systems
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 3/2/-/0.50

Topics in the engineering area of multimedia systems with particular emphasis on the theory, design features, performance, complexity analysis, optimization and application of multimedia engineering technologies. Topics include sound/audio, image and video characterization, compression, source entropy and hybrid coding, transform coding, wavelet-based coding, motion estimation, JPEG coding, digital video coding, MPEG-1/2 coding, content-based processing, and MPEG-7.

ECE463H1 S
Electric Drives

III - AECPEBASC, III - AEELEBASC, III - AEESCBASEJ, IV - AEESCBASER — 3/1.50/1/0.50

Electro-mechanical mechanisms for force and torque production in rotating machines. DC machine theory and DC machine dynamics, synchronous machines and their dynamics, stepper motors. Introduction to space vectors and vector control of AC machines. Steady state and variable speed operation of the induction machine via V/f control.
Prerequisite: ECE314H1 F or ECE315H1 F or ECE349H1 F or ECE359H1 F

ECE464H1 S
Wireless Communication

III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER — 3/1.50/1/0.50

The radio medium, radio communication system examples. Link budget: cable losses, propagation loss, antenna gains. Basic concepts of propagation: path loss, multi-path propagation and fading. Raleigh and Rician fading models, Doppler shift, delay spread, coherence time and coherence bandwidth of the channel. Analog modulation schemes and their bandwidths. Digital modulation schemes and their bandwidths and bit rates: BPSK, QPSK, MSK, GMSK. Basic concepts of speech coding. Error correction coding, interleaving, and multiple access frame structure. The physical layer description of the AMPS, IS-54, and GSM cellular systems. The cellular concept: frequency re-use, re-use cluster concept. Channel allocation. Cellular system architecture for AMPS, IS-54, and GSM. Hand-offs and transmitter power control. Cellular traffic, call blocking, concept of Erlangs. Basic ideas in spread spectrum modulation, spreading codes, bit error probability. Orthogonal and non-orthogonal CDMA Basic concepts in CDMA networks.
Prerequisite: ECE302H1 F/S and ECE316H1 F/S

ECE466H1 S
Computer Networks II

III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER — 3/1.50/1/0.50

Traffic modeling; network calculus; traffic classification; traffic regulation: shaping, filtering, policing, leaky bucket; queueing systems; scheduling; quality of service: Diffserv and IntServ/RSVP; multi-protocol label switching; call admission control / congestion control; switching; pricing; optical networks.
Prerequisite: ECE361H1 F/S

ECE469H1 S
Optical Communications and Networks

III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER — 3/1.50/1/0.50

This course provides an introduction to optical communication systems and networks at the system and functional level. Applications range from telecommunication networks (short to long haul) to computing networks (chip-to-chip, on chip communications, optical backplanes). Basic principles of optical transmission and associated components used for transmission of light and optical networks; system design tools for optical links; multi-service system requirements; optical network design tools (routing and wavelength assignment), network management and survivability.
Prerequisite: ECE302H1 F/S or ECE316H1 F/S or ECE318H1 S or ECE320H1 F

ECE470H1 S
Robot Modeling and Control

III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER — 3/1.50/1/0.50

Classification of robot manipulators, kinematic modeling, forward and inverse kinematics, velocity kinematics, path planning, point-to-point trajectory planning, dynamic modeling, Euler-Langrange equations, inverse dynamics, joint control, computed torque control, passivity-based control, feedback linearization.
Prerequisite: ECE311H1 S or ECE356H1 S

ECE472H1 F/S
Engineering Economic Analysis & Entrepreneurship

3/-/1/0.50

The economic evaluation and justification of engineering projects and investment proposals are discussed. Cost concepts; financial and cost accounting; depreciation; the time value of money and compound interest; inflation; capital budgeting; equity, bond and loan financing; income tax and after-tax cash flow; measures of economic merit in the private sector; sensitivity and risk analysis. Applications: evaluations of competing engineering project proposals; replacement analysis; economic life of assets; lease versus buy decisions; break-even analysis; decision tree analysis. Entrepreneurship, the Canadian business environment and the business plan for a new venture will be discussed.

ECE488H1 F
Entrepreneurship and Business for Engineers

3/-/2/0.50

A complete introduction to small business formation, management and wealth creation. Topics include: the nature of the Entrepreneur and the Canadian business environment; business idea search and Business Plan construction; Buying a business, franchising, taking over a family business; Market research and sources of data; Marketing strategies promotion, pricing, advertising, electronic channels and costing; The sales process and management, distribution channels and global marketing; Accounting, financing and analysis, sources of funding, and financial controls; The people dimension: management styles, recruiting and hiring, legal issues in employment and Human Resources; Legal forms of organization and business formation, taxation, intellectual property protection; the e-Business world and how businesses participate; Managing the business: location and equipping the business, suppliers and purchasing, credit, ethical dealing; Exiting the business and succession, selling out. A full Business Plan will be developed by each student and the top submissions will be entered into a Business Plan competition with significant cash prices for the winners. Examples will be drawn from real business situations including practicing entrepreneurs making presentations and class visits during the term. (Identical courses are offered: MSE488H1F, MIE488H1F, CHE488H1S and CIV488H1S.)
Exclusion: APS234 and APS432

ECE496Y1 Y
Design Project

0.30/-/0.70/1.00

A full year capstone design project course intended to give students an opportunity to apply their technical knowledge and communication skills. Working in teams under the direct supervision of a faculty member, students develop a design project of their choice from an initial concept to a final working prototype. In the first session, a project proposal is submitted early on, followed by a project requirements specification. A design review meeting is then held to review the proposed design. Lectures given during the first session

will develop expertise in various areas related to design and technical communication. In the second session, the teams present their work in a number of ways, including an oral presentation, a poster presentation, a final demonstration at the Design Fair, an individual progress report, and a group final report. Course deliverables are evaluated by both the team's supervisor and one of several course administrators.

ECE510H1 F
Introduction to Lighting Systems
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASEJ, IV - AEESCBASER, I - AEMINENR 2/-/1/0.50

An introduction to the physics of lighting systems (e.g. plasma physics, radiation spectrum, physics of light-emitting diodes) and the corresponding power electronic driver circuits (ballasts). The operating principles and the science behind different types of lamps are covered. These include incandescent, fluorescent, low and high pressure sodium, mercury, metal halide lamps and LED lighting systems. The designs and technical challenges of the electronic ballasts for each type of lighting source are discussed. Issues related to lighting regulations, layout, delivery, efficiency, control and the economic and environmental assessment of current lighting systems are briefly addressed.
Prerequisite: ECE314H1 F or ECE315H1 F or ECE 349H1 F or ECE359H1 F

ECE512H1 F
Analog Signal Processing Circuits
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 3/-/2/0.50

An overview of analog signal processing in both continuous-time and discrete-time. The design of analog filters including transfer function approximation using Matlab and implementation using active-RC, transconductance-C, and switched-capacitor circuits. Other topics include oversampling and noise in analog circuits.
Prerequisite: ECE331H1 F or ECE354H1 S

ECE516H1 S
Intelligent Image Processing
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 2/3/-/0.50

This course provides the student with the fundamental knowledge needed in the rapidly growing field of Personal Cybernetics, including "Wearable Computing", "Personal Technologies", "Human Computer Interaction (HCI)," "Mobile Multimedia," "Augmented Reality," "Mediated Reality," CyborgLogging," and the merging of communications devices such as portable telephones with computational and imaging devices. The focus is on fundamental aspects and new inventions for human-computer interaction. Topics to be covered include: mediated reality, Personal Safety Devices, lifelong personal video capture, the Eye Tap principle, collinearity criterion, comparametric equations, photoquantigraphic imaging, lightvector spaces, anti-homomorphic imaging, application of personal imaging to the visual arts, and algebraic projective geometry.

ECE524H1 F
Microwave Circuits
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 2/1.50/1/0.50

The wave equation; losses in conductors and dielectrics; RF and microwave transmission lines; transients on transmission lines; matching networks; planar transmission lines (microstrip, stripline, coplanar waveguide); design with scattering parameters; 3- and 4-port RF devices (power dividers/combiners, couplers, isolators & circulators); coupled lines and devices; microwave active circuits (RF amplifiers, mixers, and receiver front ends); RF and microwave filters. The hands-on laboratories engage students in the design, simulation, fabrication, and test of practical passive and active microwave circuits using industry-standard RF/microwave simulation tools and measurement systems.
Prerequisite: ECE320H1 F or ECE357H1 S

ECE525H1 S
Lasers and Detectors
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASEO, IV - AEESCBASEP, IV - AEESCBASER 3/-/1/0.50

This course focuses on photonic components which generate or absorb light. Lasers: spontaneous and stimulated emission, gain and absorption, gain broadening; modulation dynamics, mode-locking, Q-switching; semiconductor lasers. Photodetectors: absorption, photo-generated currents, noise in detection.
Prerequisite: One of ECE330/350H1 or PHY335/355H1, and one of ECE318/320/357H1 ECE318H1 S can also be taken as a co-requisite instead of a pre-requisite.)

ECE527H1 F
Passive Photonic Devices
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASEJ, IV - AEESCBASER 2/-/1/0.50

This course will introduce students to a range of passive photonic components; students will gain an understanding of the fundamentals of how these devices operate and an appreciation of where these components find applications in telecommunications and sensing systems. Topics covered in this course include: interaction of light with matter; Gaussian beams and resonator optics; periodic structures, optical thin films and gratings; photonic band gap materials; waveguides and couplers, birefingent materials and polarization devices.
Prerequisite: ECE318H1 S

ECE530H1 S
Analog Integrated Circuits
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 2/1.50/1/0.50

Review of MOSFET semiconductor device equations. Review of basic amplifier circuits. Basic CMOS op amp. Op amp compensation. Advanced op amp circuits: telescopic and folded-cascode op amps; fully-differential op amps. Comparators. Sample-and-hold circuits. Bandgap reference circuits. Nyquist-rate data converters: D/A converters, A/D converters.
Prerequisite: ECE331H1 F or ECE354H1 S

ECE532H1 S
Digital Systems Design
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASEC, IV - AEESCBASEE, IV - AEESCBASER 2/3/-/0.50

Advanced digital systems design concepts including project planning, design flows, embedded processors, hardware/software interfacing and interactions, software drivers, embedded operating systems, memory interfaces, system-level timing analysis, clocking and clock domains. A significant design project is undertaken and implemented on an FPGA development board.
Prerequisite: ECE342H1 S or ECE352H1 F

ECE533H1 F
Advanced Power Electronics
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASEJ, IV - AEESCBASEM, IV - AEESCBASER, I - AEMINENR 3/-/1/0.50

This course covers system issues associated with the design of switched mode power supplies for telecommunication, computer network and information applications. Topics to be covered include: power processing architectures; steady state analysis and component ratings; control loop modelling and control loop design; EMC regulatory issues.
Prerequisite: ECE314H1 F or ECE315H1 F or ECE349H1 F or ECE359H1 S

ECE534H1 F
Integrated Circuit Engineering
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 2/3/-/0.50

The course deals with the technology and design of analog, digital and RF integrated circuits, including exposure to computer aided IC design tools at the semiconductor process, device, and circuit layout level. Topics include: IC fabrication review, MOS IC process modules and components; RF (Bi) CMOS IC process modules and components; compact modelling, characterization and design automation; Bipolar/CMOS digital, analog, and RF IC building blocks; packaging and yield. The labs will expose students to the major design steps in the development of a multi-purpose (Bi) CMOS process.
Prerequisite: ECE331H1 F or ECE334H1 F/S and ECE335H1 F

ECE535H1 F
Advanced Electronic Devices
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 2/-/-/0.50

Heterojunctions, SiGe, InP and GaSb HBTs. MOS device scaling and scaling limits, Dennard's constant field scaling rules, device characteristics and short channel effects. Charge quantization, gate stack, strain and substrate engineering in nanoscale MOSFETs. Nanoscale CMOS fabrication process flow, isolation methods, strategies to suppress short channel effects, stress memorization techniques. Technology CAD for process and device simulations. SPICE models for circuit simulation. SOI (Silicon on Insulator) technology, III-V FETs and graphene transistors. High Power Devices: LDMOS, AlGaN/GaN HEMTs.
Prerequisite: ECE335H1 F or ECE350H1 F

ECE540H1 S
Optimizing Compilers
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 2/3/-/0.50

Theoretical and practical aspects of building modern optimizing compilers. Topics: intermediate representations, basic blocks and flow graphs, data flow analysis, partial evaluation and redundancy elimination, loop optimizations, register allocation, instruction scheduling, interprocedural memory hierarchy optimizations. Students will implement significant optimizations within the framework of a modern research compiler. Experience in C programming required.

ECE557H1 F
Systems Control
IV - AEESCBASEA, IV - AEESCBASEB, IV - AEESCBASER 3/1.50/-/0.50

State-space approach to linear system theory. Mathematical background in linear algebra, state space equations vs. transfer functions, solutions of linear ODE's, state transition matrix, Jordan form, controllability, eigenvalue assignment using state feedback, observability, designing observers, separation principle, Kalman filters, tracking and the regulator problem, linear quadratic optimal control, stability. Laboratories cover the state space control design methodology.
Exclusion: ECE410H1 F

ECE568H1 S
Computer Security
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASER 3/3/-/0.50

As computers permeate our society, the security of such computing systems is becoming of paramount importance. This course covers principles of computer systems security. To build secure systems, one must understand how attackers operate. This course starts by teaching students how to identify security vulnerabilities and how they can be exploited. Then techniques to create secure systems and defend against such attacks will be discussed. Industry standards for conducting security audits to establish levels of security will be introduced. The course will include an introduction to basic cryptographic techniques as well as hardware used to accelerate cryptographic operations in ATM's and webservers.
Prerequisite: ECE344H1 F/S

Engineering Science

ESC101H1 F
Praxis I
I - AEESCBASE 2/-/2/0.50

Engineering Science Praxis I supports the term's course content through design and communication. Students will participate in a weekly design studio, conducting individual and group activities in design, and both oral and written communication.

ESC102H1 S
Praxis II
I - AEESCBASE 2/-/2/0.50

A studio-based, service learning course in which students work in small teams to identify and then to design solutions for a contemporary issue situated within the Greater Toronto Area. The Design component of the course introduces formal design techniques such as framing, requirements gathering and codification, processes and heuristics, planning, and multi-criteria decision making. The Communication component introduces communicative genres such as Requests for Proposals (RFPs), brochures, posters, and oral presentations. Material from other concurrent courses is integrated through targeted activities and expectations in the Design and Communication components.

ESC103H1 F
Engineering Mathematics and Computation
I - AEESCBASE 2/-/2/0.50

This course is designed to introduce students to mathematics in an engineering context, while exposing students to computational techniques. Topics include review of trigonometry, complex numbers, vectors, lines and planes; introduction to integral calculus, techniques of integration, and differential equations; logic; methods of proof; linear transformations and matrices, inverses, determinants, solving linear systems, least squares, error analysis; 3-D visualization. Exposure to computation tools like Matlab and Maple.

ESC203H1 F
Engineering, Society & Critical Thinking
II - AEESCBASE 3/-/1/0.50

Through this course, students will examine the interrelations of science, technology, society and the environment (STSE), emphasizing a humanities and social sciences perspective. Using topics in STSE as the context, students will consider established models of critical thinking and develop their own framework for analyzing socio-technical issues. Students will have the opportunity to apply tools learned through persuasive writing and formal debate. Upon completion of the course, students will have an understanding of how structured models of thinking can aid in the analysis and evaluation of thought, and should be able to apply tools of critical thinking in other contexts.

ESC301Y1 Y
Engineering Science Option Seminar
III - AEESCBASEA, III - AEESCBASEB, III - AEESCBASEF, III - AEESCBASEI, III - AEESCBASEJ, III - AEESCBASEO, III - AEESCBASEP, III - AEESCBASER -/-/0.50/0.10

The Option seminar supports option-related curriculum through discussion of ethics, philosophy and research in a seminar-based setting. Guest speakers, presentations and other special activities will highlight various topics of interest, including the present and future research related to the Option. This course will be offered on a pass/fail basis and the assessment will be based on active discussion within the seminar. Students will be encouraged to discuss their viewpoints on philosophical and ethical issues facing the Option, as well as future directions and opportunities. Occasionally, students from across options will be brought together for special discussions and activities related to research and the engineering profession.

ESC401H1 S
Technology & Society Student Directed Seminar
3/-/1/0.50

Complementary Studies Course. Through this course, students have the opportunity to propose a topic for exploration in the realm of technology and society studies to run as a student-led seminar course. Accepted course topics in any given year will be based on student interest. The student course leader(s) are expected to work with the course coordinator to create a full course plan, including learning objectives, course topics and methods of assessment. All participants are expected to contribute to the learning experience, through presentations, suggestions of readings and subtopics. The student directed seminar provides an opportunity to explore a topic of interest, and gain experience in course planning and delivery in a collaborative learning environment. Suggested topics may include engineering & international development, engineering education & outreach, the politicization of science, gender & technology, or cross-profession collaboration; however, students may propose any topic in the broad realm of technology and society studies. Deadlines for student directed seminar proposals and seminar registration will be publicized by the Division of Engineering Science.

ESC470H1 S
Energy Systems Capstone Design
IV - AEESCBASEC, IV - AEESCBASEE, IV - AEESCBASEJ, IV - AEESCBASER -/-/5/0.50

A half-year capstone design project intended to give students an opportunity to apply their technical knowledge and communication skills, while further developing skills in teamwork and project management. Design projects will reflect challenges in generation, transmission and storage of energy from across a range of traditional and alternative energy sources. Students will work in teams on challenges presented by relevant industry and academic partners. Projects will challenge students to satisfy design requirements that relate to society, the environment, and culture, as well as safety, function, and cost. At the end of the course, students submit a final design report (text and drawings) and a poster for public exhibition.

ESC471H1 F/S
Engineering Science Capstone Design
IV - AEESCBASEB, IV - AEESCBASEC, IV - AEESCBASEE, IV - AEESCBASEO, IV - AEESCBASEP, IV - AEESCBASER -/-/5/0.50

A major design project that brings together students from different Engineering Science Options working in small groups on projects specified by course staff. Emphasis is on the creation and validation of design concepts rather than refinement of designs through detailed analysis. At the end of the course, students submit a final design report and a poster for public exhibition.

ESC490H1 F/S
Engineering Science Independent Study
-/-/6/0.50

Independent study courses are student initiated projects, open to Engineering Science students, which allow students to work one-on-one with a division faculty member. The student and supervising faculty member will develop a learning plan for the semester within the first week of term (Limited Enrollment).

ESC499H1 F/S
Thesis
IV - AEESCBASEA, IV - AEESCBASEI 3/2/-/0.50

Every student in Fourth Year Engineering Science is required to prepare a thesis on an approved subject. Instructions concerning the thesis requirements are issued during the Winter Session of Third Year and copies may be obtained in the Division office. The weight allocated to the thesis in each option is shown in the Fourth Year curriculum. Full year theses are graded after submission in the Winter Session and the grade included in the weighted average for that session only.

ESC499Y1 Y
Thesis
IV - AEESCBASEA, IV - AEESCBASEB, IV - AEESCBASEC, IV - AEESCBASEE, IV - AEESCBASEJ, IV - AEESCBASEM, IV - AEESCBASEO, IV - AEESCBASEP, IV - AEESCBASER 3/2/-/1.00

Every student in Fourth Year Engineering Science is required to prepare a thesis on an approved subject. Instructions concerning the thesis requirements are issued during the Winter Session of Third Year and copies may be obtained in the Division office. The weight allocated to the thesis in each option is shown in the Fourth Year

curriculum. Full year theses are graded after submission in the Winter Session and the grade included in the weighted average for that session only.

History and Philosophy of Science

In addition to the courses listed below, the Institute offers the following courses through the Faculty of Arts and Science. These courses are acceptable as Humanities/Social Science Electives in engineering programs: HPS210H1F/HPS211H1S Scientific Revolutions (Exclusion: HPS280H1 F), HPS201H1 F Origins of Western Technology (Exclusion: HPS281H1 S), HPS202H1 S Technology in the Modern World (Exclusion: HPS282H1 S), HPS390/91 History of Mathematics, HPS305H Technology and Society in North America (Exclusion: HPS284H1 S), HPS324H Natural Science and Social Issues.

Details of these courses are available from the IHPST office in Room 316, Old Academic Building, Victoria College 416-978-5397. Specific timetable information about Arts and Science courses is published in March, with an updated edition in September.

HPS280H1 F/S
History of Science

2/-/1/0.50

An introduction to the history of science, surveying major developments from antiquity to the present. (To be offered in the Fall Session)

HPS281H1 F/S
History of Technology and Engineering Pre-Industrial Revolution

2/-/1/0.50

The origins of technology and engineering, from the civilizations of the Ancient World, Greece and Rome, through the Medieval World and the Renaissance. Emphasis on the developments of techniques and machines with an indication of the context in which these occur. (To be offered in the Winter Session).

HPS282H1 F/S
History of Technology and Engineering

2/-/1/0.50

The development of technology and engineering from the Industrial Revolution to the present. An historical overview emphasizing new machines, power sources, materials and processes, as well as communications. Some stress is laid on innovation within historical contexts, the changing relationship between science and technology, and the nature of engineering in history. (HPS281H1 S coordinates with this course, but it is not a pre-requisite.)

HPS283H1 S
The Engineer in History

2/-/1/0.50

The emphasis in this course will be more on the history of engineers as workers, members of professional groups, and managers rather than engineering proper, although obviously engineering cannot be ignored when we talk about engineers' work. The aim of the course is to give an understanding of the heritage of engineers as participants in the economy and society.

Mathematics

MAT185H1 S
Linear Algebra

I - AEESCBASE 3/-/1/0.50

Linear systems, matrix algebra, Rn as a vector space, a normed space and an inner-product space,linear transformations on Rn, eigenvalues. Applications to circuits, mechanics, etc. Introduction to computer methods.

MAT186H1 F
Calculus I

I - AECHEBASC, I - AECIVBASC, I - AEINDBASC, I - AELMEBASC, I - AEMECBASC, I - AEMMSBASC 3/-/1/0.50

Limits, differentiation, maximum and minimum problems, definite and indefinite integrals, application of integration in geometry, mechanics, and other engineering problems.

MAT187H1 S
Calculus II

I - AECHEBASC, I - AECIVBASC, I - AEINDBASC, I - AELMEBASC, I - AEMECBASC, I - AEMMSBASC 3/-/1/0.50

Techniques of integration, introduction to differential equations, vector differentiation, partial differentiation, series. Application to mechanics and other engineering problems.

MAT188H1 F
Linear Algebra

I - AECHEBASC, I - AECIVBASC, I - AECPEBASC, I - AEELEBASC, I - AEENGBASC, I - AEINDBASC, I - AELMEBASC, I - AEMECBASC, I - AEMMSBASC 3/-/1/0.50

Systems of linear equations; matrices; determinants; vectors, lines and planes in 3 dimensions; Rn; vector spaces; eigenvalues and eigenvectors; introduction to products; applications.

MAT194H1 F
Calculus I

I - AEESCBASE 3/-/1/0.50

Theory and applications of differential and integral calculus, limits, basic theorems, elementary functions.

MAT195H1 S
Calculus II
I - AEESCBASE 3/-/1/0.50

Introduction to differential equations, techniques of integration, improper integrals, sequences, series, Taylor's theorem, introduction to functions of several variables and partial derivatives.

MAT196H1 F
Calculus A
I - AECPEBASC, I - AEELEBASC, I - AEENGBASC 3/-/1/0.50

Limits and continuity, differentiation, maximum and minimum problems, definite and indefinite integrals, application of integration to geometry, mechanics, and other engineering problems, introduction to first order differential equations.

MAT197H1 S
Calculus B
I - AECPEBASC, I - AEELEBASC, I - AEENGBASC 3/-/1/0.50

Techniques of integration, introduction to second order differential equations, sequences and series, vector-valued functions, functions of several variables, partial differentiation. Applications to mechanics and other engineering problems.
Prerequisite: MAT196H1 F

MAT234H1 S
Differential Equations
II - AEINDBASC, II - AEMECBASC 3/-/1.50/0.50

Ordinary differential equations. Classification. Equations of first order and first degree. Linear equations of order n. Equations of second order. Bessel's equation. Legendre's equation. Series solutions. Systems of simultaneous equations. Partial differential equations. Classification of types. The diffusion equation. Laplace's equation. The wave equation. Solution by separation of variables.

MAT290H1 F
Advanced Engineering Mathematics
II - AECPEBASC, II - AEELEBASC 3/-/2/0.50

An introduction to complex variables and ordinary differential equations. Topics include: Laplace transforms, ordinary higher-order linear differential equations with constant coefficients; transform methods; complex numbers and the complex plane; complex functions; limits and continuity; derivatives and integrals; analytic functions and the Cauchy-Riemann equations; power series as analytic functions; the logarithmic and exponential functions; Cauchy's integral theorem, Laurent series, residues, Cauchy's integral formula, the Laplace transform as an analytic function. Examples ar drawn from electrical systems.

MAT291H1 F
Calculus III
II - AECPEBASC, II - AEELEBASC 3/-/2/0.50

The chain rule for functions of several variables; the gradient. Maxima and minima, Lagrange multipliers. Multiple integrals; change of variables, Jacobians. Line integrals, independance of path, Green's theorem. The gradient, divergence and curl of a vector field. Surface integrals; parametric representations, applications from electromagnetic fields, Gauss' theorem and Stokes' theorem.

MAT292H1 F
Calculus III
II - AEESCBASE 3/-/2/0.50

Existence and uniqueness of solution for first-order differential equations, general second-order linear ODEs, homogeneous equations, nonhomogeneous equations, variable coefficients, variation of parameters ODEs in matrix form, Fourier series, Fourier and Laplace transforms, optimization, single-variable functions, interpretation of problems in mathematical terms, multivariable functions, hessians, optimization in the presence of constraints, Lagrange multipliers, introduction to numerical methods, introduction to numerical and computational methods.

MAT301H1 F
Groups and Symmetries
III - AEESCBASEP, IV - AEESCBASER 3/-/-/0.50

Congruences and fields. Permutations and permutation groups. Linear groups. Abstract groups, homomorphisms, subgroups. Symmetry groups of regular polygons and Platonic solids, wallpaper groups. Group actions, class formula. Cosets, Lagranges theorem. Normal subgroups, quotient groups. Classification of finitely generated abelian groups. Emphasis on examples and calculations.
Prerequisite: MAT224H1, MAT235Y1/MAT237Y1, MAT246H1/CSC236H1/CSC240H1. (These *Prerequisite*s will be waived for students who have MAT257Y1)
Exclusion: MAT347Y1

MAT337H1 S
Introduction to Real Analysis
III - AEESCBASEF, III - AEESCBASEP, IV - AEESCBASER 3/-/-/0.50

Metric spaces; compactness and connectedness. Sequences and series of functions, power series; modes of convergence. Interchange of limiting processes; differentiation of integrals. Function spaces; Weierstrass approximation; Fourier series. Contraction mappings; existence and uniqueness of solutions of ordinary differential equations. Countability; Cantor set; Hausdorff dimension.

NOTE: These *Prerequisite*s will be waived for students who have MAT257Y1
Prerequisite: MAT224H1, MAT235Y1/MAT237Y1,MAT246H1
Exclusion: MAT357H1

MAT357H1 S
Real Analysis I
III - AEESCBASEF 3/-/-/0.50

Function spaces; Arzela-Ascoli theorem, Weierstrass approximation theorem, Fourier series. Introduction to Banach and Hilbert spaces; contraction mapping principle, fundamental existence and uniqueness theorem for ordinary differential equations. Lebesgue integral; convergence theorems, comparison with Riemann integral, Lp spaces. Applications to probability.

MAT389H1 F
Complex Analysis
III - AECPEBASC, III - AEELEBASC, III - AEESCBASEA, III - AEESCBASEB, III - AEESCBASEO, III - AEESCBASEP, III - AEESCBASER 3/-/1/0.50

Course examines the following: analytic functions, Cauchy-Reimann equations, contour integration, Cauchy's theorem, Taylor and Laurent series, singularities, residue calculus, conformal mapping, harmonic functions, Dirichlet and Neumann problems and Poisson integral

formulas. Course includes studies of linear differential equations in the complex plane, including Bessel and Legendre functions.
Exclusion: MAT290H1F

MAT401H1 S
Polynomial Equations and Fields
IV - AEESCBASEP 3/-/-/0.50

Commutative rings; quotient rings. Construction of the rationals. Polynomial algebra. Fields and Galois theory: Field extensions, adjunction of roots of a polynomial. Constructibility, trisection of angles, construction of regular polygons. Galois groups of polynomials, in particular cubics, quartics. Insolvability of quintics by radicals.
Prerequisite: MAT301H1
Exclusion: MAT347Y1

MAT402H1 S
Classical Geometries
IV - AEESCBASEP 3/-/-/0.50

Euclidean and non-euclidean plane and space geometries. Real and complex projective space. Models of the hyperbolic plane. Connections with the geometry of surfaces.
Prerequisite: MAT301H1/MAT347Y1, MAT235Y1/MAT237Y1/MAT257Y1

Materials Science Engineering

MSE101H1 F/S
Introduction to Materials Science
I - AECHEBASC, I - AECIVBASC, I - AEINDBASC, I - AELMEBASC, I - AEMECBASC, I - AEMMSBASC 3/1/1/0.50

This is an introductory course in materials science examining the fundamentals of atomic structure, the nature of bonding in materials, crystal structure and defects, and phase equilibria. These basic principles provide the foundation for an exploration of structure-property relationships in metals, ceramics, and polymers, with emphasis on mechanical properties. The properties of materials then form the basis for an introduction to materials selection in design.

MSE202H1 F
Thermodynamics
III - AELMEBASC, II - AEMMSBASC 3/-/2/0.50

Enthalpy and energy balances of reactions and processes. Gibbs free energy and its use to determine equilibrium compositions for single phase and two phase systems. Introduction of Ellingham and pre-dominance area diagrams for solid-gas systems. Treatment of ideal and non-ideal solutions with the introduction of the concept of activity and activity coefficient. Binary and ternary phase diagrams and their applications to materials processing and materials properties.

MSE217H1 S
Diffusion and Kinetics
II - AEMMSBASC 3/-/2/0.50

The diffusion mechanisms in solids, liquids and gases are reviewed. The effects of imperfections in solids on diffusion rates are discussed. Topics include diffusion coefficient, Fick's law, steady state and unsteady state diffusion. The course covers factors affecting the rate at which chemical reactions take place. The effects that temperature, concentration, pressure and catalysts have on reaction rates are discussed. Topics such as homogeneous versus heterogeneous reactions, order or reaction, and activation energy are also covered.

MSE219H1 F
Structure and Characterization of Materials
II - AEMMSBASC 3/1.50/1/0.50

Both the theoretical and experimental interpretation of the structure and chemistry of inorganic materials on various length scales will be examined. Crystalline and amorphous structure is discussed in terms of electronic structure of atoms, atomic bonding, atomic coordination and packing. Extended defects in crystalline solids will be covered. Experimental techniques for characterizing materials structure and chemistry will be described including: optical and electron microscopy, x-ray diffraction, scanning probe microscopy, Auger electron spectroscopy, x-ray photoelectron spectroscopy and secondary ion mass spectrometry.

MSE235H1 S
Materials Physics
III - AECPEBASC, III - AEELEBASC, II - AEMMSBASC 3/-/1/0.50

Application of solid state physics to describe properties of materials. Thermal properties of solids: lattice vibrations (phonons), heat capacity, thermal conductivity. Electrical properties of metals: simple circuits, resistivity of metals (classical and quantum descriptions), Seebeck, Peltier, and Thomson effects. Electrical properties of semiconductors: band structure and occupancy, conductivity, Hall effect, simple devices. Electrical properties of insulators: polarization, capacitance, optical properties, ferroelectric and piezoelectric materials. Magnetic properties: diamagnetism and paramagnetism, ferromagnetic and ferrimagnetic materials, magnetic domains, B-H curves.

MSE238H1 S
Engineering Statistics
II - AEMMSBASC 3/-/2/0.25

Topics will include elements of probability theory, hypothesis testing, discrete and continuous distribution, analysis of variance. Description of a sample of measurements. Sampling distributions, parameter estimation, hypothesis testing. Elements of regression analysis. Application from materials engineering area. (Half term course taught during first 6 weeks of term)

MSE244H1 F
Inorganic Materials Chemistry and Processing
II - AEMMSBASC 3/2/1/0.50

An introduction to atomic and molecular structures, acid-base and redox reactions, transition metal complexes, systematic chemistry and physical properties of metals and elements in the periodic table. Examples of industrial practice from the metal processing industry and energy generation and storage technologies will also be discussed. The fundamentals of chemical analysis of inorganic compounds, by both classical "wet" volumetric analysis and instrumental methods are covered in the experiments.

MSE245H1 S
Organic Materials Chemistry and Properties
II - AEMMSBASC 3/2/1/0.50

Introduction to organic chemistry and organic materials. Naming of organic compounds. Properties and reactions of organic compounds. Bonding and shapes of organic molecules. Analysis of organic compounds including IR and mass spectroscopy. Introduction to natural and bio-molecules. Principles of structure of polymer molecules. Polymer synthesis. Structure of polymeric materials including amorphous, crystalline, elastomeric and fibre reinforced. Mechanical and thermal properties of polymers.

MSE250H1 S
Materials Selection in Design I
II - AEMMSBASC 2/2/1/0.25

The basic principles underlying the selection and design of engineering materials for different applications are identified. The application of Cambridge Engineering Selection computer software during material selection. Selected case studies. (Half term course taught during last 6 weeks of term)

MSE260H1 S
Molecules & Materials
II - AEESCBASE 3/-/1/0.50

This course will cover both the fundamentals and applications of molecular chemistry as it relates to the properties of materials. Fundamental topics will include: (1) the design of chemical structures and their relationship to optical and electronic properties; (2) the chemistry and physics of covalent and non-covalent bonding; (3) the relationship of atomic bonding to molecular geometry and local symmetry; (4) crystal structures of extended solids; and (5) extension of these principles to electronic structure, elasticity, and vector and tensor descriptions of materials properties. Applications to diverse areas of engineering will be discussed.

MSE270H1 F
Materials Science
II - AEMECBASC 3/0.75/1.50/0.50

Classification of materials. Elasticity and plasticity. Metal structure. Point, line and planar defects. Ferrous and non-ferrous alloys. Phase transformation in stainless steel. Strengthening mechanisms in alloys. Failure analysis and testing. Fatigue, creep, friction and wear. Polymers and plastics. Ceramics and their composites. Special purpose materials. Brittle fracture in ceramics. Failure mechanisms in metal matrix composites. Biomaterials.
Prerequisite: MSE101H1

MSE290H1 S
Communications I
II - AEMMSBASC 1/-/1/0.25

Students will select assigned reading packages from one of many areas of materials science and engineering. Written communication skills will be developed through iterative report writing.

MSE301H1 S
Mineral Processing
II - AELMEBASC 3/1.50/1/0.50

The theory and practice of mineral beneficiation including particle size measurement, comminution, sizing, liquid-solid separation and ore concentration by gravity, magnetic methods and flotation. The course also includes the relevant aspects of mineralogy, surface chemistry and the movement of solid particles in liquid media.
Prerequisite: MIN225H1F

MSE315H1 S
Environmental Degradation of Materials
I - AEMINENV, III - AEMMSBASC 3/-/2/0.50

This course deals with four major areas: electrochemistry of low temperature aqueous solvents, the corrosion of materials, mechano-chemical effects in materials and corrosion prevention in design. Electrochemistry deals with thermodynamics of material-electrolyte systems involving ion-solvent, ion-ion interactions, activity coefficients, Nernst equation and Pourbaix diagrams, and rate theory through activation and concentration polarization. Corrosion of metallic, polymeric, ceramic, composite, electronic and biomaterials will be explored along with mechano-chemical effects of stress corrosion, hydrogen embrittlement and corrosion fatigue. Corrosion prevention in terms of case histories and the use of expert systems in materials selection.

MSE316H1 S
Mechanical Behaviour of Materials
III - AEMMSBASC 3/1.50/1/0.50

The mechanical behaviour of engineering materials including metals, alloys, ceramics and polymeric materials. The following topics will be discussed: macro- and micro-structural response of materials to external loads; load-displacement and stress-strain relationships, processes and mechanisms of elastic, visco-elastic, plastic and creep deformation, crystallographic aspects of plastic flow, effect of defects on mechanical behaviour, strain hardening theory, strengthening mechanisms and mechanical testing.

MSE318H1 F
Phase Transformations
III - AEMMSBASC 3/1.50/1/0.50

Thermodynamics and phase stability. Free energy diagrams. Phase transformations in unary systems: primary crystallization, amorphization, crystallization of amorphous materials, recrystallization. Phase transformations in binary systems: solidification, precipitation from solid solution, binary invariant reactions. Diffusional transformations, nucleation and growth, diffusionless or martensitic transformations. Second order transformations. Spinodal, massive and order-disorder transformations. Influence of phase transformations on microstructure and properties.

MSE330H1 S
Introduction to Polymer Engineering
IV - AECHEBASC, IV - AEESCBASEM, I - AEMECBASC, IV - AEMMSBASC 3/-/1/0.50

The basics of polymer synthesis, structure, characterization and mechanical properties. Topics include addition and condensation polymerization, network polymerization and crosslinking, molecular mass distribution and characterization, crystalline and amorphous structure, glass transition and crystalline melting, forming and additives for commercial plastics, dependence of mechanical properties on structure, viscoelasticity, yielding and fracture.
Exclusion: CHE461H1

MSE332H1 F
Heat and Mass Transfer for Materials Processing
III - AEMMSBASC 3/-/2/0.50

Fundamental concepts of heat and mass transfer as applied in materials engineering. Steady state and transient analysis in slabs, cylinders and spheres through solutions of problems in metallurgy and material processing. Similarity between heat and mass transfer. Concepts of momentum, mass and thermal boundary layers. Coupled problems.

MSE342H1 F
Nanomaterials
III - AEMMSBASC 2/-/1/0.25

An introduction to nanostructured materials. Topics include: the different classes of nanomaterials, synthesis and characterization methods, changes in physical properties on the nanometer scale, areas of application of nanostructured materials and materials issues in nanotechnology.

MSE343H1 F
Biomaterials
III - AEMMSBASC 2/-/1/0.25

The course will provide an overview of the applications of materials (metals, polymers, ceramics, composites and modified tissue-based materials) for surgical implant fabrication. The important considerations in selection of materials for fabrication of these devices with an introduction to the biological responses expected with implantation will also be discussed. The concept of biocompatibility will be introduced as well as the essential elements of biology related to an understanding of this criterion for biomaterial selection and implant design.

MSE350H1 S
Materials Design and Engineering
IV - AEESCBASEA, III - AEESCBASEB, IV - AEESCBASEM 3/1.50/1/0.50

This course will explore the physical and chemical principles which underlie the design and use of modern materials in engineering applications. Topics covered may include the crystalline state, amorphous state, defects, microstructure and a quantitative description of the mechanical, electrical and magnetic properties of materials. Materials covered include metals, ceramics, semiconductors, polymers and composites.

MSE351H1 S
Design and Simulation of Materials Processes
III - AEMMSBASC 2/2/1/0.50

Various phenomena involved in materials processing and design will be modeled using a software package based on the finite element method. Examples will include aspects of solid state diffusion, structural stress, heat transfer, fluid flow and chemical reactions. The problems will involve unsteady state as well as 3 dimensional systems. Multi-physics phenomena such as heating of an electric component by an electric current, resulting in a change in physical properties affecting thermal properties will also be introduced. The main objective of this course is to introduce students to the use of a commercial software package to solve fairly common but complex physical and chemical phenomena related to the materials industry.

MSE354H1 S
Materials in Manufacturing
III - AEMMSBASC 2/-/1/0.25

Materials processing factors in manufacturing processes such as casting, mechanical forming, powder forming, joining and surface treatment (sprayed coatings, diffusion bonding, ion implantation etc). Materials strengthening in manufacturing. Thermo and mechanical processing. Selected case studies.

MSE355H1 S
Materials Processing and Sustainable Development
I - AEMINENR, III - AEMMSBASC 2/-/1/0.25

Materials processing requires the use of raw materials and energy resources. Various materials processing methods are analyzed in terms of efficient use of raw materials and energy. The treatment and discharge of effluent streams in an environmentally sound manner are discussed. An introduction to life cycle analysis is also given.

MSE358H1 S
Structure and Characterization of Nanostructured Materials
III - AEESCBASEO, III - AEESCBASEP, IV - AEESCBASER 3/1.50/1/0.50

This course deals with both the theoretical and experimental interpretation of the structure and chemistry of nanostructured materials. The structural characteristics of self-assembled clusters, nanoparticles, nanowires, nanotubes and quantum dots, as well as three-dimensional bulk nanocrystalline materials and their defect structures will be discussed in detail. Experimental techniques for characterizing their structure and chemistry will be described including electron microscopy, x-ray diffraction, Auger electron spectroscopy, x-ray photoelectron spectroscopy, secondary-ion mass spectroscopy and scanning probe microscopy.

MSE390H1 F
Communications II
III - AEMMSBASC 1/-/1/0.25

The goals of Communication II are to i) gain in-depth knowledge of a specific area of work within a broader field of Materials Science and Engineering ii) read technical materials that will allow you to advance in the field iii) organize, write and present about the ideas of the field at a level of sophistication and clarity appropriate to university and iv) present clear, well-organized technical presentations.

MSE401H1 F
Materials Selection in Design II
IV - AEESCBASEM, IV - AEMECBASC, IV - AEMMSBASC 2/-/3/0.50

The principles necessary for the selection of engineering materials suitable for a given application from the full range of materials available are developed through a series of case studies. Both the material properties and the capabilities of applicable fabrication processes are considered to identify the material and process which best satisfy the design requirements. Extensive use is made of an integrated materials properties and processes database system.

MSE408H1 S
Energy Management in Materials Processing
IV - AEESCBASEJ, I - AEMINENR, IV - AEMMSBASC 3/-/1/0.50

Basic materials processing flowsheets including primary processing and recycling of metals. Materials and energy balances of individual units and of overall process flowsheets. Use of computer software for flowsheet evaluation. Energy sources, transformations, utilization and requirements. Energy loss, recovery and re-use. Life cycle impact of materials processing on energy consumption and environment. Economic and environmental impacts due to the usage of various energy forms.
Prerequisite: MSE202H1 F or equivalent

MSE419H1 F
Fracture and Failure Analysis
IV - AEMMSBASC 3/-/1/0.50

Fracture mechanisms and mechanics of solid materials. Topics include: nature of brittle and ductile fracture, macro-phenomena and micro-mechanisms of failure of various materials, mechanisms of fatigue; crack nucleation and propagation, Griffith theory, stress field at crack tips, stress intensity factor and fracture toughness, crack opening displacement, energy principle and the J-integral, fracture mechanics in fatigue, da/dN curves and their significance. Practical examples of fatigue analysis and fundamentals of non-destructive testing.

MSE421H1 S
Solid State Processing and Surface Treatment
IV - AEMMSBASC 3/-/2/0.50

The fundamentals and technologies of mechanical forming (rolling, forging, extrusion, drawing, sheet-metal forming), sintering and powder forming, thermo-mechanical processing and heat treatment are discussed. Various means to enhance surfaces for the purposes of i) improving corrosion and erosion properties, ii) change mechanical, chemical or electric properties, iii) produce a visually more appealing surface are also covered. Techniques include galvanizing, hot dipping, nitriding, vapour deposition, plasma spraying.

MSE430H1 F
Electronic Materials
IV - AEMMSBASC 2/-/1/0.50

Materials parameters and electronic properties of semiconductors are discussed as basic factors in the engineering of semiconductor devices. Materials parameters are related to preparation and processing methods, and thus to the electronic properties. The implications of materials parameters and properties on selected simple devices are discussed.

MSE440H1 F
Biomaterial Processing and Properties
IV - AECHEBASC, I - AEMINBIO, IV - AEMMSBASC 3/-/1/0.50

Currently used biomaterials for formation of surgical implants and dental restorations include selected metals, polymers, ceramics, and composites. The selection and processing of these materials to satisfy biocompatibility and functional requirements for applications in selected areas will be presented. Materials used for forming scaffolds for tissue engineering, and strategies for repair, regeneration and augmentation of degenerated or traumatized tissues will be reviewed with a focus on biocompatibility issues and required functionality for the intended applications.
Exclusion: MSE452H1

MSE442H1 S
Surgical and Dental Implant Design
IV - AEESCBASEB, I - AEMECBASC, I - AEMINBIO, IV - AEMMSBASC 3/-/1/0.50

Case studies will be used to illustrate approaches for selection of biomaterials for fabrication of implants for specific applications in medicine and dentistry. Computational modeling for optimizing device design and the necessary post-design validation procedures for ensuring acceptable device performance will be discussed. Methods of manufacture to produce devices of desired form and with required in vivo characteristics will be reviewed. Design and fabrication of devices designed to be either biodegradable or non-biodegradable will be reviewed. The intent of the course is to illustrate the important considerations in material selection and fabrication methods used for producing implants.
Prerequisite: MSE440H1F
Corequisite: Recommended(For ESC students): MSE452H1 S

MSE450H1 S
Plant Design for Materials Industries
IV - AEESCBASEM, IV - AEMMSBASC 2/-/3/0.50

Analysis of plant design factors involved in the processing of materials. Topics considered include the principles of plant design, optimal allocation of resources and costs, minimizing energy requirements for new plant designs, as well as process innovations for existing plants. A case study approach will be used, employing industrial examples. The course material will be reinforced by a plant tour, visit to an engineering office, and guest lectures by industry experts.

MSE452H1 S
Biomaterials and Biocompatibility
IV - AEESCBASEB, IV - AEESCBASEO, I - AEMINBIO 3/-/1/0.50

The course presents an introduction to the field of biomaterials, covering also the relevant basics in materials science and biology. Topics include the physical and chemical principles of materials science, structure-property relations, biomaterials processing and degradation. Cell/tissue biomaterials interactions will be discussed as determinants of biocompatibility.

MSE455H1 S
Process Simulation and Computer Design
IV - AEMMSBASC 3/-/2/0.50

Various production processes use simulation software to shorten the route from the initial design to finished product. Simulation software provides the designer and practicing engineer with a powerful tool in the tasks of improving and optimizing the industrial processes. Expensive trials can be avoided and the quality of the finished product secured from the beginning of production. First, this course will cover the basics of the process simulation used in industrial setting. Subsequently, the course will focus on industrial process simulation software used extensively in foundry industry worldwide. Essential elements of CAD/CAM techniques will be covered. Numerical simulation of the filling and solidification in castings will be presented. Calculation of foundry processes with multiple production cycles will be analyzed. Another course feature will be the graphical presentation of the results on the screen. Limited enrolment.

MSE457H1 F
Micro Electro Mechanical Systems (MEMS) and Nano Electro-Opto Mechanical Systems (NEOMS)
IV - AEESCBASEO 3/1.50/1/0.50

An introduction to MEMS and NEOMS starting from the principles of devices fabrication through micro fabrication and micro machining; IC Processing; bulk micro machining; bonding, high aspect-ratio processes, surface micro machining technology (including concepts and principles and polysilicon surface micro machining). Specific topics can include application of this technology to physical micro sensors, chemical and biomedical sensors and micro actuators. The course will also address the incorporation of optical functionality in MEMS, as well as integration of nanoscale devices with MEMS technology. Limited Enrolment

MSE459H1 F
Synthesis of Nanostructured Materials
IV - AEESCBASEO, IV - AEMMSBASC 3/2/-/0.50

Various synthesis techniques to produce nanostructured materials will be introduced. These include methods involving the vapor phase (physical and chemical vapor deposition, organometallic chemical vapor deposition), the liquid phase (rapid solidification, spark erosion), the solid phase, (mechanical attrition, equal channel deformation) as well techniques producing these structures from solution (electrodeposition, electroless processing, precipitation). Secondary processing techniques to produce final products or devices will also be discussed.

MSE462H1 S
Materials Physics II
IV - AEESCBASEO 2/-/1/0.50

Electron quantum wave theory of solid-state materials will be introduced. Quantum phenomena in various materials systems, in particular nano materials, will be discussed. Electronic properties of materials such as charge transport, dielectric properties, optical properties, magnetic properties, and thermal properties will be discussed using appropriate quantum theory. Materials systems to be studied may include metals, semiconductors, organics, polymers, and insulators.

MSE488H1 F
Entrepreneurship and Business for Engineers
3/-/2/0.50

A complete introduction to small business formation, management and wealth creation. Topics include: the nature of the Entrepreneur and the Canadian business environment; business idea search and Business Plan construction; Buying a business, franchising, taking over a family business; Market research and sources of data; Marketing strategies promotion, pricing, advertising, electronic channels and costing; The sales process and management, distribution channels and global marketing; Accounting, financing and analysis, sources of funding, and financial controls; The people dimension: management styles, recruiting and hiring, legal issues in employment and Human Resources; Legal forms of organization and business formation, taxation, intellectual property protection; the e-Business world and how businesses participate; Managing the business: location and equipping the business, suppliers and purchasing, credit, ethical dealing; Exiting the business and succession, selling out. A full Business Plan will be developed by each student and the top submissions will be entered into a Business Plan competition with significant cash prizes for the winners. Examples will be drawn from real business situations including practicing entrepreneurs making presentations and class visits during the term. (Identical courses are offered: ECE488H1F, MIE488H1F, CHE488H1S and CIV488H1S.)
Exclusion: APS234 and APS432

MSE490H1 F
Professional Ethics and Practice
IV - AEMMSBASC 1/-/-/0.25

The various roles of a practicing engineer in industry and society will be presented through a series of seminars. The lecturers will include practicing engineers from local companies and consulting firms and representatives from professional and technical societies.

MSE498Y1 Y
Design and Research Project
IV - AEMMSBASC -/6/-/1.00

The students, alone or preferably organized in small groups, select a project involving original research and design work which is normally closely related to the current work of a staff member, and in close collaboration with an external partner (e.g. local industry, hospital,government lab). The students conceive and carry out a research plan under the supervision of the academic staff member usually with an external liaison person as a resource person. The project must contain a significant design component. The project work may be carried out in the department, at the external site, or both locations. The final grade will be based on interim and final written reports, oral presentations at the end of each term and a final poster presentation.

MSE504H1 F
Extractive Metallurgy
I - AEMINENR, I - AEMINENV, IV - AEMMSBASC 3/-/2/0.50

Technologies and unit operations used in the production of light metals, non-ferrous and ferrous metals will be presented and analyzed. Emphasis will be placed on analyzing overall flow-sheets used by selected companies for the purpose of determining how overall process efficiency can be improved and the environmental impact reduced. Methods and technologies used for metals recycling will also be discussed. Examples will be given from the steel, copper, nickel, zinc, aluminum and magnesium industries. The students will be exposed to a series of actual industrial case studies.

MSE550H1 S
Advanced Physical Properties of Structural Nanomaterials
IV - AEESCBASEO, IV - AEMMSBASC 3/2/1/0.50

This course deals with the physical properties of bulk nanostructured materials. Included are mechanical properties (elastic behavior, tensile and compressive strength, creep, wear and fatigue properties) electrical properties (electrical transport phenomena, electrical resistivity) magnetic properties (paramagnetic, diamagnetic, soft and hard ferromagnetic, superparamagnetic and antiferromagnetic properties), thermodynamic properties (interfacial enthalpy, thermal stability, phase transformations, heat capacity). The considerable differences observed for nanocrystalline solids compared to conventional polycrystalline and amorphous solids will be discussed in terms of the microstructural differences for these materials (pre-requisite: MSE459H1F).

MSE558H1 S
Nanotechnology in Alternate Energy Systems
IV - AEESCBASEJ, IV - AEESCBASEO, I - AEMINENR, IV - AEMMSBASC 3/0.50/1/0.50

The unique surface properties and the ability to surface engineer nanocrystalline structures renders these materials to be ideal candidates for use in corrosion, catalysis and energy conversion devices. This course deals with the fabrication of materials suitable for use as protective coatings, and their specific exploitation in fields of hydrogen technologies (electrolysis, storage, and fuel cells) linked to renewables. These new devices are poised to have major impacts on power generation utilities, the automotive sector, and society at large. The differences in observed electrochemical behavior between amorphous, nanocrystalline and polycrystalline solid materials will be discussed in terms of their surface structure and surface chemistry. A major team design project along with demonstrative laboratory exercises constitutes a major portion of this course. Limited

Enrolment. **All students who are interested in taking the course must see the instructor for written permission to enroll.**

MSE561H1 F
Engineered Ceramics
IV - AEMMSBASC 3/-/2/0.50

The unique combinations of physical, electrical, magnetic, and thermomechanical properties exhibited by advanced technical ceramics has led to a wide range of applications including automobile exhaust sensors and fuel cells, high speed cutting tool inserts and ball bearings, thermal barrier coatings for turbine engines, and surgical implants. This course examines the crystal and defect structures which determine the electrical and mass transport behaviours and the effects of microstructure on optical, magnetic, dielectric, and thermomechanical properties. The influence of these structure-property relations on the performance of ceramic materials in specific applications such as sensors, solid oxide fuel cells, magnets, and structural components is explored.

Mechanical and Industrial Engineering

MIE100H1 S
Dynamics
I - AECPEBASC, I - AEELEBASC, I - AEENGBASC, I - AEINDBASC, I - AEMECBASC 3/-/2/0.50

This course on Newtonian mechanics considers the interactions which influence 2-D, curvilinear motion. These interactions are described in terms of the concepts of force, work, momentum and energy. Initially the focus is on the kinematics and kinetics of particles. Then, the kinematics and kinetics of systems of particles and solid bodies are examined. Finally, simple harmonic motion is discussed. The occurrence of dynamic motion in natural systems, such as planetary motion, is emphasized. Applications to engineered systems are also introduced.

MIE191H1 S
Seminar Course: Introduction to Mechanical and Industrial Engineering
I - AEINDBASC, I - AEMECBASC 1/-/-/0.15

This is a seminar series that will preview the core fields in Mechanical and Industrial Engineering. Each seminar will be given by a professional in one of the major areas in MIE. The format will vary and may include application examples, challenges, case studies, career opportunities, etc. The purpose of the seminar series is to provide first year students with some understanding of the various options within the Department to enable them to make educated choices for second year. This course will be offered on a credit/no credit basis. Students who receive no credit for this course must re-take it in their 2S session. Students who have not received credit for this course at the end of their 2S session will not be permitted to register in session 3F.

MIE201H1 S
Essays in Technology and Culture
2/-/1/0.50

This course explores the relationship between changing technologies and cultural representations and teaches a methodology that bridges the world of the artist and the world of the engineer. It enables engineers to explore how the analysis of art has been used in the discussion of the social impacts of technological innovation and to use these methods as they develop new skills in essayistic argument and increase critical vocabulary.

MIE210H1 S
Thermodynamics
II - AEMECBASC, I - AEMINENR 3/1.50/1/0.50

This is a basic course in engineering thermodynamics. Topics covered include: properties and behaviour of pure substances; equation of states for ideal and real gases; compressibility factor; first and second laws of thermodynamics; control mass and control volume analyses; applications of first and second laws of thermodynamics to closed systems, open systems and simple thermal cycles.
Prerequisite: MAT186H1 F

MIE221H1 S
Manufacturing Engineering
II - AEMECBASC 3/2/1/0.50

Production Fundamentals: Metal casting; metal forming - rolling, forging, extrusion and drawing, and sheet-metal forming; plastic/ceramic/glass forming; metal removal - turning, drilling/ boring/reaming, milling, and grinding; non-traditional machining - ECM, EDM and laser cutting; welding; surface treatment; metrology. Environmental issues in manufacturing processes, recycling of materials. Automation Fundamentals: Automation in material processing and handling - NC, robotics and automatically-guided vehicles; flexible manufacturing - group technology, cellular manufacturing and FMS; and computer-aided design - geometric modelling, computer graphics, concurrent engineering and rapid prototyping.

MIE222H1 S
Mechanics of Solids I
II - AEMECBASC 3/1.50/1.50/0.50

Design of mechanical joints. Elasto-plastic torsion of circular sections. Elasto-plastic bending of beams. Residual stresses, shearing stresses in beams, analysis of plane stress and plant strain problems. Pressure vessels, design of members of strength criteria, deflection of beams. Statistically indeterminate problems.

MIE230H1 F
Engineering Analysis
II - AEMECBASC 3/-/2/0.50

Multivariate integration with application to calculation of volumes, centroids and moments. Vector calculus. Divergence, curl and gradient operators. Green's theorem. Gauss' theorem. Stokes' theorem. Integral transforms. Laplace transforms and Fourier series, integral and transform.
Prerequisite: MAT186H1 F, MAT187H1 S

MIE231H1 F
Probability and Statistics with Engineering Applications
II - AEMECBASC 3/2/2/0.50

Use of data in engineering decision processes. Elements of probability theory. Discrete and continuous random variables. Standard distributions: binomial, Poisson, hypergeometric, exponential, normal etc. Expectation and variance. Random sampling and parameter estimation. Confidence intervals. Hypothesis testing. Goodness-of-fit tests. Regression and correlation. Statistical Process Control and quality assurance. Engineering applications in manufacturing, instrumentation and process control.

MIE236H1 F
Probability
II - AEINDBASC 3/2/2/0.50

Introduction to probability (Sample space, sets, counting, independence, conditioning, Bayes' Theorem); Discrete random variables (Probability mass functions, expectation and variance, multiple random variables, functions of random variables, sums of random variable, convolution, moment-generating functions, covariance, correlation, multivariate normal) Continuous random variables (Probability density functions, expectation/variance, multiple random variables); Limit theorems (Central limit theorem, Laws of large numbers, convergence, Chebyshev/Markov inequality).

MIE237H1 S
Statistics
II - AEINDBASC 3/1/2/0.50

Design and analysis of experiments, randomization and confounding, fixed and random effects models, analysis of experiments with several factors, model building, Latin square designs, 2k factorial experiments and fractions, linear regression and correlation analysis, residual analysis and the lack-of-fit test.
Prerequisite: MIE231H1 F/MIE236H1 F or equivalent

MIE240H1 S
Human Centred Systems Design
II - AEINDBASC 3/-/2/0.50

Introduction to principles, methods, and tools for the analysis, design and evaluation of human-centred systems. Consideration of impacts of human physical, physiological, perceptual, and cognitive factors on the design and use of engineered systems. Basic concepts of anthropometrics, work-related hazards, shiftwork, workload, human error and reliability, and human factors standards. The human-centred systems design process, including task analysis, user requirements generation, prototyping, and usability evaluation. Design of work/rest schedules, procedures, displays and controls, and training systems; design for error prevention and human-computer interaction; design for aging populations.
Prerequisite: MIE242H1 F recommended

MIE242H1 F
Psychology For Engineers
II - AEINDBASC, I - AEMINBIO 3/3/-/0.50

Introduction to neuroanatomy and processes that are core to perception, cognition, language, decision making, and action. Use of experiments to test hypotheses concerning brain activities and computations. Conducting and reporting experimental research, including satisfaction of research ethics requirements.

MIE250H1 F
Fundamentals of Object Oriented Programming
II - AEINDBASC 2/3/-/0.50

Introduction to object-oriented programming using the Java programming language with heavy emphasis on practical application; variable types; console and file input/output; arithmetic; logical expressions; control structures; arrays; modularity; functions; classes and objects; access modifiers; inheritance; polymorphism.
Prerequisite: APS105/APS106 or equivalent

MIE253H1 S
Data Modelling
II - AEINDBASC 3/1/1/0.50

This course provides an understanding of the principles and techniques of information modelling and data management, covering both relational theory and SQL database systems (DBMS), as well as entity-relation conceptual modelling. The course also familiarizes the student with analytical applications (OLAP) and provides an introduction to XML data modelling. The laboratory focuses on database application development using SQL DBMS, OLAP queries and entity-relation data modelling.
Prerequisite: MIE250H1 F

MIE258H1 F
Engineering Economics and Accounting
II - AEINDBASC, II - AEMECBASC, III - AEMMSBASC 3/-/1/0.50

Engineering economic and accounting concepts needed in the design of engineering systems: time value of money, evaluation of cash flows, cost and managerial accounting concepts, defining alternatives, acceptance criteria, replacement analysis, depreciation and income tax, sensitivity and decision analysis, buy or lease, make or buy, production functions and relationship to cost functions. Introduction to financial engineering: fixed income securities, optimal portfolios, mean-variance optimization, portfolio theory, capital asset pricing model (CAPM) and derivatives (options, basic properties, risk management).
Prerequisite: MIE231H1 F/MIE236H1 F or equivalent

MIE262H1 F
Operations Research I: Deterministic OR
II - AEINDBASC, II - AELMEBASC 3/2/1/0.50

Introduction to deterministic operations research. Formulations of mathematical models to improve decision making; linear and integer programming; the simplex method; the revised simplex method; branch-and-bound methods; sensitivity analysis; duality; network models; network simplex method; Dijkstra's algorithm; basic graph theory; deterministic and probabilistic dynamic programming.
Prerequisite: MAT186H1 F, MAT188H1 F

MIE263H1 S
Operations Research II: Stochastic OR
II - AEINDBASC 3/-/2/0.50

Modeling and analysis of systems subject to uncertainty using probabilistic methods. Introduction to decision analysis. Derivation and application of Bernoulli and Poisson processes, Markov chains, and queuing models. Stochastic optimization and extensions. Applications to engineering, games of chance, health care, and management.
Prerequisite: MIE231H1 F or MIE236H1 F

MIE297H1 S
Foundations of Design Portfolio
II - AEMECBASC -/-/-/0.50

Students will assemble a short design portfolio with items drawn from engineering courses and extra-curricular experience. The portfolio will demonstrate an understanding and application of basic principles of engineering design through a showcase of the student's best work. The portfolio will further demonstrate competence in written and oral communication through a brief summary of each item and an introduction to the portfolio. Students whose communication work is not up to standard will be provided with opportunities for remediation. The course will be offered on a credit/no credit basis; students who receive no credit must retake the course in year 3.

MIE301H1 F
Kinematics and Dynamics of Machines
III - AEMECBASC 3/3/2/0.50

Classifications of mechanisms, velocity, acceleration and force analysis, graphical and computer-oriented methods, balancing, flywheels, gears, geartrains, cams. Introduction to Lagrangian Dynamics: Lagrange's equations of motion, Hamilton's equations, Hamilton's principle.
Prerequisite: MIE100H1 S

MIE303H1 F
Mechanical and Thermal Energy Conversion Processes
III - AEESCBASEJ 3/1.50/1/0.50

Engineering applications of thermodynamics in the analysis and design of heat engines and other thermal energy conversion processes within an environmental framework; Steam power plants, gas cycles in internal combustion engines, gas turbines and jet engines. Fossil fuel combustion, Alternative fuel combustions, fusion processes and introduction to advanced systems of fuel cells.

MIE312H1 F
Fluid Mechanics I
III - AEMECBASC 3/1/1/0.50

Fluid statics, pressure measurement, forces on surfaces. Kinematics of flow, velocity field, streamlines. Conservation of mass. Fluid dynamics, momentum analysis, Euler and Bernoulli equations. Energy and head lines. Laminar flow. Flow at high Reynolds numbers, turbulence, the Moody diagram. External flows. Boundary layers. Lift and drag. Flow separation.
Prerequisite: MIE100H1 S, MAT234H1 S, MIE210H1 S

MIE313H1 S
Heat and Mass Transfer
IV - AEESCBASEA, III - AEMECBASC, I - AEMINENR 3/1.50/2/0.50

Exact and numerical analysis of steady and transient conduction in solids. Solutions of one-dimensional and multidimensional systems. Principles of convection and solutions under laminar and turbulent flow over flat plates and inside and over pipes. Free convection. Thermal radiation between multiple black and grey surfaces.
Prerequisite: MAT234H1 S, MIE210H1 S, MIE230H1 F, MIE312H1 F or equivalent

MIE315H1 S
Design for the Environment
IV - AEESCBASEJ, IV - AEESCBASEM, III - AEMECBASC, I - AEMINENV 3/-/1/0.50

(1) Industrial growth and the environment, Industrial Ecology; (2) Life Cycle Assessment, inventory and impact analysis; (3) Design for the environment, recycling, pollution prevention, energy conservation, waste treatment; (4) Pollution control of air, water and soil.

MIE320H1 S
Mechanics of Solids II
III - AEMECBASC 3/3/2/0.50

Three-dimensional stress transformation, strain energy, energy methods, finite element method, asymmetric and curved beams, superposition of beam solutions, beams on elastic foundations, plate bending, buckling, fracture mechanics, impact.
Prerequisite: MIE222H1 S

MIE331H1 S
Physiological Control Systems
IV - AECHEBASC, IV - AECIVBASC, III - AECPEBASC, III - AEELEBASC, III - AEMECBASC, I - AEMINBIO 3/1/1/0.50

The purpose of this course is to provide undergraduate engineering students with an introduction to physiological concepts and selected physiological control systems present in the human body. Due to the scope and complexity of this field, this course will not cover all physiological control systems but rather a selected few such as the neuromuscular, cardiovascular, and endocrine control systems. This course will also provide an introduction to the structures and mechanisms responsible for the proper functioning of these systems. This course will combine linear control theory, physiology, and neuroscience with the objective of explaining how these complex systems operate in a healthy human body. The first part of the course will provide an introduction into physiology and give an overview of the main physiological systems. The second part of the course will focus on the endocrine system and its subsystems, including glucose regulation, thyroid metabolic hormones, and the menstrual cycle. The third part of the course will include discussion on the cardiovascular system and related aspects such as cardiac output, venous return, control of blood flow by the tissues, and nervous regulation of circulation. The fourth and final section of the course will focus on the central nervous system, the musculoskeletal system, proprioception, kinaesthetic, and control of voluntary motion.
Prerequisite: CHE353H1F

MIE333H1 S
Engineering Physics
III - AEMECBASC 3/-/1.50/0.50

This course includes introduction to oscillations leading to periodic wave phenomena of importance to modern engineering methods and instrumentation design, specifically transverse and longitudinal waves, sound, resonance, interference, Doppler effects and phenomena encountered in supersonic speeds. Elementary quantum mechanics is introduced to extend concepts of wave theory to photons and matter waves, with a view to understanding advanced modern materials and devices/ instruments encountered at the forefront of engineering practice, specifically properties of nanomaterials, the principles of operation of electronic, magnetic resonance and X-ray microscopes, and laser operation and the nature of laser light.
Prerequisite: MAT186H1 F /MAT187H1 S

MIE335H1 S
Algorithms & Numerical Methods
III - AEINDBASC 3/1/1/0.50

Numerical linear algebra, solution techniques for linear and non-linear systems of equations. The conditioning and stability of linear systems. Matrix factorization, LU and Cholesky factorization, factorization in the revised simplex method. Newton's method, the minimum norm problem and applications. Algorithmic analysis, big-O asymptotic analysis. Matching algorithms: Gale-Shapely method. Greedy methods for combinatorial optimization. Graph theory and graph theoretic algorithms. Branch and bound search methods.

Not Offered in 2010-2011
Prerequisite: MIE262H1 F

MIE341H1 S
Computer Aided Design I
IV - AEESCBASEM, III - AEMECBASC 3/3/1/0.50

This course presents modeling techniques commonly used in mechanical design and the analysis of structural systems. Students will be exposed to state of the art software packages of computer 3-D graphics and solid modeling, mechanism analysis, fluid flow, and finite element analysis. Several case studies are introduced. Emphasis is placed on gaining practical skills in solving realistic design problems through illustrating applied examples. Course work includes design laboratories and comprehensive design projects.

MIE342H1 F
Circuits with Applications to Mechanical Engineering Systems
III - AEMECBASC 3/1.50/1/0.50

This course presents analysis of complex circuits and application of circuit principles to design circuits for mechanical engineering systems. Discussions will centre around circuits and instrumentation. In-depth discussions will be given on a number of topics: (1) Mechatronics design applications of circuit principles; (2) Network theorems, node-voltage, mesh-current method, Thévenin equivalents; (3) Operational amplifier circuits; (4) 1st and 2nd order circuits; (5) Laplace transform, frequency response; (6) Passive and active filter design (low- and high-pass filters, bandpass and bandreject filters); (7) Interface/readout circuits for mechanical engineering systems, sensors, instrumentation; (8) Inductance, transformers, DC/AC machines; (9) Digital circuit and data sampling introduction.
Prerequisite: MAT186H1 F, MAT187H1 S

MIE343H1 F
Industrial Ergonomics and the Workplace
III - AEINDBASC, IV - AEMECBASC, I - AEMINBIO 3/3/-/0.50

The Biology of Work: anatomical and physiological factors underlying the design of equipment and work places. Biomechanical factors governing physical workload and motor performance. Circadian rhythms and shift work. Measurement and specification of heat, light, and sound with respect to design of the work environment.
Prerequisite: MIE231H1 F/MIE236H1 F or equivalent

MIE344H1 S
Ergonomic Design of Information Systems
III - AEINDBASC 3/3/-/0.50

The goal of this course is to provide an understanding of how humans and machines can be integrated with information systems. The focus will be on the design of human-machine interfaces, and on the analysis of the impact of computers on people. The course will also include coverage of usability engineering and rapid prototyping design, analysis of user mental models and their compatibility with design models, and quantitative modelling of human-computer interaction.
Prerequisite: MIE240H1 S or permission of the instructor

MIE345H1 F
Case Studies in Ergonomics
III - AEINDBASC 3/-/2/0.50

A detailed analysis will be made of several cases in which human factors methods have been applied to improve the efficiency with which human-machine systems operate. Examples will be chosen both from the area of basic ergonomics and from high technology. Emphasis will be placed on the practical use of material learned in earlier human factors courses.
Prerequisite: MIE240H1 S

MIE346H1 S
Analog and Digital Electronics for Mechatronics
III - AEMECBASC 3/1.50/1/0.50

A study of the fundamental behaviour of the major semiconductor devices (diodes, bipolar junction transistors and field effect transistors). Development of analysis and design methods for basic analog and digital electronic circuits and devices using analytical, computer and laboratory tools. Application of electronic circuits to instrumentation and mechatronic systems.
Prerequisite: MIE230H1 F, MAT234H1 S, MIE342H1 F

MIE350H1 F
Design and Analysis of Information Systems
III - AEINDBASC 3/1/1/0.50

Provides students with an understanding of the mothods of information system analysis and design. These include methods for determining and documenting an organization's structure (FDD), activities, behaviours and information flows (DFDs, decision tables and trees, network diagrams, etc); model acquisition (data repositories), verification and validation. Methods such as SADT, RAD and prototyping will be covered. Students will acquire a working knowledge of various frameworks for analysis (e.g., information technology categories, system and application classifications, decision types, data vs information). Throughout the course, emphasis is placed on the importance of systems thinking and organizational culture in the analysis and design process. In the laboratory, students will use a CASE-based computer program (Visible Analyst) for the analysis and design of information systems for selected organizations. Students will be asked to work in teams to create a web-based information site and to document and present their development progress through the use of a structured project log.
Prerequisite: MIE253H1 S

MIE354H1 F
Business Process Engineering
III - AEINDBASC 3/1/1/0.50

This course focuses on understanding multiple perspectives for grouping, assessing, designing and implementing appropriately integrated and distributed information systems to support enterprise objectives. The emphasis is on understanding how Business Process Management techniques and tools can contribute to align an organization’s business and information technology perspectives, as well as the characteristics of application and system types and the implications for their design, operation and support of information needs, including those associated with different platforms and technology infrastructure e.g., legacy systems, client/server, the Internet and World Wide Web including the emergence of a web-service-based service oriented architecture. Students will work in the laboratory to develop business processes that can be specified and executed by information systems supporting BPEL, a widely supported standard for describing web-service-based business process.
Prerequisite: MIE253H1 S or permission of the instructor

MIE360H1 F
Systems Modelling and Simulation
IV - AEESCBASEM, III - AEINDBASC, IV - AEMECBASC 3/-/2/0.50

Principles for developing, testing and using discrete event simulation models for system performance improvement. Simulation languages, generating random variables, verifying and validating simulation models. Statistical methods for analyzing simulation model outputs, and comparing alternative system designs. Fitting input distributions. Role of optimization in simulation studies. Simulation technology will be used to study process improvement with reference to the lean principles of the Toyota Production System.
Prerequisite: MIE231H1 F/MIE236H1 F or equivalent

MIE363H1 S
Resource and Production Modelling
III - AEINDBASC 3/-/2/0.50

Features of production/service systems and methods of modelling their operation; the material flow, information flow and control systems. Topics include process design, supply chain management, line balancing, material requirements planning, distribution requirements planning, and aggregate production planning. Basic deterministic and probabilistic inventory models will be covered, as well as the application of optimization methods to capacity planning decisions. Emphasis will be placed on the modelling aspects of operations management, as well as the application of analytical approaches in the solution of systems problems.
Prerequisite: MIE231H1 F/MIE236H1 F, and MIE262H1 S or equivalent

MIE364H1 S
Quality Control and Improvement
IV - AECHEBASC, III - AEINDBASC, III - AEMECBASC 3/1/2/0.50

In manufacturing and service industries alike, quality is viewed as an important strategic tool for increasing competitiveness. Continuous quality improvement is a key factor leading to a company's success. With more emphasis on quality, the cost and the product cycle time are reduced and the communication between producer and customer is improved. The course focuses on the following topics: introduction to quality engineering, TQM, quality standards, supplier-producer relations and quality certification, costs of quality, statistical process control for long and short production runs, process capability analysis and acceptance sampling.
Prerequisite: MIE231H1/MIE236H1 or equivalent, MIE237H1

MIE365H1 F
Operations Research III: Advanced OR
III - AEINDBASC 3/-/2/0.50

Design of operations research models to solve a variety of open-ended problems. Linear programming extensions are presented: goal programming, column generation, Danzig-Wolf decomposition, and interior point solution methods. Non-linear programming solution methods are developed: optimality conditions, quadratic programming and bi-level programming. Solutions to advanced stochastic models: stochastic programming, 2-person and n-person game theory, and Markov Decision Processes.
Prerequisite: MIE262H1 F, MIE263H1 S

MIE367H1 S
Cases in Operations Research
III - AEINDBASC 3/-/2/0.50

This course focuses on the integration of the results from earlier operations research courses and an assessment of the different methods with regard to typical applications. The course is taught using the case method. Students are expected to analyze cases based on real applications on their own, in small groups and during lecture sessions, and solve them using commercial software packages.
Prerequisite: MIE263H1 F

MIE375H1 F
Financial Engineering
III - AEESCBASEF 3/-/1/0.50

This course provides a background in the fundamental areas in financial engineering including relevant concepts from financial economics. Major topics include interest rate theory, fixed income securities, bond portfolio construction term structure of interest rates, mean-variance optimization theory, the Capital Asset Pricing Model (CAPM), arbitrage pricing theory (APT), forwards and futures, and introduction to option pricing and structured finance.

MIE376H1 S
Mathematical Programming (Optimization)
III - AEESCBASEF 3/2/1/0.50

This course deals with the formulation of optimization models for the design and operation of systems that produce goods and services, and the solution of such problems with mathematical programming methods, including linear programming: the simplex method, sensitivity analysis, duality, the revised simplex, column generation, Dantzig-Wolfe decomposition and linear programming with recourse; minimum cost network flows; dynamic programming; integer programming; non-linear programming models.

MIE377H1 S
Financial Optimization Models
III - AEESCBASEF 3/1/1/0.50

This course deals with the formulation of optimization models for the design and selection of an optimal investment portfolio. Topics include Risk Management, Mean Variance Analysis, Models for Fixed Income, Scenario Optimization, Dynamic Portfolio Optimization with Stochastic Programming, Index Funds, Designing Financial Products, and Scenario Generation. These concepts are also applied to International Asset Allocation, Corporate Bond Portfolios and Insurance Policies with Guarantees.

MIE380H1 S
Ecological Systems
III - AEINDBASC 3/-/1/0.50

Core Course in the Environmental Engineering Minor Basic concepts of ecology and the ecosystem. Particular focus will be on the interactions and transactions within and between biological and ecological systems with a special concern with the way the functioning of ecosystems can be influenced by human interventions. Response of organisms, populations, dynamic predator-prey and competition processes, and ecosystems to human interventions. Thermodynamic basis for food chains, energy flow, biodiversity and ecosystem stability. Introduction to industrial ecology and life cycle assessment principles. Response of receiving land, air and water to pollution. Additional topics include biogeochemical cycles, biogeography, habitat fragmentation and bioaccumulation.
Exclusion: EDV220H1.

MIE397Y1 Y
Design Portfolio
III - AEMECBASC -/-/-/0.50

Students will assemble a comprehensive design portfolio with items drawn from engineering courses and extra-curricular experience. The portfolio will articulate and demonstrate an understanding and application of basic and advanced principles of engineering design through a showcase of the student's best work. The portfolio shall also anticipate continued development of design skills through the capstone design courses and reflect on the transition to a career in engineering. The portfolio will demonstrate competence in written and oral communication through a brief summary of each item and an introduction to the portfolio. Students whose communication work is not up to standard will be provided with opportunities for remediation. The course will be offered on a credit/no credit basis; students who receive no credit must retake the course in year 4.

MIE402H1 S
Vibrations
I - AEMECBASC 3/1/2/0.50

Fundamental concepts of vibration of mechanical systems. Free vibration single degree of freedom systems. Various types of damping. Forced vibrations. Vibration measuring instruments. Steady state and transient vibrations. Vibration of multi-degree of freedom systems. Vibration isolation. Modal analysis. Lagrange equations and Hamilton's principle. Vibration of continuous systems. Special topics.
Prerequisite: MAT186H1 F, MAT187H1 S, MAT188H1 F, MIE100H1 S, MIE222H1 S

MIE404H1 F
Control Systems I
I - AEMECBASC 3/3/2/0.50

Modelling of dynamic systems. Analysis of stability, transient and steady state characteristics of dynamic systems. Characteristics of linear feedback systems. Design of PID control laws using frequency response methods and the root locus technique. Application of control law design tools to control pollutants in internal combustion engines.

MIE407H1 F
Nuclear Engineering I: Reactor Physics and the Nuclear Fuel Cycle
IV - AEESCBASEJ, IV - AEMECBASC, I - AEMINENR 3/-/2/0.50

This course covers the basic principles of the neutronic design and analysis of nuclear power reactors. Topics include radioactivity, neutron interactions with matter, the fission chain reaction, nuclear reactors, neutron diffusion and moderation, the critical reactor equation, nuclear reactor fuels, nuclear fuel cycle and economics, nuclear waste management and non-proliferation.
Prerequisite: MIE230H1 F or equivalent
Exclusion: CHE468H1 F

MIE408H1 S
Nuclear Engineering II: Thermal and Mechanical Design of Nuclear Power Reactors
IV - AEESCBASEJ, IV - AEMECBASC, I - AEMINENR 3/-/2/0.50

This course covers the basic principles of the thermo-mechanical design and analysis of nuclear power reactors. Topics include reactor heat generation and removal, nuclear materials, diffusion of heat in fuel elements, thermal and mechanical stresses in fuel and reactor components, single-phase and two-phase fluid mechanics and heat transport in nuclear reactors, and core thermo-mechanical design.
Prerequisite: MIE407H1/MIE222H1, MIE312H1, MIE313H1 or equivalents
Exclusion: CHE468H1

MIE411H1 F
Thermal Energy Conversion
I - AEMECBASC, I - AEMINENR 3/3/-/0.50

Engineering applications of thermodynamics in the analysis and design of heat engines and other thermal energy conversion processes within an environmental framework. Steam power plants, gas cycles in internal combustion engines, gas turbines and jet engines. Refrigeration, psychrometry and air conditioning. Fossil fuel combustion and advanced systems includes fuel cells.
Prerequisite: MIE210H1 S, MIE313H1 S

MIE414H1 F
Applied Fluid Mechanics
IV - AEMECBASC 3/3/1/0.50

This course builds upon the material introduced in Fluid Mechanics I and connects it to a wide range of modern technical applications of fluid flow. Applications include the design of pipe and microfluidic networks, transient flow phenomena, compressible flow and shocks, characteristics of pumps, open channel flow and an overview of flow measurement techniques. Lectures are complemented by laboratory experiments on topics such as centrifugal pumps, flow transients and fluid flow in microfluidic chips.
Prerequisite: MIE312H1 F

MIE418H1 S
Fluid Mechanics II
IV - AECIVBASC, I - AEMECBASC 2/2/-/0.50

This course covers the physical and mathematical principles underlying some of the fundamental tools in fluid mechanics: Poiseuille's law, the Moody chart, creeping and inviscid flow approximations, boundary layer theory, and lift/drag coefficients. Emphasis will also be placed on appreciating the explicit (and often implicit) assumptions made. Lectures are complemented by a computational fluid dynamics (CFD) laboratory component, covering the basic theory and practical use of CFD. Students will use an educational CFD package (FlowLab) to perform simulations related to topics discussed in the lectures, and solve a fluids engineering design problem.
Prerequisite: MIE312H1F or equivalent

MIE422H1 S
Automated Manufacturing
IV - AEESCBASEM, I - AEMECBASC 2/3/-/0.50

Introduction to Computer Integrated Manufactuing. Definitions, terminology. Organization of manufacturing systems. Introduction to NC machines. Introduction to robotics. Types of robot motion. Robot kinematics. Jacobians, singularities. Robot motion trajectories. Interpolation, spline fits. Robot joint control. Flexible manufacturing systems, justification. Robot cell design. Group technology. Design of group technology cell. Programmable logic controllers. Limited enrolment.
Prerequisite: MIE221H1 or equivalent

MIE438H1 S
Microprocessors and Embedded Microcontrollers
I - AEMECBASC 2/3/-/0.50

Review (number systems, CPU architecture, instruction sets and subroutines); Interfacing Memory; Interfacing Techniques; Transistors and TTL/CMOS Logic; Mechanical Switches &LED Displays; Interfacing Analog, A/D &D/A Conversions; Stepper Motors &DC Motors; RISC Technology and Embedded Processors; DAS Systems; Embedded Microcontroller System Design; CPU-based Control.

MIE439H1 F
Biomechanics I
IV - AEESCBASEB, IV - AEMECBASC, I - AEMINBIO 3/2/-/0.50

Introduction to the application of the principles of mechanical engineering - principally solid mechanics, fluid mechanics, and dynamics - to living systems. Topics include cellular mechanics, blood rheology, circulatory mechanics, respiratory mechanics, skeletal mechanics, and locomotion. Applications of these topics to biomimetic and biomechanical design are emphasized through case studies and a major, integrative group project.

MIE440H1 F
Mechanical Design: Theory and Methodology
IV - AEESCBASEM, IV - AEMECBASC 2/2/1/0.50

This course presents the engineering design process, with emphasis on theory and methodology related to conceptual design. Methods for enhancing creativity during conceptual design include using related and unrelated stimuli during idea generation, design by analogy, particularly biological analogies, and TRIZ/TIPS (theory of inventive problem solving). Design for assembly and design for manufacturing, with emphasis on design for injection molding, die casting and stamping, will be integrated into the various stages of design. Design for other life-cycle concerns, such as remanufacturing, and recycling will be introduced.
Prerequisite: MIE341H1S, MIE221H1 S or equivalent

MIE441H1 S
Design Optimization
IV - AEESCBASEM, IV - AEMECBASC 2/2/-/0.50

Problem definition and formulation for optimization, optimization models, and selected algorithms in optimization. Design for Tolerancing, Design for Manufcaturing, and Design for Assembly. State of the are Computer Aided Design packages are introduced with case studies. Emphasis is placed on gaining practical skills by solving realistic design problems.
Prerequisite: MIE341H1 S, MIE222H1 S or equivalents

MIE442H1 F
Machine Design
IV - AEESCBASEJ, I - AEMECBASC 3/1.50/3/0.50

Introduction to the fundamental elements of mechanical design including load determination, failure analysis under static and dynamic loads, surface failure and the selection of engineering materials and manufacturing processes. Consideration is given to the characteristics and selection of machine elements such as bearings, shafts, couplings, gears and fasteners. The laboratory provides experience in reverse engineering and insight into the design and manufacture of common consumer products.
Prerequisite: MIE320H1 S

MIE443H1 S
Mechatronics Systems: Design and Integration
IV - AEMECBASC 3/3/1/0.50

The course aims to raise practical design awareness, provide pertinent project engineering methodology, and generate a know-how core in integration of complex automation. This course has mainly practical content, and is integral and useful in the training and education of those students who plan to be employed in areas related to intelligent automation, as well as to the breadth of knowledge of all others. Although emphasis will be on robotic-based automation (mechatronics), the learning will be useful in all domains of system integration. This course will introduce students to the basics of integration, methodology of design, tools, and team project work. The course will be monitored based on projects from a selected list of topics. The lectures will be in format of tutorials as preparation and discussions on project related issues. A main goal is to bring the methods, means and spirit of the industrial design world to the class room. Emphasis will be on understanding the elements of integration, methodology and approaches, and will involve numerous case studies. Specifically the course will provide a practical step-by-step approach to integration: specifications, conceptual design, analysis, modeling, synthesis, simulation and bread-boarding, prototyping, integration, verification, installation and testing. Issues of project management, market, and economics will be addressed as well. Limited Enrolment.
Prerequisite: MIE346H1 S

MIE444H1 F
Mechatronics Principles
IV - AEMECBASC 2/3/-/0.50

This course provides students with the tools to design, model, analyze and control mechatronic systems (e.g. smart systems comprising electronic, mechanical, fluid and thermal components). This is done through the synergic combination of tools from mechanical and electrical engineering, computer science and information technology to design systems with built-in intelligence. The class provides techniques for the modeling of various system components into a unified approach and tools for the simulation of the performance of these systems. The class also presents the procedures and an analysis of the various components needed to design and control a mechatronic system including sensing, actuating, and I/O interfacing components.
Prerequisite: MIE342H1, MIE346H1

MIE448H1 F
Engineering Psychology and Human Performance
IV - AEESCBASEM, IV - AEINDBASC, IV - AEMECBASC, I - AEMINBIO 3/3/-/0.50

An examination of the relation between behavioural science and the design of human-machine systems, with special attention to advanced control room design. Human limitations on perception, attention, memory and decision making, and the design of displays and intelligent machines to supplement them. The human operator in process control and the supervisory control of automated and robotic systems. Laboratory exercises to introduce techniques of evaluating human performance.
Prerequisite: MIE231H1/MIE236H1/STA286H1 or equivalent required; MIE237H1 or equivalent recommended

MIE449H1 S
Human Computer Interface Design for Complex Systems
3/2/-/0.50

The course will focus primarily, but not exclusively, on how to design computer-based interfaces for complex human-machine systems, such as power plants. An ecological approach will be adopted, pointing to the importance of understanding the structure of the work environment and then trying to present that information in a way that takes advantage of human perceptual systems. Various design techniques for enhancing the informativeness of interfaces will be discussed within the context of several design applications.
Not Offered in 2010-2011
Prerequisite: MIE240H1 S

MIE451H1 F
Decision Support Systems
IV - AEESCBASEM, IV - AEINDBASC 3/1/1/0.50

Students are provided with an understanding of the contribution that various types of Decision Support Systems make within an organization. The course will cover decision processes, modeling, data representation and the importance of the user interface. Students will learn DSS design, analysis, integration and implementation. The course will also cover group decision support, executive information systems, enhancing creativity and the future of DSS. Students will construct a DSS using workstation based tools in the information systems laboratory.
Prerequisite: MIE253H1 S, MIE350H1 F

MIE457H1 S
Knowledge Modelling and Management
IV - AEESCBASEM, IV - AEINDBASC 3/1/1/0.50

This course explores both the modelling of knowledge and its management within and among organizations. Knowledge modelling will focus on knowledge types and their semantic representation. It will review emerging representations for knowledge on the World Wide Web (e.g., schemas, RDF). Knowledge management will explore the acquisition, indexing, distribution and evolution of knowledge within and among organizations. Emerging Knowledge Management System software will be used in the laboratory.
Prerequisite: MIE253H1 S, MIE350H1F

MIE459H1 S
Organization Design
IV - AEESCBASEM, IV - AEINDBASC 4/-/-/0.50

Study of design, innovation, change and implementation issues in both new and existing organizations. Consideration will be given to sociotechnical systems design methodology, work teams, support systems, project management, and union-management relations.

MIE463H1 F
Integrated System Design
IV - AEINDBASC 3/1/1/0.50

Integrated System Design is a capstone course that integrates the various perspectives of an integrated system taught in third year, including: Optimization, Quality, Management, Information, and Economics. The course approaches systems design from a Business Process perspective. Beginning with the Business Processes, it explores the concept of Business Process Re-engineering. It extends the concept of business processes to incorporate perspectives such as cost, quality, time, behaviour, etc. The second part of the course focuses on business process design tools. Namely, software tools to both design, simulate and analyse business processes. The third part of the course explores the application of process design to various domains. Guest speakers are used to provide domain background.
Prerequisite: Fourth-year, Industrial Engineering standing

MIE464H1 S
Smart Materials and Structures
IV - AEMECBASC 3/2/-/0.50

Smart materials are characterized by new and unique properties that can be altered in response to environmental stimuli. They can be used in a wide range of applications since they can exceed the current abilities of traditional materials especially in environments where conditions are constantly changing. This course is designed to provide an integrated introduction to smart materials and structures, and provide a strong foundation for further studies and research on these materials. Topics include: structure, processing, and properties of smart materials; dependence of properties on structure; processing and design; mechanical, thermal, electrical, magnetic and optical smart materials systems such as shape memory materials, electrostrictive materials, magnetostrictive materials, active polymers; design, modeling and optimization of smart materials systems using CAD and FEA software packages.
Prerequisite: MSE101H1, MSE270H1/MSE235H1, MIE222H1/MSE316H1

MIE468H1 S
Facility Planning
IV - AEESCBASEM, III - AEINDBASC 3/1/1/0.50

Fundamentals of developing efficient layouts of various production/service systems. Topics include layout procedures, computerized layout planning, single-facility and multifacility location problems, material-handling systems design for production facilities.
Prerequisite: MIE231H1 F/MIE236H1 F or equivalent, MIE262H1 F

MIE469H1 S
Reliability and Maintainability Engineering
III - AEINDBASC, I - AEMECBASC 3/-/2/0.50

An introduction to the life-cycle costing concept for equipment acquisition, operation, and replacement decision-making. Designing for reliability and determination of optimal maintenance and replacement policies for both capital equipment and components. Topics include: identification of an items failure distribution and reliability function, reliability of series, parallel, and redundant systems design configurations, time-to-repair and maintainability function, age and block replacement policies for components, the economic life model for capital equipment, provisioning of spare parts.
Prerequisite: MIE231H1 F/MIE236H1 F or equivalent, MIE258H1F

MIE488H1 F
Entrepreneurship and Business for Engineers
3/-/2/0.50

A complete introduction to small business formation, management and wealth creation. Topics include: the nature of the Entrepreneur and the Canadian business environment; business idea search and Business Plan construction; Buying a business, franchising, taking over a family business; Market research and sources of data; Marketing strategies promotion, pricing, advertising, electronic channels and costing; The sales process and management, distribution channels and global marketing; Accounting, financing and analysis, sources of funding, and financial controls; The people dimension: management styles, recruiting and hiring, legal issues in employment and Human Resources; Legal forms of organization and business formation, taxation, intellectual property protection; the e-Business world and how businesses participate; Managing the business: location and equipping the business, suppliers and

purchasing, credit, ethical dealing; Exiting the business and succession, selling out. A full Business Plan will be developed by each student and the top submissions will be entered into a Business Plan competition with significant cash prices for the winners. Examples will be drawn from real business situations including practicing entrepreneurs making presentations and class visits during the term. (Identical courses are offered: ECE488H1F, MSE488H1F, CHE488H1S and CIV488H1S.)
Exclusion: APS234 and APS432

MIE490Y1 Y
Capstone Design
IV - AEINDBASC -/-/4/1.00

An experience in engineering practice through a significant design project whereby student teams meet specific client needs through a creative, iterative, and open-ended design process. The project must include:
• The application of disciplinary knowledge and skills to conduct engineering analysis and design,
• The demonstration of engineering judgment in integrating economic, health, safety, environmental, social or other pertinent interdisciplinary factors,
• Elements of teamwork, project management and client interaction, and
• A demonstration of proof of the design concept.

MIE496H1 F/S
Thesis
IV - AEMECBASC -/6/1/0.50

The purpose of the thesis course is two-fold: to allow students to pursue a technical project of interest, and to improve their communication skills. The course is optional for fourth-year Mechanical students, and can be completed as a one-term or a two-term course. The two-term thesis course is required for fourth-year Industrial students. The grade of the "Y" course which extends over two sessions will be included in the weighted average of the Winter Session only. Students may work individually or in groups, and must obtain a supervisor (a member of the University of Toronto teaching staff). The course comprises written work and oral presentations.

MIE496Y1 Y
Thesis
IV - AEMECBASC -/6/1/0.50

The purpose of the thesis course is two-fold: to allow students to pursue a technical project of interest, and to improve their communication skills. The course is optional for fourth-year Mechanical students, and can be completed as a one-term or a two-term course. The two-term thesis course is required for fourth-year Industrial students. The grade of the "Y" course which extends over two sessions will be included in the weighted average of the Winter Session only. Students may work individually or in groups, and must obtain a supervisor (a member of the University of Toronto teaching staff). The course comprises written work and oral presentations.

MIE498H1 F/S
Research Thesis
IV - AEINDBASC -/-/4/0.50

An opportunity to conduct independent research under the supervision of a faculty member in MIE. Admission to the course requires the approval of a project proposal by the Undergraduate office. The proposal must: 1) Explain how the research project builds upon one or more aspects of engineering science introduced in the student's academic program, 2) provide an estimate of a level of effort not less than 40 productive hours of work per term, 3) specify a deliverable in each term to be submitted by the last day of lectures, 4) be signed by the supervisor, and 5) be received by the Undergraduate Office one week prior to the last add day.

MIE498Y1 Y
Research Thesis
-/-/4/1.00

An opportunity to conduct independent research under the supervision of a faculty member in MIE. Admission to the course requires the approval of a project proposal by the Undergraduate office. The proposal must: 1) Explain how the research project builds upon one or more aspects of engineering science introduced in the student's academic program, 2) provide an estimate of a level of effort not less than 40 productive hours of work per term, 3) specify a deliverable in each term to be submitted by the last day of lectures, 4) be signed by the supervisor, and 5) be received by the Undergraduate Office one week prior to the last add day.

MIE506H1 F
MEMS Design and Microfabrication
IV - AEMECBASC 3/1.50/1/0.50

This course will present the fundamental basis of microelectromechanical systems (MEMS). Topics will include: micromachining/microfabrication techniques, micro sensing and actuation principles and design, MEMS modeling and simulation, and device characterization and packaging. Students will be required to complete a MEMS design term project, including design modeling, simulation, microfabrication process design, and photolithographic mask layout.
Prerequisite: MIE222H1S, MIE342H1F

MIE515H1 F
Alternative Energy Systems
IV - AECHEBASC, IV - AEESCBASEI, IV - AEESCBASEJ, IV - AEESCBASEM, IV - AEESCBASEO, IV - AEMECBASC, I - AEMINENR, I - AEMINENV 3/-/1/0.50

This course covers the basic principles and design of selected alternative energy systems. Systems discussed include solar thermal systems, solar photovoltaic, wind technology, fuel cells, and energy storage. Limited enrolment.
Prerequisite: MIE210H1 S, MIE312H1 F and some knowledge of chemistry, or equivalent courses).

MIE516H1 F
Combustion and Fuels
IV - AECHEBASC, IV - AEESCBASEJ, IV - AEMECBASC, I - AEMINENR 3/-/-/0.50

Introduction to combustion theory. Chemical equilibrium and the products of combustion. Combustion kinetics and types of combustion. Pollutant formation. Design of combustion systems for gaseous, liquid and solid fuels. The use of alternative fuels (hydrogen, biofuels, etc.) and their effect on combustion systems.

MIE517H1 S
Fuel Cell Systems
IV - AECHEBASC, IV - AEESCBASEJ, I - AEMECBASC, I - AEMINENR 3/-/-/0.50

Thermodynamics and electrochemistry of fuel cell operation and testing; understanding of polarization curves and impedance spectroscopy; common fuel cell types, materials, components, and auxiliary systems; high and low temperature fuel cells and their applications in transportation and stationary power generation,

including co-generation and combined heat and power systems; engineering system requirements resulting from basic fuel cell properties and characteristics.

MIE540H1 S
Product Design
IV - AEESCBASEM, IV - AEMECBASC 2/-/1/0.50

This course takes a 360° perspective on product design: beginning at the market need, evolving this need into a concept, and optimizing the concept. Students will gain an understanding of the steps involved and the tools utilized in developing new products. The course will integrate both business and engineering concepts seamlessly through examples, case studies and a final project. Some of the business concepts covered include: identifying customer needs, project management and the economics of product design. The engineering design tools include: developing product specifications, concept generation, concept selection, FAST diagrams, orthogonal arrays, full and fractional factorials, noises, interactions, tolerance analysis and latitude studies. Specific emphasis will be placed on robust and tunable technology for product optimization and generating product families. Critical Parameters will be developed using the Voice of the Customer (VOC), FAST diagrams and a House of Quality (HOQ).
Prerequisite: MIE231H1 F/MIE236H1 F or equivalent.

MIE561H1 S
Healthcare Systems
IV - AEESCBASEB, IV - AEESCBASEM, IV - AEINDBASC, I - AEMINBIO 3/2/-/0.50

MIE 561 is a “cap-stone” course. Its purpose is to give students an opportunity to integrate the Industrial Engineering tools learned in previous courses by applying them to real world problems. While the specific focus of the case studies used to illustrate the application of Industrial Engineering will be the Canadian health care system, the approach to problem solving adopted in this course will be applicable to any setting. This course will provide a framework for identifying and resolving problems in a complex, unstructured decision-making environment. It will give students the opportunity to apply a problem identification framework through real world case studies. The case studies will involve people from the health care industry bringing current practical problems to the class. Students work in small groups preparing a feasibility study discussing potential approaches. Although the course is directed at Industrial Engineering fourth year and graduate students, it does not assume specific previous knowledge, and the course is open to students in other disciplines.

MIE562H1 F
Scheduling
IV - AEESCBASEM, IV - AEINDBASC 3/-/2/0.50

This course takes a practical approach to scheduling problems and solution techniques, motivating the different mathematical definitions of scheduling with real world scheduling systems and problems. Topics covered include: job shop scheduling, timetabling, project scheduling, and the variety of solution approaches including constraint programming, local search, heuristics, and dispatch rules. Also covered will be information engineering aspects of building scheduling systems for real world problems.
Prerequisite: MIE262H1 F

MIE566H1 F
Decision Analysis
IV - AEESCBASEM, IV - AEINDBASC 3/-/2/0.50

The purpose of this course is to provide a working knowledge of methods of analysis of problem and of decision making in the face of uncertainty. Topics include decision trees, subjective probability assessment, multi-attribute utility approaches, goal programming, Analytic Hierarchy Process and the psychology of decision making.
Prerequisite: MIE231H1 F/MIE236H1 F or equivalent

Mineral Engineering

MIN225H1 F
Introduction to the Resource Industries
II - AELMEBASC 3/2/1/0.50

This course introduces the global resource industries in three parts. In Module 1, students learn about mineral resources in the economy, the origin of ore deposits, mineral exploration and processing techniques, land ownership and environmental issues. Engineering applications are emphasized. Exploration and development topics are investigated. Module 2 presents an introduction to modern mining engineering. The basics of both surface (open pit) and sub-surface mining is covered. Module 3 presents an introduction on the processing of mineral resources into metals. The course helps to develop communication skills through student presentations on current issues in the industry and through training in technical communications by faculty from the Engineering Communications Program. Training for AutoCad and an extensive communications module are provided in the laboratory section. Students will participate in a field trip to an operating mine.

MIN320H1 F
Explosives and Fragmentation in Mining
III - AELMEBASC 3/-/1/0.50

Efficient drilling and blasting is important to successful mining in rock formations. This course studies the planning, design, and economics of rock blasting for a full range of surface and underground, mining and construction projects. Emphasis will be on optimization of fragmentation using blast geometry and those variables available to the field engineer. This course covers the selection of modern industrial explosives, their history, physical properties, and safe handling, including an introduction to the theory of detonation, and rock response. Safety procedures in storage and transportation will be studied along with the monitoring and control of blast side effects. A field trip is associated with this course.

MIN350H1 S
Underground and Open Pit Mining
III - AELMEBASC 3/-/1/0.50

Operational aspects of open pit and underground mine design and mine planning. Topics will include: open pit design and pit optimization; long term and short term planning considerations; underground mining methods for hard and soft rock; shaft sinking, hoisting and materials handling; equipment selection and optimization; industrial minerals production; mine safety and mine regulations; mining and the environment; mine personnel organization; ethics and professional issues.

MIN401H1 S
Mineral Reserve and Mineral Resource Estimation
IV - AELMEBASC 3/-/1/0.50

Introduction to Mineral Resource and Mineral Reserve Estimation is an advanced level course that focuses on the stages of a mineral resource and mineral reserve estimation program from assembling the database through to reporting under industry guidelines. Major course topics include: statistical analysis of sampling data, geologic interpretation and deposit models; mineral resources estimation approaches and methods, mineral reserve estimation, classification of resources and reserves, and reporting under regulatory standards and industry guidelines for professional practice.

MIN429H1 S
Rock Engineering
III - AELMEBASC 3/-/1/0.50

This course use case studies to cover the practical aspects of rock engineering. Topics include: rock mass classification, shear strength of discontinuities, structurally controlled instability in tunnels, slope stability, factor of safety and probability of failure, analysis of rockfall hazards, in situ and induced stresses, rock mass properties, tunnels in weak rock, large powerhouse caverns in weak rock, rockbolts and cables, shotcrete support and blasting damage in rock. (Note: Students in CIV529 will also be attending these scheduled lectures and tutorial.)

MIN430H1 F
Mining Environmental Management
IV - AECIVBASC, IV - AELMEBASC, I - AEMINENV 3/-/1/0.50

This course provides an overview of the major aspects of mining environmental management from exploration, through design and development of the property, into operation, and final closure implementation. An applied approach is taken utilizing case studies and examples where possible. Participation and discussion is an integral part of the course. Topics include sustainable development, environmental impacts, designing for mitigation, environmental management systems and reclamation.

MIN450H1 F
Mineral Economics
IV - AELMEBASC 3/-/1/0.50

Course covers the evaluation of mineral projects, mining operations, and mining companies. Topics will include: discounted cash flow techniques including net present value (NPV), internal rate of return (IRR), net asset value (NAV); feasibility studies and due diligence reports; reserves and resources, data sources; metal prices and markets; cash flow modeling including revenue calculations, capital and operating costs, taxes, depreciation, inflation; risk and risk assessment, discount rates, red flags, checklists; financing. Guest lectures will provide industry insights into financing, fund raising, consulting, project control, and evaluation. There are two assignments: review of an annual report; due diligence report and net asset value calculation.
Prerequisite: CIV368H1/CME368H1

MIN466H1 F
Mineral Project Design I
IV - AELMEBASC 2/2/1/0.50

Mineral Project Design is a two-part capstone course that draws on all course materials developed in the first three years of the Mineral Engineering Curriculum. The course will culminate in the design of a mining or civil rock engineering project. In the first half of the course (F) students perform individual detailed case history analyses. Additional instruction in technical aspects of communication is provided during both semesters (preparing and writing technical reports, industry research and analysis, presentation skills, as well as other technical elements as required). These skills will form a foundation for students to use in industry. Critical non-technical aspects of rock engineering projects will also be examined, and guest speakers will present on specialized topics such as: cultural and social effects of rock engineering projects on communities and the environment; economic planning and impact; ethical considerations; aboriginal land claims, etc.. The social license to operate will be emphasized. Students will receive a final grade at the end of each term course, but both courses must be taken in sequence. (MIN 567H1 S cannot be taken without successful completion of MIN 566H1 F)
Prerequisite: MIN429H1, MIN350H1

MIN467H1 S
Mineral Project Design II
IV - AELMEBASC 1/4/1/0.50

Mineral Project Design is a two-part capstone course that draws on all course materials developed in the first three years of the Mineral Engineering Curriculum. Part II (S) focuses on the design of a mining or civil rock engineering project. Students will be grouped into teams and provided with one or more data sets and a design problem to solve. The end product is a major engineering design report and oral presentation (including several interim reports and presentations). Technical aspects will serve to examine a “cradle to grave” view of a project, from initial planning through to final closure and site remediation. The course will include an intensive two-day Professional Supervisors Short Course. Topics include: Discovering a commonality among supervisors and their key role in maintaining standards. The importance of sharing information and expectations about costs, production goals and business objectives are explored in the context of motivation. The necessity of successful communication skills and techniques are discussed and demonstrated to achieve behaviours on the job, producing consistent results. A reliable methodology for handling difficult situations is provided. The fundamental rationale for safety and loss control is presented as well as a relevant perspective on management structure. A workable code of conduct that is a guide to professional behaviour is developed. Students will receive a final grade at the end of each term course, but both courses must be taken in sequence (MIN 567H1 S cannot be taken without successful completion of MIN 566H1 F)
Prerequisite: MIN466H1

MIN470H1 S
Ventilation and Occupational Health
IV - AECIVBASC, IV - AELMEBASC 3/-/1/0.50

Hydraulics of air flow through underground openings is studied leading to mine ventilation design calculations and ventilation network analysis. Related topics discussed in the course include: statutory regulations and engineering design criteria; application and selection of ventilation fans; auxiliary fan design; air conditioning (heating and cooling); dust and fume control; ventilation economics. Health hazards related to mine gasses, dust and radiation along with relevant statutory requirements are reviewed. Air quality and quantity measurement and survey techniques are presented.
Prerequisite: CIV270H1/CME270H1

MIN511H1 F
Integrated Mine Waste Engineering
IV - AECIVBASC, IV - AELMEBASC 3/-/1/0.50

The engineering design of conventional mine waste management systems, including tailings ponds, rock dumps, and underground mine backfill systems, is considered first. Emerging trends in integrated mine waste management systems, including paste stacking and "paste rock" on surface, and cemented paste backfill forunderground mining will then be covered. Engineering case studies will be used throughout, and each case study will be evaluated in terms of how the mine waste systems used contribute to the economic and environmental sustainability of the mining operation.
Prerequisite: CME321H1

MIN540H1 S
Borehole Geophysics for Engineers and Geoscientists
IV - AECIVBASC, IV - AELMEBASC 3/-/1/0.50

The process of wireline logging of boreholes for mineral, hydrocarbon and groundwater exploration, geotechnical and environmental studies involve a number of measurement devices, or sondes. Some of these are passive measurement devices; others exert some influence over the rock formation being traversed. Their measurements are transmitted to the surface by means of wire line. Logging applications include the identification of geological environment, reservoir fluid contact location, fracture detection, estimate of hydrocarbon or water in place, determination of water salinity, reservoir pressure determination, porosity/pore size distribution determination, and reservoir fluid movement monitoring.

MIN565H1 S
Design and Support of Underground Mine Excavations
IV - AELMEBASC 3/-/1/0.50

Geomechanical issues concerning the design of underground openings in hard rock are covered in the course: ground support [i.e. rock mass reinforcement] design, the dimensioning and sequencing of underground excavations and rock pillar design in hard rock applications. A review of modern concepts concerning rock and rock mass failure modes with application to support design is given. Both static and dynamic [rockburst] support design issues are addresses. Lastly instrumentation and monitoring techniques and backfill design and behaviour are also covered. Design issues are illustrated through the use of numerous field case studies .
Prerequisite: MIN429/CIV 529

Physics

PHY180H1 F
Classical Mechanics
I - AEESCBASE 3/1.50/1/0.50

Mechanics forms the basic background for the understanding of physics. This course on Classical, or Newtonian mechanics, considers the interactions which influence motion. These interactions are described in terms of the concepts of force, momentum and energy. Initially the focus is on the mechanics of a single particle, considering its motion in a particular frame of reference, and transformations between reference frames. Then the dynamics of systems of particles is examined. Textbook: Physics for Scientists and Engineers vol. 1. 6th ed. by Serway and Jewett.

PHY293H1 F
Particles & Waves
II - AEESCBASE 3/1/1/0.50

An introduction to the basic ideas of classical statistical mechanics and radiation, with applications to experimental physics. Topics include Boltzmann's interpretation of entropy, Maxwell-Boltzman statistics, energy equipartition, the perfect gas laws, blackbody radiation, wave optics, normal modes, travelling waves, wave equation, forced and damped harmonic motion, reflection and transmission at interfaces, group and phase velocity.

PHY294H1 S
Modern Physics
II - AEESCBASE 3/1/1/0.50

An introduction and a historical development of quantum mechanics and special relativity. Topics include the Michelson-Morley experiment, time dilation and length contraction, the photoelectric effect, the Compton effect, the Bohr atom, wave-particle duality, Schrodinger's wave mechanics, atomic spectra, bound states in potential wells, tunneling, and the quantum oscillator.

PHY327H1 F/S
Advanced Physics Laboratory
III - AEESCBASEO, III - AEESCBASEP -/6/-/0.50

Experiments in this course are designed to form a bridge to current experimental research. A wide range of experiments are available using contemporary techniques and equipment. In addition to the standard set of experiments a limited number of research projects are also available. Many of the experiments can be carried out with a focus on instrumentation.

PHY335H1 S
Introduction to Quantum Mechanics
III - AECPEBASC, III - AEELEBASC 2/-/1/0.50

Review of elementary quantum mechanics, (photo-electric and Compton effects, Bohr model, de Broglie waves); some bound (harmonic oscillator, hydrogen atom) and unbound (potential barriers) solutions of the Schrodiner equation; probability interpretation; operators and the theory of measurement; expectation values and uncertainties; angular momentum (orbital and spin); magnetic resonance as an application.

PHY354H1 S
Classical Mechanics
III - AEESCBASEP 2/-/-/0.50

Symmetry and conservation laws, stability and instability, generalized co-ordinates, Hamilton's principle, Hamilton's equations, phase space, Liouville's theorem, canonical transformations, Poisson brackets, Noether's theorem.

PHY356H1 F
Quantum Mechanics I (formerly PHY355H1)
IV - AEESCBASEA, III - AEESCBASEO, III - AEESCBASEP, IV - AEESCBASER 2/-/-/0.50

The general structure of wave mechanics; eigenfunctions and eigenvalues; operators; orbital angular momentum; spherical harmonics; central potential; separation of variables; hydrogen atom; Dirac notation; operator methods; harmonic oscillator and spin.
Prerequisite: MAT223H1/MAT240H1; PHY251H1/PHY250H1, PHY256H1/CHM225Y1 (PHY256H1 recommended)
Exclusion: CHM326H1, PHY355H1

PHY358H1 S
Atoms, Molecules and Solids
III - AEESCBASEO 2/-/1/0.50

Quantum theory of atoms, molecules, and solids; variational principle and perturbation theory; hydrogen and helium atoms; exchange and correlation energies; multielectron atoms; simple molecules; bonding and antibonding orbitals; rotation and vibration of molecules; crystal binding; electron in a periodic potential; reciprocal lattice; Bloch's theorem; nearly-free electron model; Kronig-Penney model; energy bands; metals, semiconductors, and insulators; Fermi surfaces. This course is not a *Prerequisite* for any PHY 400-level course.
Prerequisite: PHY355H1/PHY356H1

PHY392H1 S
Physics of Climate
III - AEESCBASEP 2/-/-/0.50

The role of radiation in the generation, maintenance and evolution of planetary atmospheres and climate: Radiation laws, absorption and emission. Simple radiative exchange processes and atmospheric models. Energy balance. Radiation and climatic change. Comparative radiation studies in planetary atmospheres. Pollution and man-made effects.

PHY395H1 S
Physics of the Earth (formerly PHY359H1)
III - AECPEBASC, III - AEELEBASC, IV - AEESCBASEJ, III - AEESCBASEP, IV - AEESCBASER, I - AEMINENR 2/-/-/0.50

Designed for students interested in the physics of the Earth and the planets. Study of the Earth as a unified dynamic system; determination of major internal divisions in the planet; development and evolution of the Earth's large scale surface features through plate tectonics; the age and thermal history of the planet; Earth's gravitational field and the concept of isostasy; mantle rheology and convection; Earth tides; geodetic measurement techniques, in particular modern space-based techniques.
Prerequisite: PHY140Y1/PHY152H1/255H1/PHY254H1, MAT235Y1/MAT237Y1, MAT244 (Or permission of instructor)
Exclusion: PHY359H1

PHY407H1 F
Computational Physics
IV - AEESCBASEP 1/3/-/0.50

Problem solving with computers, using both algebraic and numerical methods. After a brief introduction to the basic techniques, various physics problems are treated with increasingly more sophisticated techniques. Examples include the physical pendulum, heat equation, quantum mechanics, Monte Carlo simulation, differential equation, and graphical presentation of results.

PHY408H1 S
Times Series Analysis
III - AEESCBASEP 1/3/-/0.50

The analysis of digital sequences; filters; the Fourier Transform; windows; truncation effects; aliasing; auto and cross-correlation; stochastic processes, power spectra; least squares filtering; application to real data series and experimental design.
Prerequisite: PHY307H1/309H1/225H1/225H1/PHY250H1/255H1/PHY324H1
Corequisite: Any third-year lecture course in Physics
Exclusion: PHY308H1

PHY427H1 F/S
Advanced Physics Laboratory
IV - AEESCBASEO, III - AEESCBASEP -/6/-/0.50

Experiments in this course are designed to form a bridge to current experimental research. A wide range of experiments are available using contemporary techniques and equipment. In addition to the standard set of experiments, a limited number of research projects may be available. This laboratory is a continuation of PHY327.

PHY428H1 F
Advanced Practical Physics II
IV - AEESCBASEP -/6/-/0.50

See Arts and Science Description.
Prerequisite: PHY426H1

PHY429H1 S
Advanced Practical Physics III
IV - AEESCBASEP -/6/-/0.50

Prerequisite: PHY428H1

PHY452H1 S
Basic Statistical Mechanics (formerly PHY480H1)
IV - AEESCBASEO, IV - AEESCBASEP 2/-/-/0.50

Classical and quantum statistical mechanics of noninteracting systems; the statistical basis of thermodynamics; ensembles, partition function; thermodynamic equilibrium; stability and fluctuations; formulation of quantum statistics; theory of simple gases; ideal Bose and Fermi systems.
Exclusion: PHY480H1

PHY456H1 F
Quantum Mechanics II (formerly PHY457H1)
IV - AEESCBASEP, IV - AEESCBASER 3/-/-/0.50

Quantum dynamics in Heisenberg and Schrödinger Pictures; WKB approximation; Variational Method; Time-Independent Perturbation Theory; Spin; Addition of Angular Momentum; Time-Dependent Perturbation Theory; Scattering.
Prerequisite: PHY355H1/PHY356H1
Exclusion: PHY457H1

PHY459H1 S
Macroscopic Physics
IV - AEESCBASEP 2/-/-/0.50

Thermal equilibrium and temperature; the three laws of thermodynamics; entropy and free energy, phases and phase transitions; Fluid dynamics; the Euler and Navier-Stokes equations; vorticity, waves; stability and instability; turbulence.
Prerequisite: PHY252H1, 351H1/PHY354H1

PHY460H1 S
Nonlinear Physics
IV - AEESCBASEP 3/-/-/0.50

The theory of nonlinear dynamical systems with applications to many areas of physics. Topics include stability, bifurcations, chaos, universality, maps, strange attractors and fractals. Geometric, analytical and computational methods will be developed.
Prerequisite: PHY351H1/PHY354H1

PHY483H1 F
Relativity Theory I
IV - AEESCBASEP 2/-/-/0.50

Basis to Einsteins theory: differential geometry, tensor analysis, gravitational physics leading to General Relativity. Theory starting from solutions of Schwarzschild, Kerr, etc.

PHY484H1 S
Relativity Theory II
IV - AEESCBASEP 2/-/-/0.50

Applications of General Relativity to Astrophysics and Cosmology. Introduction to black holes, large-scale structure of the universe.

PHY485H1 F
Lasers and Modern Optics
IV - AEESCBASEO, IV - AEESCBASEP 2/-/-/0.50

Maxwell's equations in media, basic optics and imaging, manipulations of polarization, coherence and diffraction theory, Gaussian beams, laser resonators, simple semiclassical laser theory. End-of year student seminars from the range of modern areas of research, e.g., laser cooling, photonic bandgap structures, extreme optics, quantum information, and other topics.
Prerequisite: PHY353H1, PHY355H1

PHY487H1 F
Condensed Matter Physics
IV - AEESCBASEO, IV - AEESCBASEP, IV - AEESCBASER 2/-/-/0.50

Introduction to the concepts used in the modern treatment of solids. The student is assumed to be familiar with elementary quantum mechanics. Topics include: crystal structure, the reciprocal lattice, crystal binding, the free electron model, electrons in periodic potential, lattice vibrations, electrons and holes, semiconductors, metals.

PHY489H1 S
Introduction to High Energy Physics
IV - AEESCBASEP 2/-/-/0.50

This course introduces the basics of fundamental particles and the strong, weak and electromagnetic forces that govern their interactions in the Standard Model of particle physics. Topics include relativistic kinematics, conservation laws, particle decays and scattering processes, with an emphasis on the techniques used for calculating experimental observables.

PHY492H1 F
Advanced Atmospheric Physics (formerly PHY498H1)
IV - AEESCBASEA, IV - AEESCBASEP 2/-/-/0.50

A preparatory course for research in experimental and theoretical atmospheric physics. Content will vary from year to year. Themes may include techniques for remote sensing of the Earth's atmosphere and surface; theoretical atmosphere-ocean dynamics; the physics of clouds, precipitation, and convection in the Earth's atmosphere.
Exclusion: PHY498H1

PHY493H1 F
Geophysical Imaging I
IV - AEESCBASEP 2/-/-/0.50

This course covers wavefield and ray approximation methods for imaging the interior of the Earth (including hydrocarbon reservoirs and mineral deposits) using seismology.

PHY494H1 S
Geophysical Imaging II
IV - AEESCBASEP 2/-/-/0.50

How to investigate Earth structure at depths ranging from metres to tens of kilometres using gravity, magnetic, electrical, electromagnetic and nuclear geophysical methods. Current methodologies and the theoretical basis for them are presented.

PHY495H1 F
Experimental Global Geophysics
IV - AEESCBASEP 2/-/-/0.50

This course deals with the numerical analysis of data associated with space geodesy, earthquake seismology, geomagnetism and palaeomagnetism, isotope geochronology, as well as numerical simulations of a wide variety of geodynamic processes (e.g. mantle convection, post-glacial rebound, Earth tides).
Co-requisite: PHY395H1

PHY496H1 F
Experimental Applied Geophysics
IV - AEESCBASEP -/3/-/0.50

A laboratory course (with introductory lectures) dealing with physical methods for exploring Earth structure; i.e., seismic, gravity, magnetic, electrical, electromagnetic, and nuclear methods. It is designed to give hands on experience with the techniques of geophysical data analysis as well as data acquisition.
Co-requisite: PHY493H1/PHY494H1
Exclusion: JGP438H1

Statistics

STA286H1 S
Probability and Statistics
II - AEESCBASE 3/-/1/0.50

A course in probability and statistics for Engineering Science students focusing on building solid probabilistic and statistical foundations. Topics include: sample space, events, definitions of probability, conditional probability, Bayes' theorem, important classes of discrete and continuous random variables and their distributions, joint, conditional, and marginal distributions, expectation, moment generating and characteristic functions, transformations of random variables, central limit theorem and approximations. Graphical methods, quantile plots, point and interval estimation of population parameters, method of maximum likelihood. Hypotheses testing, simple and multiple regression, correlation analysis, and introduction to Bayesian statistics. Minitab software is used to solve some assignment problems in the course.

STA302H1 F
Methods of Data Analysis I
III - AEESCBASEF 3/-/-/0.50

Introduction to data analysis with a focus on regression. Initial Examination of data. Correlation. Simple and multiple regression models using least squares. Inference for regression parameters, confidence and prediction intervals. Diagnostics and remedial measures. Interactions and dummy variables. Variable selection. Least squares estimation and inference for non-linear regression.

STA347H1 F
Probability
III - AEESCBASEF 3/-/-/0.50

An overview of probability from a non-measure theoretic point of view. Random variables/vectors; independence, conditional expectation/probability and consequences. Various types of convergence leading to proofs of the major theorems in basic probability. An introduction to simple stochastic processes such as Poisson and branching processes.

Environment

ENV346H1 F
Terrestrial Energy Systems
III - AEESCBASEJ 3/-/2/0.50

Various earth systems for energy transformation, storage and transport are explored. Geological, hydrological, biological, cosmological and oceanographic energy systems are considered in the context of the Earth as a dynamic system, including the variation of solar energy received by the planet and the redistribution of this energy through various radiative, latent and sensible heat transfer mechanisms. It considers the energy redistribution role of large-scale atmospheric systems, of warm and cold ocean currents, the role of the polar regions, and the functioning of various hydrological systems. The contribution and influence of tectonic systems on the surface systems is briefly introduced, as well the important role of energy storage processes in physical and biological systems, including the accumulation of fossil fuel reserves.

ENV350H1 F
Energy Policy and Environment
I - AEMINENR, I - AEMINENV -/-/-/0.50

The course addresses: (1) physical, technological and economic aspects of energy and electricity systems and their associated environmental impacts; (2) current international, Canadian and Ontario energy policy; (3) technological, economic and political factors influencing policy which could significantly reduce environmental impacts of energy use.
Prerequisite: ENV222Y1/GGR222Y1/JGE221Y1 or permission of undergraduate student advisor

Biochemistry

BCH210H1 F
Biochemistry I: Proteins, Lipids and Metabolism
IV - AEESCBASEB 3/-/-/0.50

Proteins, enzymes, membranes and the metabolism of carbohydrates and lipids. This course is intended for students who are NOT taking BCH242Y1 as part of their program.
Prerequisite: CHE390H1 and CHE391H1

Ecology & Evolutionary Biology

EEB214H1 S
Evolution and Adaptation (formerly ZOO214Y1)
III - AECPEBASC, III - AEELEBASC 2/-/1/0.50

Evolution and adaptation through natural selection. Concepts and application based on faunal life goals of habitat survival, food acquisition, predator avoidance, and reproduction. Topics include: speciation, mutation, co-evolution, symbiosis, pollination, cannibalism, parasitism, eusociality, and sexual and parental conflict. Essays, debates, and reading required.

This course counts as a Science Distribution Requirement for students in all years and disciplines.
Exclusion: BIO150Y1/323H1/EEB318H1/EEB323H1/ZOO214Y1/324Y1

Forestry

FOR310H1 S
Bioenergy from Sustainable Forest Management
IV - AEESCBASEJ, I - AEMINENR 2/-/1/0.50

Socio-economic, technical, political and environmental issues associated with the utilization of forest biomass (e.g., harvesting residues, thinnings, salvage, short rotation woody crops) for a source of renewable energy.
Recommended Preparation: Completed at least 6 Science FCE's

FOR410H1 S
Bioenergy and Biorefinery Technology
IV - AEESCBASEJ, I - AEMINENR 2/-/2/0.50

Technological advances and approaches in deriving biofuels and chemical feedstocks from forest and other biomass. Fundamental chemical attributes of biomass, as they affect the fuel value and potential for deriving liquid, solid and gaseous fuels and valuable chemicals for other applications will be discussed.
Recommended Preparation: Completed at least 10 Science FCE's

Human Biology

HMB200H1 S
Introduction to Neuroscience
IV - AEESCBASEB 2/-/1/0.50

A survey of brain systems, including evolution and development of the nervous system, brain stem system for defensive and approach responses, limbic and cortical systems for learning, and higher brain functions. Techniques for study of brain systems including pharmacology, gene targeting and human brain imaging are introduced.

HMB265H1 S
General and Human Genetics
IV - AEESCBASEB, I - AEMINBIO 2/-/1/0.50

An introduction to classical and modern methods of genetic analysis. Topics include Mendelian genetics, the genetics of human population and disease, genomics, and applications of genetics to human society.

Co-requisite: BIO250Y1/(BIO240H1, BIO241H1)/BIO255Y1
Prerequisite: BIO150Y1

Exclusion: BIO260H1, BIO207H5

Physiology

PSL300H1 F
Human Physiology I
IV - AEESCBASEB, I - AEMINBIO 3/-/1/0.50

Principles of neurophysiology, endocrinology and reproductive physiology for students enroled in the Neuroscience program. Prerequisite: BIO150Y1; CHM138H1; PHY100-series
Exclusion: PSL201Y1, PSY391H1

Pharmacology and Toxicology

PCL201H1 S
Introduction to Pharmacology and Pharmacokinetic Principles
IV - AEESCBASEB, I - AEMINBIO 3/-/0.50/0.50

A general introduction to pharmacology and pharmacokinetics (PK). Topics include: absorption, distribution, biotransformation, elimination, calculation of dosages and PK parameters, variability in drug response, adverse drug reactions and special interest topics.