MECHANICAL AND MATERIALS ENGINEERING (MECH)

Review the Department of Mechanical and Materials Engineering website (http://my.me.queensu.ca/Graduate/Graduate-Courses/) for the most current list of courses available and term offered.

APSC 801 Master of Engineering Foundations
An introduction to the Master of Engineering (MEng) graduate studies program at Queen's University. The course provides students with essential administrative information, an introduction to information literacy within Smith Engineering, as well as an overview of the various support services on campus. Additionally, the course contains several modules on professional and career skills. This non-credit course is comprised of a number of individual modules, and its completion is a requirement to graduate from the MEng program. Graded on a Pass/Fail basis.
Prerequisites: Enrolment in the MEng program.
Exclusions: Students not enrolled in the MEng program.

APSC 810 Teaching and Learning in Engineering
This course is an introduction to learning principles and effective teaching in engineering, intended to prepare for roles like teaching assistant, university course instruction, or training in engineering industry. The course includes relevant theories of teaching and learning with practical elements like classroom management, designing sessions and assessments, signature engineering teaching approaches, and using digital pedagogies.

APSC 812 AI Ethics and Society
This course investigates the ethical implications of Artificial Intelligence (AI) as a social, technological and cultural phenomenon. Given the increasing use of intelligent systems for decision-making and autonomous control, it is essential that designers and developers are aware of the ethical and social implications that AI can have. The course materials will examine fundamental ethical principles related to the application of AI and investigate its influence in a number of industries including self-driving vehicles, healthcare, law and defense. The course will also examine the delicate balance between innovations in AI versus regulation, privacy, and individual rights. This course is graded on a Pass/Fail basis.

APSC 877 Engineering Project Management
The course will examine the essential skills and knowledge required for effective engineering project management. The foundational principles of project management including integration, scope, cost, time, human resources, stakeholders and procurement are examined. The course will be delivered online.
Exclusions: MECH 896, APSC 223

APSC 888 Engineering Innovation and Entrepreneurship
This course will help learners from across engineering develop an entrepreneurial mindset capable of turning problems into opportunities. Learners will investigate the relationships between innovation and industrial dynamics, and seek to understand the fundamental forces that drive the science and technology industries' evolution and industry life cycles.
EXCLUSION: CHEE 410

APSC 896 Engineering Leadership
The course is designed to develop a range of leadership skills essential for engineering professional practice. Students will explore their own leadership abilities and develop their competencies in areas such as managing conflict, team dynamics and developing others. The course content will be presented through lectures, case studies, panel discussions and other active learning activities. Fall.

MECH 810 Advanced Topics in Manufacturing Engineering

A topical course in manufacturing engineering which deals with some of today's research issues from both a theoretical and pragmatic approach. Research in areas such as Flexible Manufacturing Systems, Computer Integrated Manufacturing, Statistical Quality Control, Group Technology, Just in Time Concepts, Material Removal and Forming Technology, Design for Assemble, etc. are examined based on recent literature and publications. The specific topics to be addressed each year are selected to match the student's research interest and background. Three term-hours; may be given in any term.

MECH 811 Lasers in Manufacturing Applications
Course presents an overview of lasers as they relate to selected manufacturing applications. Topics covered include general principles of laser operation, laser types used in manufacturing, components of laser-based processing systems and their motion programming and control. Students carry out a survey-based course project. Basic computer programming skills are required for this course. Three term-hours; lectures. (3.0 credit units)

MECH 812 Corrosion
This course presents the fundamental principles of corrosion with applied examples and emphasis on metals in aqueous environments. The main topics considered are: Basics of electrochemistry and charged interfaces;

thermodynamics and Pourbaix diagrams; electrochemical kinetics; corrosion measurements; passivity; localized corrosion; high temperature oxidation; microscopy in corrosion analysis.

MECH 816 Energetics & Mechanics of Locomotion
The course covers the following topics: introduction to human locomotion, biomechanics measurements, kinematics, kinetics and mechanical energy of human walking, muscle function and metabolic energetics of human walking, biomechanical devices to assist walking. Course evaluation based on assignments, lab reports, project report, classroom presentations.

MECH 817 Systematic Review Methodology for Product Evaluation
This course provides the skills to undertake a systematic literature review as required by the FDA when seeking approval for a device. Drawing on a clinical model, this course will enable the student to define a question using PICO (population, intervention, comparison, outcome), synthesize quantitative evidence and interpret the results. Three term hours; lectures.

MECH 818 Functional Morphology
This course uses dynamics to understand how the musculoskeletal system allows movement and propulsion in animals. Topics include: a review of solutions for terrestrial locomotion, rigid body dynamics, implications of scaling, muscle and tendon dynamics, musculoskeletal lever systems, arthromechanics, and measurement modalities. Students interested in biomechanics, the animal world, dynamics, and bio-inspired engineering should take this course.
Prerequisite: Permission of the instructor.

MECH 821 Advanced Dynamics of Mechanical Systems
Mathematical modelling of the dynamics of mechanical systems using Newton's Laws, LaGrange's Equation and Hamilton's Equations; linear and non-linear systems; time-domain and frequency-domain solutions; large systems; stability; response to random excitation. Three term-hours; lectures.

MECH 823 Micro-Electro-Mechanical Systems (MEMS)
This course is an overview of the research in MEMS and BioMEMS, particularly including microactuators, microsensors and their applications. Fundamentals of photolithography, wet and dry etching, and surface micromachining will be covered. Design methodologies together with fabrication processes will be emphasized through case studies. A design project will be used to enhance the understanding of the relevant theories that are covered in class. By the end of the course, students will be expected to demonstrate mastery of several different modelling techniques for microsystems and understand the mechanisms of microsystems. Three term-hours; lectures.

MECH 824 Plasticity
Deformation of solids; analysis of stress and strain; limiting states of stress in solids; theories of mechanical strength; stress-strain and stress-strain rate relations; plane strain; slip line solutions of plastic flow problems; limit analysis. Mechanics of plastic deformation in metalworking processes; friction and lubrication; thermal phenomena. Three term-hours; lectures.

MECH 826 Experimental Vibration and Machinery Analysis
Characteristics of vibration and shock and their effects on mechanical systems and people; sensors and systems for measurement of vibratory displacement, velocity, acceleration and force; spectral analysis including applications to machinery vibration diagnostics; vibration test systems; random vibrations; modal analysis; vibration test standards; stress screening; shock testing. Three term-hours; lectures and laboratory.

MECH 828 Biomechanics of Human Gait
An overview of the research in biomechanics of human motion with particular focus on gait analysis. Topics include measuring and analysis techniques, biomechanical modelling, and data analysis techniques. Applications include the study of normal, able-bodied gait, and the evaluation of gait pattern changes associated with osteoarthritis, and total knee replacements. The course has a laboratory component that is used to give the student the opportunity to apply the theory covered in class. Three term-hours, lectures.
PREREQUISITE: permission of the instructor

MECH 829 Tissue Mechanics
Methods of characterizing biological tissues for the Mechanical Engineer with no previous biology background. Histology of ligament, tendon, cartilage and bone. Viscoelasticity and classical elasticity. Current models of ligament and tendon (Fung's quasi-linear model). Linear anisotropic elastic model for bone and cartilage. Theories for strength and failure mechanisms. Three term-hours, lectures.

MECH 830 Experimental Fluid Dynamics
A review of measurement theory including: static and dynamic characteristics of signals, spectral analysis with filtering methodologies, response of systems, and statistical/uncertainty analyses. Subsequently the course then provides insight into traditional as well as contemporary measurement techniques in fluid dynamics ranging from single-point scalar/vector measurements through to spatially resolved volumetric reconstructions. To conclude, post-processing

and data-manipulation strategies for such contemporary data sets along with a discussion of future concepts will be presented. Three term hours, lecture.

MECH 831 Convective Heat Transfer
Navier-Stokes and energy equations; boundary layer equations; integral boundary layer equations; similarity and numerical solutions for laminar forced convection; integral equation solutions for laminar forced convection; laminar flow in pipes; heat transfer in turbulent forced convection; free convection; combined forced and free convection; heat transfer with change of phase; heat exchangers (Formerly MECH 931). Three term-hours, lectures.

MECH 832 Combustion Dynamics
This course begins with a thorough review of the fundamental principles of combustion such as heat of reaction, chemical equilibrium, and chemical kinetics. Combustion aspects related to explosion phenomena such as flame acceleration, detonation wave and blast wave propagation are then covered. Finally, the single degree-of-freedom response of mechanical structures to blast wave loading will be discussed, and explosion damage mitigation techniques will be presented. Three term-hours, lectures.

MECH 833 Topics in Single Phase Convective Heat Transfer

This course deals with aspects of Convective Heat Transfer not considered in course MECH 831. The main topics considered are: Introduction to Convective Heat Transfer, Natural Convection, Mixed Convection, Convective Heat Transfer in Porous Media, Enhanced Convective Heat Transfer, Nano Heat Transfer, Convective Heat Transfer in High Speed Flows, Interaction of Convection with Other Modes of Heat Transfer. Three term-hours; lectures.

MECH 834 Fundamentals of Solar Energy Conversion for Heating and Cooling Applications
This course presents the fundamental principles of solar energy conversion, storage and distribution. Both photovoltaic and thermal energy conversion systems will be introduced; however the primary focus of the course will be on solar thermal systems for heating and cooling applications. Topics covered include the nature and prediction of the solar resource, solar collector design and performance, thermal storage, heat transport and distribution. The modeling and design of complete solar heating and cooling systems will be studied and exercises completed. Students will be required to complete a major project related to one of the above topics. Course lecture material will be augmented with laboratory exercises.
PREREQUISITE: permission of the Instructor

MECH 835 Introduction to Computational Fluid Dynamics

Objective of this course is to give students a basic understanding of the potential and limitations of Computational Fluid Dynamics (CFD), learn the fundamentals of CFD codes, find solutions for test problems, and run commercial software in a competent and critical manner. Three term hours, lectures.
PREREQUISITE: Permission of instructor.

MECH 836 Radiative Heat Transfer
This course covers the following topics related to heat transfer by thermal radiation: fundamentals of thermal radiation, blackbody thermal radiation, radiative properties of real materials, surface to surface exchange of diffuse radiation, numerical solution of diffuse radiation problems, radiation with conduction and convection, radiation in absorbing, emitting and scattering media, gas volume radiation, surface-volume radiation selected applications. Three term hours, lectures.

MECH 838 Civil Aviation and the Environment
Effects that the operation of civil aircraft have on the environment are considered and means of reducing these effects are considered. The generation of noise, local air pollution, the effect of engine emissions during cruise and the effect of contrails are discussed in detail. Potential changes in the design of aircraft and engines and in the way in which they are operated in order to reduce environmental effects are considered. Attention is given to the difficulties encountered in trying to balance conflicting environmental demands in arriving at solutions. While the course concentrates on the environmental effects of civil aviation, the material covered should provide a good basis for dealing with other complex environmental problems that arise in engineering. Three term-hours.

MECH 839 Introduction to Turbulence
This course is an introduction to the study of turbulence, covering its mathematical description, its physical features and the modelling of turbulent flows. The course is suitable for MASc and PhD students with a background in advanced fluid dynamics and numerical methods.Three term-hours; lectures. Taught in alternate years.
PREREQUISITE: Permission of the instructor.

MECH 840 Selected Topics in Thermal Fluid Systems
This course is limited to Master's students who already have a good background in the fundamental topics related to their areas of study and are interested in other areas not offered in existing graduate courses. Topics will be selected from the general areas of heat transfer, fluid mechanics and thermodynamics. The course will include lectures, open discussions and directed study. The course content for a

student or group will be specified in writing at the beginning of the course and cannot be the same as their thesis research topic. The course mark will be based on reports and/or presentations and/or exams. Instructors: Various faculty members from within the Department of Mechanical and Materials Engineering.
EXCLUSIONS: MECH 842, MECH 843, MECH 844

MECH 841 Net-Zero Energy Buildings and Communities
An introduction to what is meant by net-zero energy building or community, to how the net-zero energy state can be achieved, and to the considerations that need to be taken into account in planning and designing a net-zero energy building or community is provided. Building envelopes, building integrated photo-voltaic systems, bore-hole energy systems, day-lighting, ventilation, solar air-conditioning, energy storage, and social and economic factors are considered. Three term hours; lectures.

MECH 842 Selected Topics in Manufacturing and Design

This course is limited to Master's students who already have a good background in the fundamental topics related to their areas of study and are interested in other areas not offered in existing graduate courses. Topics will be selected from the general areas of dynamics, manufacturing and design. The course will include lectures, open discussions and directed study. The course content for a student or group will be specified in writing at the beginning of the course and cannot be the same as their thesis research topic. The course mark will be based on reports and/or presentations and/or exams. Instructors: Various faculty members from within the Department of Mechanical and Materials Engineering.
EXCLUSIONS: MECH 840, MECH 843, MECH 844

MECH 843 Selected Topics in Biomechanical Engineering
This course is limited to Master's students who already have a good background in the fundamental topics related to their areas of study and are interested in other areas not offered in existing graduate courses. Topics will be selected from the general areas of biomechanical engineering. The course will include lectures, open discussions and directed study. The course content for a student or group will be specified in writing at the beginning of the course and cannot be the same as their thesis research topic. The course mark will be based on reports and/or presentations and/or exams. Instructors: Various faculty members from within the Department of Mechanical and Materials Engineering.
EXCLUSIONS: MECH 840, MECH 842, MECH 844

MECH 844 Selected Topics in Materials Engineering
This course is limited to Master's students who already have a good background in the fundamental topics related to their areas of study and are interested in other areas not offered in existing graduate courses. Topics will be related to the structure, properties, processing and/or performance of materials. The course will include lectures, open discussions and directed study. The course content for a student or group will be specified in writing at the beginning of the course and cannot be the same as their thesis research topic. The course mark will be based on reports and/or presentations and/or exams. Instructors: Various faculty members from within the Department of Mechanical and Materials Engineering.
EXCLUSIONS: MECH 840, MECH 842, MECH 843

MECH 846 Fluid Systems Analysis
This course provides an introduction to analysis of fluid flows at the masters level. Derivation of the transport equations is completed for arbitrary control volumes in both vector and tensor forms. Inviscid flows are explored to illustrate the separate effects of inertial and viscous forces, including development of Joukowski airfoil models. Exact and approximate solutions are developed for steady and unsteady laminar flows. Boundary Layer solutions are developed by differential and integral analysis. The similarity of transport equations for thermal energy and concentration are illustrated. On completion of the course, students will be well prepared for specialized courses in convective heat transfer, turbulence, and computational fluid mechanics. Three term-hours; lectures.

MECH 847 Energy & Society
This course is a discussion course focused on fundamental ideas in energy and the social context of energy. It will feature an introduction to Energy Systems and fundamental thermodynamic tools to analyze these systems. Of particular emphasis will be the social context of energy: how societies emerge, organize and thrive or fail according to their energy supply. Factors which contribute to societal responses to changing contexts will also be discussed. In class participation is an essential element of this course. Three term-hours; lectures.
PREREQUISITE: Permission of the instructor

MECH 848 Measurement Systems I
This course focusses on practical measurement systems for masters students in mechanical engineering. On completing this course students will be able to: Select, install, test, and program a micro controller system for data acquisition and control; Select, analyze the performance of, and apply transducers for temperature; pressure; stress, strain and force; position, velocity and acceleration; Apply basic signal conditioning in analog and digital domains; Analyze data to draw conclusions from measurements and uncertainty analysis. Conceive, Design, Implement and Operate a

complete measurement system as part of a course project. Three term-hours; lectures and lab.

MECH 851 Materials Characterization
This course covers the theory and practice of materials characterization by X-ray and electron microscopy techniques. Theory includes interaction of materials with X-rays and electrons, diffraction and image formation. The following topics are discussed and illustrated by laboratory investigations: determination of crystal structure, microchemical analysis, characterization of lattice defects, determination of texture and measurement of residual stresses. Three term-hours; lecture and laboratory.

MECH 852 Mechatronics for Automation
This course covers the tools and techniques needed to design and control assembly automation machines and their machine vision-based inspection systems. The issues that arise when interfacing different components to form complex mechatronic systems are studied. Course content will be reinforced with an individual project and group laboratories.

MECH 853 From Science-Fiction to Science-Fact through Robotics Engineering Research and Design
Drawing from current examples of new technology and real ongoing or past research (i.e. official literature), students will seek to contextualize specific examples of fiction in terms of feasibility and fact. Through lectures and labs, this course will provide an overview of the following topics related to engineering and robotics: soft robotics actuator and system design, origami-inspired robotics, novel fabrication techniques (layer assembly), modular robotic systems, smart material actuators (Electrostatic/HASEL-type and Shape Memory Alloy), and embedded electronic circuits and controllers. Students will work in small groups on a final hands-on project to develop a working prototype mechatronic or robotic system inspired by their choice of “fiction”. Permission of the Instructor required. (3.0 credit units).

MECH 855 Bio-inspired Robot Locomotion
This course covers the design and fabrication of robots with a focus on bio-inspiration and locomotion. Students will be introduced to bio-inspired robotics, biological movement, prototyping and fabrication techniques, and mechatronics. Learning will take place with a combination of lectures, hands-on labs, and peer presentations. Course deliverables include quizzes, a paper presentation, lab reports, and a final project.
PREREQUISITE: Permission of instructor required.

MECH 857 Robotics
This course will cover kinematics of serial and parallel architecture robots; as well as the geometric, kinematic, static and dynamic criteria required for designing robot manipulators. The course will also include projects on advanced robotics topics and will conclude with the presentation of these projects, at least two presentations per student. Three term-hours; lectures and seminars.

MECH 858 System Dynamics and Control
The course will include “a review of important key topics from undergrad plus the introduction of advanced topics at the graduate level”. The topics include Laplace Transformation; Vibration and Time Response; Linear Graph Representation of Mechanical Systems; Matrix Algebra; State Space Representation; Transfer Functions and System Response; Controllability, Observability, Stability and Pole Placement.

MECH 861 Principles of Metal Forming
This course examines experimental, analytical and numerical methods employed for evaluating and predicting forming limits in a variety of industrial metal forming operations. The concept of a forming limit diagram (FLD) is introduced and related to classical theories for plastic instability and failure. Constitutive equations of elastic-plastic flow are derived using a continuum mechanics approach, with additional discussion regarding issues of plastic anisotropy, damage accumulation, localization and material length scales. Three term-hours.

MECH 863 Materials Selection in Design
This course presents the concept of materials selection as an integral part of the mechanical engineering design process. Materials selection addresses a number of issues: the choice of material; the method of part manufacture; potential modes/mechanisms of failure; as well as the tailoring of material microstructure to obtain optimal properties and in-service performance. Background topics will include mechanical engineering design, solid mechanics, engineering component design, and materials science and engineering. Material selection methodologies will range from conventional, holistic approaches to the deterministic method of Ashby. Course content will be reinforced through case studies that consider a variety of material classes.

MECH 864 Engineering Analysis
Methods for formulating mathematical models for engineering problems; examples drawn from dynamics, elasticity, fluid mechanics, heat transfer, and electro-mechanics; lumped-parameter and continuum models; variational techniques; boundary conditions and their effects on the character of the model; techniques for obtaining approximate solutions; methods for casting models into forms appropriate for solution on digital computers. Three term-hours, lectures.

MECH 866 Advanced Phase Transformations

This course focuses on the practical aspects and the relevant fundamentals of phase transformations in advanced manufacturing of metal alloys. The course offers a deep theoretical insight into solidification and solid-state diffusional transformations, along with an effective utilization of relevant analytical models to explore/explain the effect of material and processing variables on the evolution (i.e., types and kinetics) of phase transformations.

MECH 868 Introduction to Computational Materials Science
This course focuses in atom-scale modelling of materials using computational methods. Covered topics include electronic density functional theory, molecular dynamics, Metropolis Monte Carlo, and transition state theory. The course will cover fundamental theoretical aspects and hands-on application of the methods. It will include a short, open-ended, end-of-semester simulation project.

MECH 878 Dislocation Theory
This course attempts to cover the basic derivations from elasticity theory, the properties of dislocations in crystalline materials, and their role in inelastic material behaviour. This introduction should enable one to comprehend, examine, and criticize current literature on the mechanical behaviour of materials. Topics include: a brief introduction to applied elasticity theory; elastic stress fields of dislocations and their interactions with external ones; the role of a particular crystal structure on the properties and motion of dislocations. The use of dislocation mechanics in the theories of creep, fracture, and yield points will be discussed along with other topics as time permits. Three term-hours.

MECH 883 Advanced Nuclear Materials
A nuclear reactor presents a unique environment in which materials must perform. In addition to the high temperatures, stresses and corrosive environments to which materials are subjected in conventional applications, nuclear materials are subjected to various kinds of radiation that affect their deformation, corrosion, aging and failure. This course considers materials typically used in nuclear environments and those proposed for next generation reactors, the unusual conditions to which these materials are subjected, the physical phenomena that affect their performance and the resulting design criteria for reactor components. Approaches to modelling nuclear materials, and the use of ion irradiation as a surrogate for neutron irradiation is discussed. This course builds on the material covered in MECH 483 Nuclear Materials. Three term-hours, lectures.
PREREQUISITE: MECH 483

MECH 892 Industry-Linked Project (Part 1)
Students work on individual one-term research or development projects. Each project is defined by the academic project supervisor. The project is linked to a supporting company partner. Course evaluation is based on a final written report (typically 30-40 pages) and an end of term seminar presentation. Instructors: Various faculty members from within the Department of Mechanical and Materials Engineering. This course is graded on a Pass/Fail basis.
EXCLUSIONS: MECH 898 - Project, CMAS 898 – Project

MECH 893 Industry-Linked Project (Part 2)
Students work on individual one-term research or development projects that are the natural progression of projects started in MECH 892. The project is linked to a supporting company partner. Course evaluation is based on a final written report (typically 50-60 pages) and an end of term seminar presentation. Instructors: Various faculty members from within the Department of Mechanical and Materials Engineering. This course is graded on a Pass/Fail basis.
PREREQUISITE: MECH 892 – Industry-Linked Project (Part 1)
EXCLUSIONS: MECH 898 - Project, CMAS 898 – Project.

MECH 894 Internship
Students work on a one-term (typically summer) internship at a sponsoring company site. The internship involves the student continuing with the same project work started in MECH 892 and continued throughout MECH 893. The work will typically be conducted exclusively at the supporting partner company site. Course evaluation is based on a final written report (typically 40-50 pages) and an end of term project seminar presentation. Instructors: Various faculty members from within the Department of Mechanical and Materials Engineering. PREREQUISITE: MECH 893 – Industry-Linked Project (Part 2)

MECH 895 Industrial Internship for M.Eng.
The industrial internship involves spending 4 months in a paid industrial internship position in industry, or government. Successful completion of the course requires submission of a report on the industrial project to be submitted on the last day of the internship. Each project must be approved by the academic supervisor. Career Services manages the non-academic aspects of the course. This course is open only to Materials and Mechanical Engineering (MME) M.Eng. students. Permission of MME M.Eng. Coordinator is required for registration. This course is graded on a Pass/Fail basis.
EXCLUSIONS: MECH 892, MECH 893, MECH 894

MECH 897, 997 Graduate Seminar
Each research full-time graduate student is required to regularly attend the graduate seminar program and to give at least one seminar during their program at Queen's. M.Sc./M.Sc.(Eng.) students are required to take MECH 897 and Ph.D. students are required to take MECH 997. The

content of the seminar is to be developed in cooperation with the student's supervisor. The seminar will be evaluated by assigned faculty and a pass/referred decision will be recorded. The student must obtain a pass grade to clear this course requirement. The evaluation process for the seminar is defined in the departmental procedures. This course carries no course credit but is a degree requirement in the Department of Mechanical and Materials Engineering.

MECH 898 M.Eng. Project
This course is for M.Eng. students only. The student and supervisor should work together to create a project proposal, which must include a project description, timeline, and marking scheme. The proposal must be approved by the M.Eng. coordinator prior to registration. The work will be evaluated by the supervisor and M.Eng. coordinator, or a suitable second reader. Graded on a pass/fail basis. (3.0 credit units).
PREREQUISITE: students enrolled in the M.Eng. program in Mechanical and Materials Engineering.
EXCLUSION: students not enrolled in the M.Eng. program in Mechanical and Materials Engineering.

MECH 899 Master's Thesis Research

MECH 924 Finite Element Analysis of Non-Linear Solids
This course presents the formulation and use of finite element models for the analysis of a broad range of non-linear solid materials (plastics, metals, elastomers) subject to large deformations. Basic concepts from continuum mechanics (suffix notation, large strain theory, constitutive relations) are covered in order to provide a basis for the formulation of these models and for the interpretation of results. Testing procedures for the determination of non-linear material properties, required for model input, are also covered. Example analyses are conducted with commercial non-linear finite element code. Three term-hours; lectures.
PREREQUISITE: CIVL 821 or equivalent.

MECH 932 Advanced Topics in Convective Heat Transfer Analysis
This course is, basically, a continuation of MECH 931 but may be taken by any student who has had adequate preparation. Among the main topics considered are: Analysis of laminar and turbulent free convective flows; local similarity methods in heat transfer; heat transfer with film condensation; prediction of turbulent Prandtl numbers; mixed (or combined) convection; combined heat and mass transfer; heat transfer in compressible flows. Three term hours, lectures.

MECH 934 Computational Fluid Dynamics II
The objective of this course is to teach students to understand the potential and limitations of Computational Fluid Dynamics (CFD), develop advanced solution methods for fluid-dynamics problems, and run commercial software in a critical manner. The course begins by presenting various forms of numerical approximations of the governing equations. An in-depth analysis of iterative methods to solve linear systems will follow. Numerical methods for the solution of the Navier-Stokes equations will be presented, with emphasis on numerical stability and on conservation properties. Three term-hours; lectures.
PREREQUISITE: permission of the instructor.

MECH 935 Turbulence Simulations
The objective of this course is to analyze numerical techniques for the simulation of turbulent flows. Emphasis will be placed on the understanding of the role of modeling and numerical errors, and on the development of "best practices" to validate and establish confidence in the numerical results. The course begins with a review of the governing equations for turbulent flows, of the role of turbulent eddies, and of the statistical quantities used to characterize turbulent flows. The important features of numerical methods will then be examined. An extensive review of the potential, requirements, achievements and limitations of direct simulation, large-eddy simulation and solution of the Reynolds-Averaged Navier-Stokes equations will form the core of the course. Time permitting, additional topics such as Lagrangian particle tracking, or applications to compressible flows will be covered.
PREREQUISITE: permission of the instructor.

MECH 940 Selected Topics in Thermal-Fluids Engineering

This course is limited to those PhD students who already have a good background in the fundamental and advanced topics related to their research and are interested in other areas not offered in existing graduate courses. Topics can be selected from the general areas of heat transfer, fluid mechanics and thermodynamics. The course will include lectures, open discussion and directed study. The course content for a student or group must specified in writing at the beginning of the course and cannot be the same as their thesis research topic. The course mark will be based on reports and/or presentations and/or exams. Instructors: Various faculty members from within the Department of Mechanical and Materials Engineering.
EXCLUSIONS: MECH 942, MECH 943, MECH 944

MECH 942 Selected Topics in Dynamics, Manufacturing and Design
This course is limited to PhD students who already have a good background in the fundamental and advanced topics related to their research and are interested in other areas not offered in existing graduate courses. Topics will be selected from the general areas of dynamics, manufacturing and

design. The course will include lectures, open discussions and directed study. The course content for a student or group will be specified in writing at the beginning of the course and cannot be the same as their thesis research topic. The course mark will be based on reports and/or presentations and/or exams. Instructors: Various faculty members from within the Department of Mechanical and Materials Engineering.
EXCLUSIONS: MECH 940, MECH 943, MECH 944

MECH 943 Selected Topics in Biomechanical Engineering

This course is limited to PhD students who already have a good background in the fundamental and advanced topics related to their research and are interested in other areas not offered in existing graduate courses. Topics will be selected from the general areas of biomechanical engineering. The course will include lectures, open discussions and directed study. The course content for a student or group must specified in writing at the beginning of the course and cannot be the same as their thesis research topic. The course mark will be based on reports and/or presentations and/or exams. Instructors: Various faculty members from within the Department of Mechanical and Materials Engineering.
EXCLUSIONS: MECH 940, MECH 942, MECH 944

MECH 944 Selected Topics in Materials Engineering
This course is limited to PhD students who already have a good background in the fundamental and advanced topics related to their research and are interested in other areas not offered in existing graduate courses. Topics will be selected from the general areas of materials engineering. The course will include lectures, open discussions and directed study. The course content for a student or group will be specified in writing at the beginning of the course and cannot be the same as their thesis research topic. The course mark will be based on reports and/or presentations and/or exams. Instructors: Various faculty members from within the Department of Mechanical and Materials Engineering.
EXCLUSIONS: MECH 940, MECH 942, MECH 943

MECH 999 Ph.D. Thesis Research

ADMI Courses - Technology and Processes Stream (NOTE: this program is temporarily suspended)

DM 810 Intelligent Manufacturing
The objectives of this course are to develop a basic understanding of machine intelligence and explore modern tools in designing intelligent manufacturing systems. Through the lectures, on-site visit, reading assignments, and course project(s) the participants will examine how knowledge-based systems (KBSs) and learning systems can effectively improve the performance of machine tools, work cells, and overall manufacturing enterprises. At the end of the course each student should be able to:
- Identify the basic components of manufacturing automation
- View modern manufacturing automation as an intelligent system
- Summarize the benefits of flexible manufacturing and open-architecture controllers
- Describe how laser material removal processes can improve product quality
- Understand how knowledge-based system (KBS) technology can improve manufacturing enterprises
- Appreciate the role of knowledge acquisition in designing intelligent automation
- Describe the basic operation of artificial neural networks (ANNs)
- Design simple neural networks for signal processing, control, and pattern classification applications
- Understand the essentials of fuzzy sets and systems
- Apply fuzzy logic to intelligent control, production planning and scheduling
- Evaluate object oriented and relational data bases
- Describe fuzzy data mining and clustering

DM 811 Design for Manufacturability
Design for Manufacturability (DFM) involves a variety of systematic design approaches that ensure all elements of the product life-cycle from conception through to final disposal are addressed by the engineer during the product design process. In this course, the participants will develop an understanding of the various tools and techniques used to design high-quality products at the lowest possible cost. General topics to be covered in the course include: Design for Manufacture (DFM): Product life cycle; engineering design methods; general approaches to DFM; integrating design and manufacturing data; managing the engineering design process; organizational barriers to DFM. Design for Competitive Advantage: Design to cost; time-to-market; time-to-breakeven; design to value; mass customization. DFM and Quality Engineering: Customer needs and expectations; Quality Function Deployment (QFD); product and process FMEA (Failure Mode and Effects Analysis); Taguchi methods (TM). Design for X (DFX): Design for assembly (DFA); design for reliability; design for environment; design for human factors; software tools for DFM.

DM 812 Finite Element Analysis for Design Engineers
A course on Finite Element Analysis (FEA) as a productivity tool. Topics covered include FEA powers and shortcomings, avoiding common pitfalls and misconceptions, alternate and preferred modelling approaches, reliability of results, integrating FEA with other Computer Aided Design (CAD)

tools and finally streamlining FEA and CAD with FEA oriented Solid Modelling practices.

DM 814 Rapid Mechanical Design
Rapid Mechanical Design addresses all aspect of mechanical design, including consideration for end-of-life issues, with the focus and emphasis of the course being on rapid product development. In this course, the participants will be introduced to the various state-of-the-art methodologies and off-the-shelf tools and facilities for rapid design. The course will have an introductory section on a limited set of classical design topics in order to prepare the students for the in-depth discussion of the advanced topics on rapid prototyping.

The introductory topics will include: Manufacturing Management Strategies, Concurrent Engineering, Conceptual Design, and Design for X. The advanced rapid-design topics are categorized into virtual and physical prototyping. Virtual prototyping topics include: Geometric Modeling (including major CAD software packages), Computer-Aided-Engineering (CAE) Analysis, Engineering Optimization, Design of Experiments, and Virtual Reality. Physical prototyping topics include: Introduction to Polymerization, Sintering, Casting, and Chemical Machining, Material-Additive Layered Prototyping (including Photolithography, Sintering, Deposition, Lamination, and Laser-Induced-Fusion Based Rapid-Prototyping Systems, Material-Removal-Based Prototyping, and Reverse Engineering.

DM 816 Design for Innovation
This course will explore the role of engineering within the collaborative innovation process from an application perspective, as well as the engineering interface with others in the innovation chain. Drawing on proven techniques, it will increase competency in integrated design thinking and intrapreneurship to elevate project success rate.

DM 817 Ergonomic Design
This course provides an overview of ergonomic problems that are addressed in engineering design: including biomechanical, physical and physiological issues. Case studies will range form the design of vehicle cockpits to process control rooms, from industrial manual materials handling tasks to human direct robots, and from domestic tools to biomechanical devices. Specific topics include: anthropometry, work space design, environmental conditions (light, noise, humidity, temperature, motion), physiology, materials handling capacity, gender issues, tool design, product design and structured ergonomic design evaluation techniques.

DM 822 Mechatronics Engineering
Mechatronics is the integration of mechanical, electrical, computer and control engineering. This course deals with the analytical tools required to design, model, analyze and control mechatronic systems. Properties of linear and nonlinear systems, system identification methods, process modelling, sensor and actuators, computer interfacing, computer control of machines and processes (PLC and PC based). Laboratories will include PLC based automation applications and PC based advanced robotics.

DM 824 Materials Selection in Design
The concept of materials selection as an integral part of the design process is presented. Issues addressed include: choice of material; method of manufacture; failure modes; tailoring of microstructure to obtain optimal properties and in-service performance. Content will be reinforced through case studies that consider a variety of material classes.

DM 826 Advanced Industrial Energy Management
An overview of industrial energy management given. The advanced technical procedures required for assessing energy saving opportunities (ESOs) in industrial equipment and systems are covered. Both new and existing equipment are considered. A review of heat transfer, fluid mechanics and thermodynamics is given to support the analysis of various ESOs.

ADMI Courses - Business and Management Stream

DM 863 Financial & Managerial Accounting
Whether working in the public or private sector, engineers are constrained by financial realities. Knowledge of accounting - how it works, its assumptions, and its usefulness - is an essential prerequisite to informed to informed participation in business decision-making. The purpose of this course is therefore to provide a sound basic understanding of accounting - the "language of business" - and to develop skills in the interpretation and use of accounting information. The course will provide a thorough understanding of how accounting information is used in organizations. We briefly consider reporting to external parties (financial accounting), and consider in more depth the measurement of product and activity cost (cost accounting), and the use of cost information for decision-making, planning, budgeting, and the measurement of performance (management accounting).

DM 864 Principles of Technical Communication
The focus of this course is mastery of the fundamental elements of all effective professional communication: assessing the communicative situation, understanding the needs and expectations of the audience, creating an effective and suitable message, and projecting confidence and competence through an appropriate communication style.

The course combines theoretical understanding with practical application in four areas of communicative competence: reading, writing, listening, and speaking. Students will prepare and present a variety of messages and will be involved in the critical appraisal of the messages of others.

DM 865 Business to Business Marketing
The objectives of the course are to provide an introduction to the basic theories and concepts in marketing, with an emphasis on businesses marketing to other businesses (B2B marketing); to develop an effective decision- making framework to address practical problems and issues in marketing; to illustrate the need to integrate marketing decision-making with the other functional areas within an organization; and to offer specific insights into selected marketing contexts; e.g., services, new/high technology, developing and managing relationships, and marketing in the global environment. Emphasis will be placed on e-business and how the Internet and the World Wide Web have greatly changed the role, efficiency and effectiveness of the marketing function, especially in the business-to-business marketplace.

DM 872 Engineering Leadership
This course sets out to build on engineering leadership skills and to enhance methods for leading teams. Common leadership challenges will be addressed such as change management and vision setting. The elements of leadership include: dependability, resourcefulness, strategic thinking as well as organizational, communication and teamwork skills.

DM 881 Technical Entrepreneurship & Innovation
Technological entrepreneurship is more than having a good idea and a solid business plan, it is a process intimately connected to new product innovation and design. The steps required for successful introduction of a new product will be addressed: identification, evaluation and selection of opportunities; planning, financing and executing the new venture.

DM 885 Advanced Project Management
Advanced Project Management builds from the basic tools of project management to introduce participants to the reality of managing projects within the context of engineering organizations that can be complex, where multiple projects may be in place, where membership is drawn from a variety of specialization's and individual differences abound and where team-based functioning is the norm. The course will address issues such as management of multiple projects, individual differences, project leadership, working in teams, and change management. Case studies of managed projects will be used in the course.

DM 890 Operations and Supply Chain Management
This course has three instructional objectives: (i) acquire, understand and apply general knowledge of operations and supply chain management; (ii) advance managerial insights from both the C-suite and frontline points of view with regards to the value to be realized through efficient and effective work-related efforts; and (iii) enhance confidence in addressing operational and supply chain issues.

UNENE (University Network of Excellence in Nuclear Engineering)

UN 806 Selected Topics in Engineering Physics

UNENE course number = EP806

The course covers power reactor fuel design/performance & safety aspects; complements Eng. Physics/UNENE courses on reactor core/safety design/hydraulics; includes fissile/fertile fuels/burnup effects/fuel production/quality assurance/ CANDU fuel tech. specifications/thermal conductivity/ fuel chemistry/restructuring/grain growth/fission product behaviour/defect detection/ performance in operation/ channel behaviour in design basis & severe accidents.

UN 860 Industrial Research Project, UWO

UNENE course number = UN 0600

If they so elect, candidates for the M. Eng. (Nuclear Engineering) Degree may spend approximately four months in an industrial laboratory carrying out an industry-oriented project under the supervision of a suitably qualified staff scientist. Usually there is also a university co-supervisor. The Department will attempt to arrange an industrial project in consultation with the candidate and through negotiation with the candidate's employer. A satisfactory project topic and appropriate arrangements are required for the project to be approved by the Department and it is possible that in some cases this may not be feasible. Upon completion, the candidate will submit a substantial report on the project and make a presentation on it at the university. The industrial research project can only be undertaken after at least half the required courses have been taken. The industrial research project counts as two half courses.

UN 861 Control, Instr. Elec. Systems

UNENE Course number = UN 0601
This course covers the basic control, instrumentation and electrical systems commonly found in CANDU based nuclear power plants. The course starts with an overall view of the dynamics associated with different parts of the plant, i.e. reactor, heat transport systems, moderator, steam generator, turbine, and electrical generator. Based on such knowledge, the control and regulation functions in the above systems are then defined. Different instrumentation and measurement

techniques are examined, along with control strategies. The time and frequency domain performance characterizations of control loops are introduced with consideration of actuator and sensor limitations. Different controller design and tuning methods and instrumentation calibration procedures are discussed. Two modes of operation of CANDU plants will be analyzed, i.e. normal mode and alternate mode. Advanced control technologies, such as distributed control systems, Field bus communication protocols are introduced in view of their potential applications in the existing and newly constructed CANDU power plants. The electric systems in the CANDU plant will be examined. The modeling of the dynamics and control devices for the generator will be covered in details. The dynamic interaction between the CANDU power plants and the rest of the electric power grid with other generating facilities and various types of load will be studied.

UN 862 Nuclear Fuel Waste Management

UNENE Course Number = UN 0602

Presently, nuclear fuel waste management involves storage in water pools or dry storage containers at reactor sites. If the fuel is then defined as waste, permanent disposal at an appropriate deep geological site would be considered. This course will describe the physical and chemical properties of the fuel and these approaches to storage and disposal. Key features of the fuel include its chemical and physical structure and properties prior to, and after, in-reactor irradiation, the nature and distribution of radionuclides produced in-reactor, and the chemical and physical properties of the Zircaloy fuel cladding before and after in-reactor exposure. The principles behind pool and dry storage will be described including the design of storage containers and the chemical and corrosion processes that could influence their long-term integrity. The possible permanent disposal scenarios developed internationally will be discussed, with a primary emphasis on those potentially applicable in Canada. For this last topic, the design and fabrication of waste containers and the processes that could potentially lead to their failure, the properties of engineered barriers within the geological site, the essential geological features of the chosen site, and the computational modeling approaches used in site performance assessment calculations will be described.

UN 863 Project Management for Nuclear Engineers

UNENE Course number = UN 0603

Project Management is emerging as perhaps the key core competency in engineering in the 21st century industrial workplace. This course in Project Management will prepare nuclear engineers in the application of this discipline in their work. It is an intensive investigation into the major principles of Project Management slanted towards, but not exclusively about, the management of nuclear engineering projects. The course uses the Project Management Institute's PMBOK (Project Management Body of Knowledge) as a skeleton and expands that coverage with relevant examples from nuclear, software and general engineering. Special emphasis will be placed on Risk Management, particularly in the area of safety-critical projects. The graduate will be well-positioned both to apply the knowledge in their area of engineering and to sit the PMI's PMP examination. The course will be taught by a professional engineer holding the PMP certification, using many case studies from industry and engineering.

UN 870 Industrial Research Project, U. of Waterloo

UNENE course number = UN 0700

If they so elect, candidates for the M. Eng. (Nuclear Engineering) Degree may spend approximately four months in an industrial laboratory carrying out an industry-oriented project under the supervision of a suitably qualified staff scientist. Usually there is also a university co-supervisor. The Department will attempt to arrange an industrial project in consultation with the candidate and through negotiation with the candidate's employer. A satisfactory project topic and appropriate arrangements are required for the project to be approved by the Department and it is possible that in some cases this may not be feasible. Upon completion, the candidate will submit a substantial report on the project and make a presentation on it at the university. The industrial research project can only be undertaken after at least half the required courses have been taken. The industrial research project counts as two half courses.

UN 871 Engineering Risk and Reliability

UNENE course number = UN 0701

This course presents a broad treatment of the subject of engineering decision, risk, and reliability. Emphasis is on (1) the modelling of engineering problems and evaluation of systems performance under conditions of uncertainty; (2) risk-based approach to life-cycle management of engineering systems; (3) systematic development of design criteria, explicitly taking into account the significance of uncertainty; and (4) logical framework for risk assessment and risk-benefit tradeoffs in decision making. The necessary mathematical concepts are developed in the context of engineering problems. The main topics of discussion are: probability theory, statistical data analysis, component and system reliability concepts, time-dependent reliability analysis, computational methods, life-cycle optimization models and risk management in public policy.

UN 872 Power Plant Thermodynamics

UNENE course number = UN 0702
Theoretical and practical analysis of the following with particular reference to CANDU plants:
- STEAM POWER CYCLES: Thermodynamic Processes; Thermodynamic Laws; Superheating and Reheating; Regenerative Feedwater Heating; Moisture Separation and Reheating; Turbine Expansion Lines
- EXERGY AND HEAT TRANSFER: Available Energy Transfer; Exergy Flow Diagrams; Thermo-economic Analysis; Heat Conduction and Convection; Boiling and Condensing; Two Phase Flow
- NUCLEAR HEAT REMOVAL: Reactor Heat Generation; Heat Transfer in Boilers and Condensers; Boiler Influence on Heat Transport System; Boiler Swelling and Shrinking; Boiler Level Control; Boiler Operations.

UN 873 Nuclear Energy in Society: Regulation and Our Energy Future

UNENE course number = UN 0503

This course combines an in-depth study of regulation of nuclear power reactors with a module on the broad aspects of energy in society. It begins with an overall analysis of a regulated nuclear power industry, including why regulators are needed, their characteristics and qualities, and the impacts on industry of operating in a highly-regulated environment. Using practices from the USA, the UK, and Canada, it compares (through each stage of a plant life-cycle) prescriptive, goal-oriented, and risk informed regulation. Canadian regulatory requirements are explored in depth as a specific example. The final module examines the broader role of energy in society: how it is used, its characteristics, energy mixes, and the specific role of nuclear energy.
PREREQUISITE: permission of instructor

UN 880 Industrial Research Project

UNENE course number = UN 0800

If they so elect, candidates for the M. Eng. (Nuclear Engineering) Degree may spend approximately four months in an industrial laboratory carrying out an industry-oriented project under the supervision of a suitably qualified staff scientist. Usually there is also a university co-supervisor. The Department will attempt to arrange an industrial project in consultation with the candidate and through negotiation with the candidate's employer. A satisfactory project topic and appropriate arrangements are required for the project to be approved by the Department and it is possible that in some cases this may not be feasible. Upon completion, the candidate will submit a substantial report on the project and make a presentation on it at the university. The industrial research project can only be undertaken after at least half the required courses have been taken. The industrial research project counts as two half courses. McMaster University / Staff

UN 881 Nuclear Plant Syst. Operations

UNENE course number = UN 0801

System and overall unit operations relevant to nuclear power plants with emphasis on CANDU; includes all major reactor and process systems with nuclear plant simulator; self-study using interactive CD ROM. Two to three class, one-day meetings will be scheduled.

UN 882 Reactor Physics

UNENE course number = UN 0802

An introduction to nuclear energy and fission energy systems is presented. The energetics of nuclear reactions, interactions of radiation with matter, radioactivity, design and operating principles of fission are presented. Nuclear reactor physics including chain reactions, reactor statics and kinetics, multigroup analysis, core thermalhydraulics and the impact of these topics on reactor design are covered. Special topics such as xenon dynamics, burnup and reactor flux effects on safety are included.

UN 883 Nuclear Reactor Safety Design

UNENE course number = UN 0803

Technology and safety analysis underlying nuclear reactor safety. Topics include: Nature of the hazards; concepts of risk; probability tools and techniques; safety criteria; design basis accidents; case studies; safety analysis technology; human error; safety system design; and general safety design principles.

UN 884 Reactor Thermalhydraulics

UNENE course number = UN 0804

Fundamentals of single-phase and two-phase flow, and heat and mass transfer. Nuclear power plant primary heat transport system design and calculations, including design description and characteristics of main components and systems. Simulation methodology and tools, including development and qualification of selected thermal-hydraulics computer codes. Course also covers experimental techniques, facilities and results that describe important thermal-hydraulics phenomena. Course topics include: development of conservation equations and relevant constitutive correlations, flow patterns and boiling heat transport regimes, critical heat flux and pressure drop calculations, description of most important computer codes, description of relevant experimental facilities and results, safety margins and operational safety issues and methodologies.

UN 885 Radiation Health Risks and Benefits

UNENE course number = UN 0805

This course is designed to introduce graduate students to recent advances in radiation biology that have direct impact on our understanding of the health risks associated with ionizing radiation. The course will focus on radiation absorption in living tissue and physical and biological processes that influence the consequences of the exposure. Students will learn about the biological effects from different radiation qualities, doses, and dose rates. The course will address cellular radiation damage and repair mechanisms and introduce students to modern techniques in molecular biology used in accident and emergency biological dosimetry. The material will relate to radiation applications in medicine and industry. No prior knowledge of biology at an advanced level is required.

UN 890 Industrial Research Project, Queen's U.

UNENE course number = UN 0900

If they so elect, candidates for the M. Eng. (Nuclear Engineering) Degree may spend approximately four months in an industrial laboratory carrying out an industry-oriented project under the supervision of a suitably qualified staff scientist. Usually there is also a university co-supervisor. The Department will attempt to arrange an industrial project in consultation with the candidate and through negotiation with the candidate's employer. A satisfactory project topic and appropriate arrangements are required for the project to be approved by the Department and it is possible that in some cases this may not be feasible. Upon completion, the candidate will submit a substantial report on the project and make a presentation on it at the university. The industrial research project can only be undertaken after at least half the required courses have been taken. The industrial research project counts as two half courses. Queen's University.

UN 891 Nuclear Materials

UNENE course number = UN 0901

A nuclear reactor presents a unique environment in which materials must perform. In addition to the high temperatures and stresses to which materials are subjected in conventional applications, nuclear materials are subjected to various kinds of radiation which affect their performance, and often this dictates a requirement for a unique property (for example, a low cross section for thermal neutron absorption) that is not relevant in conventional applications. The effects of the radiation may be direct (e.g., the displacement of atoms from their normal positions by fast neutrons or fission fragments), or indirect (e.g., a more aggressive chemical environment caused by radiolytic decomposition). This course describes materials typically used in nuclear environments, the unique conditions to which they are subjected, the basic physical phenomena that affect their performance and the resulting design criteria for reactor components made from these materials.

UN 892 Fuel Management

UNENE course number = UN 0902

Nuclear fuel cycles are studied from mining to ultimate disposal of the spent fuel, including the enrichment processes and the reprocessing techniques, from a point of view of the decision-making processes and the evaluation of the operational and economical consequences of these decisions. For the steps within the fuel cycles, the method of determining the associated costs, in particular those relevant to the disposal of nuclear waste, and the overall fuel cycle costs are described. Burn-up calculations are performed for the swelling time of the fuel within the reactor core. The objectives and merits of in-core and out-of-core fuel management for CANDU Pressurized Heavy Water Reactors (PHWR) and Light Water Reactors (LWR) are analyzed in detail, for the refueling equilibrium as well as for the approach to refueling equilibrium. The course also covers fuel management for thorium-fuelled CANDU reactors and other advanced fuels such as MOX containing plutonium from discarded nuclear warheads, and DUPIC (Direct Use of PWR fuel in CANDU reactors). The fuel management problem is treated as an optimization problem, with objective functions or performance indexes identified, as well as decision variables and appropriate constraints (active and non-active). The course also includes a review of the major work done in this area along with the most important computer codes.

UN 893 Industrial Research Project, U. of Toronto

UNENE course number = UN 1000

If they so elect, candidates for the M. Eng. (Nuclear Engineering) Degree may spend approximately four months in an industrial laboratory carrying out an industry-oriented project under the supervision of a suitably qualified staff scientist. Usually there is also a university co-supervisor. The Department will attempt to arrange an industrial project in consultation with the candidate and through negotiation with the candidate's employer. A satisfactory project topic and appropriate arrangements are required for the project to be approved by the Department and it is possible that in some cases this may not be feasible. Upon completion, the candidate will submit a substantial report on the project and make a presentation on it at the university. The industrial research project can only be undertaken after at least half the required courses have been taken. The industrial research project counts as two half courses. University of Toronto

UN 894 Reactor Chemistry & Corrosion

UNENE course number = UN 1001

Corrosion and its costs, corrosion measurement, general materials and environment affects. Types of corrosion: uniform, galvanic, crevice, pitting, intergranular, selective leaching, erosion-corrosion, stress-corrosion, hydrogen effects. Corrosion testing: materials selection. Electrochemical principles: thermodynamics, electrode kinetics, mixed potentials, practical applications. High temperature corrosion. Nuclear plant corrosion, fossil plant corrosion, other industrial environments.