Toronto Metropolitan University

Graduate & Postdoctoral Studies

CHEMICAL ENGINEERING

CURRICULUM

Master of Applied Science

DEGREE REQUIREMENTS		Credits
Master's Thesis		(Milestone)
CE8102	Seminars in Chemical Engineering	Pass/Fail
Four electives (maximum of one from Group II)		4

Master of Engineering

DEGREE REQUIREMENTS		Credits
Master's Project*		(Milestone)
Eight Electives (max. of two from Group II)		8

* Students may apply to substitute two courses for the Project

Doctor of Philosophy

DEGREE REQUIREMENTS		Credits
Dissertation		(Milestone)
CE8102	Seminars in Chemical Engineering	Pass/Fail
Four Elective credits from Group I		4

ELECTIVES

Group I		Credits
CE8140	Statistics for Engineering	1
CE8141	Research Methods and Communications	1
CE8201	Model and Simulation- Chem Eng	1
CE8202	Advanced Process Control	1
CE8203	Applied Optimal Control	1
CE8213	Advanced Numerical Methods	1
CE8214	Optimization in Chemical Engineering	1
CE8301	Advanced Transport Phenomena	1
CE8303	Advanced Fluid Dynamics	1
CE8304	Rheology	1
CE8402	Applied Thermodynamics	1
CE8403	Advanced Reactor Engineering	1
CE8410	Electrochemical Engineering	1
CE8501	Polymer Science and Engineering	1
CE8603	Advances in Biomaterials	1
CE8604	Advances in Porous Materials	1
CE8606	Advanced Topics in Tissue Engineering	1
CE8610	Artificial Intelligence in Chem Eng	1
CE8703	Adv Water Treatment Tech	1
CE8711	Environmental Nanotechnology	1
CE8100	Directed St: Chem Eng (MASc)	1
CE9100	Directed St: Chem Eng (PhD)	1

Group II		
CE8210	Process and Engr Optimization	1
CE8331	Membrane Technology	1
CE8510	Plastic Technology	1
CE8710	Air Pollution and Control	1

COURSE LISTING

Master's Thesis
The student is required to conduct advanced research on a topic related to chemical engineering mainly in the water-wastewater/food treatment and polymer/chemical processing areas. The research topic is selected in consultation with the student's supervisor(s), where the student presents an outline of the research plan in writing, and the research is carried out under the direction of a faculty supervisor(s) and monitored by a thesis supervisory committee. On completion, the student is required to give an oral presentation on the research results in the Graduate Research Seminar Series. The research results are then submitted in a thesis format to the supervisor(s) and to an examining committee, before which an oral presentation is made for the assessment and grading of the thesis. Through the thesis, the student is expected to provide evidence of competence in carrying out research and a sound understanding of the material associated with the research. This is a "Milestone." Pass/Fail

Master's Project
The student is required to conduct an applied advanced research project on a topic related to chemical engineering. The project topic is selected in consultation with the student's advisor, where the student presents an outline of the project plan in writing, and then is carried out under the direction of a faculty advisor and monitored by an advisory committee. On completion of the project, the results are submitted in a technical report format to the advisor and then to an examining committee, which an oral presentation is made for assessment and grading of the project and the report. The student is expected to provide evidence of competence in the carrying out of a technical project and present a sound understanding of the material associated with the research project. This is a "Milestone." Pass/Fail

Doctoral Dissertation
The PhD student is required to conduct advanced research on a topic related to chemical engineering, mainly in the water-wastewater/food treatment and polymer/chemical processing areas. The research topic is selected in consultation with the student's supervisor(s). The student presents a proposal of the research plan in writing to a supervisory committee, and orally in the Graduate Research Seminar Series prior to taking a candidacy exam. The research is carried out under the direction of a faculty supervisor(s) and monitored by a supervisory committee. On completion, the student is required to give an oral presentation on the research results in the Graduate Research Seminar Series. The research results are then submitted in a dissertation format to the supervisor(s) and to an examining committee, before which an oral presentation is made for the assessment and grading of the dissertation. Through the dissertation, the student is expected to provide evidence of competence in carrying out original and independent research and a sound understanding of the material associated with the research. Pass/Fail

CE8100 Directed Studies in Chemical Engineering (MASc)
This course is for master's students who wish to gain knowledge in a specific area for which no graduate level classes are offered. This course would involve a directed study for which the student(s) would be given credit. Students wishing to take the class would be assigned a suitable class advisor most familiar with the specific area of interest. Students would be required to present the work of one term (not less than 90 hours in the form of directed research, tutorials and individual study), in an organized publication format. 1 Credit

CE8102 Seminars in Chemical Engineering
This course consists of presentations by graduate students, faculty members, and external speakers, if applicable. MASc and PhD students are required to attend all seminars while in the program. MASc students are required to give one presentation towards the end of his/her thesis. PhD students are required to give one presentation before his/her candidacy exam and one presentation towards the end of the dissertation. MEng students are encouraged to attend all seminars. Pass/Fail

CE8140 Statistics for Engineering
This course examines the role of the statistical design of experiments and data analysis for exploring the effect of one or more factors on one or more responses in the context of research experimentation, process troubleshooting, continuous process improvement and product development. Data analysis techniques such as regression analysis and the analysis of variance will be discussed in detail. The application of screening designs, single and multifactor including two-level factorial designs, response surface designs such as central composite and Box-Behnken designs will be covered. Finally, designed experiments will be compared with un-designed experiments. 1 Credit

CE8141 Research Methods and Comms.
This course on research methods will focus on methods for developing a research problem and honing scientific communication skills of graduate students. Effective communication is an essential part of science. The students will be trained on effective literature review, technical writing (manuscripts, proposals, and letters), best practices on quantitative and qualitative data reporting, and oral and poster presentation skills. 1 Credit

CE8201 Modelling & Simulation in Chemical Eng.
Principles of process modeling; modeling of steady state, and unsteady state processes leading to problem formulation; numerical solutions of linear and non-linear algebraic equations, ordinary differential equations, and partial differential equations; analytical solutions of ordinary and partial differential equations; advanced techniques of computer programming; introduction to object-oriented paradigm; computer simulation of chemical engineering processes; examples from thermodynamics, fluid mechanics, heat transfer, mass transfer, and chemical reaction engineering. 1 Credit

CE8202 Advanced Process Control
System identification. Review of linear control systems and state space. Design methods of multivariable control systems. Model Predictive Control: Internal Model Control (IMC) and Dynamic Matrix Control. Applications to chemical processes. 1 Credit

CE8203 Applied Optimal Control
Optimal control and optimization. Examples of optimal control problems. Functionals and their classification. Differentials of functionals. Optimality of optimal control problems-necessary and sufficient conditions. Lagrange and John Multiplier Theorems. Their applications to optimal control problems. Pontryagin's principle. Problems with different types of constraints. Optimal periodic control-necessary conditions for optimum and the Pi criterion. Numerical solution of optimal control problems. 1 Credit

CE8210 Process & Engineering Optimization
The use of optimization methods is pervasive throughout the process industries. Thus, these techniques are an important part of a chemical engineer's tool set. This course will provide a blend of important theoretical concepts and practical implementation issues. The development of a student's ability to formulate optimization problems, select solution techniques and interpret results will be emphasized. Finally, through a series of industrially relevant problem sets, the students will gain exposure to popular optimization software. Extra project/assignments are required, weighing no less than 20-30% of the final grade. Antirequisite CHE425. 1 Credit

CE8213 Advanced Numerical Methods
Review of numerical analysis. Includes: solution of systems of linear and nonlinear algebraic equations, interpolation, least squares fitting, integral and derivative evaluations, and solution of ordinary and partial differential equations. Introduction to the numerical solution of systems of linear and nonlinear partial differential equations using finite difference and finite element methods. Includes: error analysis, non-uniqueness and stability in nonlinear systems, continuation, isoparametric mapping, time integration techniques, time step controller, and mesh refinement strategies. Includes practical applications to science and engineering. Programming is required throughout the course. Antirequisite EN8913. 1 Credit

CE8214 Optimization in Chemical Engineering
This course will introduce optimization theory, methods and applications in chemical engineering. Topics will comprise single and multi-variable, functional, dynamic and multi-objective optimization. Classical and modern computational solution algorithms will be covered, including evolutionary and artificial intelligence-based techniques. Emphasis will be placed on problem solving using important software and programming tools. 1 Credit

CE8301 Advanced Transport Phenomena
Differential and integral balances applied to isothermal and non-isothermal systems, interphase transport in non-isothermal, single component and multi-component systems. Heat and mass transfer in packed and fluidized beds. 1 Credit

CE8303 Advanced Fluid Dynamics
Vectors and tensors; introduction to fluid dynamics; kinematics; microscopic mass and momentum balances; exact solutions of the Navier-Stokes equations; dimensional analysis and similitude; flows with negligible acceleration; high Reynolds number flows; regions far from boundaries (the Boundary Layer Theory); hydrodynamic stability; turbulence; macroscopic balances for isothermal systems; non-Newtonian fluid behaviour. 1 Credit

CE8304 Rheology
Rheology is the study of the deformation and flow of matter. This field is dominated by inquiry into the flow behavior of complex fluids such as polymers, foods, biological systems, slurries, suspensions, emulsions, pastes, and other compounds. The students will be introduced to the principles, measurements, and applications of rheology. 1 Credit

CE8331 Membrane Technology
A study of material transport in membranes and of the modes of operation. Modeling of mass transfer in membrane processes will also be discussed. Emphasis will be on the design and applications of various membrane processes in industry, such as: membrane filtration, reverse osmosis, gas permeation and pervaporation. Extra project/assignments are required, weighing no less than 20-30% of the final grade. Antirequisite CHE715. 1 Credit

CE8402 Applied Thermodynamics.
Definitions and basic principles; conservation of mass and energy; concept of entropy; equations of change with applications; thermodynamic properties and their determination based on the change of state of system; equilibrium and stability criteria, and their applications to single and multi-component systems; Gibbs free energy and the concept of fugacity; phase equilibrium and its calculation using various thermodynamic models, and computational algorithms; chemical equilibrium in single-phase systems; chemical equilibrium of reacting mixtures; combined phase and chemical equilibrium. 1 Credit

CE8403 Advanced Reactor Engineering
Reaction kinetics, stoichiometry and pathways; Reaction data and analysis; Design of ideal reactors; Catalysis; Mass transfer effects; Residence time distribution; Biological reactions; Modeling and simulation of reactors under isothermal, non-isothermal, steady state, and unsteady state conditions; Reactor optimization; Scale up principles. 1 Credit

CE8410 Electrochemical Engineering
This interdisciplinary engineering science course covers the topics and applications of electrochemistry and electrochemical engineering. Topics addressed are: (1) thermodynamics, kinetics and transport phenomena in electrochem. Systems; (2) elements of electrochem. systems including electrolytes, electrocatalysts, and electrodes; (3) electrochemical processes and applications including corrosion, electrodialysis, electrochlorination and electrochem. energy conversion and storage devices. 1 Credit

CE8501 Polymer Science and Engineering
Definitions and basic principles; polymerization mechanisms; kinetics of polymerization reactions; thermodynamics of polymer-solvent phase equilibria; diffusion and mass transfer in polymer systems; heat transfer and non-isothermal effects in polymer systems; polymer processing; mathematical modeling of mixing, extrusion, postdie processing, molding and forming. 1 Credit

CE8510 Plastic Technology
Materials: classification and general properties of plastics, thermosets, thermoplastics, commodity plastics, engineering plastics, fillers and reinforcements. Polymer manufacturing processes. Converting operations: injection moulding, compression moulding, extrusion, blow moulding, wire and cable coating, thermoforming. Extra project/assignments are required, weighing no less than 20-30% of the final grade. Antirequisite CHE451. 1 Credit

CE8603 Advances in Biomaterials

This course introduces principles of materials engineering, important aspects of biocompatibility and response of the tissues to biomaterials, fundamentals of biomaterials engineering including design of new biomaterials for biomedical applications such as dental, orthopedics, and artificial implants. 1 Credit

CE8604 Advances in Porous Materials
Introduction and classifications of porous materials. Syntheses and characterizations of porous materials. Self-assembly and nanotechnology of porous materials. Adsorption and diffusion in porous materials. Applications of porous materials in heterogeneous catalysis, membranes for environmental remediation, and sustainable energy. 1 Credit

CE8606 Advanced Topics in Tissue Engineering
This course covers advanced topics in *tissue engineering*: the interdisciplinary field that encompasses biology, chemistry, medical sciences and engineering to design and fabricate living systems to replace damaged or diseased tissues and organs. Integrative exploration of tissue anatomy, cell biology, biomaterial scaffolds, cell sources and differentiation, design considerations, diffusion and mass transfer limitations, effects of external stimuli, bioreactors, methods used to evaluate the engineered product(s), and implantation models. Antirequisite: BME703 1 Credit

CE8610 Artificial Intelligence in Chem Eng
This course will introduce the fundamentals of Artificial Intelligence (AI), and its utilization in solving problems related to chemical engineering. Core AI topics will be taught that include intelligent agents, conventional and evolutionary search methods, knowledge representation and reasoning, planning and decisions-making, machine learning, and artificial neural networks. Important applications in chemical engineering will be covered. 1 Credit

CE8703 Adv. Water Treatment Technologies
Covers the sources of water and wastewater, and analytical characterization of water and wastewater. It also covers advanced oxidation technologies such as UV, UV/hydrogen peroxide, photocatalysis, and other advanced oxidation processes. Biological treatment of water and wastewater will also be discussed . 1 Credit

CE8710 Air Pollution and Control
A study of air pollution and general control methods. Air pollution measurements and emission estimates will be discussed. Fixed-box and diffusion models for air pollutant concentration will be introduced. Emphasis will be given on design of typical air pollution control equipment for volatile organic compounds (VOC), sulphur dioxide, nitrogen oxides. Introduction to control of particulate pollutants will also be included. Extra project/assignments are required, weighing no less than 20-30% of the final grade. Antirequisite CHE615. 1 Credit

CE8711 Environmental Nanotechnology
This course covers the implications and applications of nanotechnology in the environment. The major topics are (1) An overview of synthesis, properties and characterization of engineered nanomaterials with applications in consumer products, (2) Fate, transport and transformation of nanomaterials in the aquatic environments, and (3) Nano-enabled technologies such as novel filters, adsorbents, membranes, and catalysts for removal and transformation of legacy and emerging contaminants of concern. 1 Credit

CE8802 Wastes from Food Processing
Sources, composition and properties of wastes in the food processing industry. Interaction between chemical components and microorganisms present in food wastes. Biotransformations. Introduction to regulatory guidelines. Systematic procedures for the design of waste process plants, process requirements, utility needs, and associated capital and operating costs. 1 Credit

CE9100 Directed St in Chemical Engineering (PhD)
This course is for PhD students who wish to gain knowledge in a specific area for which no graduate level class is offered. It would involve a directed study for which the student would be given credit. Students wishing to take the class would be assigned an advisor most familiar with the specific area of interest. Students would be required to present the work of one term (not less than 90 hours in the form of directed research, tutorials and individual study), in an organized publication format. 1 Credit

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