Chemical Engineering

Programs & Degree Requirements

As a graduate student, you can choose to enter the Master of Engineering (MEng, full time or part time), Master of Applied Science (MASc, full time) or Doctoral program (PhD, full time).

*Information from: https://www.ryerson.ca/chemical/graduate/programs-degree-requirements/

<table>
<thead>
<tr>
<th>PhD</th>
<th>MASc</th>
<th>MEng</th>
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<tbody>
<tr>
<td>Four course credits¹ (credits from Group I only)</td>
<td>Four course credits¹ (credits may include a maximum of one from Group II)</td>
<td>Eight course credits¹ (credits may include a maximum of two from Group II)</td>
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<tr>
<td>Dissertation</td>
<td>Thesis</td>
<td>Project²</td>
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¹All courses are one semester and are equal to one course credit
²MEng students may apply to substitute two courses for the program with the PDF fileMEng Course Only Option Form

Note: For a complete list of Group I and Group II courses, please visit our Courses page.

PhD

The Doctor of Philosophy (PhD) program requires the successful completion of four one-term graduate courses, a candidacy examination within 16 months from initial registration (for more information please refer to the PDF filePhD Candidacy Examination Guide), and a research dissertation based on original research in the area of water/wastewater and food treatment technologies, or polymer and process engineering. At least two of the required four courses must be taken at Ryerson. Your dissertation supervisor must approve the course selections. This is confirmed through a Program of Study agreement between you and your supervisor, with the approval of the director. You are expected to commence working on the dissertation upon registration in the program (for more information please refer to the PDF filePhD Dissertation Guidelines). The core aspect of the program is the successful defence of the doctoral dissertation containing original contributions to knowledge at both Program and School of Graduate Studies oral examinations.

MASc

The Master of Applied Science (MASc) postgraduate program requires the successful completion of four one-term course credits and a research thesis. No undergraduate credits may be taken towards the degree. At least two of the required four courses must be taken at Ryerson. The curriculum is structured to facilitate completion of course requirements in one calendar year of full-time study (12 months) or three academic semesters, however, thesis research may require an additional two to three terms. This program is designed to provide opportunities for involvement in water/wastewater and food technologies, or polymer and process engineering programs of graduate study and research. Your supervisor must approve the graduate course selection. This is confirmed through a Program of Study agreement between you and your supervisor, with the approval of the director. You are expected to commence working on your research thesis upon initial registration in the program (see PDF fileMASc Thesis Guidelines).
The Supervisory Committee must approve the thesis research plan/proposal (which you will present in writing). An oral presentation of the research thesis, and the research results, will be arranged in a seminar format. An Examination Committee will assess and grade your research thesis.

**MEng**

The Master of Engineering (MEng) postgraduate program requires the successful completion of eight one-term courses and a major project, and is available in part-time or full-time study. You may substitute the major project with two electives, if approved by the faculty advisor and program director. This program is designed to provide opportunities for further professional development. No undergraduate credits may be taken towards the degree. At least four of the required eight courses must be taken at Ryerson. The part-time curriculum is structured to facilitate completion in three calendar years (36 months) or nine academic semesters. The full-time program will normally take five to six academic semesters. Your faculty advisor must approve your graduate course selection and the proposed project plan, which you will present in writing (see PDF file MEng Project Guidelines). Course selections are confirmed through a Program of Study agreement between you and your advisor, with the approval of the director. The oral presentation of the project report, and results, will be arranged in a seminar format. The Examination Committee will assess and grade your project report.

**Degree Completion Time Regulations**

The minimum and maximum times allowed for coursework and research in the programs are indicated in the table below. Transfer from full-time to part-time status, and vice versa, requires the approval of the School of Graduate Studies, particularly when the maximum time span allowed for program completion could become an important factor for consideration.

<table>
<thead>
<tr>
<th></th>
<th>PhD Full Time</th>
<th>MASc/MEng Full Time</th>
<th>MEng Part Time</th>
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<tbody>
<tr>
<td><strong>Minimum residency requirement</strong></td>
<td>24 months (six academic terms)</td>
<td>12 months (three academic terms)</td>
<td>24 months (six academic terms)</td>
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<tr>
<td><strong>Maximum length of time to complete degree</strong></td>
<td>Six calendar years</td>
<td>Three calendar years</td>
<td>Five calendar years</td>
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Ryerson’s Yeates School of Graduate Studies requires your continuous registration throughout the residency period for the program, either PhD or master’s (full time or part time), in which you are registered.

**Grade Requirements**

You must repeat a course (or substitute with an alternate course) if a course mark is less than B- (2.67/4.33 or 70%) for both MEng and MASc, and less than B (3.00/4.33 or 73%) for PhD. Failure to maintain an acceptable academic standing could result in a request for you to withdraw from the program. Failure in more than one graduate course will be considered grounds for dismissal.
### Electives

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<tr>
<th>Course code</th>
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<tr>
<td><strong>Group I</strong></td>
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<tr>
<td>CE8139</td>
<td>Prob, Stat and Stochastic Proc</td>
<td>1</td>
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<tr>
<td>CE8140</td>
<td>Statistics for Engineering</td>
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<tr>
<td>CE8201</td>
<td>Model and Simulation- Chem Eng</td>
<td>1</td>
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<tr>
<td>CE8202</td>
<td>Advanced Process Control</td>
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<td>Applied Thermodynamics</td>
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<td>CE8403</td>
<td>Advanced Reactor Engineering</td>
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<tr>
<td>CE8410</td>
<td>Electrochemical Engineering</td>
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<td>CE8501</td>
<td>Polymer Science</td>
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<td>CE8502</td>
<td>Polymerization Reaction Engr</td>
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<td>CE8602</td>
<td>Industrial Biotechnology</td>
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<td>CE8606</td>
<td>Advanced Topics in Tissue Engineering</td>
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<tr>
<td>CE8702</td>
<td>Dsgn/Oper Sm Wtr Treat Plants</td>
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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

CE8139 Probability, Stats. & Stochastic Processes
This course is an introduction to stochastic processes and probabilistic models. Statistical interference techniques are also discussed. Topics covered include: probability and random variables, Bemoulli, Binomial, Markov, Poisson, Wiener and Gaussian models, stationarity and cyclostationarity, spectra of various signals, linear mean-square estimation, representation of random signals and Karhunen-Loeve expansion, Markov chains and processes, parameter estimation, mean variance, confidence intervals, Bayesian models, hypothesis testing. Antirequisite EN8910, ME8139. 1 Credit

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

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

CE8204 Advanced Modeling Techniques
Terminology; Model development cycle; Classification. Conservation Laws; Equations of change; Equilibrium conditions. Constitutive relations: Transport of mass, energy and momentum. Reaction kinetics; Thermodynamic relations; Empirical correlations; Dimensional analysis. Model Formulation: Assumptions; Geometry; Mathematical relationships. Model simplification: Scaling; Ordering analysis; First order approximation; Deviation variables. Model transformation. Model simulation algorithms. 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

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

CE8310 Fluidization Engineering

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

CE8401 Kinetics of Ind. Catalysis & Biocatalysis
Homogeneous catalysis reactions such as acid-base catalyses, ion catalyses, enzyme catalyses, chain reactions and polymerization will be considered. Enzymatic and microbial heterogeneous catalyses will also be described. Studies of some important industrial reactions will be made. 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**
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

**CE8502  Polymerization Reaction Engineering**

**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

**CE8602  Industrial Biotechnology**
A lecture and assignment course on the chemical, physical and biological aspect of industrial processes; the newly-emerging DNA-based methods for the identification and classification of bacteria of environmental, medical, food and agricultural importance. Introduction to regulatory guidelines, licensing and safety issues for the biotechnology industry. Assignments include problem-solving, proposal and report writing, and oral presentations. 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

**CE8605  Nanobiotechnology**
This course introduces the fundamental concepts of nanobiotechnology and the up-to-date application of nanotechnology in life science. It has the objective of investigating emerging frontiers in achieving the goals of biotechnology through the use of nanotechnology as well. It also integrates materials science, chemical engineering, physics and life science toward the biological and biochemical applications. In this course, nanofabrication and the interaction between nanostructured materials and biological system at the nano-scale are
all investigated thoroughly. Mainly, it teaches how to design and develop nano-devices that have application in the biomedical field targeting the improvement of healthcare industry. 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

CE8702 Design Operat.of Sm.Water Treat. Plants
Small water treatment plants (less than 20,000 PE) for industrial and domestic effluents play a central role in the overall water treatment policies of both developed and developing countries. The characteristics of these plants differ from those of large urban plants. Biofilm technologies like Rotating Biological Contractors, and Three-phase Fluidized Beds as well as Extended Aeration will be discussed from the point of view of design and operation. Other separation and disinfection technologies will be presented in conjunction with the treatment units. 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

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

CE8803 Advanced Food Process Engineering
Modeling of food properties. Momentum, heat and mass transfer applied to the control of moisture, microbial population, and nutritive/organoleptic properties of foods during processing operations. Optimization and scale up design. Quality systems design. 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