CIVIL ENGINEERING

CURRICULUM

Master of Applied Science

DEGREE REQUIREMENTS		Credits
Research Presentation		(Milestone)
Master's Thesis		(Milestone)
CV8010	Master's Research Seminar	Pass/Fail
Five Elective credits (One may be a Directed Studies course)		5

Master of Engineering

DEGREE REQUIREMENTS		Credits
Ten Elective credits (One may be a Directed Studies course)		10
OR		
Students with the permission of the Program Director may complete eight elective courses and a Master's Project		8
Master's Project (optional with permission 8 courses + Project)		(Milestone)

Doctor of Philosophy

DEGREE REQUIREMENTS		Credits
Research Presentation		(Milestone)
Candidacy Examination		(Milestone)
Dissertation		(Milestone)
CV8020	PhD Research Seminar	Pass/Fail
Four Elective credits (One may be a Directed Studies course)		4

ELECTIVES		Credits
CV8100	Directed Studies: Engr	1
CV8102	Advanced Construction Mgmt	1
CV8105	Construction Admin and Mgmt	1
CV8106	Advances in Concrete Materials	1
CV8107	Special Topics: Civil	1
CV8110	Infrastructure Asset Management	1
CV8200	Proc for Wtr Pollution Control	1
CV8202	Surface Wtr Pollution Analysis	1
CV8204	Soil Remediation	1
CV8205	Spec Topics: Env Engineering	1
CV8207	Waste Management	1
CV8208	Hydroinformatics	1
CV8209	Bioenergy and Biofuels	1
CV8210	Environmental Impact Analysis	1
CV8211	Urban Water Systems	1
CV8300	Solid Mechanics	1
CV8301	Appl of Finite Element	1
CV8302	Dynamics of Structures	1
CV8303	Renov/Repair - Existing Struct	1
CV8304	High Perf Concrete Structures	1
CV8306	Durability of Structures	1
CV8307	Adv. Reinforced Concrete Design	1
CV8308	Bridge Design and Construction	1

CV8309	Spec Topics: Structural Engr	1
CV8311	Risk and Reliability for Eng	1
CV8312	Advanced Composite Structural Systems	1
CV8313	Prestressed Concrete	1
CV8317	Earthquake Engineering & Seismic Design	1
CV8318	Wind Engineering	1
CV8400	Road Safety	1
CV8405	Pavement Design and Mgmt	1
CV8406	Adv Highway Geometric Design	1
CV8407	Special Topics: Transportation	1
CV8409	Urban Transport Systems	1
CV8410	Travel Demand Analysis	1
CV8411	Non-Highway Transportation Systems	1
CV8412	Advanced Traffic Engineering Analytics	1
CV8500	Satellite Positioning	1
CV8501	Adv Geospatial Info Systems	1
CV8502	Digital Stereo Image Processing	1
CV8503	Geospatial Model and Visualiz	1
CV8504	Estimation and Data Series Analysis	1
CV8505	GIS for Civil Engineering	1
CV8506	Industrial Metrology	1
CV8507	Satellite Remote Sens: Urban	1
CV8508	Special Topics: Geomatics	1
CV8601	Adv Foundation Design	1
CV8602	Mechanized Urban Tunneling	1
CV8603	Modelling of Glacial Deposits	1
CV8604	Geotechnical Eng of Embankment Dams	1

COURSE LISTING

Master's Thesis
The student is required to conduct advanced research on a topic chosen in consultation with the student's thesis supervisor. The supervisory committee and the thesis supervisor must approve the thesis research plan/proposal, which is presented in writing by the student. The student must submit the completed research in a thesis format to an examination committee and make an oral presentation of the research thesis, and the research results, to this committee. The examination committee will assess and grade the thesis. Through the thesis, the student is expected to furnish evidence of competence in research and a sound understanding of the specialty area associated with the research. This is a "Milestone." Pass/Fail

Master's Project
The Project may consist of an advanced design assignment, laboratory research project, analysis of research data, or an in-depth review of an approved aspect of the scientific literature. The student submits a written proposal of the project plan, which must be approved by the project supervisor, and the supervisory committee. The MEng candidate must submit two copies of the completed project report to the supervisor. An oral presentation of the project report, and results, will be arranged in a seminar format. The supervisor and another member of the supervisory committee will assess and grade the report. This is a "Milestone."   Pass/Fail

PhD Candidacy Examination
This is a "Milestone." Pass/Fail

PhD Dissertation
Pre-requisite: Candidacy Examination. This is a "Milestone." Pass/Fail

Research Presentation: The student is required to present one or two oral presentation(s) on his/her research work in CV8010 (1)/CV8020 (2) before graduation. This is a "Milestone." Pass/Fail

CV8010 Master's Research Seminar
This course consists of weekly seminars emphasizing current research in specialized areas of Civil Engineering, including Environmental, Geomatics, Structural, and Transportation. This course will run through Fall and Winter semesters. Presentations will be given by MASc students, faculty members, visiting scholars and guest speakers. In order to achieve a pass grade in the course, the student must attend a minimum of 75% of the seminars in each of Fall and Winter semesters of his/her first year of

study. Following year one, the student will register in a research presentation milestone and present an oral presentation on his/her research work. Pass/Fail

CV8020 PhD Research Seminar
This course consists of weekly seminars emphasizing current research in specialized areas of Civil Engineering, including Environmental, Geomatics, Structural, and Transportation. This course will run through Fall and Winter semesters. Presentations will be given by Ph.D. students, faculty members, visiting scholars and guest speakers. In order to achieve a pass grade in the course, the student must attend a minimum of 75% of the seminars in each of Fall and Winter semesters of his/her first year of study.   Following year one, the student will register in two research presentation milestones and present two oral presentations on his/her research work. Pass/Fail.

CV8100 Directed Studies in Engineering
Various possibilities exist for pursuing directed studies on topics approved by the course supervisor and thesis supervisor, including the other specialization course topics where they are not offered on a formal basis. 1 Credit

CV8102 Advanced Construction Management
This course aims to provide students with advanced management methodologies and decision-making tools, emphasizing analytical and quantitative approaches to managing complex construction projects in uncertain environments. Topics covered include project scheduling with time, resource and financial constraints, analytic hierarchy process, decision-making under uncertainty, game theory, Monte Carlo simulation, project risk management, and lifecycle infrastructure management. 1 Credit

CV8105 Construction Administration and Management
Topics on skills and techniques useful in administering and managing in a construction project environment, including international and Canadian construction, organizational design for projects and companies, management control structures and processes, meetings and negotiations, managing change in organizations, power struggles and politics in organizations, conflicts and their resolutions, claims and disputes in the industry, and the all-important issues of construction safety. 1 Credit

CV8106 Advances in Concrete Materials
Topics covered in the course will include: Chemistry and manufacturing of Portland cement; Supplementary cementing materials; Chemical admixtures for concrete; Properties of hardened concrete; Chemistry and mechanics of concrete deterioration and effects of SCM; Concrete of special properties; Advance experimental techniques in concrete.1 Credit

CV8107 Special Topics: Civil
The subject matter changes from year to year. The course description will be announced prior to the scheduling of the course. 1 Credit.

CV8110 Infrastructure Asset Management
This course will discuss the framework, concepts, and methods of infrastructure asset management. Topics include system analysis, lifecycle costing, decision making under uncertainty, demand forecasting, performance measure and monitoring, inspection technologies, condition assessment, deterioration modeling and lifetime prediction, maintenance and rehabilitation optimization, prioritization and programming, innovative project delivery, and project and program management. 1 Credit

CV8200 Processes for Water Pollution Control
This course expands on the principles and designs involved in wastewater treatment. Topics cover physical, chemical, biological treatment processes, and advanced treatment methods including biological nitrification-denitrification, enhanced biological phosphorus removal, membrane bioreactors, biofilm processes, and alternative disinfection methods. A theoretical approach, supplemented by practical design applications and problem-solving, will be adopted. Antirequisite ES8902. 1 Credit

CV8202 Surface Water Pollution Analysis
This course will overview comprehensive water pollution prevention and control planning and provide quantitative modelling approaches and analyses of surface water pollution. Topics include: surface hydrology, municipal water use cycle, urban drainage systems, point and non-point pollution control strategies for sanitary, storm, and combined sewer systems, and key concepts in surface water quality modelling. Antirequisite: ES8906 .1 Credit

CV8204 Soil Remediation
This course overviews the design and operation of processes for soil remediation. Contaminants of interest include halogenated and non-halogenated volatiles, halogenated and non-halogenated semi-volatiles, flue hydrocarbons, pesticides and inorganics. Seven groups of technologies will be examined: (1) excavation and off-site disposal, (2) soil venting, (3) bioremediation, (4) thermal technologies, (5) chemical technologies, (6) mechanical flushing and washing, and (7) natural attenuation. Antirequisite ES8908. 1 Credit

CV8205 Special Topics in Environmental Eng.
The subject matter changes from year to year. The course description will be announced prior to the scheduling of the course. 1 Credit

CV8207   Waste Management
This course describes the main issues in integrated solid waste management, waste transport and disposal. To know when solid waste is a resource, or a disposal problem requires its analysis and classification. Processing and handling of solid

waste, waste stabilization and solidification, land disposal of waste will be discussed. Physical conversion of waste including thermal, chemical, and biological conversion technologies will be described. Antirequisite: ES8904. 1 Credit

CV8208 Hydroinformatics
This course introduces the integration of water management with information and communication technologies in hydroinformatic concepts, methods and tools. Relevant systems analysis, modelling and decision support concepts are discussed in the context of current and future environmental challenges. The use of simulation models, optimization (single and multi-objective) techniques, machine learning, open data and data management are introduced and explained. 1 Credit

CV8209 Bioenergy and Biofuels
The course explores theories and applied technologies for production and conversion of biomass into energy and co-products, focusing on biomass waste for bioenergy and biofuel recovery with methane, hydrogen, and ethanol production. Biochemical processes (fermentation and anaerobic digestion) will be introduced and explained, followed by an overview of engineering tools applied to the analysis of energy conversion processes involving biomass thermochemical energy processes. 1 Credit

CV8210 Environmental Impact Analysis
The course will overview sustainable development and engineering and focus on the Canada Environmental Assessment Act and the Ontario Environmental Assessment Act. Topics include: sustainable development and engineering, concepts and methods of environmental impact assessment, physical/economic/social impacts, multi-objective evaluation of alternatives, cumulative impact assessment, and strategic environmental assessment. 1 Credit

CV8211 Urban Water Systems
Introduction to methods used for handling drinking water, wastewater and stormwater is presented through a brief history of water management in urban areas from ancient civilizations to present day. A review of key theories from hydrology and hydraulics is followed by a presentation of models used in analyses of urban water systems. The concept of integrated urban water management is introduced using case studies and associated tools. 1 Credit

CV8300 Solid Mechanics.
This course covers advanced mechanics of solids and elasticity while reviewing fundamentals of the mechanics of materials. Topics presented in this course include: Analysis of Stress, Strain and Material Properties, Problems in Elasticity, Failure Criteria, Bending of Beams, Torsion of Prismatic Bars, Numerical Methods, Stability of Columns, and Plastic Behavior of Materials. 1 Credit

CV8301 Appl.of Finite Element Meth.in Struct.Eng.
Application of stiffness method for trusses and frames. Direct formulation of CST and thermal-seepage. Finite element formulation by virtual work. Elements: triangular, Lagrangian and serendipity rectangles; numerical integration; curvilinear elements; three-dimensional elements; plates, shells and axisymmetric elements. Convergence: Rayleigh-Ritz method; patch test; reduced integration. Solution of special problems: 2D and 3D problems; secondary effects; non-linear problems; soil-structure interaction. 1 Credit

CV8302 Dynamics of Structures
Free-vibration. Damping in structures. Response to harmonic and periodic excitations. Response to arbitrary, step and pulse excitations. Numerical evaluation of dynamic response. Structural dynamics in International Building Codes. Floor vibration due to human excitation. Foundation design for machine vibration. 1 Credit

CV8303 Renovation/Repair of Existing Structures
Maintenance, renovation, rehabilitation and preservation of infrastructure. Mechanisms of mechanical, chemical and biological infrastructure degradation. Corrosion of steel condition surveys and evaluation of buildings and bridges repair and preservation of materials, techniques and strategies. Codes and guidelines. Case Studies. 1 Credit

CV8304 High Performance Concrete Structures
This course deals with the use of high performance concrete (HPC) in structures. Topics include: HPC principles, materials and mix design, early age properties, mechanical properties, producing and curing HPC, shrinkage problems, temperature effects, durability, constructability and sustainability, design issues, recent developments in HPC technology, emerging HPCs, HPC based structural elements and their design, case studies. 1 Credit

CV8306 Durability of Structures
Basic concepts, durability, safety, repair and strengthening. Deterioration mechanisms, corrective and preventive measures. Reliability analysis. Design for durability. Bridges. Parking structures. Steel, timber and masonry structures. Management systems. Strengthening and retrofitting. Case studies. 1 Credit

CV8307 Adv. Reinforced Concrete Design
Reinforced Concrete: Mechanics of reinforced concrete; truss model and compression field theory for beams failing in shear; design of two-way slabs; design of slender columns; shear friction and horizontal shear transfer; design for combined shear and torsion; design of deep beams and corbels. Antirequisite: CVL 904. 1 Credit

CV8308 Bridge Design and Construction
Types of bridges; material properties and design of timber, steel and concrete elements; bridge loads; load distribution in bridge superstructures; simplified methods of analysis, with reference to the Canadian Highway Bridge Design Code; design of slab bridges;

design of slab-beam bridges; design of box-girder bridges; joints, bearings, bridge piers and abutments. Antirequisite: CVL905. 1 Credit

CV8309 Special Topics in Structural Engineering
The subject matter changes from year to year. The course description will be announced prior to the scheduling of the course.
1 Credit

CV8311 Risk and Reliability for Eng
The main purpose of this course is to present a comprehensive introduction to risk and reliability theory as it relates to modern engineering services. Starting with a review of probability and statistics, the course will cover structural reliability methods, reliability-based structural design, statistical methods for reliability and deterioration data analysis, stochastic modeling for inspection and maintenance, and engineering decision theory. 1 Credit

CV8312 Advanced Composite Structural Systems
This course equips students with advanced knowledge of modeling, analysis, design and construction of metal-skinned composite structural systems. Topics include: plain/profiled steel & new material plated panels/girders/composite elements; concrete filled composite beams/columns/frames; composite slabs; strengthening & durability; thin walled & sandwich construction; double skin steel-concrete composite elements & shear walls; innovative high performance composite systems & recent developments. 1 Credit

CV8313 Prestressed Concrete
Basic concept of prestressing including pretensioning and post-tensioning; Material properties of concrete and prestressing steel; calculation of losses; design procedure for members subjected to direct tension, flexure and shear; crack control; estimating short and long term deflections and design for anchorages.   1 Credit

CV8317 Earthquake Engineering & Seismic Design
This course covers the fundamentals of earthquake engineering pertinent to structural engineering. Topics presented include earthquake characteristics, structural response, structural modeling and analysis, and seismic design. Additionally, this course presents seismic design procedures for building structures. After completing this course, graduate students will be able to use seismic design codes and standards with ease and apply the knowledge acquired from this course both in practice and in research. 1 Credit

CV8318 Wind Engineering
In this course, students will learn how to apply wind engineering to quantify wind-induced loads and response of structures. This include: (i) climate analysis, (ii) modeling of terrain effect, (iii) modeling for aerodynamics using CFD or wind tunnel, (iv) Accounting for structural dynamics and (v) evaluation of equivalent static loads and structural responses. Students will also evaluate design wind loads using the NBCC and understand the limitations within the code. 1 Credit

CV8400 Road Safety
This course provides an understanding of the safety management process and the variety of science-based tools used. Topics include: probability and frequency models of crash occurrence; estimation of safety in developing and evaluating countermeasures; methods for identifying hazardous elements; safety of road facilities, including intersections, roadways, roadsides, and traffic control elements; driver, pedestrian and bicycle safety; applications of human factors principles; safety audits and in service road safety reviews; and alternative safety performance indicators. 1 Credit

CV8405 Pavement Design and Management
Pavement performance and distress. Theory and stress analysis of flexible and rigid pavements. Properties and characterization of paving materials. Design of flexible and rigid pavement for highways and runways. Overlay design. Reliability analysis. Flexible and rigid pavement construction. Pavement management systems. Review of design projects. Antirequisite: CVL 900. 1 Credit

CV8406 Advanced Highway Geometric Design
This course deals with the theory and practice of highway geometric design, including design controls, horizontal and vertical alignments, intersections, interchanges, and cross sections. Driver ability, vehicle performance, and safety are considered. Advanced topics such as three-dimensional sight distance, intersection control, safety audits, value engineering, design flexibility, design consistency, and reliability analysis are discussed. Other topics such as roundabout design and effect of autonomous driving on highway geometric design are also discussed.   1 Credit

CV8407 Special Topics in Transportation
The subject matter changes from year to year. The course description will be announced prior to the scheduling of the course.
1 Credit

CV8409 Urban Transport Systems
The course teaches optimization and simulation methods to solve logistics and operations problems for urban infrastructure, including public transport systems, last-mile operations, traffic dynamics, CAVs, MaaS, and emergency response. It emphasizes methods to evaluate strategies in an urban setting complicated by density, multi-modes, high uncertainty, and ubiquitous data. Applications include transit network design, facility location problems, congestion pricing, and humanitarian logistics. 1 Credit

CV8410 Travel Demand Analysis
The travel demand analysis consists of developing behavioural models that can predict the individual mobility patterns in response to supply and demographic changes, level of service, and other external factors. This course will introduce data-driven as well as hypothesis-driven approaches that can mathematically model correlation, heterogeneity, dynamics, and latent behaviour with respect to travel related choice making. Furthermore, the use of such models in simulation to forecast the travel demand will be demonstrated.   1 Credit

CV8411 Non-Highway Transportation Systems   This course covers basic concepts in the design, operations, and management of transportation systems other than highways. The systems are airports, ports, railways, and active transportation. Topics vary by system, but general topics include physical characteristics, design, capacity, safety, and management. The systems analysis approach, which is applicable to all systems, is discussed. Specific analytical tools are briefly described, including optimization, Monte Carlo simulation, and economic analysis. Practical case studies are discussed. 1 Credit

CV8412 Advanced Traffic Engineering Analytics   The course is focused on the underlying theory and application of microsimulation and other related modeling approaches to explore the safety and operational implications of traffic engineering features for various road facilities. These applications include evaluation of intelligent transportation system treatments and investigating the implications for traffic operations and safety of connected and automated vehicles at various levels and degrees of penetration. 1 Credit

CV8500 Satellite Positioning
Overview of satellite positioning methods; geodetic concepts; description of satellite orbits; characteristics of the GPS/GNSS signals; GNSS observables; measurements errors; linear combination of GNSS observables; mathematical models for single site and relative positioning; single and multi-constellation GNSS; integer ambiguity determination; integration of GNSS and other systems; current research topics. 1 Credit

CV8501 Adv Geospatial Info Systems
This course covers such advanced topics as data models, structures and indexing; database management; geospatial analysis and modeling; geographic visualization; macro language programming and GIS software customization; distributed geospatial processing; standards and implementation issues. 1 Credit

CV8502 Digital Stereo Image Processing
Design characteristics of digital imaging systems for metric data capture; Geometric modeling and calibration of digital imaging sensors for high precision 3D data extraction; inclusion of various geometric constraints; solution approaches for multi-sensor networks; automation aspects of image correlation and feature extraction; image rectification procedures; applications in engineering deformation analysis; reverse engineering and medical imaging. 1 Credit

CV8503 Geospatial Modeling & Visualization
Remote sensing data collection and digital image processing techniques; Image quality assesssment and statiscal evaluation; Intensity transformation and spatial filtering, 3D visualization and modeling; Geospatial modeling and visualization of transportation and environmental models; Selected case studies in transportation, forestry, agriculture, and urban landscape. 1 Credit

CV8504   Estimation and Data Series Analysis
Overview of linearization and probability distributions. Least-squares estimation, batch and sequential estimation methods, constraints. Linear and nonlinear regression. Trend analysis. Concept and classification of stochastic processes, auto- and cross-correlation functions, and spectral density function. Some common stochastic models. Kalman filtering. 1 Credit

CV8505 GIS for Civil Engineering
Overview of basic concepts, methods and techniques of geospatial information systems. Application and related technologies of GIS for the planning, design, operations, and maintenance of civil engineering systems. GIS project design. Hands-on experience with GIS software and civil engineering examples/case studies. 1 Credit

CV8506 Industrial Metrology
Data acquisition systems employed for close range measurements. Close-range Photogrammetry and laser imaging. Mathematical formulations for self-calibration with geometric considerations. Bundle adjustment, DLT-type, sequential and phased methods. Photogrammetric network design and post-adjustment analysis. Processing of laser point clouds and form fitting. Industrial case studies. 1 Credit

CV8507 Satellite Remote Sensing of Urban Areas
Major topics include overview of high-resolution satellite remote sensors; Multi-sensor data fusion; Knowledge-based image analysis; Satellite images for object extraction; Intelligent change detection systems; Selected case studies in urban transportation planning, Land-use/land-cover mapping, and environmental impact analysis. A lab-based term project with a research report or paper is required.   1 Credit

CV8508 Special Topics: Geomatics
The subject matter changes from year to year. The course description will be announced prior to the scheduling of the course. 1 Credit

CV8601 Advanced Foundation Design
This course covers advanced topics on design of shallow and deep foundations, including subsurface investigation, foundation type and selection, design principle, bearing capacity and settlement of shallow and deep foundations, LRFD, and numerical simulation of foundation behavior using software . Antirequisite: CV8310. 1 Credit

CV8602 Mechanized Urban Tunneling
This course covers topics plan and design of mechanized tunneling in urban environments, including tunneling in urban environments, risk management and mitigation, tunnel alignment selection, TBM types and selections, support systems and design methods, settlement prediction and control, tunnel construction control, and numerical design of tunnel lining using software. Antirequisite: CV8315. 1 Credit

CV8603 Modelling of Glacial Deposits
Advanced soil mechanics course: nature and formation of glacial deposits; geotechnical investigation; laboratory and field testing and interpretation; effective stress and water in soil; stiffness of soil with particular reference to glacial deposits; yielding and failure of soil; critical state strength of soil; elastic-plastic model and Cam Clay model; softening-hardening model and numerical implementation of soil models. Antirequisite: CV8316. 1 Credit

CV8604 Geotechnical Eng of Embankment Dams
This course considers geotechnical engineering aspects of embankment dams, seepage and filter design, foundation design, monitoring, settlement and stability analyses, numerical simulation and prediction. 1 Credit

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