

# CIVIL ENGINEERING

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Civil Engineering focuses on the analysis, design, and improvement of the human environment—both natural and constructed. Our students will learn how the world works and will provide improvements in the overall quality of life, make better use of limited resources, develop sustainable technologies, and create attractive and functional places to live and work.

Civil Engineering at Queen's University prepares students to identify emerging issues and develop innovative solutions to the numerous civil engineering, societal, and global challenges of the future.

The core undergraduate curriculum covers the key components of today's Civil Engineering professions. The study of environmental and sustainability issues is integrated throughout the academic plan to better reflect that the assessment of these concerns is integral to all civil engineering projects. The first three years of our plan provide broad-based training in: mathematics; science (physics, chemistry & geology); fluid, structural and soil mechanics; materials (water, concrete, steel, soil & plastics); and engineering problem solving & design. Students in their fourth year are able to either specialize in an area of interest, or further diversify their training. Specialization can be under the themes of buildings & structures, water & the environment, or geoengineering. This student choice arises in the selection of: technical electives, topics for realistic design projects, areas to conduct advanced research, and practical industrial internships.

## Programs

- Civil Engineering, B.A.Sc. (Class of 2023) (<https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/civil-engineering/civil-engineering-basc-class-2022/>)
- Civil Engineering, B.A.Sc. (Class of 2024) (<https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/civil-engineering/civil-engineering-basc-class-2023/>)

- Civil Engineering, B.A.Sc. (Class of 2025) (<https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/civil-engineering/civil-engineering-basc-class-2024/>)
- Civil Engineering: Technical Electives (<https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/civil-engineering/civil-engineering-technical-electives/>)

## Courses

**CIVL 111 Elementary Surveying Units: 3.50**

**Offering Term:** N

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 115 Microcomputers In Engineering Units: 2.00**

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 118 General Chemistry Units: 3.00**

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 200 Professional Skills I Units: 2.50**

This intensive short-course serves as a kickoff to Civil Engineering at Queen's. Students will be engaged in a design challenge where they are to conceive, design, implement and operate a system to achieve some specified function bounded by constraints. Focus will be placed on development of decision making, team building, communication and engineering design skills

**Requirements:** Must be registered in BASC

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 201 Professional Skills Units: 2.50**

Within a team structure potentially involving second, third, and fourth year Civil Engineering students and a faculty advisor, students will engage in a range of exercises designed to promote written and verbal communication, decision making, team building and engineering design skills. Lectures, workshops, design charettes and both individual and team assignments will be utilized to enhance learning. This course is available only to select students, under exceptional or extenuating circumstances, at the discretion of the Head of the Department and the Undergraduate Chair. (This course may not be offered every year).

**Requirements:** CIVL201 excludes CIVL200

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 204 Effective Technical Writing Units: 2.50**

**Requirements:** Must be registered in BASC

**Offering Term:** FW

**Offering Faculty:** Fac of Engineering Appl Sci



**CIVL 205 Effective Oral Presentation Units: 1.25**

**Requirements:** Must be registered in BASC

**Offering Term:** FW

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 206 Environmental Issues Seminar Units: 1.25**

**Requirements:** Must be registered in BASC

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 208 Decision Making Units: 1.25**

**Requirements:** Must be registered in BASC

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 210 Chemistry For Civil Engineers Units: 4.50**

Application of fundamental chemistry principles with respect to their sources, reactions, effects and fates in civil and environmental engineering systems. Topics will include chemical equilibria, stoichiometry and reaction kinetics; electrochemistry and corrosion; adsorption and ion exchange; solubility and precipitation; coagulation; microbiological reactions and kinetics; biochemical, chemical and theoretical oxygen demand; acidity, alkalinity and hardness; as well as biogeochemical cycles. These concepts will be further developed and applied in tutorial and laboratory modules. A design-based laboratory is conducted as part of this course. PPE will be required for this course at student's cost (see course materials for details).

**Requirements:** Prerequisite: APSC 132 and APSC 131. Must be registered in a BSCE or BASC program.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 211 Engineering Surveying Units: 3.50**

**Requirements:** CIVL211 excludes APSC262

**Offering Term:** N

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 214 Elementary Surveying And Cad Units: 4.50**

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 215 Materials For Civil Engineers Units: 4.50**

The basic engineering properties, micro/macro structure, behaviour and applications of various civil engineering materials will be studied including materials used in structural engineering. This will include steel, concrete, timber, polymers, composites and soil. Interaction between materials will be examined. Laboratory experiments will be used to demonstrate material behaviour. PPE will be required for this course at student's cost (see course materials for details).

**Requirements:** APSC151 OR CIVL202

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 220 Statics And Solid Mechanics Units: 4.00**

Review of statics, forces and equilibrium, internal forces in simple structures; axial, torsion, shear and moment diagrams; concepts of stress and strain; mechanical properties of materials; centroids and moments of areas; axial stress; flexural stress; shear stress in shafts and beams; calculation of displacement by integration; introduction to combined loading; introduction to column buckling. This course is designed primarily for mechanical engineering students.

**Requirements:** Prerequisite of APSC111 and APSC171 and registered in a BSCE or BASC Academic Program.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 221 Solid Mechanics II Units: 4.00**

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 222 Numerical Methods Units: 5.00**

This course introduces the basics of numerical analysis and the use of computer software (MATLAB) for civil engineering analysis. Error analysis, numerical differentiation and integration, root finding, derivation and numerical solution of partial differential equations using finite difference methods, and optimization are among the topics covered. All problems emphasize engineering applications.

**Requirements:** MATH224 OR MATH225 OR MATH226

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 223 Mechanics & Strength Of Mat. Units: 4.50**

**Requirements:** (PHYS113 AND MATH128) OR (APSC111 AND APSC171)

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 224 Mech & Strength Of Materials Units: 4.00**

**Requirements:** (PHYS113 AND MATH128)

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 226 Mechanics & Materials Units: 9.00**

**Requirements:** PHYS113 OR APSC111

**Offering Term:** FW

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 227 Introd. Strength Of Materials Units: 3.00**

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 228 Statics And Solid Mechanics Units: 4.50**

**Requirements:** APSC111

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 229 Mechanics And Materials Units: 4.50**

**Requirements:** CIVL228

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 230 Solid Mechanics I Units: 4.25**

Graphic Statics; Definitions of Stress and Strain; Hooke's Law; "Axial" Member Analysis and Design; Analysis and Design of Shafts Subjected to Torsion; Analysis and Design of Beams; Columns; Inelastic Bending; Introduction to Work and Energy and the Principle of Virtual Work.

**Requirements:** APSC 111, APSC 171, APSC 182

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 231 Solid Mechanics II Units: 4.50**

Shear and bending moment diagrams; Moment-area method; Introduction to statically indeterminate structures; Virtual work for beams and frames (determinate and indeterminate); Stress review, transformed sections, and combined loading; Stress-strain transformation (including Mohr's circle); Failure theories.

**Requirements:** CIVL 230

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 250 Hydraulics I Units: 4.00**

Fluid properties, fluid statics, basic equations of fluid flow: Continuity, Momentum, Euler's Equation of Motion, Linear Momentum Equation and Bernoulli's Equation. Flow of real fluid in closed conduits: friction losses and local energy losses. Pipeline flows in engineering practice. PPE will be required for this course at student's cost (see course materials for details).

**Requirements:** Prerequisite: APSC 172 and APSC 174. Must be registered in a BSCE or BASC program.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 262 Intro To Civil Eng Plan & Desig Units: 3.50**

**Requirements:** Must be registered in BASC

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 270 Urban Plan & Transportation Units: 3.50**

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 282 Environmental Engineering Units: 4.50**

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 283 Env. Applic. In Civil Eng. Units: 3.50**

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 290 Computer Appl In Civil Engr Units: 4.00**

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 291 Differential Equations Units: 1.00**

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 293 Civil Engineering Analysis Units: 5.00**

**Requirements:** MATH225 or MATH226

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 295 Computer Simulation Civil Eng Units: 1.25**

**Requirements:** MATH225 or MATH226 and CIVL293

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 300 Professional Skills II Units: 2.50**

Professional skills relating to how engineers interact with, communicate with, and consider the implications of their actions on a wide range of potential stakeholders, ranging from colleagues to clients to society as a whole, will be developed. Students will improve their technical writing and verbal communication skills as they work through case studies intended to: deepen an understanding of the roles and responsibilities of a Professional Engineer; strengthen an ability to apply professional ethics, accountability and equity; and enhance an appreciation of the potential social and environmental impacts of engineering activities. Class discussions will normally occur every second week.

**Requirements:** CIVL200

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 304 Writing An Engineering Report Units: 1.25**

**Requirements:** CIVL204

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 305 Effective Oral Presentation Units: 1.25**

**Requirements:** Must be registered in BASC

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 306 Leadership And Teamwork Skills Units: 1.25**

The objective of this short course is to develop a sound understanding of leadership and teamwork, and to apply these skills in both small group and large group settings. The course is based on the premise that all engineers, at various stages of their career, will be called upon to be both leaders and team members. (0/0/14/0/0) ~ COURSE DELETED IN 2008/09 ~

**Requirements:** Must be registered in BASC

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci



**CIVL 308 Engineering Report Proposal Units: 1.25**

**Requirements:** (CIVL204 AND CIVL305)

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 311 Survey Field School Units: 2.25**

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 330 Structural Theory I Units: 3.75**

Analysis of statically determinate structures such as trusses and plane frames, calculation of deflections by virtual work. Flexibility and stiffness methods for analyzing statically indeterminate structures. Computer applications of the above methods. PPE will be required for this course at student's cost (see course materials for details).

**Requirements:** Prerequisite of CIVL230 and CIVL231 and registered in a BSCE or BASC Academic Program.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 331 Structural Steel and Timber Design Units: 4.00**

The objective of this course is to develop an understanding of the fundamentals in the design of steel and timber structures. To develop this understanding, the course focuses in-depth on the behaviour of steel and timber at the material, element, and system levels with specific reference to standards/codes practicing engineers use when designing with steel and timber in Canada, including CSA S16 and CSA O86. Students will learn how to design and analyze steel and timber tension members, columns, beams (laterally supported and laterally unsupported), beam-columns, and connections.

**Requirements:** Prerequisite of CIVL330 and registered in a BSCE or BASC Academic Program.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 333 Wood Design Units: 2.00**

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 336 Structural Steel/Concrete Des Units: 4.00**

Introduction to limit states design, load paths, sustainability, and life-cycle analysis. Dead and live loads for design as specified in the National Building Code of Canada. Design assumptions regarding material properties of structural steel, concrete, and reinforcing steel. Flexural design of reinforced concrete beams including singly reinforced sections, doubly reinforced sections, T-sections, and one-way slabs. Control of cracking in reinforced concrete beams as specified for design. Flexural design of laterally supported and laterally unsupported structural steel beams. Shear design of structural steel and reinforced concrete beams. Design of tension members in structural steel. Design of axially loaded columns in structural steel and reinforced concrete. (0/0/0/8/40) ~ COURSE DELETED IN 2008/09 ~

**Requirements:** CIVL226 OR CIVL228 OR CIVL226

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 340 Geotechnical Engineering 1 Units: 3.75**

An introductory course focussing on the fundamental mechanics of soil materials (gravel, sand, silt and clay) applied to geotechnical engineering problems. Topics studied include: phase relationships; index properties of coarse and fine grained soils; one-dimensional steady state seepage; effective stress; one-dimensional compression and consolidation; drained and undrained shear strength; and lateral earth pressure. Theoretical material is applied to examine real engineering issues with a particular focus on developing design skills and engineering judgement. Students will conduct physical experiments to explore soil behaviour. The important role of geology on the mechanics of geotechnical materials is emphasized through classroom discussions and problem sets. PPE will be required for this course at student's cost (see course materials for details).

**Requirements:** Prerequisite: CIVL 215 or GEOE 281 (GEO 281), CIVL 230 and registered in a BSCE or BASC Academic Program.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci



**CIVL 341 Geotechnical Engineering 2 Units: 4.00**

A course focussing on design issues and methods of analysis for practical geotechnical engineering problems. Topics studied include: site investigation; capacity and settlement of shallow and deep foundations; two-dimensional steady state seepage; landslides and slope stability. Commercial software will be introduced to perform stability, deformation and seepage analyses. Students will conduct physical experiments to explore how design methods compare with real soil behaviour. The important role of geology in geotechnical design is emphasized through classroom discussions and problem sets. PPE will be required for this course at student's cost (see course materials for details).

**Requirements:** CIVL340

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 342 Geotechnical Design Units: 4.00**

A study of foundation design methods including stress distribution, slope stability, lateral earth pressure, retaining walls, braced walls, anchors, ultimate bearing capacity, foundation design, and piles. (0/0/0/12/36)~ COURSE DELETED IN 2008/09 ~

**Requirements:** CIVL340

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 350 Hydraulics 2 Units: 3.75**

Topics in open channel flow including friction, specific energy, free-surface profiles, culverts and hydraulic-jump energy dissipaters. Lake dynamics and environmental hydraulics will be introduced. The basic underlying concepts of water resources and hydrology will be discussed. PPE will be required for this course at student's cost (see course materials for details).

**Requirements:** CIVL250

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 352 Hydraulic Engineering Units: 3.00**

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 354 Fluid Mechanics Units: 4.00**

Fluid properties, fluid statics, basic equations of fluid flow: Continuity, Momentum, Euler's Equation of Motion, Linear Momentum Equation and Bernoulli's Equation. Flow of real fluid in closed conduits: friction losses and local energy losses. Pipeline flows in engineering practice. (0/4/0/22/22)~ COURSE DELETED IN 2008/09 ~

**Requirements:** Must be registered in BASC

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 355 Introd. Hydraulic Engineering Units: 4.00**

Topics in open channel flow including friction, specific energy, free-surface profiles, culverts and hydraulic-jump energy dissipaters. Turbomachinery including pump characteristics, pump selection and analysis of combinations of pumps and piping systems. Fluid measurement, lift and drag, cavitation and water hammer, dispersion and diffusion are also discussed. (0/5/0/10/33) ~ COURSE DELETED IN 2008/09 ~

**Requirements:** CIVL354

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 360 Civil Engineering Design and Practice III Units: 4.00**

Students will develop and employ Engineering Design and Practice skills to resolve a complex, open-ended design task. This will involve the iterative application of Civil Engineering technical knowledge to identify and evaluate design options. The economic, environmental and societal implications of the preferred solution(s) will be assessed. Students will select, detail and communicate their final design in a logical, traceable and defensible manner. Ethical, legal and other relevant professional issues will be studied and discussed through case studies. Students will also develop and enhance written, graphical and oral communications skills.

**Requirements:** Prerequisite: APSC 200. Must be registered in a BASC or BSCE Academic program.

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 371 Groundwater Engineering Units: 3.75**

This course introduces students to the fundamentals of groundwater systems with an emphasis on the engineering design of extraction systems for water supply, site dewatering, and parameter estimation tests. Source water protection methods will be discussed. Equations governing the flow of groundwater, flownets, and capture zones are presented. Detailed case histories are presented. Laboratories make extensive use of commercial grade software for surface and groundwater flow simulation. PPE will be required for this course at student's cost (see course materials for details).

**Requirements:** Prerequisite of MTHE 224 OR MTHE 225 OR MTHE 232 and registered in a BSCE or BASC Academic Program.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 372 Water and Wastewater Units: 4.00**

The focus of this course is to introduce water and wastewater engineering systems through active learning strategies and hands-on lab experiences. Students will have the opportunity to learn about environmental indicators/measurements/guidelines, reactors, engineered and natural systems, biological and chemical reactions, mass and energy balances, risk assessment, life cycle assessment, and environmental and human health impact assessment. These concepts will allow students to assess a variety of aspects of environmental engineering and design.

**Requirements:** PREREQUISITE: CIVL 210. EXCLUSION: CHEE 370

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 391 Civil Engineering Computation Units: 3.00**

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 393 Systems Analysis In Civil Engr Units: 3.50**

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 400 Professional Skills III Units: 2.50**

Professional skills relating to how engineers interact with, communicate with, and consider the implications of their actions on a wide range of potential stakeholders, ranging from colleagues to clients to society as a whole, will be developed. Students will improve their technical writing and verbal communication skills as they work through case studies intended to: deepen an understanding of the roles and responsibilities of a Professional Engineer; strengthen an ability to apply professional ethics, accountability and equity; and enhance an appreciation of the potential social and environmental impacts of engineering activities. Class discussions will normally occur every second week.

**Requirements:** CIVL 300

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 404 Effective Communication Skills Units: 1.25**

**Requirements:** CIVL304

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 408 Project Management Units: 1.25**

**Requirements:** Must be registered in BASC

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 430 Reinforced Concrete Design Units: 3.75**

Flexural design of reinforced concrete beams including singly reinforced sections, doubly reinforced sections, T-sections, and one-way slabs. Control of cracking in reinforced concrete beams as specified for design. Design of continuous beams and one-way slabs; short and slender columns; footings and retaining walls. A design project is undertaken in this course. PPE will be required for this course at student's cost (see course materials for details).

**Requirements:** CIVL215 CIVL330 CIVL331

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 431 Infrastructure Rehabilitation Units: 4.00**

This course deals with evaluation of the deterioration of the infrastructure and the design of rehabilitation measures. Items discussed include corrosion of reinforcement in concrete, microbiological corrosion of buried pipelines, asphalt deterioration and repair, deterioration of timber in buildings, and issues of sustainability of infrastructure. Design techniques to reduce deterioration in new construction are also discussed. The laboratory portion involves some of the test methods used to evaluate deterioration and field trips to observe some common forms of deterioration. PPE will be required for this course at student's cost (see course materials for details).

**Requirements:** Prerequisite of CIVL 430 and registered in a BSCE or BASC Academic Program.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 433 Structural Theory II Units: 3.00**

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 436 Prestressed Concrete Units: 4.00**

Behaviour, analysis and design of pretensioned and post-tensioned concrete systems including simply-supported and continuous beams, and two-way slabs. Considerations of prestress losses, cracking and deflection. A design project is undertaken in this course. Three term-hours, winter; lectures and tutorials.

**Requirements:** Prerequisite of CIVL 430 and registered in a BSCE or BASC Academic Program.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 437 Concrete Design Units: 4.00**

**Requirements:** CIVL336

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 438 Wood And Masonry Design Units: 3.50**

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 442 Geotechnical Design Units: 3.75**

A design-based course where geotechnical principles are applied to study the design of a variety of geotechnical engineering structures. Topics studied include: design of a site investigation program, interpretation of site stratigraphy, estimation of soil parameters, design of shallow and/or deep foundations, design of earth retaining structures, and construction issues such as dewatering schemes or temporary excavations. Students will conduct practical design tasks to experience a range of aspects of the geotechnical design process, to utilize common models used in geotechnical design, and to communicate with project partners such as structural consultants, site investigation companies, and construction contractors. The important role of geology in geotechnical problems is emphasized through classroom discussions, planning a site investigation and constructing a geologic model.

**Requirements:** PREREQUISITE: CIVL 341. Must be registered in a BSCE or BASC Academic Program.

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 443 Geoenvironmental Design Units: 4.00**

A design-based course where geotechnical and hydrogeologic principles are applied to study environmentally sustainable disposal of solid waste. Topics studied include: source and nature of waste: disposal options; environmental legislation and regulations; public impact and perception; contaminant transport; use of geosynthetic materials; and design issues and tradeoffs. Students will conduct practical design tasks to investigate the planning, design, construction, operation and post-closure of phases of an engineered waste disposal facility. The important role of geology in geoenvironmental problems is emphasized through classroom discussions, planning a site investigation and constructing a geologic model.

**Requirements:** CIVL340

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 450 Municipal Hydraulics Units: 3.75**

The course will present concepts and tools to analyze and design water services, including storm sewers, sanitary sewers, and water mains, at the site- and sub-division level. Many of the concepts and tools are used in the fields of land-development engineering and municipal engineering. The course will provide an introduction to hydrological processes, design rainfall prediction with intensity-duration-frequency curves, estimation of time of concentration, peak runoff prediction in small drainage areas with the Rational Method and the unit hydrograph method, reservoir routing and storm water management tank and pond design, storm sewer analysis and design with Manning's equation, wastewater flow prediction, sanitary sewer analysis and design, water demand prediction, steady-state analysis of pressurized pipes, water main design, and designing water services according to municipal design standards.

**Requirements:** CIVL350

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 451 Lake, Reservoir and Coastal Units: 3.75**

The fundamental hydraulic processes affecting coastal engineering and water reservoir operation are discussed. Topics include wave theory, wave measurement, wave record analysis, wave transformation, seiches, tides, storm surges, turbulent mixing and transport of pollutants. Student projects are assigned on computational water reservoir modelling, analysis of field data and reservoir operation as well as the design of breakwaters and ocean structures and the use of hydraulic and numerical coastal models. PPE will be required for this course at student's cost (see course materials for details).

**Requirements:** CIVL350

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 455 River Engineering Units: 4.00**

A course in the basics of river engineering including the study of alluvial processes, the prediction and consequences of sediment transport, the design of measures to control erosion and accretion, and the design of dams, spillways and diversions. Critical aspects in the design of river engineering structures and assessment of environmental impact of river engineering projects are discussed. The use of physical and numerical models in the practice of river engineering is illustrated. The principles of natural channel design, stream restoration, and bioengineering in river environments are also addressed. PPE will be required for this course at student's cost (see course materials for details).

**Requirements:** CIVL 350

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci



**CIVL 460 Civil Engineering Design and Practice IV Units: 6.00**

This fourth year design capstone course has student teams undertake a comprehensive engineering design project which involves the creative, interactive process of designing a structure/system to meet a specified need subject to economic, health, safety and environmental constraints. The teams will work in collaboration with an industry partner. Each team will submit an engineering report and make an oral presentation PPE will be required for this course at student's cost (see course materials for details) (0/0/12/0/60)

**Requirements:** APSC 200 and APSC 293 and CIVL 360

**Offering Term:** FW

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 462 Civil Engineering Colloquium Units: 3.50**

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 471 Subsurface Contamination Units: 4.00**

This course deals with subsurface contamination by hazardous industrial liquids such as PCB oils, gasoline, jet fuel, chlorinated solvents and coal tars. The fundamentals of multiphase/multicomponent flow and transport in soil and groundwater are outlined followed by specific treatment of both dense and light non-aqueous phase liquids. The course will examine the subsurface distribution of these liquids, site characterization methods, indoor air intrusion, regulatory aspects, remediation technologies, and selected case histories.

**Requirements:** CIVL371 OR GEOE343

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 472 Water Treatment Units: 3.75**

This course describes the physical-chemical treatment processes for water treatment. Students in this course will learn about the chemical and microbiological constituents in source water that determine downstream treatment requirements. Students will explore the fundamental physical, chemical and biological principles that govern unit operations (e.g. coagulation and flocculation; screening, sedimentation, and floatation; filtration; disinfection) and their applications in water treatment plants. Students will learn about plant optimization and apply systems thinking to analyze and design water treatment scenarios. The responsibilities of a professional engineer in ensuring safe drinking water will also be discussed.

**Requirements:** Pre-requisite CIVL 372

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 473 Water Resources Systems Units: 3.75**

This course will present concepts and tools for designing and modelling large-scale water resources systems in urban catchments. Focus will be placed on the design and analysis of urban drainage systems and urban water supply/distribution systems at the catchment level. Hydrologic, hydraulic, and statistical modelling tools used in industry will be used to evaluate the performance of water resources systems. Topics will include: the urban water cycle, environmental considerations in master planning of drainage and water supply systems, climate change impacts on water resources systems, floodplain analysis and flood control, statistical analysis of rainfall and stochastic hydrology, continuous simulation modelling, planning and modelling of large-scale urban drainage systems, planning and modelling of large-scale water distribution systems, reliability analysis and water quality analysis of water distribution systems, and the master planning process for urban drainage and drinking water systems.

**Requirements:** Prerequisite: CIVL 350. Must be registered in a BSCE or BASC Academic Program.

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 484 Environmental Systems Mgmt Units: 3.00**

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 490 Selected Topics in Civil Engineering Units: 3.75**

Providing advanced study and application of selected topics in Civil Engineering, this course will be offered periodically by visiting faculty and professionals. Consult the department homepage for opportunities.

**Requirements:** Must be registered in the BASC program and Successful completion of 3rd year Civil Engineering and permission of the Department.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 491 Selected Topics in Civil Engineering Units: 4.00**

Providing advanced study and application of selected topics in Civil Engineering, this course will be offered periodically by visiting faculty and professionals. Consult the department homepage for opportunities.

**Requirements:** Must be registered in the BASC program and Successful completion of 3rd year Civil Engineering and permission of the Department.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci



**CIVL 500 Civil Engineering Thesis Units: 4.00**

Working closely with a faculty member, students will conduct research on a civil engineering or related applied science topic. Students will: identify a problem; formulate a research question; and devise and implement a research plan. The nature of the research may involve obtaining experimental measurements, performing field testing and/or numerical analysis, and analysing and interpreting research results. Students will prepare a comprehensive, written technical report and will defend their research in an oral examination. Registration is limited to a maximum of twenty (20) students. PPE will be required for this course at student's cost (see course materials for details).

**Requirements:** PREREQUISITES: successful completion of 3rd year civil engineering with a minimum sessional average of 70%

**Offering Term:** FW

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 801 Health and Safety in Civil Engineering Research Units: 0.00**

**Offering Faculty:** School of Graduate Studies

**CIVL 820 Topics In Elasticity & Plast. Units: 3.00**

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 822 Structural design of buried pipes Units: 1.50**

Overview of soil-pipe interaction, design of rigid pipes for bending moments, design of flexible pipes for thrust and deformation, and design of profiled thermoplastic pipes considering local buckling and local bending. (1.5 credit units)

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 823 Pipe repair using liners Units: 1.50**

Overview of pipe deterioration and lining methods available for repair, liner design of gravity flow pipes to withstand external fluid and soil loads, and liner design for pressure pipes. Introduces the design code for cured in place liners and the instructor's design procedures. (1.5 credit units)

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 824 Pipe replacement using bursting Units: 1.50**

Overview of pipe replacement by pipe bursting, the causes of ground movement and their effects on other infrastructure, and the expected and allowable pulling forces needed to pull the new pipe into place. It introduces the instructor's simplified design tools and their limitations. (1.5 credit units)

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 825 Horizontal directional drilling Units: 1.50**

Overview of directional drilling, use of drilling mud and causes for and prevention of mud loss, soil-pipe interaction and the expected and allowable pulling forces. It introduces the current ASTM design code and the instructor's simplified design tools and their limitations. (1.5 credit units)

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 828 Serviceability Of Concr Struct Units: 3.00**

This course is intended to provide structural engineers with an in-depth understanding of the performance of reinforced, prestressed and composite concrete-steel structures under service conditions, including both the short and long term performances. The course deals with the effects of creep and shrinkage of concrete, relaxation of prestressing steel, temperature, and settlement of supports on deflections, cracking and internal forces. The displacement and force methods of analysis are used to account for these affects in calculating the deformations and time dependent forces and moments. The course also covers the effects of construction and loading in different stages. The course deals only with service conditions and doesn't deal with concrete structures at the ultimate stage or at failure. Lecture based, 3 hrs/week.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 830 Advanced Structural Analysis Units: 3.00**

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 831 Assessment and Monitoring of Infrastructure Units: 3.00**

This course provides an introduction to commonly used numerical assessment techniques (e.g. plastic collapse and FEA) and discusses the pros and cons of these techniques. Monitoring technologies (e.g. fibre optic sensors, conventional transducers etc.) are then investigated and discussed with a focus on supporting experimental work and assessment.

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 832 Finite Element Analysis Units: 3.00**

The objective of this course is to introduce the students to the finite element method and its applications in civil engineering using commercial finite element software. A course presenting the fundamental ideas involved in conventional finite element analysis in civil engineering. Domain discretization, interpolation and shape functions, element derivation and types, element stiffness or property equations, assembly procedure, boundary conditions, solution methods for the algebraic equation system, and stress analysis. Students will, throughout the course, write and test their own finite element code through individual subroutine construction as the course progresses. PREREQUISITE: Students must have a strong background in Numerical Methods, Structural Analysis and Applied Mathematics for Civil Engineers to take this course.

**Offering Faculty:** Fac of Engineering Appl Sci



**CIVL 833 Advanced Materials for Civil Engineering Units: 3.00**

Engineering materials, material properties and characterization, modern steel manufacturing; ferrous alloys, structural carbon steels, special steels; structural aluminum, welding effects on metals, Portland cement concretes, morphology and properties, advanced engineering concretes, durability, pozzolans, admixtures, polymers and fibre reinforced polymers, mechanics and durability, selected additional topics, recent advances and applications. Laboratory experiments will be used to strengthen lecture topics. A seminar project is usually undertaken in this course.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 834 Advanced Reinforced Concrete Units: 3.00**

Philosophy of design criteria, elementary probabilistic considerations; strength theory for reinforced and prestressed elements in bending, shear and torsion and their interactions; yield line and strip method of slab design; theory of plasticity as applied to concrete. A seminar project is usually undertaken in this course. Three term-hours; lectures.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 835 Adv. Infrastructure Materials Units: 3.00**

History of engineering materials, material properties and characterization; Portland cement concretes, morphology and properties, advanced engineered concretes, durability; ferrous alloys, structural steels, corrosion, special steels; structural aluminum; fibre reinforced polymers, mechanics and durability; selected additional topics; recent advances and applications. A seminar project is usually undertaken in this course. Three term-hours.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 836 Advanced Steel Design Units: 3.00**

Limit States Design theory; stability theory, P-delta effects and the design of beam-columns; design of suspended spun roofs; cost estimation; welded connections; design of plate girder; fatigue design; assessment and repair of fatigue damage. A project is usually undertaken in this course. Three term-hours.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 837 Prestressed Concrete Units: 3.00**

Behaviour, analysis and design of pretensioned and post-tensioned concrete systems including simply supported and continuous beams. Considerations of prestress losses, cracking, deflection and anchorage zones. A design project is undertaken in the course. Three term-hours.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 838 Fibre Reinforced Polymers Units: 3.00**

This course considers the design of new concrete structures reinforced or prestressed with fibre reinforced polymer (FRP) reinforcement, and the design of FRP repairs for existing concrete structures. Topics will include properties of FRP reinforcement, flexural design with internal FRP, shear design of concrete reinforced with internal FRP, prestressing with FRP, flexural and shear strengthening of concrete beams and slabs with external FRP, and confinement of concrete columns with FRP. Three term hours.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 839 App. Struc. Analysis Units: 3.00**

This course will present a number of advanced approximate methods for analyzing structures. Topics covered include: analysis of statically indeterminate trusses and frames; model analysis; energy principles; numerical integration for solving structural problems including Newmark's method and beams on elastic foundations; structural vibrations including Rayleigh's principle, Stodola's iteration technique, and distributed mass systems using Newmark's method; structural stability including the energy criterion for stability, lower-bound methods, the method of Vianello, columns with lateral loads, Perry's approximation, the conjugate beam method, stability of unbraced frames and multi-storey building frames; plastic collapse of plane frames, including the plastic moment of a cross-section, and limit theorems of plastic collapse; limit analysis of plates and slabs including the upper and lower bound methods, failure mechanisms, combined loading, and the strip method for slab design. Three term hours.

**Offering Term:** N

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 840 Advanced Soil Mechanics Units: 3.00**

Current theories on the yielding and failure of normally consolidated and overconsolidated clays and granular materials are presented and discussed in lectures. The usefulness and limitations of critical state theory to predict soil behaviour is then evaluated against real soil behaviour observed in triaxial tests. Additional advanced topics include: fracture, anisotropy, partial saturation, creep and cyclic loading. A seminar project is usually undertaken in this course. Three term-hours, (every second year beginning 2005-2006).

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 842 Foundation Engineering Units: 3.00**

Topics and seminars to be chosen from soil classification, compaction, swelling, frost, seepage, stress distribution, settlement, site investigation, shallow and deep foundations, site and soil improvements, excavations, retaining and support structures, and overall stability problems. Three term-hours. Held at Queen's or RMC depending on enrolment. NOTE: This is a joint course with RMC Civil Engineering Department.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 843 Landslides Units: 3.00**

Current theories on the behaviour of partially saturated soils are presented and discussed in lectures with particular attention paid to their application to the topic of slope stability. The slope stability issues of limit analyses, rapid drawdown, seismic analysis, static liquefaction, three-dimensional effects, and the appropriate choice of design parameters will be discussed. Design and seminar projects are usually undertaken in this course. Three term-hours, (every second year beginning 2006-2007).

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 844 Geotechnical analysis 1: Elasticity Units: 1.50**

Overview of equilibrium and classical elasticity; introduction to elastic finite element analysis; derivation of stiffness equations using the principle of virtual work; static and kinematic boundary conditions; error checking. (1.5 credit units)

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 845 Geotechnical analysis 2: Inelastic analysis Units: 1.50**

Overview of equilibrium and classical plasticity; failure criteria; flow rule and elastic plastic constitutive response; inelastic finite element analysis; modelling and solution of geotechnical engineering problems. (1.5 credit units)

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 846 Human Factors and GeoEngineering**

**Projects Units: 3.00**

Human factors affecting the success of geoengineering projects are examined predominantly through a series of Case Studies. A major focus will be on the human related causes of engineering failures (often ending in legal cases). Technical issues will be discussed as needed to understand the issues but a focus will be made on how many poor engineering and/or management decisions accumulated to result in the final problem in most cases.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 847 Geosynthetics In Geotech. Engr Units: 3.00**

Topics include: types of geosynthetics and manufacturing processes; properties and test methods; methods of analysis and design for geosynthetics used for separation, filtration, soil reinforcement, erosion control and liquid/hazardous waste containment. Held at Queen's or RMC depending on enrolment. Three term-hours, lectures. NOTE: This is a joint course with RMC Civil Engineering Department.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 848 Landfill Design Units: 3.00**

Geoenvironmental aspects of waste management are examined with particular emphasis on the design of systems to provide long term protection against groundwater contamination. A major focus is the integration of engineering design and hydrogeologic considerations and contaminant transport through barrier systems and natural soils. Three term-hours.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 849 Polymer Microstructure and Testing in Civil Engineering Applications Units: 1.50**

This course introduces the Microstructure and testing for polymeric materials used in civil engineering applications. This course will be focused on fundamental knowledge essential to civil engineers to understand the performance of polymeric materials used in different applications such as geotechnical engineering and structural engineering. (1.5 credit units)

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 850 Advanced Fluid Mechanics Units: 3.00**

Fundamental equations of real fluid flows are developed and discussed using vector and tensor notations. Some exact and approximate solutions of these equations are introduced. The stability of laminar flows and the transition to turbulence are examined; the Reynolds equations are derived and some applications of these equations are investigated. The boundary layer concept is introduced. Recent developments in the theory of turbulence are outlined and discussed. Three term-hours.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 852 Environmental Fluid Dynamics Units: 3.00**

Topics to include: conservation equations for turbulent flows; wall-bounded shear flows; spectral dynamics; measurement and modelling of mixing and dissipation in stratified flows; stability of stratified flows; linear, nonlinear and dispersive waves (e.g. seiches, Kelvin waves, Poincare waves and solitary waves); internal wave breaking; convection. Theory will be discussed with reference to field observation, computational and laboratory modelling of lake and ocean flows. Three term-hours. Lectures.

**Offering Term:** N

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 853 Water Waves Units: 3.00**

Theories of periodic gravity waves, wave spectrum concepts and applications such as wave-sediment interaction, coastal modelling, coastal morphology and design of structures are the major topics treated. Emphasis will be on both theoretical analysis and practical design as well as on both hydraulic and mathematical modelling. Three term-hours.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 855 Hydrodynamics Of Coasts Units: 3.00**

Equilibrium theory of tides, tide recording, tidal analysis and prediction, one and two-dimensional tidal computation in estuaries and seas, salinity, sedimentation, pollution in estuaries, storm surges and tsunamis, and tidal inlets are the major topics treated. Emphasis will be on both theoretical analysis and practical design. Three term-hours.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 856 River Morphodynamics Units: 3.00**

Aspects of the bed and bank deformation of alluvial rivers will be addressed. Topics covered include hydraulics of flow in river channels; mechanics and quantification of sediment transport; sediment transport continuity equation; bed forms and flow resistance; regime concept and determination of equilibrium (stable) alluvial channels; adjustments of equilibrium and river channel changes; geometry and mechanics of meandering and braiding streams; local scour and related problems. Computer-aided study of alluvial river processes will be discussed. Three term-hours.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 857 River Engineering Units: 3.00**

A course in the basics of river engineering including the study of alluvial process, the prediction and consequences of sediment transport, the design of measures to control erosion and accretion, and the design of dams, spillways and diversions. Hydraulic modelling of fluvial processes and engineering structures is addressed. Water quality including transport and mixing of conservative and non-conservative substances is discussed. Techniques for water quality monitoring, and control and bioengineering in a riverine environment are also addressed. Three term-hours.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 858 Computational Hydraulics Units: 3.00**

Fundamental numerical algorithms and computational schemes will be introduced and applied to the solution of flows frequently encountered in the practice of hydraulic engineering. Topics covered include solution of non-linear equations; tridiagonal and block-tridiagonal systems of equations; solution of partial differential equations (finite difference schemes, control volume approach); grid generation. Applications to the determination of flow velocity and pressure fields of selected 1-D and 2-D laminar and turbulent open-channel flows will be considered. Three term-hours.

**Offering Faculty:** Fac of Engineering Appl Sci



**CIVL 859 Fundamentals Of Coastal Engr. Units: 3.00**

This course covers basic wave theory, wave measurement, wave statistics, wave record analysis, wave transformation, tides, water levels and storm surges. It introduces design of breakwaters and ocean structures, and uses hydraulic and numerical coastal models. Utilization of bioengineering in the coastal zone is addressed. Design and construction issues associated with harbours and marinas are discussed. Shoreline stability in relation to sediment transport and external environmental parameters are introduced. Environmental considerations, coastal zone management, coastal sediment transport and design in the coastal zone are also treated. Three term-hours.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 870 Transportation Studies Units: 3.00**

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 874 Advanced Pavement Design Units: 3.00**

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 879 Transportation Systems Units: 54.00**

**Offering Faculty:** Faculty of Arts and Science

**CIVL 880 Subsurface Contamination Units: 3.00**

This course deals with subsurface contamination by hazardous industrial liquids such as PCB oils, gasoline, jet fuel, chlorinated solvents and coal tars. The fundamentals of multiphase/multicomponent flow and transport will be outlined followed by specific treatments of both dense and light non-aqueous phase liquids. The course will examine the subsurface distribution of these liquids, sampling and detection, clean-up technologies, regulatory aspects, and selected case histories. (CIVL-480 plus additional material.) Three term-hours.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 881 Fractured Rock Flow/Transport Units: 3.00**

The course will cover a review of structural geology relevant to hydrogeology, an introduction to the cubic law, transport in discrete fractures, flow and transport in fracture networks, methods for measurement of parameters (i.e. hydraulic testing), modelling of flow through fractures and fracture networks, groundwater flow in low permeability environments and a detailed case study.

**Offering Faculty:** Faculty of Arts and Science

**CIVL 882 Groundwater Modeling Technique Units: 3.00**

This course will provide an advanced treatment of groundwater modeling techniques. The student will be introduced to analytical methods based on advanced calculus and to traditional and novel numerical methods. Topics in analytical methods will include the Laplace transform technique for PDEs, other integral transform methods, the analytical element method, and applications to radial groundwater flow and linear solute transport problems. Topics in numerical methods will include the Galerkin finite element technique, the use of quadrilateral, triangular, and line elements, an introduction to direct and iterative solvers, and applications to linear and non-linear groundwater flow and transport problems. Three term hours.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 883 Gases in Groundwater Units: 3.00**

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 884 Field Methods in the Hydrogeology of Fractured Rock Units: 3.00**

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 885 Chemistry Of Natural Waters Units: 3.00**

This course covers several topics in the area of natural water chemistry including: dilute aqueous solution chemistry of surface and groundwater systems; chemical kinetics and equilibrium; acid-base chemistry; coordination chemistry; precipitation, dissolution and complex formation; carbonate, phosphate and chlorine chemistry; oxidation-reduction reactions and corrosion; and solution of multi-equilibria problems. Three term hours.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 886 Biological Treatment Processes Units: 3.00**

This course will develop the principles and operation of biological treatment processes with particular emphasis on the microbiological aspects of these operations. The application and design of different treatment methodologies, incorporating aerobic and anaerobic techniques, will be detailed for various wastes. The management, processing and disposal of treatment residuals will be presented. Selected advanced and innovative small-scale treatment options will be described. Three-term-hours.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 887 Biomass Conversion Units: 3.00**

This course introduces the pertinent underlying concepts for the conversion of biomass to bioenergy, biofuels and higher value bio-based products considering the interface of biotechnology, microbiology, chemistry and material science and how processes can be successfully engineered to support/promote environmentally sound practices.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 888 Groundwater Flow & Transport Units: 3.00**

This advanced course examines the theoretical foundations of ground-water flow and contaminant transport. Topics covered include potential concepts, groundwater flow, aquifer-aquitard systems, unsaturated flow, reactive and non-reactive solute transport, stochastic flow and transport, fractured media, and density-dependent transport. Three term-hours.

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 889 Bioremediation Units: 3.00**

Bioremediation as an option to treat contaminated soils, ground water, fresh water and the marine environments. Advantages and disadvantages of bioremediation compared to nonbiological processes. Factors affecting choice of in situ or ex situ processes. Assessment of biodegradability; biostimulation vs. bioaugmentation; mineralization vs. partial degradation; factors affecting microbial activity (choice of electron acceptor, toxicity of pollutant, C/N/P ratio, co-substrates, soil humidity, pH and temperature); bioavailability of pollutant. Biodegradation of specific contaminants (eg. Diesel fuel, polychlorinated biphenyls, dyestuffs, aromatic and polyaromatic hydrocarbons) will be studied in detail. This course is co-taught with CHEE-884.

EXCLUSION: CHEE-884

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 890 Water Network Analysis/Design Units: 3.00**

Topics to include: review of basic fluid mechanics of closed-conduit flow; hydraulic characteristics of pumps, valves, tanks and reservoirs; network hydraulics (includes pipes in series and parallel, systems of equations for steady state network flow and solution algorithms, fire analysis, unsteady flow conditions, extended period simulation, hydraulic transients); water quality simulation (includes transport mechanisms, reaction kinetics, mixing in storage facilities, transport and mixing in pipe network, steady state and dynamic water quality modelling); water demand and design standards; master planning of water networks. The course will also cover advanced topics in: water network optimization, sensor placement, contaminant detection, sustainable water systems, dual water systems and water re-use. Three term hours.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 891 Water Quality in Distribution Systems Units: 3.00**

This course presents approaches to analyze and model drinking water quality and discolouration in distribution systems. The course covers approaches in aquatic chemistry for the testing of drinking water. Transport processes and advanced topics in discolouration of drinking water are examined with emphasis on the measurement and modelling of the growth and mobilization of cohesive layers in pipes.

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 892 Structural Dynamics Units: 3.00**

The objective of this course is to introduce students to structural dynamics and its practical application in earthquake engineering. Topics include single and multi-degree-of-freedom systems, formulation of equations of motion, methods of analytical mechanics, free and forced vibration, numerical methods and the use of computer software for the response analysis of structural systems.

**Offering Term:** W

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 895 Special Topics In Civil Engr. Units: 3.00**

Current topics of interest to civil engineering students, as well as other engineering and non-engineering students, will be presented. Staff

**Offering Term:** F

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 896 Sustainable Engineering in Remote Areas Units: 3.00**

This seminar/workshop series and associated online modules are comprised of three main streams including Aboriginal issues (culture, legal and policy issues), social issues and sustainability standards, and business skills training. This course is a mandatory component of the NSERC CREATE training program on Sustainable Engineering in Remote Areas.

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 897 Water Policy and Governance Units: 3.00**

This course investigates waters governance from the science, engineering and policy aspects found around the world.

This course is designed to engage graduate students in discussions on a wide range of governance issues relating to water in a way that is relevant to their current field of study. Specific policies and governance that are relevant world-wide will be covered and include climate change, water quality, water supply, water and the environment and water and human health. This course, although placed in the Department of Civil Engineering, is designed for inclusion in the course offerings from departments across Queen's University.

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 898 Master's Project Work Units: 3.00**

The department requires three copies of a Master's Report. These will be retained by the department.

**Offering Term:** FWS

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 899 Master's Thesis Research Units: 6.00**

See Graduate School regulations concerning thesis requirements.

**Offering Term:** FWS

**Offering Faculty:** Fac of Engineering Appl Sci

**CIVL 999 Ph. D. Thesis Research Units: 6.00**

See Graduate School regulations concerning thesis requirements.

**Offering Term:** FWS

**Offering Faculty:** Fac of Engineering Appl Sci