

# CIVIL ENGINEERING (CIVL)

NOTE: Most courses offered in the Civil Engineering Department are of one term in length (3.0 credit units). Courses that are 1.5 credit units are as shown in the course descriptions below. Examinations are held at the end of each term.

All listed courses may not be offered each year.

## **APSC 801 Master of Engineering Foundations**

An introduction to the Master of Engineering (MEng) graduate studies program at Queen's University. The course provides students with essential administrative information, an introduction to information literacy within the Faculty of Engineering and Applied Science, as well as an overview of the various support services on campus. Additionally, the course contains several modules on professional and career skills. This non-credit course is comprised of a number of individual modules, and its completion is a requirement to graduate from the MEng program. Graded on a Pass/Fail basis.

Prerequisite: Enrolment in the MEng program.

Exclusion: Students not enrolled in the MEng program.

## **APSC 810 Teaching and Learning in Engineering**

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

## **APSC 812 AI Ethics and Society**

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

## **APSC 877 Engineering Project Management**

The course will examine the essential skills and knowledge required for effective engineering project management. The foundational principles of project management including integration, scope, cost, time, human resources, stakeholders

and procurement are examined. The course will be delivered online.

Exclusions: MECH 896, APSC 223

## **APSC 888 Engineering Innovation and Entrepreneurship**

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

EXCLUSION: CHEE 410

## **APSC 896 Engineering Leadership**

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

## **CIVL 801 Health and Safety in Civil Engineering Research**

An introduction to safety procedures in civil engineering research. This non-credit course consists of a general introduction lecture and modules on: (i) specimen & experiment fabrication, (ii) chemical & biohazard safety and (iii) field research. ALL students must successfully complete CIVL 801 at the first opportunity. Fall, Winter and Summer.

## **CIVL 822 Structural design of buried pipes**

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)

## **CIVL 823 Pipe repair using liners**

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)

## **CIVL 824 Pipe replacement using bursting**

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)



### **CIVL 825 Horizontal directional drilling**

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)

### **CIVL 828 Serviceability of Concrete Structures**

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.

### **CIVL 831 Assessment and Monitoring of Infrastructure**

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.

### **CIVL 832 Finite Element Analysis**

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.

### **CIVL 833 Advanced Materials for Civil Engineering**

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. Three term-hours, Fall. D. Cree

### **CIVL 834 Advanced Reinforced Concrete**

This course aims at developing an in-depth understanding of the fundamental structural behavior of reinforced concrete members subjected to a variety of loading conditions. The topics include introduction of material properties and design approaches, flexural behavior using actual material constitutive relationships, bi-axial bending with or without axial loads, slender columns, serviceability, ductility, shear analysis using various advanced approaches such as truss model, strut and tie model and compression field theories, torsion, two-way slabs including yield line theory, and FRP reinforcement for concrete structures (Three lecture hours a week).

### **CIVL 835 Advanced Infrastructure Materials**

Design of masonry, fibre reinforced polymer (FRP) and wood structures is covered. Topics include design of masonry beams and walls; seismic design of masonry structures; manufacturing techniques for FRPs; stiffness and strength design for FRPs; design of wood beams and columns; wood connections. A project is normally undertaken in the course. Three term-hours, fall (offered in alternating years).

### **CIVL 836 Advanced Steel Design**

Applications of Linear Elastic Fracture Mechanics; Fatigue of Steel Structures; Stability and Design of Columns; Stability and Design of Beams; Stability and Design of Beam-Columns; Stability, Analysis, and Design of Frames. Three term-hours, Summer.

### **CIVL 837 Prestressed Concrete**

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, winter. A.Z. Fam

### **CIVL 838 Design of Concrete Structures with Fibre Reinforced Polymers**

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, Winter.

### **CIVL 839 Approximate Structural Analysis**

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, spring. C. MacDougall.

### **CIVL 840 Advanced Soil Mechanics**

Current theories on the yielding and failure of soils are presented and discussed in lectures. Topics include stress-dilatancy, critical state soil mechanics, and the interpretation of triaxial test data. Additional advanced topics are investigated through a seminar project including fracture, anisotropy, time dependent behavior, and cyclic loading. Three term-hours, Fall (offered in alternating years).W.A. Take.

### **CIVL 842 Foundation Engineering**

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, winter. Held at Queen's or RMC depending on enrolment. NOTE: This is a joint course with RMC Civil Engineering Department.

### **CIVL 843 Landslides**

Mechanisms and methods of analysis of landslide triggering are presented and discussed in lectures along with various remedial and preventative measures. Topics include triggering processes, and remediation through earthworks, erosion control measures, dewatering, anchors, and retaining structures. A seminar project is usually undertaken in this course. Three term hours, Fall (offered in alternating years). W.A. Take.

### **CIVL 844 Geotechnical analysis 1: Elasticity**

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)

### **CIVL 845 Geotechnical analysis 2 : Inelastic analysis**

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)

### **CIVL 846 Human Factors and GeoEngineering Projects**

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.

### **CIVL 847 Geosynthetics in Geotechnical Engineering**

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, fall, lectures. NOTE: This is a joint course with RMC Civil Engineering Department.

### **CIVL 848 Sustainable Barrier System Design**

Design of fluid containment systems considering hydrogeology, climate change, and contaminant transport for applications including landfills (e.g., containing PFAS), lagoons (containing leachate, mining, brine, and RO water), tailings storage facilities, heap leach mining, and dams for storage of clean energy. UN SDG 6, 7, 9 & 12. (3.0 credit units). Three term-hours, winter. R. Brachman.

### **CIVL 849 Polymer Microstructure and Testing in Civil Engineering Applications**

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).

### **CIVL 850 Advanced Fluid Mechanics**

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, fall. A.M. da Silva.

#### **CIVL 851 Introduction to Hydrodynamic Modelling**

This course will develop fundamental modelling tools that are used to model surface- and groundwater processes. Students will be introduced to the essential elements of dimensional analysis, scaling analysis, and model development, which provide the leading-order solution of a system. Emphasis will be placed on comparing model predictions with measured data. (3.0 credits: term course delivered in one 12-week semester, 3 hours/week)

Prerequisites:

- Permission of instructor;
- Graduate students in science and engineering must have a strong background in Applied Mathematics to take this course;
- Students should have previously taken courses in numerical methods and environmental hydraulics.

#### **CIVL 852 Environmental Fluid Dynamics**

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. L. Boegman.

#### **CIVL 853 Water Waves**

Fundamentals of surface gravity wave physics including generation, propagation, dispersion, refraction, diffraction, reflection and dissipation are covered. Topics include wave theories, spectral analysis, wave momentum flux, wave-driven currents, wave-sediment interactions, wave forces and design of structures. Emphasis will be on theoretical analysis and practical engineering design, as well as on physical and numerical modelling (Three lecture hours per week). R.P. Mulligan.

#### **CIVL 855 Hydrodynamics of Coasts and Estuaries**

An advanced class in physical processes acting in coastal environments ranging across the continental shelf to estuaries, river deltas, beaches, barrier islands and tidal inlets. Topics include surface waves, long waves, storm surges, tides, mixing, coastal circulation, wind forcing, upwelling, salinity, morphology, sediment transport and contaminant dispersion. Observation and prediction methods will be covered and examples from major events such as

hurricanes and tsunamis will be discussed. Emphasis will be on theoretical analysis, numerical model applications and engineering designs (Three lecture hours per week). R.P. Mulligan

#### **CIVL 856 River Morphodynamics**

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, fall.

#### **CIVL 857 River Engineering**

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, winter. A.M. da Silva.

#### **CIVL 858 Computational Hydraulics**

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, winter.

#### **CIVL 859 Fundamentals of Coastal Engineering**

This course covers wave theory, wave measurement, wave statistics, wave transformation, wave modelling, tides, water levels and storm surges. It introduces design of breakwaters and other coastal structures, and uses hydraulic and numerical coastal models. Utilization of bioengineering and beach nourishment 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 considered. (Three lecture hours per week). R.P. Mulligan

#### **CIVL 880 Subsurface Contamination**

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, fall. B. Kueper

#### **CIVL 881 Flow and Transport in Fractured Rock**

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.

#### **CIVL 882 Analytical and Numerical Methods in Groundwater Modeling**

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 and other integral transform methods, with applications to radial groundwater flow and linear solute transport problems. Topics in numerical methods will include a brief introduction to Finite Difference and Finite Element theory and the practical application of numerical methods to groundwater flow and transport problems. Three term hours, Fall.

#### **CIVL 883 Gases in Groundwater**

Advanced topics in multiphase flow relevant to gases in subsurface porous media, focused on contamination and remediation, with emphasis on fundamental theory and conceptual models. Lecture topics include interfacial properties, pore-scale conceptual models, phase partitioning, vapour transport, bubble flow, and mass transfer to trapped gases. Three term-hours, Winter (alternating years). K.G. Mumford

#### **CIVL 884 Field Methods in the Hydrogeology of Fractured Rock**

This course will provide students with hands-on experience in conducting the field techniques typically used for the

characterization of fractured rock aquifers. The course will include a combination of lecture material and field testing. The course will be delivered at the Kennedy Field Station and will involve approximately six days of on-site testing.

#### **CIVL 885 Chemistry of Natural Waters**

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, winter.

#### **CIVL 886 Biological Treatment Processes**

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, fall. B.C. Anderson.

#### **CIVL 887 Biomass Conversion**

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.

#### **CIVL 888 Theory of Groundwater Flow and Transport**

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, winter. B.H. Kueper

#### **CIVL 889 Bioremediation**

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

#### **CIVL 890 Water Network Analysis/Design**

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, winter.

#### **CIVL 891 Water Quality and Discolouration in Drinking Water Distribution Systems**

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.

#### **CIVL 892 Structural Dynamics**

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. Three term-hours, fall.

#### **CIVL 895 Special Topics in Civil Engineering**

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

#### **CIVL 896 Sustainable Engineering in Remote Areas**

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.

#### **CIVL 897 Water Policy and Governance**

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.

#### **CIVL 898 Master's Project**

The department requires three copies of a Master's Report. These will be retained by the department. (3.0 credit units)

#### **CIVL 899 Master's Thesis**

See Graduate School regulations concerning thesis requirements.

#### **CIVL 999 Ph.D. Thesis**

See School of Graduate Studies and Postdoctoral Affairs regulations concerning thesis requirements.