



## **Confirmatory Exam Program Requirements Geological Engineering**

**Geological Engineering Technical Exams.** You must choose three of your four exams from the Geological Engineering Technical Exam list. Two of these exams must be from Group A and one from Group B listed below.

**The following restrictions apply:**

If you choose 18-Geol-A2, **do not** choose 18-Geol-B1

<b>Geological Engineering Technical Exams</b>			
<b>Group A</b>		<b>Group B</b>	
18-Geol-A1	Mineralogy and Petrology	18-Geol-B1	Contaminant Hydrogeology
18-Geol-A2	Hydrogeology	18-Geol-B2	Terrain Analysis
18-Geol-A3	Sedimentation and Stratigraphy	18-Geol-B3	Site Investigation
18-Geol-A4	Structural Geology	18-Geol-B4	Geomorphology and Pleistocene Geology
18-Geol-A5	Rock Mechanics	18-Geol-B5	Environmental Geology
18-Geol-A6	Soil Mechanics	18-Geol-B6	Resource Geology – Select <u>ONE</u> from 18-Geol-B6-1 Petroleum Deposits 18-Geol-B6-2 Coal Deposits 18-Geol-B6-3 Metallic and Industrial Mineral Deposits
18-Geol-A7	Applied Geophysics	18-Geol-B7	Petroleum Development
		18-Geol-B8	Resource Economics & Valuation
		18-Geol-B9	Exploration & Mining Geology
		18-Geol-B10	Geophysical Exploration Methods Select <u>ONE</u> from 18-Geol-B10-1 Gravity and Magnetic Fields 18-Geol-B10-2 Electrical Methods 18-Geol-B10-3 Exploration Seismology

**Complementary Studies.** You must also choose one exam from the Complementary Studies below.

<b>Complementary Studies</b>	
11-CS-1	Engineering Economics
11-CS-2	Engineering in Society – Health & Safety
11-CS-3	Sustainability, Engineering and the Environment
11-CS-4	Engineering Management





## PEO'S TECHNICAL EXAMINATION PROGRAMS

### WHY A TECHNICAL EXAM PROGRAM?

The academic requirement for licensing as a professional engineer in Ontario is a bachelor's degree in engineering from an accredited program at a Canadian university or its equivalent.

The Canadian Engineering Accreditation Board (CEAB) accredits undergraduate engineering degree programs on behalf of the provincial/territorial engineering associations/order, including PEO.

Applicants who do not hold a bachelor's degree in engineering from a CEAB-accredited program may be required to pursue either PEO's *Confirmatory* or *Specific* exam program to demonstrate that they possess the equivalent academic background for licensing purposes.

**PEO's TECHNICAL EXAM PROGRAMS *Confirmatory Exam Program (CEP)*.** Applicants whose undergraduate Bachelor's engineering degree was obtained via a program that appears to be similar to the respective CEAB-accredited program are usually assigned a Confirmatory Exam Program, which consists of four exams. The intent is to give the applicant an opportunity to demonstrate that s/he has an academic preparation that is deemed to be equivalent to that of a graduate of a CEAB-accredited program.

***Specific Exam Program (SEP)*.** If PEO's assessment reveals that an applicant's academic qualifications are below the established Canadian standard, s/he will be assigned a Specific Exam Program aimed to remedy identified deficiencies for licensing purposes. A Specific Exam Program may consist of Basic Studies exams, discipline-specific exams, Complementary Studies exams and a thesis.

Basic Studies exams are a prerequisite and must be addressed first; PEO will re-evaluate the applicant's file following the successful completion of all Basic Studies exams and may modify the original exam program, and advise the applicant of the options available to address any outstanding exams.

### TIME LIMITS FOR WRITING EXAMS

PEO's technical exams are offered twice annually (in May and December).

Applicants must write at least one exam within two academic years following the date of receipt of their exam program notification. Once the exam program is commenced, the applicant must write at least one exam each academic year or the file will be closed. All exam programs must be successfully completed within eight academic years of the date that the applicant was notified of his/her exam program. ("Academic Year" means the period starting September 1 in a year and ending August 31 in the following year.)

### HAVING THE FILE CLOSED

An application file will be closed if any one of the following conditions applies:

- not completing all exam requirements within the specified time limit;
- not writing at least one exam in each academic year after writing the first exam;
- failing the same exam on three attempts;
- failing a total of five exams;
- failing two Basic Studies exams; or
- failing to write a failed exam within one academic year for CEP.

### PERFORMANCE STANDARDS

The pass mark for all PEO exams is 50%.

***Confirmatory Exam Program.*** An applicant will be considered to have successfully completed the CEP if the average of the technical exam marks is at least 55% and a pass mark (at least 50%) was received on the Complementary Studies exam.

If an applicant fails two exams or fails the same exam twice in a CEP, s/he may be assigned a Failed-to-Confirm exam program, which may consist of additional exams in the Basic Studies, discipline-specific and Complementary Studies categories.

### GOOD-PERFORMANCE REVIEW POLICY

***Confirmatory Exam Program.*** To meet the "good-performance" review criterion, an applicant must have written two technical exams at the first sitting and achieved a minimum average of 65% with no mark below 60%.

After a second exam sitting, if an applicant has passed three technical exams with no mark below 60%, s/he may receive consideration for exemption from writing the Complementary Studies exam. If an applicant attempted two exams in the first sitting but failed one, s/he may still qualify for a "good-performance" review if s/he passes the failed exam with a mark of 70% or higher and achieves 60% or higher on the previously unwritten technical exam attempted at the second sitting.

**Important:** If an applicant has been assigned a **Directed Confirmatory Exam Program**, the good performance criteria are different; to be eligible, in addition to meeting the above criteria, all the directed exams must be addressed as well. Applicants are advised to contact the Exam Centre to discuss further.

#### Note:

- Good-Performance reviews are not applicable to Specific Exam Program and Failed-to-Confirm exam program applicants.

### WHEN AND WHERE PEO EXAMS ARE OFFERED

PEO technical exams are held in May and December at 14 centres in Ontario. Exams are usually offered over a five-day period.

Registration packages to write are mailed in January for the May sitting and in July for the December sitting.

If the technical exam package is not received by the times indicated above, applicants should call the Exam Centre.

### PROCUREMENT OF TEXTS AND OTHER MATERIALS FOR AN EXAM

To help in the procurement of all the suggested technical text books Contact customer service of Login Brothers at [orders@lb.ca](mailto:orders@lb.ca), through the website [www.lb.ca](http://www.lb.ca) or 1-800-665-1148 to assist you. It is recommended to always purchase the latest edition of any suggested textbook.

If an applicant does not have the current text listing or the text(s) is out of print, the applicant is advised to contact the Exam Centre (see below).

Recent written exams (i.e., reprints) are available on-line at PEO's website at [www.peo.on.ca](http://www.peo.on.ca) for free download. These past exams are available to provide the applicant with knowledge of the exam format, etc. The answers/solutions of past exams are not available at PEO.



## PEO'S TECHNICAL EXAMINATION PROGRAMS

### EXAM FEES

All Exam Fees are non-refundable.

First Exam Fee	\$700
Each Subsequent Exam Fee	\$200
Submission of an Engineering Thesis	\$360

### COURSES-IN-LIEU

For all course(s)-in-lieu of PEO exam(s), applicants must get prior approval from PEO. A request must be in writing and should include a description of the proposed university calendar course and should be submitted at least two months in advance of the course's registration deadline.

Applicants must arrange for the official grade report(s) to be forwarded to the Licensing and Registration Department upon the completion of the course(s).

**NOTE: Courses-in-lieu are not acceptable for:**

- *Basic Exams,*
- *Confirmatory Exams,*
- *Directed Confirmatory Exams,*
- *Failed exams*

### EXAM CENTRES

Exams are offered annually in May and December at the following centres in Ontario:

Belleville	London	Sudbury
Chalk River	Ottawa	Thunder Bay
Hamilton	Peterborough	Toronto
Kingston	Sarnia	Windsor
Kirkland Lake	St. Catharines	

The timetable information and exact location of exams are posted on PEO's website early in April to applicants writing exams in May, and early in November for those writing in December.

Applicants living inside Ontario must write at an Ontario centre. One of the centres listed may be selected. Applicants living outside Ontario may make special arrangements to write outside Ontario or Canada. Call the Exam Centre for further instructions if special arrangements are required.

### ADDITIONAL INFORMATION

**Order of exams.** Basic Studies exams are a prerequisite and must be written first. Following the successful completion of all Basic Studies exams, applicants may write the remaining exams in any order. However, it is recommended that exams in less-advanced subjects be written first. Passing an exam in an advanced subject does not merit credit for a less-advanced subject.

**English Language Skills.** An acceptable level of English—both written and spoken—is required to practise engineering and to successfully complete PEO exams. If an applicant needs to improve English language skills, s/he should contact one of the many English as a Second Language Programs run by schools and community organizations throughout Ontario.

**Penalties.** Using notes or other aids in an exam where these are not allowed is strictly forbidden. Applicants caught doing so will have their paper confiscated and risk having their licence application withdrawn.

**Exam Results.** Exam results are normally mailed within 45 working days following writing of the exam. No results will be given over the telephone or in person at PEO office. Exam papers will not be returned to applicants and answers are not available. Failed exams are automatically re-read. However, applicants may request a formal re-read

of an exam paper. A non-refundable fee of \$330 is charged in the event a formal re-read is requested by an applicant. Requests for a re-read must be received within 30 days after an applicant has been notified of the exam mark.

**Reapplying After A File Has Been Closed.** If a file has been closed, an applicant may reapply with the understanding that the regulations and policies in effect at the time of the new application will be enforced.

An application for licence fee and all other associated fees will be required.

If a file was closed for poor academic performance, the applicant may be required to show that s/he has taken course(s) in the subject(s) covered by any failed exam(s).

All recorded failed exams from a previous application must be successfully addressed before an applicant will be allowed to pursue the new program.

### WORKING IN ENGINEERING BEFORE LICENSURE

Applicants may work in engineering provided a licensed professional engineer takes responsibility for the work. It is illegal to use the title "professional engineer" or any variation thereof (project engineer, systems engineer, etc.) as an occupational or business title that might lead to the belief that a person is a licensed professional engineer.

### NEED MORE INFORMATION?

For more information about licensing/registration requirements, please contact:

Licensing and Registration Department  
Professional Engineers Ontario  
40 Sheppard Avenue West, Suite 101  
Toronto, ON M2N 6K9  
Tel: (416) 224-1100 / 1-800-339-3716  
Fax: (416) 224-8168 / 1-800-268-0496  
<http://www.peo.on.ca>

# PEO'S CONFIRMATORY EXAMINATION PROGRAM

## **Confirmatory Exam Program (CEP)**

PEO's *Confirmatory Exam Program* (CEP) consists of three technical exams in the applicant's engineering discipline and a *Complementary Studies* exam.

- This program must be completed within eight academic years following the date of receipt of the exam program notification. ("Academic Year" means the period starting September 1 in a year and ending August 31 in the following year.)
- Applicants will have successfully completed the *Confirmatory Exam Program* if the average of their three technical exams is at least 55% with no mark below 50% and they achieve a pass (50%) on the *Complementary Studies* exam.
- To qualify for the good performance review, applicants must address all the directed exams, if the applicant is assigned a *Directed Confirmatory Exam Program*

**Good-Performance review** for CEP applicants may be warranted as follows:

- Applicants who pass any two technical exams at their first sitting, with a minimum average of 65% and with no mark below 60%, may be exempted from completing the remaining exams in the *Confirmatory Exam Program*.
- Applicants who complete three technical exams in two sittings with no mark below 60% may be exempted from the *Complementary Studies* exam.
- Applicants who fail one technical exam and achieve a mark of 70% or higher on the failed exam on their second attempt, and 60% or higher on a previously unwritten technical exam attempted at the same sitting, may be exempted from completing the remaining exams in their *Confirmatory Exam Program*.

A **Failed-to-Confirm** Exam Program for CEP applicants, consisting of additional exam(s), will be assigned to applicants who do not confirm their engineering knowledge via their *Confirmatory Exam Program*. At least one of the following will apply:

- Applicants who do not achieve an average mark of at least 55% on the three technical exams will be assigned a *Failed-to-Confirm* Exam Program and one additional technical exam will be assigned.
- Applicants, who failed the same exam twice or failed two different exams will be assigned a *Failed-to-Confirm* Exam Program where an additional exam will be assigned for each exam failure. They must also pass the failed exams.

**Please note:** For applicants who are assigned a **Failed-to-Confirm** Exam Program, their engineering experience does not begin until after the academic requirements for licencing are met, and they will be required to demonstrate 48 months of engineering experience from that time.

A **file will be closed** under the following circumstances:

- If there is loss of contact (no active mailing address), the applicant's file will be closed.
- Applicants who do not attempt any exams within two academic years after notification of their exam program will have their file closed.
- Once an exam program commences, applicants must write at least one exam each academic year or their file will be closed even if the applicant has successfully passed exams in the past.
- Applicants who fail a technical/Complementary Studies exam on their first sitting must pass the failed exam within one academic year or their file will be closed.

If you have any questions concerning the above listed, please contact the Exam Centre  
416-840-1097, 1057, 1096, 1095 or 1(800) 339-3716 1097, 1057, 1096, 1095  
e-mail: [exams@peo.on.ca](mailto:exams@peo.on.ca)

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**GEOLOGICAL ENGINEERING EXAMINATIONS**

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**INTRODUCTION**

Each discipline examination syllabus is divided into two examination categories: compulsory and elective. A full set of Geological Engineering examinations consists of eighteen, three-hour examination papers and an engineering report. Candidates will be assigned examinations based on an assessment of their academic background. Examinations from discipline syllabi other than those specific to the candidates' discipline may be assigned at the discretion of PEO's Academic Requirement Committee.

Information on examination scheduling, textbooks, materials provided or required, and whether the examinations are open or closed book, will be provided by PEO's examinations Centre.

**BASIC STUDIES****04-BS-1 Mathematics**

Calculus, Vector, and Linear Algebra: Applications involving matrix algebra, determinants, eigenvalues; first and second order linear ordinary differential equations, Laplace transforms. Vector algebra; vector functions and operations; orthogonal curvilinear coordinates; applications of partial derivatives, Lagrange multipliers, multiple integrals, line and surface integrals; integral theorems (Gauss, Green, Stokes). Power series.

**04-BS-2 Probability and Statistics**

Concepts of probability, events and populations, probability theorems, concept of a random variable, continuous and discrete random variables, probability distributions, distributions of functions of a random variable, sampling and statistical estimation theory, hypothesis testing, simple regression analysis.

**04-BS-3 Statics and Dynamics**

Force vectors in two- and three-dimensions, equilibrium of a particle in two- and three-dimensions; moments and couples; equilibrium of rigid bodies in two- and three-dimensions; centroids, centres of gravity; second moment of area, moment of inertia; truss, frame and cable static analysis; friction. Planar kinematics of particles and rigid bodies; planar kinetics of particles and rigid bodies; work and energy, impulse, and momentum of particles and rigid bodies.

**04-BS-5 Advanced Mathematics**

Series Solutions of Differential Equations: Series solutions of ordinary differential equations, boundary value problems and orthogonal functions, Fourier series.

Numerical Methods: Use of computers for numerical solution of engineering problems, including techniques involving library subroutines and spreadsheets. Approximations and errors, interpolation, systems of linear and non-linear algebraic equations, curve fitting, numerical integration and differentiation, and ordinary differential equations.

**04-BS-6 Mechanics of Materials**

Definitions of normal stress, shearing stress, normal strain, shearing strain; shear force and bending moment diagrams; members subjected to axial loading; members subjected to torsional loading; compound stresses, Mohr's circle; deformation of flexural and torsional members; failure theories; elastic and inelastic strength criteria; columns.

**04-BS-7 Mechanics of Fluids**

Fluid characteristics, dimensions and units, flow properties, and fluid properties; the fundamentals of fluid statics, engineering applications of fluid statics; the one-dimensional equations of continuity, momentum, and energy; laminar and turbulent flow, flow separation, drag and lift on immersed objects; wall friction

and minor losses in closed conduit flow; flow of incompressible and compressible fluids in pipes; dimensional analysis and similitude; flow measurement methods.

**04-BS-10 Thermodynamics**

Thermodynamic states of simple systems; the laws of thermodynamics; equilibrium, PVT and other thermodynamic diagrams; equation of state; compressibility charts and steam tables; calculation of property changes; enthalpy; applications of thermodynamics, cycles, reversibility; thermodynamics of phase changes, Gibbs phase rule, gas-vapour mixtures.

**04-BS-11 Properties of Materials**

Properties of materials for mechanical, thermal and electrical applications. Atomic bonding, solid solutions, crystallization. Equilibrium phase diagrams, applications to steel and aluminium alloys, heat treatments. Structure and special properties of polymers and ceramic materials. General characteristics of metallic composites, polymeric composites and concrete. Introduction to materials in hostile environments: corrosion, creep at high temperature, refractory materials, subnormal temperature brittle fracture.

**04-BS-12 Organic Chemistry**

Principles of organic chemistry developed around the concepts of structure and functional groups. The main classes of organic compounds. Properties of pure substances. Introduction to molecular structure, bond types, properties, synthesis and reactions, reaction mechanisms, as a means of systematizing organic reactions.

**04-BS-14 Geology**

The structure of the earth, plate tectonics, earthquakes and igneous activity. Minerals and rocks including their formation, identification, basic properties, and classification. Processes of weathering, erosion, transport, and deposition of geological materials and their results of significance to engineering. Occurrence, flow, and quality of groundwater. Introductory aspects of structural geology including faulting, folding, and the overall formation of discontinuities and their effect on the engineering properties of rock masses. Aerial photography and geological maps.

**04-BS-15 Engineering Graphics and Design Process**

Engineering drawing: Orthographic sketching. Standard orthographic projection. Principal views, selection and positioning of views. Visualization. Conventions and practices. First and second auxiliary views. Basic descriptive geometry. Section views, types, hatching conventions. Basic dimensioning requirements. Tolerance for fits and geometry control. Detail drawings and assembly drawings, other drawings and documents used in an engineering organization. Bill of materials. Fasteners and welds. Design process and methods. Project management & teamwork. Requirements and function analysis in design. Conceptual design and testing. Concept evaluation design factors such as: cost, quality, manufacturability, safety, etc. Systems modelling & design detail.

**GROUP A****18-Geol-A1 Mineralogy and Petrology**

Introduction to crystallography and crystal chemistry. Physical and chemical properties of minerals in hand specimens. Identification of minerals and rocks with the petrographic microscope. Field and laboratory classification of igneous and metamorphic rocks. The nature of magmas and processes of magmatic differentiation. Metamorphic facies concepts. Interpretation of mineral assemblages of igneous and metamorphic rocks in the light of the phase rule and phase relations of relevant mineral assemblages. Textural and physical properties of rocks relevant to engineering problems.



**18-Geol-A2 Hydrogeology**

Hydrologic cycle: precipitation, evaporation, transpiration, deep and shallow groundwater circulation. Physics of flow through porous media. Hydraulic conductivity and groundwater storage. Occurrence, transmissivity and storage characteristics of surficial and bedrock aquifers. Groundwater exploration methods: geophysics, remote sensing, mapping, borehole investigations. Groundwater flow patterns: recharge, discharge, flow net construction and analysis. Aquifer development and management. Control of pore pressures and groundwater flow in geotechnical engineering.

**18-Geol-A3 Sedimentation and Stratigraphy**

Classification of sedimentary rocks, processes of weathering, erosion, sedimentation and diagenesis. Formation of carbonate, clastic and chemical precipitate rocks. Principles of stratigraphic and paleontological correlation; sedimentary facies: geological and practical significance. Distribution of major Precambrian and Phanerozoic systems. Facies associations; modern and ancient sedimentary environments. The engineering properties and behaviour of sedimentary rocks and the use of stratigraphic principles in the solution of engineering problems.

**18-Geol-A4 Structural Geology**

Stress and strain. Brittle and ductile rock deformation behaviour. Fabric analysis of deformed rocks. Structural features of stable and mobile parts of the crust. Fold and fault development. Mountain building and orogenies. Theories in geotectonics. Methods of structural analysis. Field mapping and graphical data processing; maps, cross-sections, block diagrams, structure contour maps, stereographic projections, equal area nets, and strain indicators. Kinematic and dynamic interpretation. The application of structural geology to the solution of engineering problems.

**18-Geol-A5 Rock Mechanics**

Engineering properties and classification of intact rocks. Rock mass properties and classification. Laboratory and in-situ testing of rock. In-situ stresses and stress measurement techniques. Stability analysis of rock slopes and excavations. Rock excavation techniques. Design of excavations, slopes, tunnels and shafts. Rock reinforcement and support. Groundwater considerations in rock engineering.

**18-Geol-A6 Soil Mechanics**

Rock weathering and development of soils. Engineering classification of soils. Soil physical properties: porosity, density, capillarity, permeability. Shear strength, consolidation and settlement. Normally and over consolidated soils. In-situ stresses in soil masses. Lateral earth pressures. Mechanics, stability and analysis of soil slopes. Pore water pressure, seepage pressure, groundwater considerations in soil engineering.

**18-Geol-A7 Applied Geophysics**

Basic principles, interpretation, and limitations of geophysical methods applied to the exploration for coal, oil and natural gas, minerals, groundwater, and for geotechnical studies of the surface and subsurface. Introduction to electrical, electromagnetic, and magnetotelluric surveys; magnetic and gravity surveys; seismic reflection and refraction surveys; radiometric methods. Introduction to geophysical well logging techniques. Case histories of applications to engineering problems.

**GROUP B****18-Geol-B1 Contaminant Hydrogeology**

Groundwater geochemistry, isotopes in groundwater. Movement of dissolved species. Diffusion and dispersion regimes. Classification of contaminants. Organic contaminants, introduction to multiphase flow, LNAPLs and DNAPLs. Assessment, control and remediation of contaminants. Waste management. Deep well disposal.

**18-Geol-B2 Terrain Analysis**

Elements of photogrammetry. Interpretation of aerial photos – recognition elements (tone, pattern, texture, size and shape, occupancy). Identification of structures and terrain features. Glacial, fluvial, coastal, and permafrost landforms – identification and engineering characteristics. LANDSAT imagery. Operation, characteristics, and uses of thermal infrared and RADAR remote sensing.

**18-Geol-B3 Site Investigation**

Uses and sources of geological and geotechnical information. Methods of site investigation: trial pits, boreholes, sampling, laboratory and in-situ testing, geophysical methods. In-situ instrumentation and post construction monitoring: measurement of stress, deformation and settlement, pore pressures, permeability, groundwater contamination. Design of site investigations and monitoring schemes.

**18-Geol-B4 Geomorphology and Pleistocene Geology**

Basic geomorphological concepts: formation and composition of landforms, geomorphologic cycles. Weathering and soils. Mass wasting. Fluvial processes and landforms. Coastal processes and landforms. Glacial geomorphology and landforms. Frozen-ground phenomena. Karst geomorphology. Physical geology of Canada. Quaternary geology of selected areas of Canada. Influence of geomorphology on human activity.

**18-Geol-B5 Environmental Geology**

Geological hazards, volcanoes, landslides, earthquakes, subsidence, floods, erosion. Preparation of hazard maps. Return period concepts and risk assessment. Environmental considerations for landfills, deep cavern and deep well disposal of wastes. Mining reclamation. Acid rock drainage. Control of sediment and dissolved contaminants. Preservation and restoration of soils, landscaping and contour restoration, revegetation and erosion control. Preparation of environmental impact statements. Laws and procedures pertaining to environmental assessments.

**18-Geol-B6 Resource Geology**

Select ONE from:

**18-Geol-B6-1 Petroleum Deposits**

Physical properties, geochemistry, origin, migration, accumulation, and history of oil and natural gas, and their associated waters. Geological conditions of oil and gas entrapment. Structural and

stratigraphic factors controlling the distribution of reservoir rocks, porosity, permeability and fluid saturations. Environmental problems associated with the development of hydrocarbons.

### **18-Geol-B6-2 Coal Deposits**

Coal depositional environments and their significance. Nature, origin, diagenesis, metamorphism, and classification of organic sediments. Rank, physical, and petrological properties of coal. Glacial and tectonic deformation effects on rank and seam dimensions. Trace element geochemistry of coal. Stratigraphic and geographic occurrence of Canadian (and world) coals. Properties of environmental and mining significance.

### **18-Geol-B6-3 Metallic and Industrial Mineral Deposits**

Nature, mode of occurrence and processes of formation of metallic and industrial minerals including minerals deposited from magmas, high-temperature vapours and aqueous solutions; formed by evaporation or precipitation in surface waters; formed by mechanical accumulation or accumulated by residual weathering. Processes of element/mineral migration and concentration. Stratigraphic and structural controls on occurrence. Solution geochemistry and isotopic characteristics of ore bearing fluids and ore deposits. Illustrative case histories for important deposits of sulphides, oxides, native elements, silicates, and ionic salts.

### **18-Geol-B7 Petroleum Development**

Drilling equipment, controls and techniques. Circulation systems and well completions. Drilling problems associated with overpressure, underpressure, permafrost, evaporites, sour-gas, loss of circulation. Reservoir fluid phase behaviour. Material balance equations. Porosity and permeability characteristics of reservoirs. Steady and transient flow of oil, water and gas through porous media. Well stimulation. Capillary pressure and multiphase flow. Segregated and diffuse flow regimes. Oil and gas well testing and analysis. Natural drive mechanisms. Secondary and tertiary oil recovery. Introduction to history matching and numerical simulators. Conventional and geostatistical methods of oil and gas reserve estimation.

### **18-Geol-B8 Resource Economics & Valuation**

Growth of mining and petroleum industries. Estimation of future demands. Significance of the resource sector in the Canadian economy. Prices, exchanges and futures markets. Types and grades of concentrates, smelter charges and returns. Properties, specifications and markets for industrial rocks and minerals. Relative value of hydrocarbon fractions. Evaluation of mining and oil prospects; mining and oil law, taxes and tariffs, labour, transportation, technical factors, property acquisition and claims, development methods, production estimates. Evaluation of geological engineering and commercial aspects of developed properties. Feasibility reports. Costs: access; transportation; mining; milling; well-development, well stimulation; primary, secondary and tertiary recovery. Capital costs, amortization and depreciation, rate-of-return on investment calculations.

### **18-Geol-B9 Exploration & Mining Geology**

Planning and execution of exploration programs. Sampling methods. Legal aspects of exploration in Canada. Principles of geochemistry in mineral exploration. Field analytical techniques. Primary and secondary dispersion patterns, weathering, soil formation. Anomalies in residual and transported overburden, stream waters, stream sediments, vegetation. Factors affecting relative mobility of elements. Background values, threshold values, orientation surveys. Application, planning and interpretation of

geophysical surveys. Planning surface drilling programs. Logging, sampling, analysis and interpretation of drill core data. Mineralogical study of ore and recommendations for beneficiation. Introduction to mining methods, equipment selection, layout, environmental logistics during life of mine and at closure, and integration of these with a clear understanding of their compatibility with the geological and geotechnical parameters of the site materials. Mapping and sampling underground. Planning subsurface drilling programs. Structural interpretation and analysis of underground drilling. Quality control aspects of mining and milling. Conventional and geostatistical methods of ore-deposit reserve estimation.

### **18-Geol-B10 Geophysical Exploration Methods**

Select ONE from:

#### **18-Geol-B10-1 Gravity and Magnetic Fields**

Theory and quantitative interpretation of the gravity and magnetic fields in geophysical exploration. Interpretation of regional gravity and magnetic maps. Identification of local anomalies. Data acquisition and data reduction for gravimeters and magnetometers. Design and conduct of field surveys. Potential field, Fourier, forward modeling and inversion methods in data interpretation and analysis.

#### **18-Geol-B10-2 Electrical Methods**

Theory and quantitative interpretation of electrical, electromagnetic and magnetotelluric data in geophysical exploration. Electrical properties of rocks. Self-potential, induced polarization, electromagnetic induction and magnetotelluric methods. Operation of field instrumentation, data reduction. Design and conduct of field surveys. Potential field, forward modeling and inversion methods for data interpretation.

#### **18-Geol-B10-3 Exploration Seismology**

Theory of elasticity and elastic properties of rock. Wave propagation in elastic media. Interaction of waves with boundaries. Body-wave seismology. Surface waves. Earthquake source studies. Artificial energy sources. Refraction and reflection methods. Theory of operation and selection of seismometers. Design and conduct of field refraction and reflection surveys. Fundamentals of digital processing: static corrections, velocity analysis and corrections, Fourier analysis and filtering, stacking, migration. Interpretation of refraction and reflection seismograms.

## COMPLEMENTARY STUDIES

### 11-CS-1      **Engineering Economics**

Basic concepts of engineering economics through understanding of the theoretical and conceptual financial project analysis. Types and applications of engineering economic decisions. Capital, cash flow, and the time value of money concepts. Nominal and effective interest rates when considering loans, mortgages, and bonds. The application of present worth analysis, annual equivalent analysis and rate of return analysis in evaluating independent projects, comparing mutually exclusive projects, analyzing lease vs. buy alternatives and making decisions. After-tax financial analysis requiring an understanding of capital cost allowance (depreciation) and corporate income tax. Understanding methods of financing and capital budgeting. Break-even, sensitivity and risk analyses.

### 11-CS-2      **Engineering in Society – Health and Safety**

The duties and legal responsibilities for which engineers are accountable; safety laws and regulations; and a basic knowledge of potential hazards and their control: biological hazards – bacteria, viruses; chemical hazards - gases, liquids and dusts; fire and explosion hazards; physical hazards – noise, radiation, temperature extremes; safety hazards – equipment operation; workplace conditions - equity standards, human behaviour, capabilities, and limitations; managing safety and health through risk management, safety analyses, and safety plans and programs; practices and procedures to improve safety. The roles and social responsibilities of an engineer from a professional ethics point of view, as applied in the context of Canadian values. The integration of ethics into engineering practice, and its effect on public safety and trust.

### 11-CS-3      **Sustainability, Engineering and the Environment**

Basic knowledge of soil, water and air quality engineering: soil and water interaction, water supply issues, human activities and their interaction on soil, air and water resources. Fundamentals of: soil erosion, water quality, atmospheric pollution (carbon and nitrogen cycle), climate change, risk assessment. Basic knowledge of renewable energy sources: solar, photovoltaic, wireless electricity, thermal, wind, geothermal, and biofuels. **Introduction to** renewable materials engineering; nano materials, new material cycles. Eco-product development, and product life cycle assessment; recycling technologies; reuse of products; design for disassembly, recycling, e-waste, and reverse manufacturing. Consumption patterns; transportation; environmental communication; consumer awareness. Optimized energy and resources management. Sustainable methods: sustainability indicators; life cycle assessment; regulatory aspects of environmental management, ecological planning.

**11-CS-4      Engineering Management**

Introduction to management principles and their impact upon social and economic aspects of engineering practice. Engineering management knowledge topics including: market research, assessment and forecasting; strategic planning; risk and change management; product, service and process development; engineering projects and process management; financial resource management; marketing, sales and communications management; leadership and organizational management; professional responsibility. New paradigms and innovative business models, including: sustainable production, products, service systems and consumption; best practices and practical examples of successful implementations of sustainable scientific and engineering solutions.

**3.2                      ENGINEERING REPORT**

Upon passing the examination(s) assigned by PEO's Academic Requirements Committee, a candidate may be required to write an Engineering Report. The report must demonstrate the candidate's ability to present an engineering problem, observation, or idea, and to analyze it logically and accurately using engineering principles, and to draw conclusions or make recommendations. The work must include acceptable technical content involving engineering analysis, design, development, or research. The report must also demonstrate a satisfactory level of writing and graphical skills, thus the quality of the presentation will be a factor in determining the acceptability of the report.

The report itself need not prove originality of ideas, but the candidate should demonstrate his/her ability to appreciate, present, differentiate between and draw conclusions from observations and ideas. The definition of a "report" is flexible and could also include discussion and judgement of opposed theories or methods, or a description of a novel technique or process and a discussion of the practicality of its application. The key consideration is that the report address a new issue, and not repeat the coverage of the particular subject available in textbooks. It is the current state of the art, the novel or the contentious that is expected to be explored in the report.

While no rigid rules of format are specified, it is recommended that the report be suitably subdivided and include:

- a) A title page and date
- b) A signed declaration of authorship
- c) A table of contents
- d) A summary of the report and its conclusions
- e) Technical content including analysis, design, development or research
- f) Conclusions and/or recommendations
- g) A list of the technical literature cited
- h) A list of acknowledgements, contributors, reviewers and sources of information

The report should be about 5,000 words long, not including tables and graphs. Diagrams, illustrations, etc. should be clearly and properly identified. It is preferable to locate graphs, diagrams, etc. necessary for the understanding of the text at the place where reference to them is made.

**NOTE: Please feel free to use the most recent edition of textbooks referenced in this list**  
**NOTA : Utilisez l'édition la plus récente des manuels cités dans cette liste.**

**18-Geol-A1 Mineralogy and Petrology**

Raymond, L.A., Petrology, The study of igneous, sedimentary, and metamorphic rocks. 2<sup>nd</sup> Ed., McGraw Hill, 2002.

Perkins, D. and K. Henke, Minerals in Thin Section. 2<sup>nd</sup> Ed. Prentice Hall, 2004.

MacKenzie, W.S. and A.E. Adams, A Color Atlas of Rocks and Minerals in thin Section. J. Wiley, 1994.

Nesse, William D., Introduction to Optical Mineralogy. Oxford University Press, 2003.

Philpotts, Anthony R., Petrography of Igneous and Metamorphic Rocks. Prentice Hall, 2003.

Klein, C., Dutrow, B., The Manual of Mineral Science (after James D. Dana), 23rd Ed., John Wiley and Sons, New York, 20082.

Blatt, H. and R.J. Tracy, Petrology: Igneous, Sedimentary and Metamorphic. 2<sup>nd</sup> Ed., W.H. Freeman and Co., 1996.

Prinz, Martin, George E. Harlow, and Joseph Peters, eds. Simon and Schuster's Guide to rocks and minerals, Simon & Schuster, 1978.

**18-Geol-A2 Hydrogeology**

Freeze, R. Allan, and John A. Cherry, Groundwater, 604 pp. (1979). Online at:  
<http://hydrogeologistswithoutborders.org/wordpress/textbook-project/>

Schwartz, F.W., and H. Zhang, Fundamentals of Ground Water, Wiley, 2003.

Domenico, P.A., and F.W. Schwartz, Physical and Chemical Hydrogeology. 2<sup>nd</sup> Ed., Wiley, 1998.

**18-Geol-A3 Sedimentation and Stratigraphy**

Boggs, S., Principles of Sedimentology and Stratigraphy. 3<sup>rd</sup> Ed., Prentice Hall, New York, 2001.

**18-Geol-A4 Structural Geology**

Fossen, Haakon, Structural geology, Cambridge University Press, 2016.

van der Pluijm, Ben A., and Stephen Marshak, Earth Structure: An Introduction to Structural Geology and Tectonics. New York, W.W. Norton, 2004.

Davis, G.H., and S.J. Reynolds, Structural Geology of Rocks and Regions. 2<sup>nd</sup> Ed., New York, John Wiley and Sons, Inc., 1996.

**18-Geol-A5 Rock Mechanics**

Hoek, Evert and John Bray, Rock Slope Engineering. London: Institution of Mining and Metallurgy, 1981.

Hoek, Evert and Edwin T. Brown, Underground Excavations in Rock. London: Institution of Mining and Metallurgy, 1982.

**18-Geol-A6    Soil Mechanics**

Coduto, D.P., Component: Geotechnical Engineering: Principles and Practices. Prentice Hall, NJ, 1999.

Lambe, T.W., Soil Testing for Engineers. BiTech Publishers, Vancouver, 1991.

**18-Geol-A7    Applied Geophysics**

Sharma, P.V., Environmental and Engineering Geophysics. Cambridge University Press, 1997.

Reynolds, J.M., An Introduction to Applied and Environmental Geophysics. Wiley, 1997.

Kearey, P., M. Brooks and I. Hill, An Introduction to Geophysical Exploration. 3<sup>rd</sup> Ed., Blackwell Science, 2002.

**18-Geol-B1    Contaminant Hydrogeology**

Fetter, C.W., Contaminant Hydrogeology. 2<sup>nd</sup> Ed., MacMillan Publishing Co., New York, 1999.

Bedient, Philip B., Hanadi S. Rifai, and Charles J. Newell, Ground Water Contamination: Transport and Remediation, 2<sup>nd</sup> edition. Upper Saddle River, NJ: Prentice Hall, 1999. <https://www.amazon.ca/Ground-Water-Contamination-Transport-Remediation/dp/0130138401>.

Council, National Research, Contaminants in the Subsurface: Source Zone Assessment and Remediation, 2004. <https://www.nap.edu/catalog/11146/contaminants-in-the-subsurface-source-zone-assessment-and-remediation>.

Domenico, P.A., and F.W. Schwartz, Physical and Chemical Hydrogeology. 2<sup>nd</sup> Ed., Wiley, 1998.

**18-Geol-B2    Terrain Analysis**

Mollard, J.D. and J.R. Janes, Airphoto Interpretation and the Canadian Landscape. Energy, Mines and Resources Canada, 1984. ISBN 0-660-11591-3

Required Materials for Examination:

- 1 pocket stereoscope + plates from Mollard and Janes (1984) p. 187-399 only.

**18-Geol-B3    Site Investigation**

Hunt, Roy E., Geotechnical engineering investigation handbook, CRC Press, 2005.

Hunt, Roy E., Geologic hazards: a field guide for geotechnical engineers, CRC Press, 2007.

Canadian Geotechnical Society, Canadian Foundation Engineering Manual. 3<sup>rd</sup> Ed. Canadian Geotechnical Society, Technical Committee on Foundations, BiTech Publishers Ltd., Richmond, British Columbia, 1992.

Nielsen, David M., (ed.). Practical Handbook of Ground-Water Monitoring. Lewis Publishers Inc., Chelsea, Michigan, 1991.

**18-Geol-B4    Geomorphology and Pleistocene Geology**

Easterbrook, D.J., Surface Processes and Landforms. 2<sup>nd</sup> Ed., Prentice-Hall, 1999.

Trenhaile, AS, Geomorphology: A Canadian Perspective. Oxford University Press, 1998. ISBN 0-19-541277-X



Fulton, RJ, (ed.), Quaternary Geology of Canada and Greenland. Geological Survey of Canada, 1989. ISBN 0-660-13114-5 (Any one section of Part I (Sect. 1-5), and Part II: Sect. 11, 12.)

**18-Geol-B5      Environmental Geology**

Keller, Edward A. (2011) Environmental Geology (9<sup>th</sup> ed.) Pearson.

Merritts D, Menking K, and DeWet A (2014) Environmental Geology: An Earth Systems Approach (2<sup>nd</sup> ed.) Macmillan.

**18-Geol-B6      Resource Geology**

Select **ONE** from:

**18-Geol-B6-1      Petroleum Deposits**

Gluyas, J.G. and R.E Swarbrick, Petroleum Geoscience. Blackwell, 2004.

Hunt, J.M., Petroleum Geochemistry and Geology. 2nd Edition, Freeman, New York, 1996.

**18-Geol-B6-2      Coal Deposits**

Not available at this time.

**18-Geol-B6-3      Metallic and Industrial Mineral Deposits**

Evans, Anthony M., Ore Geology and Industrial Minerals - An Introduction. 3<sup>rd</sup> Ed., Blackwell Science, Oxford, UK, 1993.

**18-Geol-B7      Petroleum Development**

Dake, L.P., The Practice of Reservoir Engineering. Elsevier, 1994.

**18-Geol-B8      Resource Economics & Valuation**

Gentry, D.W. and T.J. O'Neill, Mine Investment Analysis. Society of Mining Engineers, American Institute of Mining, Metallurgical, and Petroleum Engineers, New York, 1984.

Rudenno, V., The Mining Valuation Handbook. Wrightbooks, Australia, 1998.

**18-Geol-B9      Exploration & Mining Geology**

Evans, Anthony M., Ore Geology and Industrial Minerals - An Introduction. 3<sup>rd</sup> Ed., Blackwell Science, Oxford, UK, 1993.

Evans, Anthony M., and William L. Barrett, Introduction to Mineral Exploration. Blackwell Publications, UK, 1995.

Peters, W.C., Exploration and Mining Geology. 2<sup>nd</sup> Ed., John Wiley & Sons, Inc, 1987.

**18-Geol-B10    Geophysical Exploration Methods**

Select ONE from:

**18-Geol-B10-1    Gravity and Magnetic Fields**

Telford, W.M., L.P. Geldart, and R.E. Sheriff, Applied Geophysics. Cambridge University Press, 1990.

Sharma, P.V., Environmental and Engineering Geophysics. Cambridge University Press, 1997.

**18-Geol-B10-2    Electrical Methods**

Telford, W.M., L.P. Geldart, and R.E. Sheriff, Applied Geophysics. Cambridge University Press, 1990.

Sharma, P.V., Environmental and Engineering Geophysics. Cambridge University Press, 1997.

**18-Geol-B10-3    Exploration Seismology**

Telford, W.M., L.P. Geldart, and R.E. Sheriff, Applied Geophysics. Cambridge University Press, 1990.

Sharma, P.V., Environmental and Engineering Geophysics. Cambridge University Press, 1997.

**11-CS-1      Engineering Economics****Primary Text**

Fraser, Niall; Jewkes, Elizabeth; Bernhardt, Irwin and Tajima, May. Global Engineering Economics: Financial Decision Making for Engineers. Fourth edition, Pearson Education Canada, 2008. ISBN: 978-0132071611.

**Additional Resources**

Sonyi, Andrew; Fenton, Robert and White, John. Principles of Engineering Economics Analysis. Canadian edition, Wall & Emerson Inc., 2000. ISBN: 978-0921332497.

**Web Resources**

Key words: engineering economics, cost engineering, financial analysis

Organizations: International Cost Engineering Council, Association of Cost Engineers, Association for the Advancement of Cost Engineering

**11-CS-2      Engineering in Society – Health & Safety****Primary Text**

Brauer, Roger L. Safety and Health for Engineers. Second edition, John Wiley & Sons Inc., 2006. ISBN: 978-0471286325.

**Web Resources**

Key words: health and safety, public safety, engineering ethics

Organizations: Canadian Society of Safety Engineering (CSSE), Canadian Centre for Occupational Health and Safety (CCOHS), Health Canada, National Academy of Engineering Center for Engineering, Ethics and Society

**11-CS-3      Sustainability, Engineering and the Environment**

Mihelcic, J.R. and Zimmerman, J.B. (2014) *Environmental Engineering: Fundamentals, Sustainability, Design, 2<sup>nd</sup> edition*. John Wiley & Sons, Hoboken, NJ.

Berg, L., Hager, M.C., Goodman, L. and Baydack, R. (2010) *Visualizing the Environment* (Canadian Edition). John Wiley & Sons, Hoboken, NJ. (Chapters 10, 11)

Wimmer, W. and Kauffman, Joanne. Handbook of Sustainable Engineering. First edition, Springer Publishing, 2011. ISBN: 978-1-4020-8939-8.

**Additional Resources**

The Report of the Brundtland Commission ("Our Common Future")  
1972 Stockholm Report of the United Nations Conference on the Human Environment  
1992 United Nations international Earth Summit in Rio de Janeiro

**Web Resources**

Key words: Sustainability; Sustainable engineering; Energy, Engineering and the Environment

Organizations: Environment Canada, Natural Resources Canada, Organisation for Economic Co-operation and Development (OECD) sustainable development

**11-CS-4      Engineering Management****Primary Text**

American Society for Mechanical Engineers. Guide to the Engineering Management Body of Knowledge. American Society for Mechanical Engineers, 2010. ISBN: 978-0791802991

**Additional Resources**

Gray, Clifford F. and Larson, Erik W. Project Management: The Managerial Process. Canadian 5<sup>th</sup> edition. Irwin/McGraw-Hill, 2011. ISBN: 978-0073403342

*aussi disponible en français :*

Gray, Clifford F. et Larson, Erik W. Management du projet. Chenelière McGraw-Hill, 2006. ISBN: 978-2765104537

**Web Resources**

Key words: engineering management, financial management, strategic management, resource management, operations management

Organizations: American Society for Mechanical Engineers (ASME), Canadian Society for Engineering Management, Project Management Institute, American Society for Engineering Management

*Updated: October 2014*

**TOTAL EXAMINATION PROGRAM**  
**PEO Syllabus of Examinations, 2018 Edition**

**GEOLOGICAL ENGINEERING**

**INTRODUCTION**

A full set of Geological Engineering examinations consists of the following, three-hour examination papers and an engineering report. Candidates will be assigned examinations based on an assessment of their academic background. Examinations from discipline syllabi other than those specific to the candidates' discipline may be assigned at the discretion of PEO's Academic Requirement Committee.

**BASIC STUDIES EXAMINATIONS**

04-BS-1	Mathematics
04-BS-2	Probability and Statistics
04-BS-3	Statics and Dynamics
04-BS-5	Advanced Mathematics
04-BS-6	Mechanics of Materials
04-BS-7	Mechanics of Fluids
04-BS-10	Thermodynamics
04-BS-11	Properties of Materials
04-BS-12	Organic Chemistry
04-BS-14	Geology
04-BS-15	Engineering Graphics and Design Process

**PROFESSIONAL EXAMS – SPECIFIC TO GEOLOGICAL ENGINEERING**

**GROUP A**

18-Geol-A1	Mineralogy and Petrology
18-Geol-A2	Hydrogeology
18-Geol-A3	Sedimentation and Stratigraphy
18-Geol-A4	Structural Geology
18-Geol-A5	Rock Mechanics
18-Geol-A6	Soil Mechanics
18-Geol-A7	Applied Geophysics

**GROUP B**

18-Geol-B1	Contaminant Hydrogeology
18-Geol-B2	Terrain Analysis
18-Geol-B3	Site Investigation
18-Geol-B4	Geomorphology and Pleistocene Geology
18-Geol-B5	Environmental Geology
18-Geol-B6	Resource Geology – Select <u>ONE</u> from
	18-Geol-B6-1 Petroleum Deposits
	18-Geol-B6-2 Coal Deposits
	18-Geol-B6-3 Metallic and Industrial Mineral Deposits
18-Geol-B7	Petroleum Development
18-Geol-B8	Resource Economics & Valuation
18-Geol-B9	Exploration & Mining Geology
18-Geol-B10	Geophysical Exploration Methods – Select <u>ONE</u> from
	18-Geol-B10-1 Gravity and Magnetic Fields
	18-Geol-B10-2 Electrical Methods
	18-Geol-B10-3 Exploration Seismology

**COMPLEMENTARY STUDIES**

11-CS-1	Engineering Economics
11-CS-2	Engineering in Society – Health & Safety
11-CS-3	Sustainability, Engineering and the Environment
11-CS-4	Engineering Management

3.2	Engineering Report
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