Professional Engineers
Ontario

Confirmatory Exam Program Requirements
Geomatics Engineering

Geomatics Engineering Technical Exams. You must choose three of your four exams from the Geomatics Engineering Technical Exam list. <u>Two</u> of these exams must be from Group A and <u>one</u> from Group B listed below.

Geomatics Engineering Technical Exams			
Group A		**Group B**	
18-Geom-A1	Surveying	18-Geom-B1	Digital Terrain Modelling
18-Geom-A2	Adjustment of Observations and Data Analysis	18-Geom-B2	Satellite Navigation
		18-Geom-B3	Networks and Precise Engineering Surveys
18-Geom-A3	Geodesy and Positioning		
18-Geom-A4	Photogrammetry	18-Geom-B4	Hydrography
18-Geom-A5	Remote Sensing and Image Analysis	18-Geom-B5	Survey Law
		18-Geom-B6	Land Use Planning and Environmental Management
18-Geom-A6	Cadastral Studies		
18-Geom-A7	Geospatial Information Systems		

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

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

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 , through the website 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 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.

Professional Engineers
Ontario

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

GEOMATICS ENGINEERING EXAMINATIONS

INTRODUCTION

Each discipline examination syllabus is divided into two examination categories: compulsory and elective. A full set of Geomatics 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-4   Electric Circuits and Power
Basic laws, current, voltage, power; DC circuits, network theorems, network analysis; simple transients, AC circuits. Impedance concept, resonance; use and application of phasors and complex algebra in steady-state response; simple magnetic circuits; basic concepts and performance characteristics of transformers; an introduction to diodes and transistors; rectification and filtering; simple logic circuits.

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-8   Digital Logic Circuits
Boolean algebra, encoders, decoders, shift registers, and asynchronous and synchronous counters together with timing considerations. Design of asynchronous circuits, synchronous sequential circuits, and finite state machines. Karnaugh mapping techniques, and state tables and diagrams. Introduction to programmable logic.

04-BS-9   Basic Electromagnetics
Introduction to the basic electromagnetic principles upon which electrical engineering is based (laws in both integral and differential form). Classical development of electrostatics and magnetostatics leading to Maxwell's equations. Application of electromagnetic theory to calculation of d-c circuit parameters, study of plane wave transmission in various media.

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,   rystallization. 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-13 Biology

Cellular reproduction, growth, and differentiation; metabolism and bioenergetics of living cells; cell structure and function related to the material properties of plant and animal tissues; introductory microbiology — characteristics and classification of microorganisms; interactions of microorganisms with man in the natural world; kinetics and mathematical models of microbial growth; engineered biological systems such as bio-reactors, bio-instrumentation, and waste treatment systems.

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.

04-BS-16 Discrete Mathematics

Logic: propositional equivalences, predicates and quantifiers, sets, set operations, functions, sequences and summations, the growth of functions. Algorithms: complexity of algorithms, the integers and division, matrices. Methods of proof: mathematical induction, recursive definition. Basics of counting: pigeonhole principle, permutations and combinations, discrete probability. Recurrence relations: inclusion-exclusion. Relations and their properties: representing relations, equivalence relations. Introduction to graphs: graph terminology, representing graphs and graph isomorphism, connectivity, Euler and Hamilton paths. Introduction to sorting.

GROUP A

18-Geom-A1   Surveying

Basic principles; instruments and procedures for angle, distance and height measurements; plane coordinate computations such as intersections, resections, traverses; coordinate transformation; simple horizontal and vertical curves; area and volume computations; cross-sections and profiles; setting-out surveys; pre-analysis, design and planning of precise surveys for horizontal and vertical control; principles of electronic distance and angle measurements; total stations; propagation of EM energy in the atmosphere and its application to EM ranging; theodolite observations and precise positioning systems; sources of errors in angle, distance and precision levelling surveys; influence of atmospheric refraction. Systematic and random errors, design, processing and analysis of angle, distance, and height difference measurements. Route survey and design; surveys for route planning, setting-out and as-built surveys, easement curves, alignment and grade for roads, sewers and pipelines, bridges, buildings, dams, tunnels, mining.

18-Geom-A2   Adjustment of Observations and Data Analysis

Geomatics engineering methodology and estimation. Accuracy and precision; errors and their propagation. Classes and combination of mathematical models; undetermined, uniquely determined and over determined models. Weight matrix; variance factor; covariance propagation. Least squares methods: parametric, condition and combined cases. Problem formulation and solution: theory of errors and adjustment of observations, problems with a priori knowledge of the parameters, step by step methods, sequential solution methods, summation of normals, examples. Uni- and multi-variate statistical testing. Data classification, analysis and bias identification. Kalman filtering and real-time data analysis. Introduction to signal processing, time series analysis and FFT techniques and examples of Practical applications of data analysis and processing in Geomatics engineering.

18-Geom-A3   Geodesy and Positioning

Concepts of geodesy; size and shape of the Earth; geoid and ellipsoid; terrestrial, celestial and orbital coordinate systems; coordinate transformations; computations of positions in three dimensions; computations of positions on the ellipsoid and on a conformal mapping plane; azimuthal, conic and cylindrical projections, UTM and 3TM; Canadian horizontal and vertical datums; height determination. Static and kinematic positioning with the Global Positioning System (GPS). Elements of inertial positioning; time systems; astronomic positioning; VLBI positioning; orbit computations; satellite laser ranging. Horizontal, vertical and three-dimensional networks; pre-analysis and post-analysis; theory of heights; gravimetry; global and local geoid determination; astrogeodetic, gravimetric and combined methods; levelling by GPS and the geoid. Introduction to Global Navigation Satellite Systems GNSS concepts.

18-Geom-A4   Photogrammetry

Airborne, space and terrestrial data acquisition systems. Metric and non-metric cameras, digital cameras, linear sensors, and non-conventional imagery. Fundamental coordinate systems and mathematical relationships between image, model and object space. Direct and inverse problems of projective and similarity coordinate transformations. Correction of photogrammetric measurements. Geometry of vertical and tilted aerial photographs. The collinearity and coplanarity conditions; analytical space resection and space intersection. Interior and exterior orientation; relative and absolute orientation of single model; stereomodel formation and error analysis. Flight project planning. Multi-image processing, mathematical models for image-triangulation for strip and block adjustment including self calibration and direct georeferencing. Concepts of terrain extraction from airborne sensors. Principles of digital photogrammetry, digital image acquisition, scanning and sampling; resampling, image enhancement; image matching, spatial filtering, stereo-vision techniques; digital rectification and orthorectification and their error analysis.

18-Geom-A5   Remote Sensing and Image Analysis

Basic physical principles of electro-optical, infra-red and microwave remote sensing; space- and air-borne sensor systems, active and passive sensors; properties of digital image data; radiometric processing including correction of instrumental artifacts and atmospheric corrections; geometric corrections and registration. Concepts of terrain extraction from space-borne sensors. Image statistics. Radiometric enhancement including histogram matching; Fourier representation of image data; image pyramids; geometric enhancement including spatial filtering, edge detection and enhancement; multispectral transformations including IHS, principle component analysis and vegetation indices; overview of remote sensing image interpretation; thematic classification and clustering; supervised classification including minimum distance and maximum likelihood classification; accuracy assessment of classification. Concepts of hyderspectral image analysis.

18-Geom-A6   Cadastral Studies

Legal, economic and social concepts of land tenure; land ownership and land registration; fiscal, judicial and multipurpose cadastral systems; the proprietary land unit; use, valuation and management of land resources; the role of the cadastral surveyor, liability of surveyors; the Dominion Land Survey System, history, detailed description and calculations; land registration systems in Canada; Introduction to other Legal Survey Systems; descriptions of land.. History of Cadastres. Essential Elements of a modern cadastre.

18-Geom-A7   Geospatial Information Systems

Design and implementation of geospatial information systems (GIS) and their role in digital mapping and spatial data management including: concept of information and GIS; spatial data management systems; georeferencing; spatial data modelling; spatial representation; geoprocessing; input/output operations; file storage; database management systems and distributed processing. Techniques involved in project specification, design and implementation and the selection of computer hardware and software for GIS. GIS data models and structures. Spatial indexing. Algorithms for data manipulation, transformation.

Spatial analysis and visualization. Strategies and steps on GIS design and implementation. Data standards and metadata management. Concepts of data fusion and interoperability, including internet-based handling of spatial data and web-based geo-information services.

GROUP B

18-Geom-B1 Digital Terrain Modelling

Digital Terrain Modelling (DTM) and Digital Elevation Modelling (DEM) concepts, their implementation and applications in geomatics engineering and other disciplines. Methods for DTM generation from optical and SAR stereo-imagery, digitisation of cartographic sources, hydrographic surveys, Interferometric SAR (InSAR), laser altimetry (LIDAR) and other capturing methods. Mathematical techniques and automation for terrain extraction, LIDAR and InSAR systems. Sampling, soft and hard breaklines. Structures of DTM (Contours, Grid, and TIN). Types of DEM (eg. CDED, DTED). Processing, storage, and manipulation of DTM. Surface representation from point data using moving averages, linear projection, and Kriging techniques. Grid resampling methods and search algorithms used in gridding and interpolation. DTM derivatives (slope maps, aspect maps, viewsheds, and watershed). Applications of DTM in orthoimage generation, volume computation, and drainage networks, telecommunications, flood prediction, data fusion, and 3D models and visualization. DEM error analysis and impact on DEM-based derived products.

18-Geom-B2 Satellite Navigation

Performance requirements, mathematical models, observation methods, processing strategies, uncertainties and other characteristics associated with moving marine, land airborne, and space vehicle positioning, orientation and attitude applications. Description of GPS signal structure and derivation of observables; characteristics of instrumentation; analysis of atmospheric, orbital, random and non-random effects; derivation of mathematical models used for absolute and differential static and kinematic positioning; pre-analysis methods and applications; software considerations; introduction to GPS quality control; static and kinematic survey procedures and operational aspects; integrated GPS-INS systems. Global navigation satellite system.

18-Geom-B3 Networks and Precise Engineering Surveys

Network concepts and their implementation. Reference systems and surfaces, datum, and fiducial networks. Special surveying and photogrammetric methods and instrumentation used for precise engineering and mining surveying; applications of lasers; deformation measurements and analysis; pre-analysis including reliability and sensitivity of engineering surveys; testing and laboratory calibration of surveying instruments; mapping of open pits and underground mines; shaft plumbing; use of lasers and gyrotheodelites; rock deformation measurements; underground construction surveys; tunnelling; subsidence measurements; special instruments and methods for high precision measurements, optical tooling, electronic theodolite and total station systems. Geotechnical measurements of tilt, strain, stress, etc. New network concepts. Wide Area Differential WADGPS and the concept of dynamic networks.

18-Geom-B4 Hydrography

Objectives and basic principles of physical oceanography and hydrography surveying; tides, water levels and vertical reference surfaces. Hydrography positioning including mathematical models, optical and radio techniques, radio propagation, satellite, acoustic and self-contained techniques. Depth determination including underwater acoustics, single and multi-beam systems, sea water properties, acoustic and non-acoustic techniques, sea tides, sea surface topography and sea bed properties. Data visualization and standards for safety of navigation.

18-Geom-B5 Survey Law

The Canadian Legal System: sources of law, statutes, regulations, rules; case law and precedent; common law; civil law in Quebec; administration of law and justice in Canada. Real Property Law: estates and tenures; legal and equitable interests; encumbrances; leases; mortgages; covenants; land use controls and rights in land; easements and rights of way; reservation; prescription; possession; freehold fee simple; adverse possession; limitation of actions; registration of deeds; registration of title; conveyancing. Boundary Law: nature of boundaries; creation of boundaries; principles of evidence; creation of evidence; retracement; artificial boundaries; natural boundaries; riparian rights; littoral boundaries; high and low water mark; erosion and accretion; dedication and acceptance; navigable waters; descriptions of land; offshore boundaries; leases at sea.

18-Geom-B6 Land Use Planning and Environmental Management

The evolution of urban planning in Canada; its present institutional, administrative and legal arrangements and its application. Site analysis prior to planning and design; criteria that are applicable to the design of residential site and subdivision plans. Resource management including environmental and ecological concerns that relate to resource development especially in remote areas. Contributions of geomatics technologies such as Geographic Information Systems (GIS), remote sensing, and ocean mapping to environmental engineering. Earth systems modelling, climate change, sustainable development and the general impacts of anthropogenic activity. Water quantity and quality issues; inland, costal, and ocean environments; and atmospheric and land-based processes are presented with applications of how geomatics technology supports monitoring and modelling efforts.

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.

18-Geom-A1 Surveying

Anderson, M.J., and E.M. Mikhail, _Surveying: Theory and Practice_. McGraw Hill, (5th Edition), 2017.

Wolf, P.R., and C.D. Ghilani, _Elementary Surveying. An Introduction to Geomatics_. Prentice Hall, New Jersey (10th Edition), 2002.

Moffitt, F.H. and H. Bouchard, _Surveying_. 9.th edition. Harper & Row Publishers, 1992. ISBN 0065000595.

Brinker, R.C. and P. Wolf, _Elementary Surveying_. 9th edition. Harper-Row, 1984. ISBN 0065003993.

Kissam, P., _Surveying for Civil Engineers_. 2nd edition. McGraw-Hill Book Co. Inc., 1981. ISBN 0070348820.

Kavanagh, B.F., _Surveying Principles and Applications_. Prentice Hall, New Jersey (6th Edition), 2003.

Surveying for Engineers, 5th Editing 2010

18-Geom-A2   Adjustment of Observations and Data Analysis

Mikhail, E.M., _Observations and Least-squares_. Thomas Y. Crowell, New York, 1976.

Mikhail, E.D., and G. Gracie, _Analysis & Adjustment of Survey Measurements_. Van Nostrand Reinhold, 1981.

Wolf, P.R., and C.D. Ghilani, _Adjustment Computations_. John Wiley & Sons Inc., 1997, ISBN 0-471-16833-5.

Krakiwsky, E.J. (Ed.), _Papers for the CISM Adjustment and Analysis Seminars_. 2nd edition. Canadian Institute of Geomatics, Ottawa, 1987.

18-Geom-A3   Geodesy and Positioning

Vanicek, P. and E.J. Krakiwsky, _Geodesy: The Concepts, (Parts IV and V)_. E.J. North Holland Publishing Co., 1986. ISBN 0444877770.

Heiskanen W.A., and H. Moritz, _Physical Geodesy_. Technical University, Gratz (reprint), 1979.

Moritz, H., _Advanced Physical Geodesy_. Abacus Press, Tunbridge Wells, U.K, 1980.

Torge, W., _Geodesy_. Walter de Gruyter, Berlin (3rd Edition), 2001.

18-Geom-A4   Photogrammetry

Mikhail E., J. Bethel, and J.C. McGlone, _Introduction to modern photogrammetry_. Wiley, 2001.

McGlone C. (Ed.), E. Mikhail & J. Bethel (Associate Editors), _Manual of Photogrammetry_. 5th Edition, Published by the American Society for Photogrammetry and Remote Sensing, 2004.

Schenk T., Digital photogrammetry. TerraScience, 1999.

Konecny G., _Geoinformation: remote sensing, photogrammetry and geographic information systems_. Taylor & Francis, 2003.

Ghosh S.K., _Analytical Photogrammetry_. 2nd ed, Pergamon Press, 1988.

Wolf P.R, and B.A. Dewitt, *Elements of photogrammetry: with applications in GIS.* 3rd ed, McGraw-Hill, 2000.

Kraus K., *Photogrammetry, Vol 1 and 2.* 4th rev. ed, Ferd. Dümmlers Verlag, 1993.

Ghosh S.K., Phototriangulation. Lexington Books, 1975.

18-Geom-A5   Remote Sensing and Image Analysis

Lillesand T.M., and R.W. Kiefer, *Remote sensing and image interpretation.* 4th ed, John Wiley & Sons, 2000.

Ryerson R.A., (ed.), *Manual of remote sensing.* 3rd ed, Wiley, 1996.

Avery T.E., and G.L. Berlin, *Fundamentals of remote sensing and airphoto interpretation.* 5th ed, Maxwell Macmillan International, 1991.

Jensen J.R., *Introductory digital image processing: a remote sensing perspective.* 2nd ed Prentice Hall, 1996.

Richards J.A., and X. Jia, *Remote sensing digital image analysis: an introduction.* 3rd ed Springer, 1999.

Mather P.M., *Computer processing of remotely-sensed images: an introduction.* Wiley, 1988.

Schowengerdt R.A., *Remote sensing - models and methods for image processing.* 2nd ed, Academic Press, 1997.

Leberl F.W., *Radargrammetric image processing.* Artech House, 1989.

French Textbooks:

Bonn & Rochon, *Précis de télédétection, volume 1: Principes et méthodes.* Presses de l'Université du Québec, 1992.

Caloz & Collet, *Précis de télédétection, volume 3: Traitements numériques d'images de télédétection.* Presses de l'Université du Québec, 2001.

Girard & Girard, *Traitement des données de télédétection.* DUNOD, Paris, 1999.

Henri Maitre, *Le traitement des images.* Hermès Sciences, Paris, 2002.

18-Geom-A6   Cadastral Studies

Teskey, W.F., T.C. Swanby, W.D. Usher, and A. Hittel, *Cadastral Studies Lecture Notes.* A Division of Surveying Engineering, University of Calgary, 1983.

Survey Law in Canada (Note: Now out of print, but approved photocopies may be obtained through the offices of the Canadian Council of Land Surveyors in Ottawa)

Dale, P.F. and J.D. McLaughlin, *Land Information Management: An Introduction with Special Reference to Cadastral Problems in Third World Countries*, Oxford University Press 1988.

18-Geom-A7   Geospatial Information Systems

Longley, P.A., M.F. Goodchild, D.J. Maguire, and D.W. Rhind, *Geographic Information Systems and Science.* Wiley Ed. ISBN 0-471-89275-0, 2001.

Date, C.J., *Introduction to Database Systems.* 8th edition. Addison-Wesley, Reading Mass., 2003. ISBN: 0321197844.

Groot R. and J. McLaughlin, (eds) *Geospatial data infrastructure: concepts, cases, and good practice.* Oxford University Press, 2000.

Monmonier, M.S., *Computer Assisted Cartography: Principles and Prospects*. Prentice Hall, 1982.

Keates J.S., *Cartographic Design and Production*. 2nd edition. Halsted Press, 1989.

Robinson, A.H. et al., *Elements of Cartography*. 6th edition. John Wiley and Sons, 1995. ISBN 0471555797.

Maling, D.H., *Coordinate Systems and Map Projections*. 2nd edition. George Philip and Son Ltd., London, 1992. ISBN 0080372341.

Molenaar M., *An introduction to the theory of spatial object modelling for GIS*. Taylor & Francis, 1998.

Burrough P.A. and R.A. McDonnell, *Principles of geographical information systems*. University Press, 1997.

Kraak M.-J. and F. Ferjan Ormeling, *Cartography: visualization of spatial data*. Longman, 1996.

Green D. and T. Bossomaier, *Online GIS and spatial metadata*. Taylor & Francis, 2002.

Aronoff S., *Geographic information systems: a management perspective*. WDL Publications, 1989.

Goodchild M. and R. Jeansoulin (eds) *Data quality in geographic information: from error to uncertainty*. Hermès, 1998.

18-Geom-B1 Digital Terrain Modelling

Petrie, G. and T. J. M. Kennie (edit). *Terrain modelling in surveying and civil engineering*. New York: McGraw-Hill, 1991.

Maune, D.F. (Editor). *Digital Elevation Model Technologies and Applications, the DEM Users Manual*. Published by the American Society for Photogrammetry & Remote Sensing, 2001.

McGlone C. (Editor), E. Mikhail & J. Bethel (Associate Editors), *Manual of Photogrammetry*. 5th Edition, Published by the American Society for Photogrammetry and Remote Sensing, 2004.

Greve C. (Editor). *An Addendum to the Manual of Photogrammetry*. Published by the American Society for Photogrammetry and Remote Sensing, 1996.

Leberl F.W., *Radargrammetric image processing*. Artech House, 1989.

Davis, John C., *Statistics and data analysis in geology*. New York, Wiley, 2nd ed , 1986.

Lodwick G.D., *Digital Terrain Modelling*. University of Calgary, Publication No. 10007, 1983.

18-Geom-B2 Satellite Navigation

Wells et. al., *Guide to GPS Positioning*. Canadian GPS Associates, Fredericton, N.B., 1986.

Torge, W., *Geodesy*. Walter de Gruyter. Berlin (3rd Edition), 2001.

Vanicek P. and E. Krakiwsky, *Geodesy: The Concepts*. North Holland, Amsterdam (2nd Edition). (Chapters 15 and 16), 1986.

Leick, A., *GPS Satellite Surveying*. 2nd edition. Wiley, 1995. ISBN 0471306266.

El-Rabbany, A., *Introduction to GPS, the Global Positioning System*. Artech House, Boston, 2002.

18-Geom-B3 Networks and Precise Engineering Surveys

Anderson, M.J., and E.M. Mikhail, *Surveying: Theory and Practice*. McGraw-Hill, (7th Edition). 1998.

Kuang, S., *Geodetic Network Analysis and Optimal Design: Concepts and Applications*. Ann Arbor Press, Inc., Chelsea, Michigan, 1998.

Caspary, W.F., *Concepts of Network and Deformation Analysis*. Monograph 11, School of Surveying, The University of New South Wales, Kensington, N.S.W., Australia, 183 pp, 1988.

Teskey, W.F. (editor), *Proceedings of 7th International FIG Symposium on Deformation Measurements and 6th Canadian Symposium on Mining Surveying*. Canadian Institute of Geomatics, Ottawa, 1993.

Wolf, P.R. and C.D. Ghilani, *Adjustment Computations*. John Wiley & Sons Inc., 1997, ISBN 0-471-16833-5.

18-Geom-B4 Hydrography

Ingham, A.E. *Hydrography for the Surveyor and Engineer*. 3rd edition. Wiley, 1994. ISBN 0632029439.

Bowditch, N., *American Practical Navigator, Volumes I and II*. Topographic Centre, United States Defence Mapping Agency, 1976. ISBN 0403089948.

De Jong, C.D., G. Lachapelle, S. Skone, and I. Elema, *Hydrography*. Delft University Press, 2002.

Appleyard, S.F. et al., *Marine Electronic Navigation*, 2nd edition. Routledge & Kegan Paul, 1988.

Forrester, W. D., *Canadian Tidal Manual*. Department of Fisheries and Oceans, Canadian Hydrographic Service, 1983. ISBN 0660113414.

18-Geom-B5 Survey Law

Ziff, Bruce, *Principle of Property Law*, 3rd edition, CARSWELL, 2000.

Survey Law in Canada (Note: Now out of print, but approved photocopies may be obtained through the offices of the Canadian Council of Land Surveyors in Ottawa)

18-Geom-B6 Land Use Planning and Environmental Management

Chapin, F.S. and E.J. Kaiser, *Urban Land Use Planning*. 4th edition. University of Illinois Press, 1995. ISBN 0252021010.

Ratcliffe, J. *An Introduction to Town and Country Planning*. 2nd edition. Longwood Publication Group, 1984.

Lynch, *Site Planning*, 3rd edition. M.I.T. Press, 1984. ISBN 0262121069.

So, F.S. et al. (editors), *The Practice of Local Government Planning*, 2nd edition. Planners Press, 1988. (International City Management Association in cooperation with APA. ISBN 0873260775.

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, 2nd 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 5th 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

GEOMATICS ENGINEERING

INTRODUCTION

A full set of Geomatics 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-4	Electric Circuits and Power
04-BS-5	Advanced Mathematics
04-BS-6	Mechanics of Materials
04-BS-7	Mechanics of Fluids
04-BS-8	Digital Logic Circuits
04-BS-9	Basic Electromagnetics
04-BS-10	Thermodynamics
04-BS-11	Properties of Materials
04-BS-12	Organic Chemistry
04-BS-13	Biology
04-BS-14	Geology
04-BS-15	Engineering Graphics and Design Process
04-BS-16	Discrete Mathematics

PROFESSIONAL EXAMS – SPECIFIC TO GEOMATICS ENGINEERING

GROUP A

18-Geom-A1	Surveying
18-Geom-A2	Adjustment of Observations and Data Analysis
18-Geom-A3	Geodesy and Positioning
18-Geom-A4	Photogrammetry
18-Geom-A5	Remote Sensing and Image Analysis
18-Geom-A6	Cadastral Studies
18-Geom-A7	Geospatial Information Systems

GROUP B

18-Geom-B1	Digital Terrain Modelling
18-Geom-B2	Satellite Navigation
18-Geom-B3	Networks and Precise Engineering Surveys
18-Geom-B4	Hydrography
18-Geom-B5	Survey Law
18-Geom-B6	Land Use Planning and Environmental Management

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