The Association of Professional Engineers,
Geologists and Geophysicists of Alberta

GEOMATICS ENGINEERING
SYLLABUS OF EXAMINATIONS
2004 EDITION

For textbook information please refer to the **Textbooks** section on page 3 of the document entitled **Information for Students and Examinations Candidates**.

GEOMATICS ENGINEERING EXAMINATIONS
GROUP A
COMPULSORY EXAMINATIONS (SEVEN REQUIRED)

04-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.

04-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. 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 Practical applications of data analysis and processing in Geomatics engineering.

04-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.

04-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.

04-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.

04-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.

04-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
ELECTIVE EXAMINATIONS (THREE REQUIRED)

04-Geom-B1   Digital Terrain Modelling
Digital Terrain Modelling (DTM, DEM, DHM, DSM) concepts and 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.

04-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.

04-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. Special surveying methods and

instrumentation of high precision. New network concepts. WADGPS and the concept of dynamic networks.

04-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.

04-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.

04-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 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.

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