1. PREAMBLE
The geophysical knowledge required by APEGA for registration as a Professional Geoscientist (P.Geo.) follows the national syllabi of minimum qualifications recommended by Geoscientists Canada. Information about these recommendations is provided on the Geoscientists Canada website (http://geoscientistscanada.ca/) which includes a link (https://geoscientistscanada.ca/wp-content/uploads/2014/11/GC-Knowledge-Requ.BKLT-.REV-.EN-.web-.final-.pdf) to the downloadable booklet, "Geoscience Knowledge and Experience (GKE) Requirements for Professional Registration in Canada".

Minimum Required Knowledge
Examinations offered by APEGA in connection with the above-mentioned GKE document are based on the subject descriptions in the GKE document recommending the geoscience knowledge requirements for professional registration, outlined below. The fundamental unit of knowledge in the outline below is the educational unit (EU). One educational unit in a subject is defined as formal instruction equivalent to a one-term (one semester) course in an Honours B.Sc. degree program at a Canadian university. For example, one EU could consist of approximately 3 hours of lectures or equivalent per week, with or without a lab, for thirteen weeks. An EU can be considered as the equivalent of one 3-credit-hour course in a 120 credit-hour, 4-year degree program.

SECTION 1: FUNDAMENTAL SCIENCE
(9 EUs required)

1A. COMPULSORY FOUNDATION SCIENCE  (3 EUs required)
- Chemistry - 1 EU
- Mathematics - 1 EU
- Physics - 1 EU

AND

1B. ADDITIONAL FOUNDATION SCIENCE  (6 EUs required; maximum of two in any subject area, e.g. two in biology, two in chemistry, etc.)
- Biology
- Chemistry
- Computer Programming
- Mathematics
- Physics
- Statistics
SECTION 2: GEOSCIENCE as outlined by Geoscientists Canada
(18 EUs required, in addition to Section 1 Fundamental Science)

2A. COMPULSORY FOUNDATION GEOSCIENCE  (4 EUs required, with 1 EU from each subject area)
- Field techniques (field-based instruction in geophysics, not classroom lectures)
- Mineralogy & petrology
- Stratigraphy and sedimentation
- Structural geology

2B. ADDITIONAL FOUNDATION GEOSCIENCE  (5 EUs required, with 1 EU from each of 5 of the 6 subject areas)

- Digital Signal Processing
- Global Geophysics / Physics of the Earth
- Seismology / Seismic Methods
- Exploration Geophysics
- Radiometrics / Gravity & Magnetics
- Electrical & Electromagnetic Methods

2C. OTHER GEOSCIENCE/SCIENCE  (9 EUs required. The 9 EUs must be at the second level (not introductory) or higher acceptable for science credit toward a degree in science, applied science, or engineering, and relevant to geoscience. Extra courses not used in 2A and 2B can be used in 2C. EUs must chosen from at least 4 of the 11 subject areas listed below.
- Applied Math / Physics
- Communication (e.g., thesis, technical writing)
- Earth & Planetary Geoscience
- Field Techniques
- Fundamental Math / Physics
- Geology
- Geophysical Methods & Interpretation
- Modern Physics
- Near-surface Geoscience (e.g., environmental geophysics)
- Regional Geology
- Resource Geoscience (e.g., hydrology, petroleum geology)
APEGA Geophysics Syllabus

Checklist for Course-by-Course Assessment    Date: ____________________

Applicant Name: ______________________________________  Application Type: _________________

Applicant Education: __________________________________________________________________

Applicant - Other Info: _________________________________________________________________

For detailed descriptions of the subject areas listed below, refer to the GKE document, at

<table>
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<tr>
<th>1A. All 3 required</th>
<th>2B. 5 required, with 1 from each of 5 of the 6 subject areas</th>
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<tr>
<td>1. Chemistry</td>
<td>1. Digital Signal Processing</td>
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<th>1B. 6 required. No more than 2 from any one subject area</th>
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<td>6. Electrical &amp; Electromagnetic Methods</td>
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<tr>
<th>1. Biology</th>
<th>2. Chemistry</th>
<th>2C.* 9 required from at least 4 of the 11 subject areas. Extra courses not used in 2A and 2B may be used in 2C</th>
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<tbody>
<tr>
<td>1A. All 4 required</td>
<td>2A. All 4 required</td>
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<tr>
<td>1. Field Techniques (Geophysics)</td>
<td>3. Earth &amp; Planetary Geoscience</td>
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<td>2. Mineralogy &amp; Petrology</td>
<td>4. Field Techniques</td>
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<td>3. Sedimentation &amp; Stratigraphy</td>
<td>5. Fundamental Math / Physics</td>
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<td>4. Structural Geology</td>
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<tr>
<td>5. Fundamental Math / Physics</td>
<td>7. Geophysical Methods &amp; Interpretation</td>
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*Courses for 2C must be at a second level (not introductory) or higher acceptable for science credit towards a degree in science, applied science, or engineering, and relevant to geoscience.
Group 1A  Compulsory Foundation Science

1A.1 Chemistry

First year (or higher) university/CEGEP level Chemistry for Science or Engineering degrees with labs such as:

1A.1a Chemistry


1A.1b Chemistry

“Chemistry II”: Acid/base concepts. Chemical kinetics and equilibrium. Acid-base and solubility equilibria. Elementary thermodynamics. Oxidation and reduction, electrochemistry, or

1A.1c Chemistry

“General Chemistry I”: Atomic and molecular structure, stoichiometry in chemical reactions. Chemical bonding. Structures and reactions of organic and inorganic compounds. Materials science, or

1A.1d Chemistry


1A.2 Mathematics

First-year (or higher) university CEGEP-level Mathematics courses for Science or Engineering degrees such as:

1A.2a Mathematics  (similar to 2C.1a – credit for both not allowed)

Calculus I: Review of analytical geometry. Differentiation and integration of simple functions. Applications, or

1A.2b Mathematics  (similar to 2C.1a – credit for both not allowed)

Calculus II: Differentiation and integration of trigonometric, exponential and logarithmic functions. Indeterminate forms and improper integrals. Applications, or

1A.2c Mathematics  (similar to 2C.1a – credit for both not allowed)

Introductory Calculus: Functions and graphs, differentiation and integration of simple functions, analytical geometry.

NOTE: Remedial high school level algebra, trigonometry, geometry or pre-calculus, are not acceptable.

1A.3 Physics

First-year (or higher) university CEGEP-level Physics courses for Science or Engineering degrees w/labs such as:

1A.3a Physics (similar to 2C.5d – credit for both not allowed)
Physics I: Vectors, kinematics in 1D, kinematics in 2D, forces and Newton’s laws of motion, work and kinetic energy, potential energy and conservative forces, linear momentum and collisions, linear and rotational kinematics, rotational dynamics, static equilibrium, gravitational forces, elasticity and simple harmonic motion, oscillations and resonance, waves and sound, or

1A.3b Physics (similar to 2C.5c – credit for both not allowed)

Physics II: Fluids, temperature and heat, kinetic theory of gases, thermodynamics, phase changes, electric charge, electric field, electric potential and potential energy, electric currents, DC circuits, AC circuits, magnetism, Ampere’s law, magnetic flux and Faraday’s law of induction, or

1A.3c Physics (similar to 2C.5d – credit for both not allowed)

Introductory Physics I: Fundamental concepts, definitions and physical laws. Vectors, kinematics and statics. Newton’s laws, force, work and energy, conservation laws, or

1A.3d Physics (similar to 2C.5d – credit for both not allowed)


**Group 1B  Additional Foundation Science**

1B.1 Biology

1B.1a Biology

Course covering one or more of these topics: (a) unity, (b) diversity, (c) continuity and (d) interaction. Unity encompasses the historical events leading to major biological concepts, the chemistry of cells, cell structure and hereditary mechanisms. Diversity deals with the variety of cell types, organ systems and organisms from developmental and evolutionary points of view. Continuity covers the mechanisms of heredity as they relate to evolution. Darwinian evolution and the evolution of man are emphasized. Interaction places the emphasis on the ecosystem and the interaction of organisms with their environment, or

1B.1b Biology

Higher-level course for degree in science or engineering with a bioscience prerequisite - e.g. vertebrate zoology, invertebrate zoology, microbiology.

1B.2 Chemistry

1B.2a Chemistry

Chemistry I or II, whichever was not counted in 1A or

1B.2b Chemistry

Physical Chemistry: (a second-year or higher level course with first-year chemistry prerequisite). Fundamental concepts of matter in relation to energy. The laws of classical thermodynamics and their application to the properties of gases, liquids, solids and solution. Transport phenomena. The basic laws of chemical kinetics, and their application to reactions in gaseous and liquid phases. Catalysis, or

1B.2c Chemistry

Organic Chemistry: (a second-year or higher level course with first-year chemistry prerequisite) A study of compounds of carbon with emphasis on reaction mechanisms to illustrate the basic principles of organic chemistry. Structure and bonding, physical properties, and stereochemistry; addition, elimination, and displacement reactions by function group classification; structure reactivity relationships; aromaticity and
aromatic substitution; condensation reactions; spectroscopic methods for structure determination, or

1B.2d Chemistry

Inorganic Chemistry: (a second-year or higher level course with first-year chemistry prerequisite) The structure of many-electron atoms, bonding and stereochemistry in inorganic compounds, elementary crystallography, solid-state science and aspects of inorganic solution chemistry. The chemistry of metals and ligand field theory; coordination compounds, metal carbonyls and organometallic compounds of the transition elements; descriptive chemistry of the first-row transition elements; industrial extraction of metals; uses of transition metal complexes as catalysts; an introduction to the role of metals in biology, or

1B.2e Chemistry

Higher-level chemistry courses for degree in science or engineering that require one or more of the above courses as prerequisites.

1B.3 Computer Programming

1B.3a Computer Programming

Computer science course that requires students to develop familiarity with a high level programming language (one of Fortran, Pascal, or C) and develop facility in writing computer programs. Organization of stored program computers; principles of structured programming (input/output, assignment, selection and repetition, modular design using functions and procedures/subroutines, data structures including arrays and text files; design and testing of algorithms; introduction to numerical methods) curve fitting, numerical integration, root finding, or

1B.3b Computer Programming

Computer Programming: Application of programming techniques using a high-level language for the manipulation of large data sets and the solution of problems in mathematics and physics.

NOTE: Computer science courses that do not involve any programming are not acceptable.

1B.4 Mathematics

1B.4a Mathematics (similar to 2C.1a – credit for both not allowed)

Calculus I or II, whichever was not counted in 1A, or

1B.4b Mathematics (similar to 2C.5b – credit for both not allowed)

Differential equations and transform methods: linear ordinary differential equations; the Laplace transformation; series solutions of differential equations; boundary value problems and orthogonal functions; Fourier series; Fourier integrals, or

1B.4c Mathematics (same as 2C.1l – credit for both not allowed)

Linear algebra: linear transformations; matrices and matrix operations; determinants; simultaneous linear algebraic equations; eigenvalues and eigenvectors, or

1B.4d Mathematics (same as 2C.1r – credit for both not allowed)

Vector analysis: vector algebra; vector functions and operators; orthogonal curvilinear multiple coordinates; applications of partial derivatives, multiple integrals, line and surface integrals; integral theorems, or

1B.4e Mathematics
Higher-level mathematics courses for science or engineering majors that require one or more of the above courses as prerequisites.

1B.5  Physics

1B.5a  Physics

Physics I or II, whichever was not counted in 1A, or

1B.5b  Physics (similar to 2C.5e – credit for both not allowed)

Thermodynamics: (a second-year or higher level course with first-year physics prerequisite).
Thermodynamic states of simple systems; the laws of thermodynamics; equilibrium, PVT and other thermodynamic diagrams; energy of state; compressibility charts and steam tables; calculation of property changes; enthalpy; applications of thermodynamics, cycles, reversibility; thermodynamics of phase changes, the Gibbs phase rule; gas-vapor mixtures, psychrometrics, or

1B.5c  Physics (similar to 2C.5f – credit for both not allowed)

Optics and waves - a second year or higher level course with first year physics prerequisite, or

1B.5d  Physics

Planetary physics – a second-year or higher level course for science or engineering majors with first year physics prerequisite.

1B.5e  Physics

Higher level physics courses for science or engineering majors that require one or more of the above courses as prerequisites.

NOTE: general interest courses such as Introduction to Astronomy are not acceptable.

1B.6  Statistics

Descriptive statistics; probability distributions, estimation; hypothesis testing; normal, chi-squared, t- and F-distributions; mean and variance tests; regression and correlation; and the use of statistical computer software.

Group 2A Compulsory Foundation Geoscience

2A.1  Field Techniques

2A.1a  Field Techniques (Geophysics) (same as 2C.4a – credit for both not allowed)

Field surveys and data collection techniques for seismic, gravity, magnetic, electromagnetic, electrical and radiometric methods. Surveys for elevation and position location. Field analysis of geophysical data. Instrumentation.

2A.1b  Field Techniques (Geology & Envir. Geosci.) (same as 2C.4b – credit for both not allowed)

Navigation, geological mapping techniques, sampling, field reports.

2A.2  Mineralogy and Petrology

Systematic mineralogy (including: identification, classification and description), Physical and chemical properties of minerals. Crystallography and crystal systems (symmetry, crystal structure, crystal systems) Descriptions of rocks in hand samples. Optical techniques in mineral identification.
2A.3 Sedimentation and Stratigraphy

Principles of correlation, facies concept, dynamic processes and their geological record.

2A.4 Structural Geology

Description and classification of geological structures, maps, cross-sections, stereographic projections, mechanical principles, stress and strain.

Group 2B Additional Foundation Geoscience

2B.1 Digital Signal Processing (same as 2C.1e – credit for both not allowed)

Introduction to the theory of basic computational techniques of digital processing in geophysics sampling theory; Fourier transforms, convolution, correlation, z-transforms, design and application of digital filters, deconvolution, spectral analysis, 2D signal processing.

2B.2 Global Geophysics / Physics of the Earth : one of

2B.2a Global Geophysics (same as 2C.3c – credit for both not allowed)

Physics of the Earth, gravity, the geoid, geomagnetism, paleomagnetism, heat flow, earthquake seismology, mantle convection.

2B.2b Physics of the Earth (same as 2C.3c – credit for both not allowed)

Physics of the Earth, gravity, the geoid, geomagnetism, paleomagnetism, heat flow, radioactivity and geochronology. Earthquake seismology. Solar system, meteorites.

2B.3 Seismology / Seismic Methods : one of

2B.3a Seismology (same as 2C.7f – credit for both not allowed)


2B.3b Seismic Methods

Basic understanding of seismic wave propagation and seismic velocities of rocks and overburden; principles of refraction and reflection seismology; field methods to acquire and process refraction seismic data; methods to acquire and process reflection seismic data; obtaining velocity and depth information from refraction and reflection surveys; basics of seismic resolution.

2B.4 Exploration Geophysics (similar to 2C.9a – credit for both not allowed)

Applied geophysics: reflection and refraction seismology, gravity and magnetics, electrical and electromagnetic methods applied to exploration and environmental problems.

2B.5 Radiometrics / Gravity & Magnetics : one of

2B.5a Radiometrics (same as 2C.7g – credit for both not allowed)

Common rock-forming radioactive minerals; gamma ray spectra; gamma spectrometers and crystal detectors; ground and airborne radiometric techniques; geological interpretation using radiometrics; borehole radiometric logging.
2B.5b Gravity & Magnetics (same as 2C.7e – credit for both not allowed)


2B.6 Electrical & Electromagnetic Methods (same as 2C.7d – credit for both not allowed)


Group 2C Other Geoscience/Science. These lists are not meant to be exhaustive.

2C.1 Applied Math / Physics

2C.1a Calculus (similar to 1A.2a,b,c & 1B.4a – credit for both not allowed)


2C.1b Computer-Controlled Instrumentation

Data communications, including signals, modulation and reception. Performance of optimum and sub-optimum systems. Data transmission characteristics, including half/full duplex, asynchronous/synchronous, point-to-point/multidrop and character/bit oriented. Error detecting and correcting codes. Character sets and message communications. Local area networks.

2C.1c Condensed Matter Physics


2C.1d Continuum Mechanics

Stress and strain in continuous media; elasticity. Mechanics of fluid flow in two and three dimensions. Thermodynamics and mechanics of compressible and viscous flows. Turbulence and convection.

2C.1e Digital Signal Processing (same as 2B.1 – credit for both not allowed)

Introduction to the theory of basic computational techniques of digital processing in geophysics sampling theory; Fourier transforms, convolution, correlation, z-transforms, design and application of digital filters, deconvolution, spectral analysis, 2D signal processing.

2C.1f Electromagnetic Theory

Time varying electromagnetic fields up to Maxwell's Equations including topics such as induced fields. Gradient, divergence, curl. Boundary value problems in electrostatics and magnetostatics. Electrical and magnetic properties of materials.

2C.1g Electronics for Scientists

Basic principles of electronics. Active and passive components, feedback, operational amplifiers, digital electronics, interfacing.

2C.1h Fluid Dynamics
Flow of viscous and non-viscous fluids, dimensional methods in turbulence.

2C.1i Fluid Flow in Porous Media (same as 2C.11a – credit for both not allowed)

Porosity, fluid saturation, permeability, interfacial tension, wettability, capillary pressure, effective and relative permeability, steady and unsteady state fluid flow.

2C.1j Geostatistics

Theory and application of geostatistics. Understanding of available methods and their limitations. Preparation and analysis of data for use in geostatistical models, understand the basics of geostatistical modeling, and ability to build and interpret complex geological models.

2C.1k Integral Transforms

Fourier and Laplace transforms and their applications in the physical sciences.

2C.1l Linear Algebra (same as 1B.4c – credit for both not allowed)

Vector and matrix algebra, determinants, linear systems of equations, vector spaces, eigenvalues and eigenvectors. Applications.

2C.1m Mathematical Physics

Functions of a complex variable; residue calculus; introduction to Cartesian tensor analysis; matrix eigenvalues and eigenvectors; diagonalization of tensors; vector differential operators in curvilinear coordinate systems; introduction to partial differential equations; boundary value problems; derivation of the classical equations; separation of variables.

2C.1n Numerical Methods/Computing

Basic methods in computational physics including numerical algorithms applied to problems in nonlinear mechanics (chaotic dynamics, iterative maps, etc.), wave motion, electrodynamics, statistical physics, and quantum mechanics, parallel computing methods, writing programs and running simulation algorithms.

2C.1o Optics

Review of waves and EM theory, the electromagnetic spectrum, interaction of light with matter and optical materials, geometrical optics and aberrations, polarization, electro-optic modulators, diffraction, diffraction gratings, spot size and resolution of imaging systems, Fourier optics and image processing, laser fundamentals and examples of laser systems.

2C.1p Partial Differential Equations


2C.1q Signal Analysis

Advanced methods of data analysis in exploration and production geophysics including advanced filtering, migration, inversion and tomography.

2C.1r Vector and Tensor Analysis (same as 1B.4d – credit for both not allowed)

Vector algebra; vector functions and operators; orthogonal curvilinear multiple coordinates; applications of partial derivatives, multiple integrals, line and surface integrals; integral theorems.

2C.2 Communication
2C.2a Thesis

Experimental, theoretical, applied research project in an area of geoscience, carried out independently and under faculty supervision.

2C.2b Technical Writing

Principles of effective written communication in geoscience in technical, professional and business contexts.

2C.3 Earth & Planetary Geoscience

2C.3a Geomagnetism/ Paleomagnetism

Fundamental principles of rock magnetism, paleomagnetism, and geomagnetism; origin and behaviour of the geomagnetic field; physical and chemical basis of paleomagnetism; physics of magnetism as it applies to rocks and minerals; origin of remanent magnetization; mineralogy of magnetic minerals; paleomagnetic measurement techniques.

2C.3b Global Tectonics

Global aspects of plate tectonics, basin development and regional geology through time. Contributions of geophysics, sedimentary basin analysis, geochemistry and petrology to the modern plate tectonic model. Analysis and interpretation of major structural provinces as they relate to the plate boundary interactions.

2C.3c Global Geophysics (same as 2B.2a,b – credit for both not allowed)

Physics of the Earth, gravity, the geoid, geomagnetism, paleomagnetism, heat flow, earthquake seismology, mantle convection.

2C.4 Field Techniques

2C.4a Field Techniques (Geophysics) (same as 2A.1a – credit for both not allowed)

Field surveys and data collection techniques for seismic, gravity, magnetic, electromagnetic, electrical and radiometric methods. Surveys for elevation and position location. Field analysis of geophysical data. Instrumentation.

2C.4b Field Techniques (Geology & Envir. Geosci.) (same as 2A.1b – credit for both not allowed)

Navigation, geological mapping techniques, sampling, field reports.

2C.5 Fundamental Math / Physics

2C.5a Complex Analysis

Mapping by elementary functions; conformal mapping; applications of conformal mapping; Schwartz-Christoffel transformation; Poisson integral formula; poles and zeros; Laplace transforms and stability of systems; analytic continuation.

2C.5b Differential Equations (similar to 1B.4b – credit for both not allowed)

First- and second-order linear differential equations with applications. Series solutions about regular points and singular points.

2C.5c Electricity & Magnetism (similar to 1A.3b – credit for both not allowed)
Electrostatics, DC circuits, electric field, electric potential, Gauss's law, electromagnetic induction, capacitance. AC circuits. Electrical and magnetic properties of materials.

2C.5d Mechanics (similar to 1A.3a,c,d – credit for both not allowed)

Introductory Newtonian particle mechanics and rigid bodies in rotational equilibrium: kinematics, Newton's laws, conservation of momentum and mechanical energy.

2C.5e Thermodynamics  (similar to 1B.5b – credit for both not allowed)

Thermodynamic states of simple systems; the fundamental relation of thermodynamics; the first and second laws of thermodynamics; equilibrium, PVT and other thermodynamic diagrams; energy of state; compressibility charts and steam tables; calculation of property changes; enthalpy; Helmholtz and Gibbs function; the Maxwell equations; applications of thermodynamics, cycles, reversibility; thermodynamics of phase changes, the Clapeyron equation, Gibb's phase rule, gas-vapor mixtures, psychrometrics.

2C.5f Vibrations, Waves & Optics (similar to 1B.5c – credit for both not allowed)

Harmonic damped and forced oscillators. Geometrical optics, interference, waves, diffractions. Wave-equation.

2C.6 Geology

2C.6a Geochemistry

Chemistry of Earth and Earth environments, geological processes, geological cycles and reservoirs, stability diagrams, balancing chemical reactions.

2C.6b Igneous Petrology

Classification, mineralogy and textures, igneous processes origin, evolution, description in hand sample and thin section.

2C.6c Metamorphic Petrology

Classification, mineralogy and textures, metamorphic processes, facies, P-T-composition interpretation, description in hand sample and thin section.

2C.6d Sedimentary Petrology

Origin of sedimentary rocks, including the physics and chemistry of their deposition, diagenesis and weathering processes. Laboratory includes hand specimen and microscopic petrography, classification, and grain size and shape analysis.

2C.6e Structural Geology


2C.6f Tectonics

Analysis and interpretation of major structural provinces as they relate to the plate boundary interactions.

2C.7 Geophysical Methods & Interpretation

2C.7a Analytical Methods (Geophysics)
Infinite series of constants; sequences; series of functions; uniform convergence; power series; Taylor series; Weierstrass Approximation; iterative methods for nonlinear equations in one variable; interpolation and polynomial approximation; discrete least-squares approximation; numerical differentiation and integration.

2C.7b Analytical Methods (Geoscience)

Instruments and methods used to analyze the chemistry of samples, such as ICP-MS (inductively coupled plasma mass spectrometry), IC (ion chromatography), XRF (x-ray fluorescence), XRD (x-ray diffraction), AAS (atomic absorption spectrophotometry). Understanding of the theory of the instruments as well as practical aspects of sample preparation and improving data quality.

2C.7c Marine Geophysics

The application of the various geophysical techniques to the study of the sea floor and the examination of principal results obtained. The processes involved in the creation, evolution and destruction of ocean basins and the implications of the experimental observations.

2C.7d Electrical and Electromagnetic Methods (same as 2B.6 – credit for both not allowed)


2C.7e Gravity & Magnetics (same as 2B.5b – credit for both not allowed)


2C.7f Seismology (same as 2B.3a – credit for both not allowed)


2C.7g Radiometrics (same as 2B.5a – credit for both not allowed)

Common rock-forming radioactive minerals; gamma ray spectra; gamma spectrometers and crystal detectors; ground and airborne radiometric techniques; geological interpretation using radiometrics; borehole radiometric logging.

2C.7h Rock Properties/Rock Physics

Physical properties of minerals and rocks. Measurement methods and their relationship to geophysical surveys and interpretation.

2C.7i Seismic Interpretation

Principles of seismic stratigraphy, and seismic sequence analysis, and structural interpretation of reflection seismic data, depth conversion methods.

2C.7j Geodesy/Geomatics
Advanced principles of geodesy and geomatic methods, including projections, co-ordinate systems, reference states.

2C.8 Modern Physics
2C.8a Elements of Modern Physics

Experimental evidence leading to the development of quantum mechanics including the photoelectric effect, the Compton effect, X-ray production and electron diffraction; Heisenberg uncertainty principle, Schrodinger theory of quantum mechanics; the simple harmonic oscillator; atomic physics; hydrogen atom; periodic table.

2C.8b Quantum Mechanics

Origins of quantum mechanics; wave functions; Schrodinger equation and its application to one dimensional systems, postulates and physical interpretation of quantum mechanics; orbital angular momentum, central potentials and three-dimensional systems.

2C.8c Statistical Physics

Quantum states, probability distributions, temperature and entropy; canonical ensemble and the partition function; ideal gases, paramagnets; blackbody radiation. Debye model for phonons; quantum statistics; Fermi-Dirac distribution and electrons in metals; Bose-Einstein distribution.

2C.9 Near Surface Geoscience

2C.9a Environmental Geophysics (similar to 2B.4 – credit for both not allowed)

Methods for determining the composition and structure of shallow subsurface materials, including refraction seismic, high resolution reflection seismic, direct current resistivity, induced polarization (IP), low induction number electromagnetic profiling and depth sounding, ground penetrating radar, magnetics and microgravity.

2C.9b Geomorphology

Processes and principles of landform development, introduction to air photo interpretation.

2C.9c Geomorphology (Advanced)

Examination of one or several geomorphic environments, including applied topics. Recognition and interpretation of sediments and landforms and the processes involved in their formation. In the case of applied geomorphology, to analyze problems caused by geomorphic processes pertinent to engineering or resource development.

2C.9d Geographic Information Systems

Fundamentals, concepts and components of geographic information systems (GIS) as applied to geoscience. Ability to acquire, manipulate and analyze digital terrain data for geological, engineering and/or environmental applications.

2C.9e Glacial Geology (credit allowed for only one of 2C.9e, 2C.9f)

Processes and products of glaciation (the growth, movement, and decay of glacial ice masses) and interpretation of glacigenic sediments and landforms. The stratigraphic and geomorphic record of glaciation and its relationship to climate change.

2C.9f Quaternary Geology (credit allowed for only one of 2C.9e, 2C.9f)

Glacial and non-glacial depositional environments, Quaternary stratigraphy, history and the processes
responsible for change; dating methods. Interpretation of sediments, facies associations and land forms in a chronological context.

2C.9g Remote Sensing

Imaging of the Earth by EM waves, with data analysis. Recognition of surficial materials relevant to mapping or geological/engineering applications.

2C.10 Regional Geology

2C.10a Geology of Canada

Description and understanding of the processes involved in the development and evolution of the Precambrian and Phanerozoic rocks of Canada.

2C.10b Geology of North America

The application of plate tectonic theory to the Precambrian and Phanerozoic evolution of the North American continent.

2C.11 Resource Geoscience

2C.11a Fluid Flow in Porous Media (same as 2C.1i – credit for both not allowed)

Porosity, fluid saturation, permeability, interfacial tension, wettability, capillary pressure, effective and relative permeability, steady and unsteady state fluid flow.

2C.11b Hydrogeology (credit allowed for only one of 2C.11b, c)

Theory of groundwater flow, groundwater resources, role of groundwater in geologic processes, controls on groundwater chemistry.

2C.11c Hydrology (credit allowed for only one of 2C.11b, c)

Description and analysis of surface and shallow groundwater at various scales, techniques of measurement and data analysis.

2C.11d Mineral Deposits Geology

Ore formation and mechanisms of concentration. Stratigraphic and structural control of mineral deposits and their metallogeny. The application of chemical principles to the understanding of mineral deposits.

2C.11e Petroleum Geology

Origin and distribution of petroleum. Geochemistry and maturation of organic matter; microbiological and thermal degradation of hydrocarbons, conventional and unconventional source and reservoir rocks; principles of primary and secondary migration; diagenesis of carbonate and clastic reservoir rocks, with reference to seals and traps.

2C.11f Reservoir Engineering

Rock properties, rock-fluid interactions, flow through porous media, and material balance.

2C.11g Well Log Analysis

Petrophysics and modern well-logging methods. Theory and applications of measurements of physical properties of the formation near the well bore, types of well logging devices, interpretation and use of information in petroleum and natural gas engineering.