GEOPHYSICS
SYLLABUS OF EXAMINATIONS
2005 Edition

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

Introduction

The regulations associated with the EGGP act require that a candidate have at least two years of post-secondary education in one or more of geology, physics, or mathematics before attempting any of the examinations in this syllabus. Each examination discussed in this syllabus covers a body of material that might normally be taught in a one-semester course at a Canadian University, but different university programs cover this material in different ways. Students could encounter parts of the material specified for an exam in different courses.

FUNDAMENTAL EXAMINATIONS *(All 7 compulsory)*

These examinations cover subjects normally taken in the first two years of a university course in physical sciences or engineering. They do not usually have university level pre-requisites.

MATHEMATICS

05-GP-F1   Introductory Calculus

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

05-GP-F2   Linear Algebra

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

PHYSICS

05-GP-F3   Introductory Physics I

Fundamental concepts, definitions and physical laws. Vectors, kinematics and statics. Newton's laws, force, work and energy, conservation laws.

05-GP-F4   Introductory Physics II

Applications of Newton's laws. Particle dynamics. Rotational Mechanics, Work and energy with variable forces. Fluid mechanics, kinetic and wave theory. First law of thermodynamics.

CHEMISTRY

05-GP-F5   General Chemistry I

Atomic and molecular structure, stoichiometry in chemical reactions. Chemical bonding. Structures and reactions of organic and inorganic compounds. Materials science.

05-GP-F6   General Chemistry II

Gas laws. Kinetics and chemical equilibrium, acids and bases. Oxidation-reduction processes and electrochemistry. Elementary thermodynamics.

05-GP-F7   Computing Science

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.

CORE SUBJECTS *(Eleven examinations which consist of the 6 compulsory examinations in Section A and any 5 examinations from Section B)*

With the exception of the geology courses, most core subjects require one or more fundamentals as prerequisites. They may appear after the first year of a Canadian University Course in science or engineering, but are more likely to be taken after the second year.

SECTION A - *6 compulsory exams*

MATHEMATICS

05-GP-C1   Differential Equations

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

05-GP-C2   Intermediate Calculus

Differential and integral calculus to multiple integrals, with applications. Trigonometric, exponential and logarithmic functions and their inverses. Numerical integration, Taylor Series. Partial differentiation.

PHYSICS

05-GP-C3   Electricity and Magnetism

Electrostatics, DC circuits, electric field, electric potential, Gauss's law, electromagnetic induction, capacitance. AC circuits. Electrical and magnetic properties of materials.

05-GP-C4   Vibrations, Waves and Optics

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

GEOLOGY AND GEOPHYSICS

05-GP-C5   Physical Geology

Composition and internal structure of the Earth. Surface and internal processes. Continents, oceans, rocks and minerals. Global tectonics and mountain building.

05-GP-C6   Physics of the Earth

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

SECTION B - *Any 5 examinations from this section*

MATHEMATICS

05-GP-C7   Probability and Statistics

Concepts of probability, events and populations, probability theorems, concept of a random variable, continuous and discrete random variables, probability distributions, moments, skewness, kurtosis, estimation of moments, joint distributions, probability. Distribution of functions of a random variable, sampling and statistical estimation theory, hypotheses testing, simple regression analysis, introduction to the design of experiments.

05-GP-C8   Integral Transform Methods and their Application

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

05-GP-C9   Complex Variable Calculus

Analytic functions, poles, residues, contour integration and its applications, and conformal mapping.

05-GP-C10   Database Management, or Computer Graphics, or Computational Physics

Database Management
Concepts and structures for design and implementation. Data models, data normalization, data description languages, query facilities, data integrity and reliability, concurrency. File organization, including sequential, indexed and direct access, multiple key, indexed files and hashing. File processing, including records, files and compaction. Sorting, merging and updating files. Algorithms for inverted lists, multilist, indexed sequential and hierarchical structures.

Computer Graphics
Graphics hardware, including architecture and circuits. Vector and raster graphics systems. Input and output devices. Techniques for describing images, including point, vector and raster approaches. Image transformations, including scaling, translation, rotation, clipping and windowing. Graphics software and data structures.

Computational Physics
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.

PHYSICS

05-GP-C11   Thermodynamics

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 Gibbs phase rule; gas-vapor mixtures, psychrometrics.

05-GP-C12   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.

05-GP-C13   Optics and Lasers

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.

05-GP-C14   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. Dielectric and magnetic properties of materials.

GEOLOGY AND GEOPHYSICS

05-GP-C15   Historical Geology

Methods of interpretation of the history of the Earth. Structural geology and application of plate tectonics. Global change. Paleontology, origin and evolution of life. Resource geology, principles of stratigraphy. Relative and radiometric age dating.

05-GP-C16   Crystallography and Mineralogy

Morphological crystallography. Crystal systems, rotation and inversion axes, crystal classes, Miller indices, axial ratios and stereonets. Determinative and descriptive mineralogy. Optical crystallography.

05-GP-C17   Sedimentation and Stratigraphy

Sedimentary processes, environments and facies. Properties and classification of sedimentary rocks. Stratigraphic nomenclature and the stratigraphic column. Stratigraphic relationships and interpretations.

05-GP-C18   Structural Geology

Orientation, measurement, representation and geometric analysis of planar and linear geologic structures such as faults and folds; relation of faults to stress. Geologic maps and cross-sections. Descriptive geometry, stereographic and equal area projections. Mechanical principles involved in the deformation of rocks.

05-GP-C19   Introduction to Applied Geophysics

Reflection and refraction seismology, gravity and magnetics, and electrical and electromagnetic methods applied to exploration and environmental problems.

MAJOR OPTIONS *(Seven examinations are required with at least 4 examinations from Section A and at least 2 from Section B)*

The major options define the geophysics content of the academic qualifications of a professional geophysicist. The subject matter here should be at the level of third or fourth year in science or engineering programs in most Canadian Universities. Major Options all require Fundamentals and or core subjects as prerequisites. In some cases these options may be taught as graduate courses in some Canadian Universities.

SECTION A - *At least 4 examinations from this section*

05-GP-M1   Quantitative Seismology

Theory of body and surface wave propagation, techniques in exploration seismology. Earthquake source mechanisms. Seismic attenuation.

05-GP-M2   Digital Signal Processing

Basics of geophysical data processing, convolution, correlation, z-transforms, basic spatial, time and frequency domain analysis.

05-GP-M3   Principles of Applied Seismic Methods

Introduction to refraction and reflection seismic methods applied to the exploration for resources and their use in engineering studies. Elasticity theory, seismic instrumentation, velocity surveys, near-surface corrections.

05-GP-M4   Principles of Applied Electrical and Electromagnetic Methods

Electromagnetic, resistivity, induced polarization, and self-potential methods applied to problems in the search for metallic mineral deposits. Theory and application of Maxwell's equations. Direct and indirect methods of inversion.

05-GP-M5   Principles of Applied Gravity and Magnetic Methods

The nature of the magnetic and gravity fields of the Earth. Density, porosity, magnetic susceptibility. Gravity meters and magnetometers. Potential theory. Theory and applications of gravity and magnetic methods of geophysical exploration.

05-GP-M6   Advanced Global Geophysics or Global Geology

Global Geophysics
Theory and research applications in gravitation, rotation and figure of the Earth, seismology and Earth structure, free oscillations of the Earth, seismic risk, geomagnetism and the core, paleomagnetism and continental drift. Thermal energy at plate boundaries and hot-spots. Mantle convection.

Global Geology
Global aspects of plate tectonics and regional geology through time. Application of fundamental stratigraphic and structural principles. Contributions of geophysics, geochemistry, experimental and theoretical petrology to the modern plate tectonic model. Analysis and of major structural provinces as they relate to plate interactions.

05-GP-M7   Petroleum Geology

Origin and distribution of petroleum. Geochemistry and maturation of organic matter; microbial 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.

05-GP-M8   Metallic Mineral deposits

Processes of ore formation and concentration in association with all the major geological processes. Stratigraphic and structural control of ore deposits. Examples of the occurrence of the economically more important types of deposits in Canada and the world. Study of ores in polished and thin section. The application of chemical principles to the understanding of ore deposits; solution chemistry, phase equilibria, isotope geochemistry. Exploration for, and evaluation of metallic mineral deposits.

05-GP-M9   Hydrogeology

The occurrence of groundwater; rock properties that affect groundwater, quality of groundwater; geology of groundwater basins; procedures for surface and subsurface investigations. Hydrology of groundwater flow, derivation of Darcy's law from fundamental concepts of fluid mechanics, and its generalization to spatially varied flows. Permeability parameters and validity of Darcy's law in terms of Reynold's number.

05-GP-M10   Physical Properties of Rocks/Engineering Geology

Physical properties of minerals and rocks. Measurement methods and their relationship to geophysical surveys and interpretation. Engineering site surveys and exploration, geological aspects of a given site with regard to the engineering design of foundations, hydraulic structures and the stability of natural or man-made slopes and open cuts.

05-GP-M11   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.

05-GP-M12   Partial Differential Equations

Orthogonal sets of functions. Numerical solution of partial differential equations. Classification of second order linear equations. Hyperbolic and parabolic equations, methods of descent.

05-GP-M13   Solid State Physics

Crystal structure. Classification of solids and their bonding. Elastic, electric and magnetic properties of solids. Lattice structure, Fermi surfaces.

SECTION B - *At least 2 examinations from this section*

05-GP-M14 Geostatistics

Same as 2005-Glgy-26

Analysis of quantitative geological data using digital computers, simple and multivariate statistical models (multiple regression, factor analysis and discriminant functions). Application of these methods to real and hypothetical geological situations.

05-GP-M15   Advanced Signal Processing

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

05-GP-M16   Advanced Seismic Methods

Acquisition design of three-dimensional (3-D) seismic surveys; processing and interpretation of 3-D seismic data volumes. Multi-component seismic methods.

05-GP-M17   Advanced Seismic Interpretation

Principles of seismic stratigraphy, and seismic sequence analysis, and structural interpretation of reflection seismic data, Depth conversion Methods.

05-GP-M18   Advanced Electrical and Electromagnetic Methods and Interpretation

Advanced topics in electromagnetic, resistivity, induced polarization and self-potential methods. Advanced problems starting at Maxwell's Equations.

05-GP-M19   Advanced Gravity and Magnetic Methods

Advanced applications of gravity and magnetic methods of geophysical exploration. Filtering, upward and downward continuation techniques. Reduction to the pole. Modeling and inversion methods.

05-GP-M20   Reservoir Engineering

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

05-GP-M21   Geophysical Field Methods

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.
(There is no textbook for this course. No exam will be set by APEGGA but the candidate can qualify here with the geophysical field course included in most Canadian geophysics curricula.).

05-GP-M22   Isotope Geophysics

Theory and systematics of radioactive decay, geochronology using K-Ar, Rb-Sr, U-Pb, Pb-Pb, Fission-track, C-14, U-series disequilibrium and Sm-Nd systems.

05-GP-M23   Fluid Dynamics

Flow of viscous and non-viscous fluids, dimensional methods in turbulence.

05-GP-M24 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, including bus, ring and tree topologies, protocols and hardware.

05-GP-M25 Igneous Petrology (Same as 2005 Glgy-3)

Mineralogical and chemical classification of igneous rocks. Physics and chemistry of igneous rock formation.

05-GP-M26 Metamorphic Petrology (Same as 2005 Glgy-5)

Mineralogy and textures of metamorphic rocks. Concepts of metamorphic facies and facies series, and their pressure-temperature-composition interpretation.

05-GP-M27 Advanced Sedimentology (Same as 2005- Glgy-20)

Processes of sedimentation: weathering, transportation, deposition and diagenesis; classification and description of the principal types of detrital and chemical sedimentary rocks.

05-GP-M28 Advanced Structural Geology (Same as 2005-Glgy-25)

Structural features of complexly folded and faulted strata. Simple statistical analysis of structural data. Analysis of strains. Computer-based procedures for determining the geometry of faults and folds. Structural analysis in plutonic and metamorphic rocks.

05-GP-M29 Fluid Flow in Porous Media

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

05-GP-M30 Geochemistry

Chemical processes taking place in geologic settings with emphasis on the abundance relationships of the elements in the Earth's crust and the laws governing the migration and distribution of elements of the Earth. Application of geochemistry in the search for mineral deposits.

05-GP-M31 Numerical Modeling Methods

Numerical modeling methods in geophysics, including finite difference and finite element techniques.

05-GP-M32 Remote Sensing

Sensor principles and capabilities. Image analysis. Interpretation of geological structure and landforms.

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