

First Semester

Required Courses

Geology 201 Principles of Geoscience

Composition and internal structure of the Earth; surface processes; internal processes and global tectonics; rocks and minerals, topographic and geologic maps.

Course Hours:

3 units; (3-3)

Chemistry 211 Foundations of Chemistry: Structure and Bonding

Same core topics as Chemistry 201 but taught with a greater emphasis on critical thinking, scientific observation and problem solving and the application of chemistry to topics such as drug design and environmental issues.

Chemistry 201: An introduction to university chemistry from theoretical and practical perspectives, that focuses on an exploration of the fundamental links between electronic structure, chemical bonding, molecular structure and the interactions of molecules using inorganic and organic examples.

Course Hours:

3 units; (3-3)

Mathematics 211 Linear Methods I

An introduction to systems of linear equations, vectors in Euclidean space and matrix algebra. Additional topics include linear transformations, determinants, complex numbers, eigenvalues, and applications.

Course Hours:

3 units; (3-1)

Selected Courses

Physics 221 Mechanics

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

Course Hours:

3 units; (3-2)

Mathematics 275 Calculus for Engineers and Scientists

An extensive treatment of differential and integral calculus in a single variable, with an emphasis on applications. Differentiation: derivative laws, the mean value theorem, optimization, curve sketching and other applications. Integral calculus: the fundamental theorem of calculus, techniques of integration, improper integrals, and areas of planar regions. Infinite series: power series, Taylor's theorem and Taylor series.

Course Hours:

3 units; (3-1T-1.5)

Second Semester

Required Courses

Geology 202 Applications of Geoscience

Applications of geology and geophysics to the study of earthquakes, volcanoes and other geologic hazards; natural resources; environmental management; human impact on the Earth and global change.

Course Hours:

3 units; (3-3)

Physics 223 Introductory Electromagnetism, and Thermal Physics

Electrical forces and energy. Static electric fields due to point charges. Parallel-plate capacitor. Simple DC circuits. Lorentz force. Static magnetic fields generated by electric currents. Electromagnetic induction. Gas Laws; kinetic theory of gases; temperature, thermal energy, specific heat; energy transfer; laws of thermodynamics; PVT diagrams.

Course Hours:

3 units; (3-3)

Chemistry 213 Foundations of Chemistry: Change and Equilibrium

Same core topics as Chemistry 203 but taught with a greater emphasis on critical thinking, scientific observation and problem solving and the application of chemistry to topics such as materials, explosives and medicine.

Chemistry 203: An introduction to university chemistry from theoretical and practical perspectives that focuses on an exploration of the fundamental links between kinetics, equilibria and thermodynamics and explores acidity/basicity and redox behaviour using inorganic and organic examples.

Course Hours:

3 units; (3-3)

Selected Courses

Mathematics 277 Multivariable Calculus for Engineers and Scientists

An introduction to calculus of several real variables: curves and parametrizations, partial differentiation, the chain rule, implicit functions; integration in two and three variables and applications; optimization and Lagrange multipliers.

Course Hours:

3 units; (3-1T-1.5)

Option Courses

Engineering 212 Fundamentals of Fluid Behaviour

An introduction to the behaviour of fluids for engineers. Fluid properties; equilibrium, phase transformations, the phase rule, phase diagrams, vapour pressure. Ideal and real gases; simple kinetic theory and equations of state. Fluid mechanics; ideal fluids, viscosity, flow of fluids in macro- and microfluidic systems. Engineering applications of fluids.

Course Hours:

3 units; (3-1.5T-3/2)

Third Semester

Required Courses

Geology 313 Mineralogy

The chemical and physical properties of the common minerals in the context of the common rock types; introduction to crystallography; optical properties of minerals; introduction to mineral associations and rock textures in hand samples and thin sections; introduction to analytical techniques (XRD, electron microprobe, etc.).

Course Hours:

3 units; (3-3)

Geology 343 3D Geologic Structures and Methods

Methods of 3D geologic data collection, manipulation and interpretation. Special emphasis on maps and cross sections and the geometric methods and data types used to understand and work with 3D geologic relationships. Course will emphasize hands-on exercises and teach the application of: geologic maps, subsurface data; relative dating; cross-cutting relations, and 3D visualization of the architecture of geological bodies and surfaces and their relationship to causative processes.

Course Hours:

3 units; (3-3)

Geology 353 Surficial Systems

Overview of the geomorphologic and hydrologic processes that operate on and just beneath the Earth's surface. Includes hydrology (precipitation, evaporation, soil water, ground water, and their interaction in watersheds), surface processes (erosion, weathering, rivers, glaciers, Quaternary geology, landforms); engineering properties of surface materials; applications (including aggregates and water as resources, geotechnical issues, water quality, etc.).

Course Hours:

3 units; (3-3)

Geology 381 Sedimentary Rocks and Processes

Origin, identification, classification and interpretation of sediments, siliciclastic, carbonate and evaporite rocks. Study of sediment/rock components (minerals), fossils and textures in hand sample and thin section; sedimentary structures and processes; introduction to depositional environments; burial, lithification and diagenesis; applications, including introduction to basin analysis/tectonics, exploration for water and petroleum resources, etc.

Course Hours:

3 units; (3-3)

Geophysics 351 Introduction to Geophysics and Planetary Physics

Key physical concepts and methods used to study Earth and other planetary bodies. Seismology, gravity, magnetism, figure of the Earth, isostasy, heat flow, radioactivity, geochronology, geodynamics. Applications and case studies.

Course Hours:

3 units; (3-3)

Fourth Semester

Required Courses

Geology 323 Geochemical Processes

Focus is on chemical processes taking place in geological settings with emphasis on the abundance relationships of the elements in the Earth and the processes governing the differentiation, migration and distribution of the elements. Discussions include mineral, rock and aqueous chemistry; applications of radiogenic and stable isotopes; thermodynamics and phase diagrams; biogeochemistry and organic geochemistry; analytical techniques; applications and case studies.

Course Hours:

3 units; (3-3)

Geology 333 Igneous, Metamorphic and Ore Rocks and Processes

Origin, identification, classification and interpretation of igneous and metamorphic rocks. Including common rock types, mineral assemblages and textures in hand samples and thin section, volcanic and plutonic processes and conditions, thermo-chemical conditions of metamorphic rock formation, introduction to ore deposits and ore minerals in hand sample, Canadian examples of ore deposits, tectonic settings of igneous, metamorphic and ore rocks.

Course Hours:

3 units; (3-3)

Science 311 Writing and Reviewing Scientific Reports

Elements of writing and reviewing scientific reports, use and enhancement of library skills, ethical principles of reviewing reports, and exposure to the literature of science. Papers and reviews will be transmitted electronically.

Course Hours:

3 units; (3-1T)

Selected Courses

Statistics 327 Statistics for the Physical and Environmental Sciences

Introduction to the collection of data. Probability and probability distributions. Single and Multi-sample estimation of distribution parameters. Regression and Goodness of Fit tests. Experimental Design and Analysis of Variance.

Course Hours:

3 units; (3-1)

Computer Science 217 Introduction to Computer Science for Multidisciplinary Studies I

Introduction to problem solving, analysis and design of small-scale computational systems and implementation using a procedural programming language. For students wishing to combine studies in computer science with studies in other disciplines.

Course Hours:

3 units; (3-2T)

Fifth Semester

Required Courses

Geology 445 Structural Geology

Mechanical principles involved in the deformation of rocks; classification of tectonic structures in stratified and non-stratified rocks; manipulation of structural data and its predictive use. Includes basic kinematics, dynamics, rheology, and descriptive structural geology. Also includes a strong lab component emphasizing 3D problem solving, structural analysis, and the use of geologic data sets to construct geologic cross-sections.

Course Hours:

3 units; (3-3)

Geology 493 Evolution of Earth through Life and Time

Origin and evolution of life within the framework of evolution of continents, oceans and atmosphere. Processes and signature of life. Concepts and patterns of evolutionary biology/paleobiology, extinctions, and diversity of life forms. Morphology and taxonomy of fossil groups and geological applications.

Course Hours:

3 units; (3-3)

Selected Courses

Geophysics 355 Exploration and Environmental Geophysics

Geophysical surveying methods applied to resource exploration, environmental monitoring, and engineering applications. Surveying theory and interpretation for refraction seismic, reflection seismic, gravity, electrical and electromagnetic methods.

Course Hours:

3 units; (3-3)

Geology 433 Metamorphic Petrology

Petrogenesis of metamorphic rocks. Application of metamorphic petrology to Earth processes and evolution.

Course Hours:

3 units; (3-3)

Prerequisite(s):

Geology 323 and 333

Engineering 311 Engineering Thermodynamics

Energy, thermodynamic systems, properties and state, temperature and the zeroth law, equilibrium, properties of the pure substance, equations of state. Work, reversibility, heat, first law, specific heats, enthalpy, ideal gas, flow systems. Entropy and the second law, Carnot cycle, thermodynamic temperature scale, process efficiencies, cycles, calculation of entropy change, exergy analysis.

Course Hours:

3 units; (3-1.5T-3/2)

Sixth Semester

Required Courses

Geology 337 Introduction to Geologic Field Methods

Study of various rock types and sediment exposures focusing on recognition and description of rock types, construction of geological maps and cross-sections and measurement of stratigraphic sections. Field skills will include map interpretation, navigation, and measuring planar and linear features.

Course Hours:

3 units; (96-120 hours)

Selected Courses

Physics 321 Harmonic Motion, Waves, and Rotation

Newtonian mechanics of rigid body rotation. Simple harmonic oscillations. Progressive waves in one dimension. Energy of a wave. Superposition. Standing waves. Fluids.

Course Hours:

3 units; (3-2T)

Option Courses

Geology 401 Physical Hydrogeology

Hydrologic cycle, conservation principle, Darcy's Law, groundwater flow systems, aquifer testing, soil hydrology, effective stress, land subsidence, solute transport.

Course Hours:

3 units; (3-2)

Needed for Geology 441

Chemical Engineering 331 Process Fluid Dynamics

Fluid Properties; Newtonian and non-Newtonian fluids. Fluid statics. Bernoulli equation; derivation and applications. Control volume and system representation. Differential analysis of Flows. The Navier-Stokes equation; applications. Dimensional analysis. Flow in conduits; laminar and turbulent flows; single-pipe and multiple-pipe systems. Forces on immersed bodies; fluidization. Metering.

Course Hours:

3 units; (3-1T-3/2)

Needed for Petroleum Engineering 523

Seventh Semester

Selected Courses

Geology 441 Field Techniques in Hydrogeology

Entails a week at a hydrogeology field site in Alberta or British Columbia. Hydrogeology and geotechnical techniques will be demonstrated and will involve hands-on participation by students. After the field work, students will conduct extensive analysis and interpretation of data gathered during the field session, complete exercises and prepare a written report.

Course Hours:

3 units; (3-3)

Prerequisite: Geology 401

Petroleum Engineering 523 Introduction to Reservoir Engineering

Basic concepts of fluid flow in porous media; important reservoir rock and fluid properties affecting productivity; reserve estimation using volumetric and material balance methods in gas, gas-condensate

and oil reservoirs; discussion of different reservoir drive mechanisms; aquifer models; decline analysis; Darcy's Law and single phase flow through porous media. Introduction to well testing, solution of radial diffusivity equation corresponding to infinite-acting and pseudo-steady state flow of slightly compressible fluids and real gases.

Course Hours:

3 units; (3-1)

Prerequisites: Engineering 311 and Engineering Chemistry 331

Option Courses

Geology 577 Introduction to Petroleum Geology

Fundamental concepts of petroleum geology from deposition/maturation of source rocks to hydrocarbon generation, migrate on and accumulation. Principles of hydrocarbon production, introduction to techniques of subsurface geological analysis applied to the evaluation and quantification of oil and gas reservoirs.

Course Hours:

3 units; (3-3)

Geology 579 Basin Analysis

Origin of basin subsidence, basin fills and petroleum systems. Basins in their geodynamic environment. Physical state of the lithosphere. Basins due to lithospheric stretching, flexure, and strike-slip deformation. Effects of mantle dynamics. Sediment provenance and routing system. Basin stratigraphy. Subsidence and thermal history. Petroleum basins from around the world.

Course Hours:

3 units; (3-3)

Engineering 202 Engineering Statics

Force vectors; equilibrium of a particle in two and three dimensions; force system resultants; equilibrium of a rigid body in two and three dimensions; internal forces in trusses; frames, machines and beams; bending moment and shear force diagrams; friction; centre of gravity; centroids of areas; composite bodies.

Course Hours:

3 units; (3-1.5T)

Eighth Semester

Selected Courses

Petroleum Engineering 525 Waterflooding and Enhanced Oil Recovery

Review of rock-fluid properties; trapping and mobilization of residual oil; displacement theory; linear waterflood calculations; viscous fingering; flood patterns and sweep efficiency considerations; characterization of reservoir heterogeneity; analytical waterflood prediction models; black-oil reservoir simulation models; design engineering aspects of waterflooding; and overview of enhanced recovery methods.

Course Hours:

3 units; (3-1)

Prerequisite: Petroleum Engineering 523

Option Courses

Geology 581 Advanced Petroleum Geology

Principles and applications of the characterization of petroleum systems, reservoirs and their fluids with a focus on unconventional resources. Methods of reservoir characterization, log analysis, subsurface mapping and the evaluation of reservoir heterogeneity with respect to geological characteristics and fundamental fluid flow related reservoir and fluid properties. Also examines subsurface CO₂ storage and other routes to eliminating CO₂ emissions from fossil fuel use as well as looking at the role of geoscience in energy recovery innovation and technology development.

Course Hours:

3 units; (3-3)

Prerequisite: Geology 577

Geography 254 Society and Environment

Foundations of human geography presented with integrative case studies of current and urgent human-environment issues from global to regional to local. Examines the complex interconnections between humans and environment using topics such as climate change, sustainability, development, poverty, food, urbanization, and technologies of the digital age.

Course Hours:

3 units; (3-1/2T) or (3-0)

Geography 380 Geospatial Communication

An introduction to fundamentals in cartography, remote sensing, geographic information systems, and descriptive spatial statistics.

Course Hours:

3 units; (3-2)

Engineering 317 Mechanics of Solids

Axial-force, shear-force and bending moment diagrams; stress and strain; stress-strain relations; elastic and plastic behaviour; elastic constants; simple statically indeterminate (one-degree) problems; review of moment of inertia, product of inertia and principal axes of inertia; elastic torsion of circular shafts; elastic and plastic bending about principal axes of beams with symmetrical cross-section; composite beams; shear stresses due to bending; Mohr's circle for stress; thin-walled pressure vessels; deflection of beams by integration; Euler buckling.

Course Hours:

3 units; (3-1.5T-3/2)

Prerequisite: Engineering 202 & Mathematics 275

Students must successfully complete a minimum of 54 units, to a maximum of 66 units, in Courses Constituting the Field of Geology while fulfilling the following requirements:

33 units - Geology **201, 202, 313, 323, 333, 337, 343, 353, 381, 445, 493**

3 units - Geology 435, **441**, 537, 545 or Geophysics 549

3 units - Geophysics **351**

9 units - Options from the Field of Geology at the 300 level or higher

Geology 401

Geology 433

Geology 571

9 units - Options from the Field of Geology at the 500 level or higher

Geology 577

Geology 579

Geology 581

6 units - Geology, Geophysics or Engineering (GGE) options from the following:

Petroleum Engineering 507, 513, 515, **523, 525**, 533, 543, 563, 573

A maximum of two of these may be counted towards APEGA Geology requirements. Some of these courses have Petroleum Engineering 523 as a prerequisite. Students are advised to take Petroleum Engineering 523 in the Fall Term.

Courses in the Fields of Geology and Geophysics

6 units - Physics 211 or **221**, and **223**

6 units - Chemistry 201 or **211**, and 203 or **213**

3 units - Mathematics 249 or 265 or **275**

3 units - Mathematics 267 or **277**

3 units - Mathematics **211**

3 units - **Computer Science 217**, 231 or Data Science 211

3 units - **Science 311**

6 units - Science options from the following (see Note):

Biology 205, 241, 243

Chemistry 311, 315, 331 or 431, 333 or 433, 351, 353, 371, 373

Computer Science 219 or 233

Mathematics 311, 367, 375, 376, 377, 413

Physics 321, 323, 229 or 325

Statistics 205 or 213 or 321 or **327**

Recommended options

15 units - Breadth Requirement: Options from faculties other than the Faculty of Science, excluding courses in Table I. These 15 units and Science 311 form the 18 units non-science course requirements selected from faculties other than the Faculty of Science.

Engineering 212

Engineering 311

Chemical Engineering 331

Of these 15 units, students must take at least 6 units from the Faculty of Arts.

Geography 254

Geography 380

3 units - Non-Major Field Requirement: Options outside of the Field of Geology

Data Science 221

6 units – Options

Engineering 202

Engineering 317

Note: In order to meet the academic requirements for registration with APEGA, 6 units from the Science Options and/or the Options must be chosen from one or more of biology, chemistry (3 units maximum), computer science, physics (3 units maximum), or statistics.