Course Outline

And

Year long study guide/outcomes

Earth Systems 3209 Course Outline

Unit 1: Introduction to Earth Science – The Evolution of Planet Earth	10%
Unit 2: Historical Geology	13%
Unit 3: Earth Materials	32%
Unit 4: The Forces within Earth	27%
Unit 5: Earth's Resources	18%

Evaluation Plan for Earth Systems 3209:

Tests/Quizzes	20%
Performance Assessment	15%
Midyear Examination	15%
Public Examination	50%

NOTE: If a student receives 80% or higher on the Earth Systems 3209 public exam, MUN will give credit
for Earth Sciences 1000. If a student receives between 70 and 79% on the public, then the student will have to write a multiple choice exam. MUN will give a student credit for Earth Sciences 1000 if a student receives 70% or higher on that multiple choice exam.

Course Outcomes/Study Guide

Unit 1: Introduction to Earth Science – The Evolution of Planet Earth 7%

1. • describe at least two aspects of Earth Science that makes it different from other sciences (114-6)
   - define Earth Science (Geoscience)
2. • identify the major branches of Earth Science (114-6). Include:
   (i) astronomy
   (ii) geology
   (iii) oceanography
   (iv) meteorology
   - relate Earth Science to other scientific fields.
3. • describe the formation of the universe using the Big Bang Theory (333-1)
   - describe the four stages of the nebular hypothesis that led to the formation our solar system.
   - describe the segregation/formation of Earth Layers.
   - identify the various layers. Include:
   (i) inner core;
   (ii) outer core;
   (iii) mantle (asthenosphere);
   (iv) lithosphere (crust)
4. • describe major interaction among the hydrosphere, lithosphere, and atmosphere (332-3)
   - identify that Earth is a dynamic planet.
   - recognize that Earth processes operate within spheres. Include:
   (i) atmosphere
   (ii) geosphere
   (iii) hydrosphere
   (iv) biosphere

Unit 2: Historical Geology 8%

1. • Recognize that Uniformitarianism is a fundamental principle of geology and contrast this principle with catastrophism (332-5)
   a. Define Uniformitarianism
2. • explain the appropriate applicatons of absolute and relative dating (332-6)
   a. Distinguish between absolute and relative time
   b. Demonstrate an understanding of the principles and laws used to establish relative time. Include:
      i. Superposition
      ii. Cross-cutting relations
      iii. Horizontality
      iv. Inclusions
      v. Fossil succession (index fossils)

vi. Unconformities

c. Demonstrate an understanding of the processes and features used to establish absolute time. Include:

i. Varves;

ii. Growth rings;

iii. Radioactive dating

3. • Explain how the half-lives of radioactive elements are used in estimating ages of materials (332-4)

a. Define half-life

b. Define isotope

c. Identify parent and daughter elements

d. Determine the age of a sample using radiometric data

4. • Evaluate the sources of error and limitations in estimating a radiometric age (214-10).

5. • Describe how fossils are used to distinguish geologic time (332-7)

a. Define fossil

b. Describe three conditions necessary for fossilization

c. Describe the formation of various types of fossils. Include:

i. petrifaction by replacement

ii. carbonization

iii. mould and cast

iv. preserved intact (frozen, amber)

v. imprints (soft tissue)

vi. trace fossils (e.g., dinosaur eggs, coprolite)

6. • illustrate the geologic time scale and compare to human time scales (332-4)

a. Identify that the geologic time scale is divided into eons, eras, periods, and epochs

b. Recognize that Precambrian time represents the greatest part of Earth history

c. Recognize that the Phanerozoic Eon represents the emergence of complex life forms

d. Distinguish between Precambrian time and the Palaeozoic, Mesozoic, and Cenozoic Eras

e. List the time frame that correlates with the dominant life form on Earth. Include:

i. Cenozoic – Age of Mammals;

ii. Mesozoic – Age of Reptiles;

iii. Paleozoic (late) – Age of Amphibians;

iv. Paleozoic (middle) - Age of Fishes

v. Paleozoic (early) - Age of Invertebrates

f. List the dominant life forms present at each Era. Include:

i. Single-celled and other simple life forms (Precambrian);

ii. Invertebrates (early Paleozoic);

iii. Fishes (middle Paleozoic);

iv. First land plants (between early and middle Paleozoic);

v. Amphibians (late Paleozoic)
vi. Reptiles (Mesozoic)
vii. Birds (Mesozoic)
viii. Flowering plants (Mesozoic)
ix. Mammals (Cenozoic)

7. • recognize that life forms, climate, continental positions, and Earth‘s crust have changed over time (332-7)
    a. Describe life through time. Include the evolution of life and/or mass extinctions in relation to the Eras
    b. Identify two mass extinction events in Earth’s history. Include:
        i. Permian-Triassic boundary
        ii. Cretaceous-Tertiary boundary

Unit 3: Earth Materials 40%

1. • Classify common minerals according to their physical and chemical characteristics (330-3)
    (i) Define mineral chemistry terms. Include:
        i. atom
        ii. ion
        iii. element
        iv. compound
        v. molecule
    (ii) Describe how atoms combine to form compounds. Include:
        i. ionic
        ii. molecular
        iii. metallic
    (iii) Recognize the names and symbols of the elements that are involved in common Earth minerals.
    Outline the abundance of the elements that comprise Earth’s crust. Include:
        i. oxygen
        ii. silicon
        iii. aluminum
        iv. iron
        v. calcium
        vi. sodium
        vii. potassium
        viii. magnesium
    (iv) Define a mineral.
    (v) Recognize the relationship between the abundance of the elements that comprise Earth’s crust and the mineral groups. Include:
        i. silicates

ii. carbonates
iii. halides
iv. sulfides
v. sulfates
vi. oxides
vii. native elements

(vi) Name and differentiate between the major mineral groups. Include:

i. silicates
ii. carbonates
iii. halides
iv. sulfides
v. sulfates
vi. oxides
vii. native elements

(vii) Identify mineral groups based on mineral formulas.

(viii) Describe the arrangement of silicon and oxygen within a tetrahedron.

(ix) Describe the mineral properties that are used for identifying minerals. Include:

i. crystal shape (form)
ii. cleavage
iii. fracture
iv. hardness
v. specific gravity
vi. colour
vii. streak
viii. luster
ix. acid test
x. taste
xi. magnetism
xii. double refraction
xiii. fluorescence

(x) Explain why minerals exhibit different mineral properties. Include:

i. type of bonding involved
ii. elemental composition
iii. internal atomic structure

(xi) Identify minerals based on their mineral properties.

2. • Identify careers that relate to mineral chemistry (117-7). Include:

i. minerology

ii. crystallography
iii. geochemistry
iv. gemology

3. • Classify rocks according to their structure, chemical composition, and method of formation (330-2)
   (i) Define Rock
   (ii) Distinguish between rocks and minerals
   (iii) Recognize that minerals are the building blocks of rocks.
   (iv) Describe the pathways comprising the rock cycle.
4. • Classify rocks according to their structure, chemical composition, and method of formation (330-2)
   (i) Recognize that igneous rocks are classified according to their mineral composition and texture .
   (ii) Describe how mafic igneous rocks differ from felsic igneous rocks based on chemical composition.
   (iii) Identify igneous rocks that have similar chemical compositions. Include:
      i. rhyolite and granite
      ii. andesite and diorite
      iii. basalt and gabbro
5. • Classify rocks according to their structure, chemical composition, and method of formation (330-2)
   (i) Identify igneous rocks based on texture. Include:
      i. rhyolite and granite
      ii. andesite and diorite
      iii. basalt and gabbro
   (ii) Describe igneous rock textures. Include:
      i. coarse-grain (aphanitic)
      ii. fine-grain (phaneritic)
      iii. glassy (compact and frothy)
      iv. vesicular
      v. porphyritic
   (iii) Describe how cooling rate and mineral composition determine rock types based on Bowen's Reaction Series.
6. • Classify rocks according to their structure, chemical composition, and method of formation (330-2)
   (i) Identify igneous rocks based on mineral composition and texture.
   (ii) Describe the formation kimberlite and its relationship with diamond deposits.
   (iii) Describe the process of metamorphism.
   (iv) Describe possible changes that result from metamorphism. Include:
      i. texture
      ii. volume change
      iii. chemical change
7. • Classify rocks according to their structure, chemical composition, and method of formation (330-2)

(i) Describe the result of selected rocks being metamorphosed. Include:

i. limestone to marble
ii. sandstone to quartzite
iii. shale to slate (to phyllite to schist to gneiss)
iv. granite to gneiss

(ii) Contrast the two types of metamorphism. Include:

i. contact
ii. regional

(iii) Describe the locations where contact metamorphism occurs. Include:

i. beneath lava flows
ii. adjacent to magma intrusions
iii. beneath where meteorites impact
iv. dykes and sills
v. fault zones

8. • Classify rocks according to their structure, chemical composition, and method of formation (330-2)

(i) Describe how contact metamorphism can be used to distinguish between a buried lava flow and an intrusion of magma.

(ii) Describe the locations where regional metamorphism occurs. Include:

i. areas of mountain building
ii. subduction zones

(iii) Identify metamorphic rocks.

9. • Classify rocks according to their structure, chemical composition, and method of formation (330-2)

(i) Describe the origin and process of formation of sedimentary rocks.

(ii) Describe the classes of sedimentary rocks. Include:

i. clastic (detrital)
ii. chemical
iii. biochemical

(iii) Identify clastic sedimentary rocks. Include:

i. shale
ii. siltstone
iii. sandstone
iv. conglomerate
v. breccia

(iv) Relate sediment sorting to clastic sedimentary rocks.

(v) Relate particle size to current velocity.

10. • Classify rocks according to their structure, chemical composition, and method of formation (330-2)

(i) Describe the environments and rock types that relate to clastic sedimentary rocks. Include:

i. fluvial
ii. Flood plains
iii. Deltaic
iv. Alluvial fans
v. Aeolian dunes
vi. Turbidites
vii. Beaches
viii. glacial
ix. shallow marine
x. deep marine

11. Identify chemical sedimentary rocks. Include:

Evaporites

i. halite
ii. gypsum
iii. sylvite

12. Precipitates

(i) limestone
(ii) dolomite
(iii) travertine

13. • Classify rocks according to their structure, chemical composition, and method of formation (330-2)

(i) Describe the environments and rock types that relate to chemical sedimentary rocks. Include:

i. shallow marine
ii. deep marine
iii. cave

(ii) Identify biochemical sedimentary rocks. Include:

i. coquina
ii. chaulk
iii. chert
iv. limestone (coral)
v. coal

(iii) Describe the sequence of formation of coal. Include:

i. peat
ii. lignite
iii. bitumous
iv. anthracite

14. • Classify rocks according to their structure, chemical composition, and method of formation (330-2)

(i) Describe the environments and rock types that relate to biochemical sedimentary rocks. Include:

i. swamp
ii. shallow marine
iii. beach
iv. deep ocean

15. • Identify careers that relate to the study of rocks (117-7). Include:
    (i) petrology
    (ii) volcanology
    (iii) geochemistry
    (iv) sedimentologist
    (v) hydrology

Unit 4: The Forces within Earth 30%

1. • explain the roles of evidence, theories, and paradigms in the development of scientific knowledge (114-2)
    (ii) Describe the Theory of Continental Drift
    (iii) Describe the evidence to support the Theory of Continental Drift. Include:
        i. Fit of continents;
        ii. Fossil evidence (fossil correlation);
        iii. Rock types (shields);
        iv. Structural similarities (e.g. folded mountains);
        v. Paleoclimatic (e.g., striations, coal deposits, glacial deposits)
2. 115-3 explain how a major scientific milestone revolutionized thinking in the scientific communities
    (ii) Describe the evolution of plate tectonic theory through the contributions of various scientists. Include:
3. (i)Frank Taylor
4. (ii)Alfred Wegener
5. (iii)Arthur Holmes
6. (iv)Alexander DuToit
    (ii) Harry Hess and Robert Deitz
    (iii) Fredrick Vine and Drummond Matthews
    (iv) J. Tuzo Wilson
    (v) Xavier Le Pichon and Dan McKenzie
7. • explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised, or replaced (115-7)
    (ii) Contrast the explanations provided by Wegener and Holmes for the mechanism for continental movement.
    (iii) Describe the Theory of Plate Tectonics
8. • analyse evidence for plate tectonics theory(332-8)
    (ii) Describe the evidence which supports plate tectonic theory. Include:

i. Paleomagnetism;
ii. Magnetic reversals;
iii. Earthquakes (Wadati-Benioff Zone);
iv. Deep-ocean drilling
v. Hot spots

9. • describe examples of Canadian contributions to science and technology (117-10)
10. • analyse examples of Canadian contributions to science (117-11)
11. • use appropriate evidence to describe the geologic history of an area (330-12)
    (ii) Describe the geology of Newfoundland
    (iii) Describe the geology of Labrador.
12. • describe geological evidence that suggests life forms, climate, continental positions, and Earth's crust have changed over time (332-7)
    (ii) Define crustal deformation.
    (iii) Define force.
    (iv) Define stress.
    (v) Describe the types of forces/stresses that produce crustal deformation. Include:
        i. compressional;
        ii. tensional;
        iii. shear
    (vi) Describe the types of deformation. Include:
        i. elastic;
        ii. brittle;
        iii. ductile
    (vii) Describe the factors that affect deformation. Include:
        i. temperature;
13. (ii) confining pressure;
        i. rock type;
        ii. time
    (iii) Define folding
    (iv) Relate folding to the factors that affect deformation.
    (v) Describe the two common types of folds. Include:
        i. anticline;
        ii. syncline.
    (vi) Define faulting as the breaking of rock layers and their subsequent motion.
    (vii) Relate faulting to the factors that affect deformation.
    (viii) Describe the two major types of faults and associated forces/stresses. Include:
        i. dip-slip
    (ix) normal (tensional force)

(x) horst and graben (tensional force)

(xi) reverse (compressional force)

(xii) thrust (compressional force)

(xiii) strike-slip (transform)

(xiv) left-lateral (shear force)

(xv) right-lateral (shear force)

14. • describe methods of analyzing, monitoring and predicting earthquakes, volcanic eruptions, and plate interactions (331-9)

(ii) Define earthquake.

(iii) Describe the causes of an earthquake. Include:

i. moving magma;

ii. elastic rebound;

iii. faulting

(iv) Define earthquake terminology. Include:

i. seismic wave;

ii. focus;

iii. epicentre;

iv. foreshock;

v. aftershock

(v) Identify the location of earthquakes and relate them to their plate boundary. Include:

i. divergent boundaries (Shallow)

ii. Transform (Shallow)

iii. Convergent (Shallow, intermediate, and deep)

(vi) Describe properties of the different seismic waves. Include:

i. Surfaces waves (L waves);

ii. Primary waves (P waves);

iii. Secondary waves (S waves)

(vii) Distinguish between earthquake scales. Include:

i. Richter;

ii. Modified Mercalli

(viii) Identify that the Richter scale increases in amplitude by a factor of ten for every increment of one.

(ix) Identify in relation to the Richter scale, energy released increases by a factor of 30 (rounded down) for every increment of one.

(x) Describe how seismographs and resulting seismograms are used to measure seismic waves.

(xi) Define volcano

(xii) Describe the three types of volcanoes, which include:

i. shield;

ii. ash and cinder;
iii. composite cone

(xiii) Describe the formation of a lava plateau

(xiv) Describe the type of eruption for each volcano type in relation to the different plate boundaries.

(xv) Identify the rocks that form in relation to each type of volcano. Include:

i. Shield Volcano – basalt;
ii. Ash and Cinder – basalt and scoria;
iii. Composite – andesite, basalt, rhyolite

(xvi) Distinguish between the types of lava. Include:

i. pahoehoe (ropy);
ii. aa (jagged, angular)

(xvii) Describe intraplate volcanism as it relates to hotspots.

15. • describe major interactions among the hydrosphere, lithosphere, and atmosphere (332-3)

(ii) Explain the global effects of volcanic activity

16. • identify and describe science and technology-based careers related to the science they are studying (117-7)

(ii) Identify careers related to plate tectonics, earthquakes, and volcanoes. Include:

i. structural geologist;
ii. volcanologist;
iii. seismologist;
iv. geomorphologist;
v. geochemist;
vi. geophysicist;
vii. hydrologist;
viii. petrologist;
ix. sedimentologist

Unit 5: Earth's Resources 15%

1. • describe the importance of minerals and mineral exploration at the local, provincial, national and global levels (330-8)

a. Define economic minerals
b. Define ore
c. Describe the different types of economic mineral deposits. Include:

i. magmatic (layered and disseminated);
ii. hydrothermal (vein deposits);
iii. placer;
iv. secondary enrichment (sedimentation);
v. metamorphism

2. • describe the evolution of extraction and the use of several resources obtained from the lithosphere (330-9)
    a. Identify the types of mines. Include:
        i. open pit;
        ii. underground

    b. Identify exploration techniques. Include:
        i. seismic records;
        ii. remote sensing;
        iii. prospecting;
        iv. observing drill cores;
        v. cross-sections;
        vi. geological mapping;
        vii. magnetic survey;
        viii. gravity survey;
        ix. geochemistry
    c. Construct and interpret cross-sectional diagrams of Earth using geological concepts, which include:
        i. horizontality;
        ii. superposition;
        iii. correlation;
        iv. cross-cutting relationships;
        v. unconformities;
        vi. inclusions;
        vii. folding and faulting;
        viii. metamorphism
3. • describe the processes and techniques involved in processing ore materials (330-10)
    a. Describe techniques for processing ore deposits. Include:
        i. floatation;
        ii. gravity separation;
        iii. heap leaching;
        iv. pyromet;
        v. hydromet
4. • describe the processes and techniques involved in extracting and refining hydrocarbons (330-10)
    a. Define petroleum.
    b. Define crude oil.
    c. Define hydrocarbons.
    d. Describe the origin and the process of formation of petroleum. Include:
        i. organic matter

ii. preservation potential

e. Define Kerogen.

f. Identify the three phases in the evolution of organic matter to petroleum. Include:
   i. diagenesis
   ii. catagenesis
   iii. metagenesis

g. Describe the components involved in the formation of petroleum traps. Include:
   i. source rock;
   ii. reservoir rock;
   iii. cap rock

h. Describe the types of petroleum traps. Include:
   i. anticline trap;
   ii. fault trap;
   iii. salt dome trap;
   iv. stratigraphic trap

i. Describe the distribution of petroleum in a reservoir.

j. Describe the two main means of extracting petroleum from Earth, which include:
   i. drilling
   ii. surface extraction (open pit mining) (TAR SANDS)
   iii. steam injection

k. Describe the methods of refining petroleum. Include:
   i. distillation;
   ii. cracking;
   iii. reforming

l. Describe sustainable development in relation to the use of Earth's resources.

m. identify and describe core components involved in the sustainable development of Earth's resources

Unit 1:

Introduction to Earth Science – The Evolution of Planet Earth

Earth Systems 3209 - Preface – Careers

Before we begin learning about The Earth and how it works, it is important to note the kinds of work associated with Geosciences. Below, there is a list of fields and careers that identify specific areas and "jobs" an Earth Science background can get you. Please take some time to identify each. Some terms may not be familiar to you, but as the year progresses will come to know them.

Field	Description
Minerology	
Crystallography	
Gemology	
Petrology	
Volcanology	
Geochemistry	
Sedimentologist	
Hydrology	
Structural geologist	
Volcanologist	
Seismologist	
Geomorphologist	
Geochemist	
Geophysicist	
Hydrologist	
Petrologist	