Earth and Space Science

UNIT I: Materials and Processes that Shape a Planet

Goal 1. The student will demonstrate the ability to use concepts of system analysis to identify major topics in geology and to discuss their relationship to other fields of Earth and Space Science.

Objectives – The student will be able to:

a. Identify and describe the components of the physical Earth as a system (inner core, outer core, mantle, crust).
b. Explain and give examples of the dynamic balance between matter and energy within and on the physical Earth.
c. Give examples of how changes in the physical Earth affect other Earth systems and human activity.

Goal 2. The student will demonstrate the ability to describe and classify materials that make up Earth.

Objectives – The student will be able to:

a. Illustrate the chemical structure of the atom and describe characteristics of protons, neutrons, electrons, and the nucleus.
b. Distinguish among compounds, mixtures, molecules, and isotopes.
c. Use selected properties to identify common rock forming mineral groups, including carbonates, halides, oxides, silicates, sulfates, and sulfides.
d. Describe the physical characteristics of igneous, metamorphic, and sedimentary rocks, including crystal size and shape, mineral and chemical composition, density, and origin.

Goal 3. The student will demonstrate the ability to explain how rock formation, weathering, sedimentation, and rock reformation constitute a continuing "rock cycle" in which the total amount of material stays the same even as its form changes.

Objectives – The student will be able to:

a. Describe how convection, density, and the law of conservation explain the movement of materials within the rock cycle.
b. Describe the constructive and destructive processes that drive the rock cycle, including sedimentation, lithification, crystallization, deformation, deposition, erosion, melting, cooling, metamorphism, subsidence, and weathering.
c. Explain the role of gravity and natural agents (water, wind, glaciers) on Earth (landform changes) and how they impact the rock cycle.
d. Explain the principles of hydrology, including evaporation, transpiration, surface and groundwater flows, aquifers, porosity, water retention, permeability, particle surface area, desalinization, and sources of water contamination and pollution.

e. Describe current efforts and technologies used to study Earth's land features, including spectroscopy, remote sensing, GIS, GPS, imaging, and topographic mapping using satellite and ground-based data.

UNIT II: Earth's History

Goal 1. The student will demonstrate the ability to use concepts of system analysis to identify major historical geology topics and discuss their relationship to other fields of Earth and Space Science.

Objectives – The student will be able to:

a. Identify and describe the components of historical geology.
b. Explain and give examples of the dynamic balance between matter and energy throughout the geologic history of Earth.
c. Give examples of how changes in one part of historical geology affected other parts of Earth's systems.

Goal 2. The student will demonstrate the ability to explain the Theory of Plate Tectonics and relate it to Earth's dynamic nature.

Objectives – The student will be able to:

a. Summarize the evidence and thinking that resulted in the development of the Theory of Plate Tectonics.
b. Explain plate tectonics in terms of magnetic reversals and outer core circulation, mantle convection, sea floor spreading, and subduction.
c. Describe how the Theory of Plate Tectonics explains the location of earthquakes, volcanoes, hot spots, mountains, mid-ocean ridges, deep-sea trenches, and island arcs.
d. Give examples of how progressive changes on Earth's surface, including Pangaea, are used to document the evolution of Earth through time.
e. Describe the purpose of current tools and techniques used to study plate tectonics including seismograph data, triangulation (epicenter location and travel-time graphs), satellite sensors, image analysis, sonar and distance measurement, and magnetometers.

Goal 3. The student will demonstrate the ability to explain how artifacts and events of Earth's past are dated.

Objectives – The student will be able to:

a. Compare similarities and differences between relative age and absolute age.
b. Describe the principles used to determine relative age, including Law of Superposition, Principle of Horizontality, Principle of Crosscutting Relationships, Law of Included Fragments, unconformities, intrusions, rock layer correlation, and fossil correlation.
c. Describe the principles used to determine absolute age, including radioactive dating, index fossils, fossil correlation, and the Principle of Uniformitarianism.

Goal 4. The student will demonstrate the ability to use geologic dating principles to determine a sequence of events making up a core sample, rock column, or cross-section.

Objectives – The student will be able to:

a. Create a geologic time scale (using eras, periods, and epochs) that shows the major geologic and biologic events, including human's place in the time continuum.
b. Interpret the geologic history of an area using geologic maps, rock outcrops, and core samples.
c. Describe how progressive changes in fossil evidence can be used to document the evolution of life.
d. Describe the dramatic changes in the composition of Earth's atmosphere (introduction of O_2) once the presence of single-celled life forms became established.

UNIT III: Interactions of the Atmosphere and Hydrosphere

Goal 1. The student will demonstrate the ability to use concepts of system analysis to identify major atmosphere and hydrologic cycle topics and discuss their relationships to other fields of Earth and Space Science.

Objectives – The student will be able to:

a. Identify and describe the components of the atmosphere and the hydrosphere.
b. Explain and give examples of the dynamic balance between matter and energy within the atmospheric and hydrospheric systems.
c. Give examples of how changes in one part of the atmosphere or hydrologic cycle affect other Earth systems and human activity.

Goal 2. The student will demonstrate the ability to analyze the major components, thermal structure, and chemical composition of the atmosphere.

Objectives – The student will be able to:

a. Analyze and compare the heat transfer systems (radiation, convection, conduction) affecting atmospheric circulation patterns.
b. Describe Earth's energy budget using the radiative properties (absorption, reflection/albedo, and scattering) of the land, water, and atmosphere (cloud cover).
c. Describe the causes of local and global air and wind patterns, including pressure gradients, density, land and sea breezes, Coriolis effect, and energy exchange.
d. Describe stratospheric ozone concentration and distribution.
e. Describe current efforts and technologies, such as remote sensing and imaging, Doppler radar, spectroscopy, and weather satellites, which are used to study, analyze, and predict changes in Earth's atmosphere.

Goal 3. The student will demonstrate the ability to explain how the transfer of energy affects the water cycle.

Objectives – The student will be able to:

a. Analyze energy transfer systems that influence phase changes (condensation, melting, deposition, freezing, sublimation, and evaporation) and latent heat in the atmosphere.

b. Analyze measurable elements of weather (atmospheric pressure, dew point, relative humidity, forms of precipitation, wind speed and direction, etc.) essential to predicting large-scale and local weather events.
c. Identify causes of vertical air motions and their effects on cyclones and anticyclones.
d. Describe the causes of global ocean circulation patterns, including energy transfer, Coriolis effect, and density differences.

Goal 4. The student will demonstrate the ability to analyze how the transfer of energy through the hydrosphere and atmosphere influences Earth's climate and weather.

Objectives – The student will be able to:

a. Identify and describe how Earth's weather patterns and conditions (temperature and precipitation) influence climate type and distribution from a regional and global perspective.
b. Explain how the angle of insolation (incoming solar radiation) influences Earth's climate.
c. Explain how factors, including radiation, aerosols, volcanism, continental movements, and oceanic current changes alter atmospheric and hydrologic conditions, including the greenhouse effect, photosynthesis, global warming/cooling, El Niño/La Niña, ice-age cycles, sea ice, glaciers, sea level, and shifting of biomes.
d. Identify pollutants such as tropospheric ozone, acid rain, and particulates that affect Earth's climate.
e. Interpret the effects of atmospheric and hydrologic cycles on human activity (severe weather, floods, sea level changes, emergent and submergent coastlines, etc.).
f. Research and describe how changes in atmospheric and hydrologic conditions cause long-term climatic changes.

Goal 5. The student will demonstrate the ability to describe how the transfer of mass affects the carbon cycle.

Objectives – The student will be able to:

a. Describe the carbon cycle, and identify carbon sinks, including atmospheric CO_2, organic carbon, fossil fuels, and carbonate rocks.
b. Describe processes, natural and human-induced, that affect the carbon cycle, including volcanism, fire, weathering, decomposition, photosynthesis, deforestation, agriculture, burning of fossil fuels, and CO_2 accumulation.

UNIT IV: Astronomy

Goal 1. The student will demonstrate the ability to use concepts of system analysis to identify major topics in astronomy and discuss their relationship to other fields of Earth and Space Science.

Objectives – The student will be able to:

a. Identify and describe the components of the universe.
b. Explain and give examples of the dynamic balance between matter and energy that exists in the universe.

c. Give examples of how changes in one part of the universe affect other parts of the Earth and Space system.

Goal 2. The student will demonstrate the ability to identify and describe the properties, natural forces, and theories of formation and operation of the solar system and universe.

Objectives – The student will be able to:

a. Describe current efforts and technologies used to study the universe, including optical telescopes, radio telescopes, satellites, space probes, spectroscopes, high altitude platforms, and explain how their research impacts human activity.
b. Apply Kepler's Laws and Newton's Universal Law of Gravitation to planetary motion.
c. Describe the life cycle of stars (nebulae, protostar, red giants, white dwarfs, neutron stars, pulsars, supernovas, black holes), and the role of gravity in their stellar evolution.
d. Explain the relationship between absolute magnitude and surface temperature of stars using the Hertzsprung-Russell diagram.
e. Use bright and dark line spectra to determine the movement and elemental composition of stars.
f. Describe the structure and evolution of galaxies using their visible characteristics.
g. Explain how the Doppler effect supports the concept of an expanding universe and the Big Bang Theory.
h. Research and describe current theories about the formation of the solar system, including the Nebular Theory.

Goal 3. The student will demonstrate the ability to explain the role and interaction of revolution, rotation, and gravity on the components of the Sun-Moon-Earth system.

Objectives – The student will be able to:

a. Describe the Sun-Moon-Earth system.
b. Describe the characteristics of our sun, including structure, thermonuclear reactions, coronal mass ejections, flares, sunspot cycles, solar wind, and auroras, and their impact on Earth.
c. Explain how revolution, rotation, and precession of the Sun-Moon-Earth system produce changes in the solar angle of incidence (altitude, azimuth) that result in seasons (solstices and equinoxes) and changes in the length of a day, month (sidereal and synodic lunar month), and year.
d. Explain how the movements and distances (perigee, apogee) between Earth and Moon produce tides including the relationship between phases and tides and tidal bulge and rate of lunar revolutions.
e. Explain the relative position of the Sun, Earth, and Moon during a solar and lunar eclipse (total, annular, partial) and the shadows (umbra, penumbra) they cast.
f. Explain the length of visibility of the moon, the monthly variations in lunar position, and how often eclipses occur per year.
g. Relate knowledge of geologic processes and features on Earth to geologic processes and features on the moon.