| **Required Course Numbers** | | | | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test Content Categories** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **I. Basic Scientific Principles and Processes (12%)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **A. Science Methodology, Techniques, and History** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Scientific inquiry methods |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Observations, hypotheses, experiments, conclusions, theories, models, and laws |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Experimental design, including variables, controls, and sources of error |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Scientific knowledge is consistent with evidence, subject to change |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Collect, evaluate, process, interpret, and report data |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Units of measurement |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. b. Scale [orders of magnitude], uncertainty in measurement, accuracy versus precision |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. c. Appropriate calculations and conversions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. d. Scientific notation and significant figures |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. e. Organization and presentation of data |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Interpretation of data using inductive and deductive reasoning processes |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Interpret and draw conclusions from models and data presented in various forms |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Trends in data |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Maps (e.g., geologic, topographic, weather) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Models (e.g., Earth systems, solar system) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Map projections |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Tables, graphs, charts, and cross sections |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4. Use materials and equipment in the laboratory and the field safely and appropriately |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Preparation, use, storage, and disposal of materials |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Use and calibration of equipment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Safety procedures |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Value and limitations of investigative technology |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| – computer as a tool (e.g., modeling, Internet) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| – data gathering and collection of evidence (e.g., ground-based versus space-based telescope) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5. Ocean and space exploration and the use of various technologies to gather data |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Satellites, space probes, remote sensing |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Telescopes, spectroscopy |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Search for water and life on other planets |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Submersibles, research ships, sonar |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6. Historical roots of the Earth and Space Sciences |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. How current concepts in Earth and Space Science developed over time |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Major historical figures and their contributions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B. Basic Principles of Matter and Energy** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Structure of matter |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Atoms, molecules, ions, elements, and compounds |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Mixtures, solutions, and precipitates |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Solids, liquids, gases, plasmas |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Kinetic molecular theory of gases and the ideal gas laws |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Relationships between energy and matter |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Conservation of matter in chemical processes |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Conservation of energy |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Forms of energy |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Methods of thermal energy transfer |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Specific heat capacity |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Energy required for phase transitions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| g. Temperature scales |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| h. Thermal expansion and contraction |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Nuclear reactions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Radioactive decay processes (e.g., isotopes, half-life) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Fusion and fission |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Heat production in nuclear reactions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4. Biological, chemical, and physical processes |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Chemical and physical properties and changes (e.g., solubility, pH, oxidation, phase changes) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. b. Chemical bonding |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. c. Wave properties and phenomena (e.g., wavelength, frequency, amplitude, reflection, refraction) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. d. Electromagnetic spectrum (e.g., visible, infrared, ultraviolet, gamma) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. e. Photosynthesis and respiration |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Forces and motion (e.g., gravity, friction) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **C. Science, Technology, and Society** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Impact of science and technological advancements on the environment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Interrelationships between humans and the hydrosphere (e.g., water pollution and treatment, acid rain, impact of sea level rise on populations, availability of water resources, irrigation, desalinization) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. b. Interrelationships between humans and the atmosphere (e.g., air pollution, greenhouse gases, importance of UV absorption by stratospheric ozone, ozone layer depletion) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Impact of human activity on the natural fluctuations in global systems (e.g., rate of climate change, rate of sea level change, rate of depletion of aquifers) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Issues associated with the use of various energy sources |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. a. Renewable and nonrenewable energy sources |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. b. Energy conservation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Pros and cons of power production based on various types of sources, such as fossil fuel, nuclear, hydro, solar, wind, and geothermal |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Issues associated with the use and extraction of various Earth resources |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Mining-related effects |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. b. Increased erosion |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. c. Deforestation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Degradation of soils (e.g., agricultural practices) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4. Importance of Earth and Space Sciences to everyday life |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Conservation of resources (e.g., recycling, sustainable technology) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Waste management |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Technology (e.g., satellites, GPS) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Human health (e.g., radon in basements of homes) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Identification and prediction of natural hazards (e.g., tsunamis, earthquakes, hurricanes, coastal erosion) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **II. Tectonics and Internal Earth Processes (17%)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Theory of plate tectonics and its supporting evidence |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Plate movement |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Convergent, divergent, and transform boundaries |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Hot spots |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Potential driving forces (e.g., mantle convection) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Seismic, magnetic, fossil, and other evidence for plate tectonics |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Geographic features (e.g., trenches, mountains, rift zones) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Deformation of Earth’s crust and resulting features |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Folds and faults |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Mountain building and rifting |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Compression, tension, and shear stresses |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Isostasy (e.g., postglacial rebound) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Characteristics of earthquakes and how they provide information about Earth’s interior |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Distribution and types (deep versus shallow) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Magnitude and intensity |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Seismic waves and seismograms |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Epicenter, focus |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Causes of earthquakes |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4. Layered structure of Earth and related processes |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Characteristics and composition of the crust, mantle, and core |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Properties of the lithosphere and asthenosphere |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Evidence from seismic waves |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Shape and size of Earth |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Magnetic field and geomagnetic reversals |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5. Volcanic characteristics and processes |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. How volcanoes are formed |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Features of volcanoes (e.g., vent, magma chamber) and eruptive products (e.g., pyroclastics, gases) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Types of volcanoes and their characteristics |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Distribution (e.g., ring of fire, hot spots) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **III. Earth Materials and Surface Processes (23%)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Identification of minerals |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Definition of a mineral |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Physical properties (e.g., density, streak, cleavage, luster, crystal structure) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Identification tools (e.g., Mohs’ hardness scale) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Cycling of Earth materials |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Rock cycle |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Water cycle |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Carbon cycle |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Characteristics and formation of igneous, sedimentary, and metamorphic rocks |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Rock identification and classification |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Formation and characteristics of the following: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| – intrusive and extrusive igneous rock |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| – clastic, chemical, and biological sedimentary rocks |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| – regional and contact metamorphic rocks |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4. Earth’s surface changes over time |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Chemical and physical weathering |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Erosion and deposition |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Uplift |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Interaction between the biosphere and the geosphere (e.g., weathering caused by plants, nutrient uptake from soil by plants) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Interaction between the hydrosphere and the geosphere (e.g., cave formation, ocean salinity, streams, and drainage systems) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Processes of soil formation and resulting characteristics (e.g., soil profiles, factors such as geology, climate, time) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **IV. History of the Earth and its Life-Forms (14%)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Rocks are used to determine geologic time and provide a record of Earth’s history |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Principle of uniformitarianism (e.g., definition, applications, limitations) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Principles of relative age dating including: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| – principle of original horizontality |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| – principle of superposition |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| – principle of cross-cutting relationships |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| – principle of fossil succession |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| – stratigraphic correlation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| – unconformities |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Principles of absolute (radiometric) age dating |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Geologic time scale (e.g., Earth’s age, scope of time) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Fossil record as evidence of the origin and development of life |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Origin of major groups of life-forms |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Fossilization methods |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Mass extinctions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Fossil evidence for major divisions of the geologic time scale |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Theories of Earth’s formation and development of its systems including the history of the following: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Earth’s atmosphere |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Earth’s hydrosphere |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Earth’s landmasses |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **V. Earth’s Atmosphere and Hydrosphere (19%)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Unusual properties of water and effect on Earth systems |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Density changes (e.g., ice floats in water) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Excellent solvent |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. High specific heat and heat of vaporization |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Exists as solid, liquid, and gas on Earth |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Water cycle and the energy transfers involved |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Phase changes (e.g., vaporization, condensation, sublimation) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. General structure of the water cycle |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Distribution of water on Earth |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Basic structure and composition of the atmosphere |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Chemical composition |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Various layers and their physical properties (e.g., stratosphere, troposphere, thermosphere) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Interaction of the atmosphere with hydrosphere/biosphere/geosphere (e.g., respiration, transpiration, photosynthesis, nitrogen fixation, evaporation, precipitation, effect of the atmosphere on weathering) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4. Basic physical principles and processes involved in meteorology |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Variations in atmospheric temperature, pressure, and density |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Energy budget (e.g., energy absorption and reflection) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Processes involving greenhouse gases |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Circulation, Coriolis effect |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Cloud formation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Origin of wind |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| g. Absolute and relative humidity |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| h. Dew point and frost point |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| i. Daily/seasonal/annual variations in meteorology (e.g., sea breezes, monsoons, El Niño) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5. Development and movement of weather systems |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Cloud types |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Formation of various types of precipitation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Air masses, fronts, storms, and severe weather such as hurricanes and tornados |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Development and movement of weather patterns |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Interpretation of atmospheric data (e.g., dew point, isobars) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Fundamentals of weather forecasting |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6. Factors and processes that influence climate and lead to climate zones |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Effects of the following: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| – latitude, geographical location, and elevation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| – atmospheric circulation (e.g., trade winds, jet stream) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| – ocean circulation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Characteristics and locations of climate zones |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Effect of the Earth’s tilt on seasons |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7. Effects of natural phenomena on climate change |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Volcanic eruptions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Asteroid impacts |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Variations in solar radiation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 8. Characteristics and processes of surface water and groundwater |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Streams (e.g., erosion, deposition, channel migration) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Lakes and wetlands |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Geysers and springs |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Groundwater, aquifers, water table |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Runoff and infiltration |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Porosity and permeability |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| g. Hazards (e.g., flooding, sinkholes) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| h. Human interactions (e.g., wells, levees, diversion for irrigation, saltwater intrusion) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 9. Characteristics of glaciers and polar ice and how they move and change over time |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Characteristics of continental and mountain glaciers |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Glacial-interglacial cycles, advance and retreat |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Depositional and erosional features |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Icebergs |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Sea ice |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 10. Physical and chemical characteristics and processes of the oceans |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Salinity, temperature, and density |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Surface currents, deep-ocean circulation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. El Niño, la Niña |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Wave formation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Seafloor topography |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 11. Interrelationships between the oceans and the solid Earth |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Tidal effects (e.g., tidal range, tidal patterns) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Wave effects (e.g., coastal erosional and depositional processes) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Tsunamis |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Island formation and change (e.g., barrier islands, volcanic islands, atolls) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Hydrothermal vents |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Estuaries (e.g., characteristics, formation) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| g. Marine sediments (e.g., origin, rate of deposition) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| h. Sea level changes |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 12. Interrelationships between the hydrosphere and the biosphere/atmosphere |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Light penetration and photosynthesizers in oceans |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Upwelling of nutrients |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Coral reefs |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Organisms around hydrothermal vents |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **VI. Astronomy (15%)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Earth’s motions and their characteristics and consequences |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Rotation and revolution |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Time zones |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Effect of axial tilt (e.g., seasons, solstices, and equinoxes) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Long-term changes in Earth’s motions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Relationships within the Earth-Moon-Sun system |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Tides (e.g., causes, cycles, spring, neap) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Eclipses (solar, lunar) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Phases of the Moon |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Effect of solar wind on Earth |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Characteristics of the components of our solar system and how they formed |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Laws of motion |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Theories of the formation of the solar system |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Location, orbits, and characteristics of the planets |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Structure and characteristics of the Sun |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Structure, characteristics, and orbit of the Earth’s moon |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Natural satellites |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| g. Characteristics of asteroids, meteoroids, comets, dwarf/minor planets |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4. Characteristics of stars and the processes that occur within them |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Stages in the life cycle of stars (e.g., protostar, main sequence, white dwarf, supernova) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Color, temperature, apparent brightness, and luminosity, including Hertzsprung-Russell diagram |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Formation of elements (e.g., carbon, iron) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5. Characteristics of the Milky Way and other galaxies |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Structure and classification of galaxies (e.g., spiral, elliptical) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Relative distances and motions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Supermassive black holes |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Dark matter |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6. Theories and observations that relate to the origin and development of the universe |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Theories about the origin of the universe |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Redshift and background radiation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |