Missouri Educator Gateway Assessments

FIELD 077: EARTH SCIENCE
TEST FRAMEWORK

June 2019

DRAFT

	Content Domain	Range of Competencies	Approximate Percentage of Test Score
I.	Earth's Place in the Universe	0001–0003	15%
II.	Earth's Systems: Geosphere	0004–0006	15%
III.	Earth's Systems: Hydrosphere, Atmosphere, Weather, and Climate	0007–0009	15%
IV.	Earth and Human Activity	0010–0012	17.5%
V.	Chemistry	0013	12.5%
VI.	Physics	0014	12.5%
VII.	Biology	0015	12.5%

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TEST FRAMEWORK
FIELD 077: EARTH SCIENCE

EARTH'S PLACE IN THE UNIVERSE

0001 Demonstrate knowledge of the origin, evolution, and structure of the universe.

For example:

1.1 Analyze current scientifically accepted theories for the origin of the universe (e.g., the Big Bang) and their supporting evidence.

1.2 Demonstrate knowledge of types and characteristics of different forms of energy and matter (e.g., ordinary matter, dark matter, dark energy) and evidence for the existence of dark matter and energy.

1.3 Demonstrate knowledge of the current scientifically accepted theories of the formation and characteristics of different types of galaxies in the universe, including the Milky Way.

1.4 Demonstrate knowledge of data, methods, and technologies used to understand the size, structure, and motions of objects in the universe (e.g., stars, exoplanets, galaxies).

1.5 Apply knowledge of scientific principles, crosscutting concepts, and engineering practices to the origin, evolution, and structure of the universe (e.g., simulating matter separation during universe expansion, sorting galaxy images into groups) and make connections between science, engineering, and daily life (e.g., creating spectrographs from common materials, exploring telescope designs).

0002 Apply knowledge of stars and their life cycles.

For example:

2.1 Demonstrate knowledge of types, formation, and characteristics of stars and other objects in the universe (e.g., nebulae, black holes, quasars, pulsars).

2.2 Apply the Hertzsprung–Russell (HR) diagram to the life cycle of stars.

2.3 Analyze the process of nuclear fusion and nucleosynthesis in stars, including the sun.

2.4 Demonstrate knowledge of how the properties of stars can be used to determine their age, distance, and relative motion.

2.5 Demonstrate knowledge of the history and perception of constellations and individual stars, including how they vary based on location.

2.6 Apply knowledge of the characteristics and structure of the sun, energy transfer mechanisms between the sun's core and Earth (e.g., sun spots, solar flares, solar wind), and the effects on Earth of variation in the sun's energy output.

2.7 Apply knowledge of scientific principles, crosscutting concepts, and engineering practices to the stars and their life cycles (e.g., constructing the life cycle of a specific star based on information provided, building a model of the life cycle of the sun) and make connections between science, engineering, and daily life (e.g., examining false color images of stellar objects and then translating that to invisible electromagnetic spectra, identifying stellar spectra and sorting them according to observed patterns).

0003 Analyze the solar system and the interactions of the Earth-sun-moon system.

For example:

3.1 Demonstrate knowledge of the current scientifically accepted theories of the formation and early history of the solar system and the characteristics of objects within the solar system (e.g., planets, comets, asteroids, moons, dwarf planets).

3.2 Apply knowledge of Newton's and Kepler's laws to understand the position and motion of objects in the solar system and the apparent motion of stars and planets as seen from Earth.

3.3 Demonstrate knowledge of the formation and characteristics of the moon and the relationship of Earth and the moon (e.g., tidal locking, change in orbital distance, stabilization of Earth's axis).

3.4 Analyze how the interaction between Earth and the sun produce the seasons and associated changes (e.g., sun's path, angle of incidence of solar radiation).

3.5 Analyze how the interaction between Earth, sun, and moon produce the phases of the moon; eclipses; tides; and the length of the year, month, and day.

3.6 Apply knowledge of scientific principles, crosscutting concepts, and engineering practices to the solar system and the interactions of the Earth-sun-moon system (e.g., exploring Kepler's laws, constructing explanations of the apparent motions of celestial objects) and make connections between science, engineering, and daily life (e.g., observing an eclipse safely, tracking the position of the sun in the sky over time).

EARTH'S SYSTEMS: GEOSPHERE

0004 Apply knowledge of Earth's internal structure and the history of Earth.

For example:

4.1 Demonstrate knowledge of the current scientifically accepted theory of the layered structure and composition of Earth, the source and movement of heat in Earth's interior, and the methods and technology used to study Earth's interior.

4.2 Demonstrate knowledge of the current scientifically accepted theory of the Earth's origin, key events in Earth's history (e.g., uniformitarianism), and the consequences of those events for Earth's geosphere, atmosphere, hydrosphere, and biosphere.

4.3 Apply knowledge of the current scientifically accepted theory of the origin of life, major events in the history of life (e.g., mass extinction events, diversification), fossilization processes, and the fossil record.

4.4 Demonstrate knowledge of the geologic timescale, absolute and relative dating, and the relevant techniques and technology used for determining dates.

4.5 Apply principles of stratigraphy (e.g., law of original horizontality, law of superposition), including to reconstruct the geologic history of a sequence of deposits.

4.6 Apply knowledge of scientific principles, crosscutting concepts, and engineering practices to Earth's internal structure and the history of Earth (e.g., examining radiometric dating using a model system, graphing the geological timeline with major events annotated) and make connections between science, engineering, and daily life (e.g., observing stratigraphic bands to correlate rock type with the geologic timescale, relating seismic data to where the wave is traveling within Earth).

0005 Analyze plate tectonics and the impact of plate movement.

For example:

5.1 Demonstrate knowledge of the current scientifically accepted theory of, and historical evidence for, plate tectonics.

5.2 Demonstrate knowledge of the mechanisms that drive plate movement and the spatial and temporal scale of plate tectonic activity.

5.3 Analyze interactions of tectonic plates (e.g., seafloor spreading, subduction of oceanic plates, collision of continental plates, development of sea trenches).

5.4 Analyze the geologic and topographic features that result from tectonic processes (e.g., seamounts, island chains, rift valleys, intrusions, mid-ocean ridges, mountain chains, volcanos, earthquakes, tsunamis).

5.5 Apply knowledge of scientific principles, crosscutting concepts, and engineering practices to plate tectonics and the impact of plate movement (e.g., observing convection currents using common materials, examining types of rock stress using common materials) and make connections between science, engineering, and daily life (e.g., using evidence to rebuild Wegener's idea of Pangaea, calculating the rate of Hawaiian island formation and movement).

0006 Apply knowledge of Earth materials, the rock cycle, and the processes of weathering, erosion, and deposition.

For example:

6.1 Demonstrate knowledge of the formation, characteristics, and classification of common rocks (e.g., granite, limestone, basalt, shale, schist, sandstone, chert) and rock-forming minerals and of the methods used to identify minerals (e.g., hardness, cleavage, streak, specific gravity, special properties).

6.2 Analyze the processes that drive the rock cycle and the characteristics and properties of sedimentary, igneous, and metamorphic rocks.

6.3 Apply knowledge of the processes and effects of weathering, the susceptibility of different types of rock to weathering, factors that affect the rate at which rocks weather, and the process of soil formation.

6.4 Apply knowledge of erosional agents (e.g., wind, water, glaciers), erosional processes and effects, and factors that affect erosion rates and patterns.

6.5 Apply knowledge of depositional processes and the topographic features that are formed by various agents of weathering, erosion, and deposition (e.g., beaches, dunes, mesas, valleys, eskers, moraines).

6.6 Apply knowledge of scientific principles, crosscutting concepts, and engineering practices to Earth materials, the rock cycle, and the processes of weathering, erosion, and deposition (e.g., growing a salt crystal, identifying unknown rocks and minerals based on common characteristics) and make connections between science, engineering, and daily life (e.g., using knowledge of rock weathering, determining the ideal location for a sandy beach on a shoreline, examining the properties of rocks to determine their suitability for different engineering challenges).

EARTH'S SYSTEMS: HYDROSPHERE, ATMOSPHERE, WEATHER, AND CLIMATE

0007 Demonstrate knowledge of the processes of the hydrosphere and characteristics of oceanic and freshwater systems.

For example:

7.1 Analyze the physical and chemical properties of water (e.g., surface tension, water's role as a solvent), the phase changes of water, the kinetic molecular theory, and associated energy changes of water (e.g., latent heat, specific heat).

7.2 Demonstrate knowledge of the hydrologic cycle, the processes that move water through the cycle (e.g., infiltration, runoff, transpiration, evaporation, condensation, precipitation), and the relationship to heat transfer.

7.3 Demonstrate knowledge of characteristics of surface (e.g., lakes, streams, glaciers) and groundwater and freshwater reservoirs (e.g., aquifers, water table), and factors that affect the storage and movement of groundwater (e.g., porosity, permeability, aquitards).

7.4 Demonstrate knowledge of the physical and chemical characteristics of ocean water, characteristics of ocean layers and zones (e.g., benthic, pelagic, tidal), and the current knowledge of the topography of the ocean floor.

7.5 Demonstrate knowledge of ocean circulation and currents (e.g., thermohaline circulation, surface currents) and factors that influence them, and the causes and characteristics of different types of ocean waves (e.g., surface, tidal, tsunami).

7.6 Apply knowledge of scientific principles, crosscutting concepts, and engineering practices to the processes of the hydrosphere and characteristics of oceanic and freshwater systems (e.g., exploring solid properties that direct groundwater flow using a model, modeling the distribution of water on Earth) and make connections between science, engineering, and daily life (e.g., examining the molecular structure of water and seeing how it interacts with other molecules in the environment; exploring factors that create and maintain salt and freshwater reserves, such as estuaries).

0008 Demonstrate knowledge of the composition, structure, and processes of the atmosphere.

For example:

8.1 Demonstrate knowledge of the evolution and changing composition of Earth's atmosphere over time, its current composition, the structure and properties of its layers, and the impact of outside forces (e.g., gravitational, magnetic).

8.2 Analyze processes of energy transfer in the atmosphere (e.g., insolation, latent heat of water) and the role of uneven heating in the generation of winds.

8.3 Demonstrate knowledge of global wind patterns, factors that affect prevailing wind speed and direction (e.g., Coriolis effect, geographic barriers, elevation).

8.4 Demonstrate knowledge of factors influencing the formation of fog and clouds (e.g., adiabatic temperature changes, dew point) and the relationship of different cloud types to those factors.

8.5 Demonstrate knowledge of factors affecting the interactions of the atmosphere with water, land surfaces, solar wind, and biosphere (e.g., plant cover, albedo, ocean absorption, retention of heat, auroras).

8.6 Apply knowledge of scientific principles, crosscutting concepts, and engineering practices to the composition, structure, and processes of the atmosphere (e.g., predicting how much insolation that a certain area receives, modeling the rain shadow effect) and make connections between science, engineering, and daily life (e.g., comparing radar images showing where weather is occurring with air pressure maps, using instrumentation to measure wind and examine where the force originates).

0009 Demonstrate knowledge of Earth's weather and climate.

For example:

9.1 Demonstrate knowledge of the characteristics and movements of high- and low-pressure systems, air masses, and fronts; their effects; and the conditions under which they form.

9.2 Analyze factors that affect weather conditions (e.g., movement of jet streams, topography, proximity to large bodies of water).

9.3 Demonstrate knowledge of the use of weather models and data (e.g., barometric pressure, dew point, humidity), the use of instruments for collecting weather data, and the interpretation of weather maps and symbols.

9.4 Demonstrate knowledge of the biotic and abiotic characteristics of Earth's major climate systems, factors that influence regional climates, and how to compare and contrast climate and weather.

9.5 Analyze evidence for climate change in the past and factors that have caused past fluctuations in climate.

9.6 Apply knowledge of scientific principles, crosscutting concepts, and engineering practices to Earth's weather and climate (e.g., examining the causes of common types of weather, observing when the probability of precipitation increases based on environmental factors) and make connections between science, engineering, and daily life (e.g., designing and building a weather station, analyzing weather maps to make future forecasts about a given location).

EARTH AND HUMAN ACTIVITY

0010 Analyze geochemical cycles, natural resources, and energy.

For example:

10.1 Demonstrate knowledge of the cycling of elements (e.g., nitrogen, carbon, phosphorous) through Earth's geological, hydrological, atmospheric, and biological systems and factors that affect their movement.

10.2 Analyze the characteristics, availability, distribution, and management of renewable and nonrenewable natural resources (e.g., wind, freshwater, soil types, biological resources).

10.3 Analyze the formation, extraction, availability, and use of geologic resources (e.g., precious metals, minerals, ores, fossil fuels); and the effects of these processes on the biosphere.

10.4 Analyze the advantages and disadvantages of renewable and nonrenewable sources of energy (e.g., solar, geothermal, wind).

10.5 Demonstrate knowledge of how access to natural resources has historically influenced human societies and how the extraction and use of natural resources affects human health and societies today (e.g., overuse of fertilizer, increased available food supplies).

10.6 Apply knowledge of scientific principles, crosscutting concepts, and engineering practices to geochemical cycles, natural resources, and energy (e.g., predicting which renewable and nonrenewable energy sources are best for an area given parameters, examining energy-efficient housing) and make connections between science, engineering, and daily life (e.g., mining chocolate chips from cookies to simulate ore production and examine a cost-benefit analysis, determining the location of natural resources based on the geologic history of the area).

0011 Demonstrate knowledge of natural hazards and their effects on human societies.

For example:

11.1 Analyze the causes and characteristics of natural hazards and catastrophic events (e.g., tornadoes, tsunamis, droughts, earthquakes, volcanoes), including the ability to predict different events.

11.2 Demonstrate knowledge of the models and technologies (e.g., tiltmeters, satellite imagery) used to predict certain natural hazards and catastrophic events.

11.3 Demonstrate knowledge of the short- and long-term impacts of natural hazards and catastrophic events on human communities and societies.

11.4 Demonstrate knowledge of strategies and technologies to limit and to mitigate the causes and effects of natural hazards.

11.5 Demonstrate knowledge of the evidence for global climate change, the possible mechanisms behind climate change, and the likely effects of climate change on Earth systems and human societies.

11.6 Apply knowledge of scientific principles, crosscutting concepts, and engineering practices to natural hazards and their effects on human societies (e.g., graphing gas concentrations in ice cores, exploring ancient climate change by looking at leaf fossils) and make connections between science, engineering, and daily life (e.g., designing model levees, analyzing hurricanes using technology).

0012 Demonstrate knowledge of the effects and mitigation of human activities on Earth systems.

For example:

12.1 Analyze the effect on Earth systems of human population changes and per-capita consumption of natural resources over time, including how population and consumption vary across the globe.

12.2 Demonstrate knowledge of positive and negative effects of human activities (e.g., release of greenhouse gases, sulfur dioxide, enacted legislation to improve air quality) on the atmosphere, strategies for monitoring these effects, possible mitigating solutions, and future improvements.

12.3 Demonstrate knowledge of positive and negative effects of human activities (e.g., pollution, nutrient runoff, overuse of groundwater, development of water-saving technology) on the hydrosphere, strategies for monitoring these effects, possible mitigating solutions, and future improvements.

12.4 Demonstrate knowledge of positive and negative effects of human activities (e.g., fracking, mining, clear-cutting, crop rotation, development of no-till drill) on the lithosphere, strategies for monitoring these effects, possible mitigating solutions, and future improvements.

12.5 Demonstrate knowledge of positive and negative effects of human activities (e.g., urbanization, introduction of invasive species, overfishing, improved agricultural methods) on the biosphere, strategies for monitoring these effects, possible mitigating solutions, and future improvements.

12.6 Analyze how a change in one Earth system due to human activities may lead to changes in other Earth systems (e.g., permafrost melting leading to increased methane release, loss of Arctic sea ice leading to increased atmospheric water vapor, restricted use of pesticides leading to increased raptor populations).

12.7 Apply knowledge of scientific principles, crosscutting concepts, and engineering practices to the effects and mitigation of human activities on Earth systems (e.g., using the cyclone method to collect and remove air pollutants, examining green infrastructure and low-impact development) and make connections between science, engineering, and daily life (e.g., applying environmental indicators to determine the water quality of a nearby stream or wetland, designing a sanitary landfill).

CHEMISTRY

0013 Apply knowledge of chemistry concepts.

For example:

13.1 Apply knowledge of predominant historical models of the atom; the experimental techniques used to refine and revise those models; and the properties of elements, including development of the periodic table and basic periodic trends in the elements.

13.2 Distinguish between various forms of matter (i.e., pure substances and mixtures).

13.3 Analyze the various types of chemical bonds (i.e., covalent, ionic, and metallic), predict what types of bonds specific elements will form, and apply general rules of nomenclature.

13.4 Analyze energy transfer during chemical reactions and identify exothermic and endothermic reactions.

13.5 Analyze and identify types of reactions in terms of conservation of mass, energy, and charge; and balance common chemical equations.

13.6 Apply the mole concept and solve basic stoichiometry problems.

13.7 Demonstrate knowledge of solutions, suspensions, and colloids; analyze the acid/base nature of solutions; and predict the extent of dissociation.

PHYSICS

0014 Apply knowledge of physics concepts.

For example:

14.1 Apply concepts of mechanical forces and interactions to describe the motion of an object (e.g., position, velocity, and acceleration; Newton's laws; momentum and collisions; the universal law of gravitation).

14.2 Apply concepts of electric and electromagnetic forces in a variety of situations (e.g., Coulomb's law, Ohm's law, circuits, electromagnets).

14.3 Apply knowledge of energy and the conservation of energy, including kinetic energy, potential energy, and thermal energy, and conversions among them (e.g., evaluate real-world devices that convert energy from one form to another).

14.4 Apply knowledge of relationships between frequency, wavelength, and speed of a wave; wave reflection, refraction, and superposition; principles of optics; and applications of waves in technologies for information transfer.

BIOLOGY

0015 Apply knowledge of biology concepts.

For example:

15.1 Apply knowledge of the structure of prokaryotic and eukaryotic cells; the function of membranes and organelles; and the processes of photosynthesis and cellular respiration.

15.2 Analyze how bacteria, plants, and animals obtain, store, and use energy, nutrients, and water to maintain homeostasis, including through the use of the levels of biological organization in multicellular organisms.

15.3 Demonstrate knowledge of cellular division and the cell cycle.

15.4 Apply knowledge of the synthesis, structure, and function of nucleic acids; factors controlling gene expression; the processes involved in protein synthesis; and basic methods and applications of genetic engineering (e.g., restriction enzymes, DNA sequencing, recombinant DNA).

15.5 Analyze the patterns and processes of inheritance, including asexual and sexual reproduction.

15.6 Demonstrate knowledge of population genetics and the primary mechanisms of evolution, natural selection, and speciation.

15.7 Analyze how biotic and abiotic factors affect carrying capacity and biodiversity of an ecosystem, population curves, the types of relationships that exist between organisms in communities, and factors that produce change in communities.

15.8 Analyze energy flow and biogeochemical cycling in ecosystems and the trophic roles of organisms in different ecosystems (e.g., food chain, food web).