Massachusetts Tests for Educator Licensure® (MTEL®)

FIELD 14: EARTH SCIENCE
TEST OBJECTIVES

Subarea	Multiple-Choice	Range of Objectives	Approximate Test Weighting
I.	Nature of Science	01–04	16%
II.	Geology	05–08	16%
III.	Oceanography and Freshwater Systems	09–11	16%
IV.	Meteorology	12–15	16%
V.	Astronomy	16–19	16%
			80%
	Open-Response		
VI.	Integration of Knowledge and Understanding	20	**20%**

Effective September 1, 2009

Massachusetts Tests for Educator Licensure® (MTEL®)
Test Objectives
Field 14: Earth Science

SUBAREAS:

NATURE OF SCIENCE
GEOLOGY
OCEANOGRAPHY AND FRESHWATER SYSTEMS
METEOROLOGY
ASTRONOMY
INTEGRATION OF KNOWLEDGE AND UNDERSTANDING

NATURE OF SCIENCE [16%]

0001 Understand the nature of scientific inquiry and scientific processes.

For example:

- Demonstrate knowledge of the principles of scientific inquiry, the dynamic nature of science, and the role of serendipity and creativity in science.
- Demonstrate the ability to formulate scientific questions and testable hypotheses.
- Evaluate the validity of an experimental design in collecting data and testing a hypothesis.
- Identify sources of bias and strategies for avoiding bias in scientific investigations.

0002 Understand the processes of gathering, organizing, analyzing, and reporting scientific data.

For example:

- Demonstrate knowledge of appropriate methods and procedures for collecting and analyzing data for earth science investigations, including the use of computer applications.
- Demonstrate knowledge of various methods of organizing, representing, and reporting experimental results.
- Apply mathematical concepts to measurement and the analysis and interpretation of data (e.g., accuracy, precision, significant figures, scientific notation, unit conversion, statistical analysis).
- Demonstrate the ability to draw conclusions and make predictions from empirical data.
- Demonstrate knowledge of the use of models in earth science and applications of computer modeling, remote sensing, and cartography (e.g., topographic and geologic maps).

0003 Understand scientific tools, instruments, materials, and safety practices.

For example:

- Demonstrate knowledge of types and functions of scientific tools, instruments, and materials used in earth science investigations.
- Demonstrate knowledge of the safe and proper use of equipment and materials for earth science investigations.
- Recognize appropriate field procedures for collecting and handling materials and chemicals used in earth science investigations.
- Demonstrate knowledge of the appropriate protocols for maintaining safety and responding to emergencies in laboratory and field situations.

0004 Understand the historical and contemporary relationships among science, technology, and society.

For example:

- Demonstrate knowledge of scientific theories (e.g., plate tectonics, evolution, Big Bang, climate change) and the events and experiments that contributed to their development.
- Demonstrate knowledge of interactions of the components of the earth system and how these components affect human societies.
- Recognize the integration and interdependence among scientific disciplines and between science and technology, including related aspects of chemistry, physics, and biology.
- Identify the benefits, risks, and ethical concerns associated with scientific research and developing technologies.
- Recognize how societal conditions support or inhibit scientific research and technological advances.
- Demonstrate knowledge of engineering and technical applications related to earth science (e.g., slope stabilization, strain gauges, tsunami warning systems).
- Analyze scientific claims in the media.

GEOLOGY [16%]

0005 Understand the characteristics, classification, and formation of rocks, minerals, and geologic energy resources.

For example:

- Recognize the characteristics of common rocks and minerals.
- Apply knowledge of methods used to identify common rock-forming minerals (e.g., Mohs scale, crystal form, chemical composition).
- Demonstrate knowledge of the rock cycle and the formation and characteristics of sedimentary, igneous, and metamorphic rocks.
- Analyze the role of the lithosphere in the cycling of carbon.
- Analyze the development, use, and management of geologic energy resources (e.g., fossil fuels, geothermal, nuclear).

0006 Understand the earth's structure and its internal dynamics and the constructional forces that have shaped its surface.

For example:

- Demonstrate knowledge of the earth's interior and the use of seismic waves to infer the earth's internal structure.
- Demonstrate knowledge of the theory of plate tectonics; the evidence on which it is based; and how it relates to landscape development, volcanism, and tectonic faulting.
- Analyze the characteristics of, causes of, and landforms produced by different types of volcanism.
- Analyze the characteristics of, causes of, and landforms produced by earthquakes and faulting.
- Demonstrate knowledge of isostasy and its relationship to landscape evolution.

0007 Understand processes of weathering, erosion, and deposition and the landforms they produce.

For example:

- Demonstrate knowledge of the processes of mechanical, chemical, and biological weathering and factors that affect the rate at which rocks weather and soils are produced.
- Demonstrate knowledge of the processes of erosion by various agents (e.g., wind, water, glaciers) and factors that affect erosion rates and patterns.
- Demonstrate knowledge of the erosional and depositional processes by which major landscape features are formed.
- Demonstrate knowledge of the effects of erosional and depositional processes (e.g., glaciation, coastal erosion) on the Massachusetts landscape.

0008 Understand geologic time divisions, methods of relative and absolute dating, and major events in the earth's geologic history.

For example:

- Demonstrate knowledge of the chronology of geologic time divisions and major events in the earth's history (e.g., formation of oxygen-rich atmosphere, mass extinctions, continental glaciations, mountain-building episodes).
- Recognize the processes involved in fossil formation and the environmental conditions and fossils that characterize the various geologic periods.
- Apply the laws and principles of geology (e.g., law of original horizontality, principle of superposition, principle of cross-cutting relationships) to interpret diagrams of rock strata.
- Recognize the principles and applications of radiometric dating.
- Analyze stratigraphic and paleontological information to infer the geologic history of a given area.
- Demonstrate knowledge of events in the geologic history of Massachusetts and New England (e.g., formation of Appalachian Mountains and the Connecticut Valley).

OCEANOGRAPHY AND FRESHWATER SYSTEMS [16%]

0009 Understand the hydrologic cycle and types, characteristics, and uses of freshwater systems.

For example:

- Demonstrate knowledge of the physical and chemical properties of water, the hydrologic cycle, and the movement of water through the earth system.
- Recognize changes in the distribution of water over time (e.g., sea-level changes, fossil aquifers, continental glaciations) and factors that affect the global distribution and use of freshwater resources.
- Recognize the characteristics of watersheds and surface waters, including lakes, ponds, and rivers.
- Analyze the effects of various factors (e.g., vegetation, gradient, soil type, topography) on water moving through a watershed.
- Analyze a cross-sectional diagram of a water table and surrounding rock strata to predict the movement of groundwater and the behavior of wells.
- Demonstrate knowledge of factors affecting the movement of groundwater (e.g., permeability and porosity of aquifer sediments, gradient, recharge rate).

0010 Understand the characteristics of ocean water, ocean currents, tides, and waves.

For example:

- Demonstrate knowledge of the physical and chemical characteristics of ocean water.
- Demonstrate knowledge of the effects of the oceans on other earth systems (e.g., atmosphere, lithosphere).
- Analyze ocean currents (e.g., thermohaline circulation, surface currents) and factors that influence them (e.g., temperature and salinity variations, wind systems, the Coriolis effect).
- Demonstrate knowledge of the properties of ocean waves, the causes and characteristics of tides, and the characteristics of tsunamis.
- Demonstrate knowledge of the depositional and erosional processes affecting coastal landforms (e.g., beaches, barrier islands, deltas).

0011 Understand the origin, structure, and topography of ocean basins and continental shelves.

For example:

- Demonstrate knowledge of the sediments and major structural features of ocean basins and continental shelves (e.g., canyons, trenches, ridges).
- Analyze the origin of ocean basins and passive and active continental margins, including the role of tectonic forces in shaping them.
- Analyze the geologic and biological processes involved in the development of geologic features of oceans and the role of these processes in the carbon cycle.
- Recognize the physical characteristics of ocean layers and ocean zones (e.g., littoral, benthic).

METEOROLOGY [16%]

0012 Understand the composition, structure, and properties of the earth's atmosphere.

For example:

- Demonstrate knowledge of the properties of the atmosphere from the earth's surface through the thermosphere and the significance of changes in these properties.
- Analyze how various wavelengths of radiation (e.g., ultraviolet, visible light, infrared) are affected as the radiation enters and passes through the atmosphere and is absorbed by and radiated from the earth's surface (e.g., greenhouse effect).
- Analyze the processes by which energy is transferred to and within the atmosphere (e.g., radiation, convection, conduction).
- Demonstrate knowledge of global wind patterns in terms of latitudinal variations in insolation and the Coriolis effect.
- Recognize types and characteristics of air masses, their movements, and the kinds of fronts that form between air masses.
- Analyze the role of the atmosphere in the cycling of carbon and nitrogen from the lithosphere, biosphere, and hydrosphere.

0013 Understand the characteristics of the earth's major climatic regions and analyze factors that affect global and regional climate conditions.

For example:

- Identify the characteristics and distribution of different climates.
- Demonstrate knowledge of factors that affect the climate in a given region (e.g., latitude, insolation, wind patterns, topography, ocean currents).
- Analyze climate phenomena (e.g., El Niño-Southern Oscillation, North Atlantic Oscillation, monsoons, jet streams) and their relationship to regional weather patterns.
- Demonstrate knowledge of the causes and effects of past changes in the earth's climate system.

0014 Understand the conditions in the atmosphere that produce different types of weather.

For example:

- Relate the physical properties of water (e.g., high specific heat, surface tension) to processes that produce various types of weather, including energy changes involved in the transition between phases of water.
- Demonstrate knowledge of atmospheric conditions under which fog and clouds form (e.g., adiabatic temperature changes, dew point, ocean currents, atmospheric stability).
- Demonstrate knowledge of the conditions under which different types of precipitation and severe weather form.
- Analyze the horizontal and vertical movements of air in high- and low-pressure areas.
- Demonstrate knowledge of weather instruments.
- Analyze weather conditions using weather-map symbols and the station model.

0015 Understand the effects that weather and climate have on society and the causes of atmospheric pollution and climate change.

For example:

- Analyze how weather and climate affect human society.
- Recognize the sources and characteristics of common air pollutants and how they affect the atmosphere, people, and the environment.
- Demonstrate knowledge of strategies for reducing atmospheric pollution.
- Analyze the evidence for human-induced changes in regional and global climate systems.
- Analyze renewable and nonrenewable resources, including fossil fuels, solar, and wind power.

ASTRONOMY [16%]

0016 Understand the characteristics, movements, and interactions of the earth, moon, and sun.

For example:

- Demonstrate knowledge of the formation, physical characteristics, and motions of the earth and moon.
- Analyze how the motions and interactions of the earth, moon, and sun produce solar and lunar eclipses, changes in daylight, seasons, tides, and the phases of the moon.
- Recognize how the earth's rotation and orbit cause the apparent movement of stars, planets, and the sun.
- Demonstrate knowledge of the sun's structure, sunspots, and the solar cycle.

0017 Understand the organization and components of the solar system.

For example:

- Demonstrate knowledge of the origin of the solar system and its components, including comets, asteroids, and smaller objects.
- Demonstrate knowledge of the position of the planets on the ecliptic and their physical characteristics.
- Recognize the properties and motions of comets and asteroids.
- Demonstrate knowledge of the motion of objects in the solar system, including apparent motion, Kepler's laws, and the effects of gravity and inertia.

0018 Understand stars and their evolution.

For example:

- Demonstrate knowledge of types of stars and their characteristics.
- Analyze stellar life cycles, including that of the sun, and the formation of pulsars, white and brown dwarfs, and black holes.
- Use the Hertzsprung-Russell diagram to analyze the life cycle of stars.
- Demonstrate knowledge of how the properties of stars can be used to determine their age, distance, and relative motion.

0019 Understand the origin, structure, and evolution of the universe.

For example:

- Demonstrate knowledge of the characteristics of different types of galaxies, including the Milky Way galaxy.
- Demonstrate knowledge of dark matter and dark energy.
- Demonstrate knowledge of theories for the origin of the universe (e.g., Big Bang, inflation).
- Analyze the evidence for an expanding universe (e.g., red shift).
- Recognize the uses of different types of telescopes (e.g., optical, radio, infrared, ultraviolet) and spectroscopy for determining the properties and motion of objects in the universe.

INTEGRATION OF KNOWLEDGE AND UNDERSTANDING [20%]

In addition to answering multiple-choice items, candidates will prepare written responses to questions addressing content summarized in the objective below.

0020 Prepare an organized, developed analysis on a topic related to one or more of the following subareas: Nature of Science, Geology, Oceanography and Freshwater Systems, Meteorology, and Astronomy.

(Refer to objectives 0001 through 0019 and associated descriptive statements.)