MICHIGAN TEST FOR TEACHER CERTIFICATION (MTTC)

TEST OBJECTIVES
FIELD 020: EARTH/SPACE SCIENCE

Subarea	Approximate Percentage of Questions on Test
Foundations of Scientific Inquiry	20%
Physical and Historical Geology	20%
Oceanography and Freshwater Systems	20%
Meteorology	20%
Astronomy	20%

I. FOUNDATIONS OF SCIENTIFIC INQUIRY

001 Demonstrate knowledge of principles and procedures for conducting scientific research.

Includes identifying procedures for conducting scientific investigations; developing valid experimental designs for collecting data and testing hypotheses; analyzing data; recognizing the limitations of scientific investigations; analyzing procedures used in setting up and conducting experiments in natural and laboratory settings; identifying experimental variables being held constant, being manipulated, and responding; applying methods for presenting data with graphs, tables, equations, and maps; and applying mathematics (e.g., statistics, algebra, trigonometry).

002 Apply knowledge of materials, methods, and equipment commonly used in earth/space science.

Includes recognizing the safe use of tools and materials (e.g., field equipment, chemicals, MSDS) related to earth/space science investigations conducted in laboratory and natural settings; identifying the tools, techniques, and procedures used in the observation, analysis, and prediction of natural phenomena in earth/space science (e.g., Geographic Information Systems, telescopes, computer models); identifying appropriate procedures for dealing with emergencies; applying procedures for selecting and using measurement devices (e.g., compasses, pH meters, scales); solving problems involving field and laboratory measurements; and applying procedures for interpreting and using maps and charts (e.g., topographic maps, geologic maps, astronomical charts).

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003 Understand the nature and history of scientific thought and inquiry.

Includes recognizing the reliance of scientific investigations on empirical data, verifiable evidence, and logical reasoning; analyzing the cumulative process of developing scientific evidence in support of models and theories concerning earth/space science; recognizing the effects of personal and cultural bias on scientific investigations and the interpretation of data; and identifying major scientific ideas from societies and individuals of different periods and cultures.

004 Understand the relationship of earth/space science to contemporary, historical, technological, and societal issues.

Includes identifying how society influences the practice and development of earth/space science and how scientific developments and technological changes affect society; evaluating historical and contemporary controversies related to developments in earth/space science and applications of new technologies (e.g., energy production and use, space flight, overuse of marine resources, mining); identifying types and sources of pollution (e.g., water, air, soil); and analyzing the effects of pollution and conservation on the environment.

005 Demonstrate knowledge of the interrelationships among the life, physical, and earth/space sciences and among science, mathematics, and technology.

Includes analyzing the relationship of science and technology; identifying unifying themes and concepts that are common to the various scientific disciplines (e.g., classification, cause and effect, conservation of matter and energy) and that connect science, mathematics, and technology; and analyzing how common themes of science, mathematics, and technology (e.g., feedback, scale, systems) apply in real-world contexts.

II. PHYSICAL AND HISTORICAL GEOLOGY

006 Demonstrate knowledge of the structure, characteristics, and processes of the earth.

Includes analyzing the physical and chemical processes involved in the rock cycle that produce igneous, metamorphic, and sedimentary rocks; identifying the evidence for plate tectonics; describing the mechanisms that produce plate movements and crustal deformation (e.g., folding, faulting); interpreting geologic features (e.g., mountain ranges, rift valleys, wave-cut terraces) in terms of the tectonic processes by which they were formed; identifying different types of earth materials (e.g., minerals, rocks, soils) and the processes by which they are formed; describing the internal structure of the earth; and explaining the evidence upon which knowledge of the earth's internal structure is based (e.g., the earth's magnetic field, seismic waves, meteorites).

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TEST OBJECTIVES
FIELD 020: EARTH/SPACE SCIENCE

007 Understand the causes and consequences of volcanism and earthquakes.

Includes identifying the locations and characteristics of volcanoes and earthquakes; identifying the geologic processes responsible for different kinds of volcanism; analyzing the processes that produce earthquakes; recognizing the factors that influence the propagation (e.g., depth, ground composition) and destructive consequences of earthquakes; analyzing the methods used to monitor, measure, and predict earthquake activity and volcanism; and understanding the consequences of both (e.g., tsunamis, landslides).

008 Understand processes and consequences of weathering, erosion, and deposition.

Includes demonstrating knowledge of the integrated processes of weathering, erosion, and deposition, including the formation of karst topography; identifying the agents and effects of erosion and deposition; recognizing the processes and results of mass wasting; analyzing processes of soil formation under different conditions; identifying types and characteristics of continental and mountain glaciers and the associated glacial deposits; analyzing processes by which glaciers form, advance, and retreat; and analyzing the roles of weathering, erosion, and glaciation in shaping the Great Lakes region.

009 Demonstrate knowledge of the geologic time scale and the methods of relative and absolute dating.

Includes identifying the relative and absolute ages of important physical and biological events on the geologic time scale; recognizing the historical development and organization of the geologic time scale; identifying major evolutionary trends over the course of geologic time; recognizing factors that have affected life forms over geologic time (e.g., climate changes, plate tectonics); identifying the processes involved in fossil formation; analyzing the physical evidence for the age of the earth and biological evolution; and identifying the methods used in relative dating (e.g., crosscutting relations, superposition, index fossils) and absolute dating (e.g., radiometric dating, dendrochronology).

010 Understand the formation and use of geologic resources, and the relationship between the geosphere and human activities.

Includes identifying the types and characteristics of renewable (e.g., water, soils) and nonrenewable (e.g., fossil fuels, ores, minerals) geologic resources; analyzing factors that affect the availability and use of geologic resources (e.g., accessibility, environmental considerations, economics); identifying strategies for managing geologic resources (e.g., land-use planning, watershed protection, reclamation, recycling); and analyzing the types, sources, and effects of pollutants and ways of dealing with these problems (e.g., technological, ecological, cultural).

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III. OCEANOGRAPHY AND FRESHWATER SYSTEMS

011 Demonstrate knowledge of the physical components and processes of the marine system.

Includes identifying the physical characteristics of ocean waters (e.g., salinity, chemical composition, thermal layering) and ocean basins (e.g., physiography, sediments, deep-ocean vents, atolls); identifying ocean zones (e.g., littoral, pelagic, benthic) in terms of their physical characteristics; recognizing the types of ocean currents and the connections between them; analyzing circulation patterns in the oceans and factors that influence these patterns (e.g., thermohaline gradients, wind systems, Coriolis effect); recognizing the causes and effects of waves (e.g., coastal erosion and deposition) and tides; recognizing the interrelationship between the marine environment and marine organisms; and recognizing the geologic processes that shape the ocean basins.

012 Understand the distribution of freshwater and the processes involved in the hydrologic cycle.

Includes recognizing factors that affect the distribution of freshwater resources; analyzing changes in the distribution of water over time (e.g., glaciers, fossil aquifers); analyzing the physical and chemical properties of water (e.g., structure, bonding, specific heat); explaining phase changes of water in terms of energy flow; analyzing the movement of water in the hydrologic cycle; and demonstrating knowledge of the movement of water in the Great Lakes system.

013 Apply knowledge of groundwater.

Includes using the hydrologic cycle to explain the movement and renewal of groundwater in different types of aquifers (e.g., confined, unconfined); describing the factors that affect the flow of groundwater through unconsolidated sediments and bedrock (e.g., porosity, grain-size distribution, fracturing, faulting); demonstrating knowledge of infiltration and recharge and the factors that affect them (e.g., soil type, surface geology, vegetation, urbanization); analyzing the interaction of groundwater with surface water; and identifying factors (e.g., pH, mineral content) that affect the quality and processing of groundwater used for human consumption.

014 Apply knowledge of freshwater systems.

Includes identifying the geological, chemical, and physical characteristics of watersheds, rivers (e.g., water chemistry, turbidity, flow rate), ponds, and lakes (e.g., thermocline, mass balance) and the interactions of rivers, ponds, and lakes; analyzing the processes that affect ponds and lakes (e.g., eutrophication, seasonal turnover); analyzing the effects of the aquatic environment (e.g., oxygen levels, pH) on aquatic organisms; and describing the physical characteristics of the Great Lakes (e.g., depth, size, drainage).

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015 Understand the relationship between the hydrosphere and human activity.

Includes recognizing the characteristics and uses of renewable and nonrenewable marine and freshwater resources; identifying environmental issues related to the use of marine and freshwater resources; analyzing factors that affect the availability of local and global freshwater and marine resources; identifying the availability and uses of freshwater resources in the Great Lakes region; identifying types, sources, and effects of pollution, including invasive species, in freshwater and marine environments; analyzing strategies for preventing, monitoring, and cleaning up pollution problems in the hydrosphere; recognizing physical factors that affect the biological resources of the oceans; and identifying the tools and methods used to explore marine and freshwater systems.

IV. METEOROLOGY

016 Understand the structure and characteristic features of the atmosphere and the atmospheric conditions and processes that affect weather and climate.

Includes identifying the relative positions and characteristics of the different layers of the atmosphere; recognizing the importance of different components of the atmosphere in regulating the earth's weather, including temperature, precipitation, and radiation budget; identifying the electromagnetic spectrum; analyzing the processes of radiation, convection, and conduction in the earth's atmosphere that affect weather and climate; explaining the formation of air masses; analyzing the interaction of ocean currents and continental glaciers over time; and recognizing factors that influence global and local wind patterns (e.g., Coriolis effect, distribution of land and water, convection, jet stream).

017 Understand the formation of clouds, precipitation, and condensation.

Includes recognizing the conditions and processes that produce condensation (e.g., presence of condensation nuclei, adiabatic cooling); identifying types and characteristics of clouds and analyzing the conditions and processes that produce them (e.g., water vapor, heat energy, atmospheric stability and instability); identifying types and characteristics of precipitation; and analyzing the conditions under which different types of precipitation form.

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018 Understand the causes of different kinds of weather.

Includes explaining how various factors (e.g., pressure, temperature, winds) initiate different kinds of weather; identifying characteristics of air masses, fronts, cyclones and anticyclones, and analyzing how they affect weather; identifying characteristics of severe weather (e.g., floods, blizzards, hurricanes, tornadoes) and analyzing the processes responsible for its formation; applying knowledge of the jet stream to explain its effect on weather patterns; describing how regional weather is affected by large-scale patterns in the atmosphere (e.g., monsoons, the Bermuda high, the Pacific high, the Intertropical Convergence Zone); and analyzing the effects that the Great Lakes exert on regional and local weather (e.g., lake-effect precipitation, land and shore breezes, rainfall, shadow zones).

019 Apply knowledge of the earth's climate systems and analyze the factors that influence climate.

Includes analyzing the characteristics and distribution of different climates; analyzing factors that affect climate (e.g., temperature, amount of precipitation); describing climate changes that have occurred during the history of the earth (e.g., ice age); identifying the causes of climate changes (e.g., orbital variations, changes in the composition and circulation of the atmosphere, plate tectonics); analyzing the conditions associated with the different phases of the El Niño/Southern Oscillation (ENSO) climate phenomenon; and applying knowledge of the conditions associated with the different phases of the ENSO climate phenomenon to explain its effects on global weather patterns.

020 Understand the relationship between the atmosphere and human activity.

Includes identifying the evidence used in the study of climate change (e.g., chemical analysis of ice cores, oxygen isotope analysis, sedimentary deposits, pollen diagrams); recognizing the causes and effects of human-induced changes in local and global climate systems (e.g., deforestation and overgrazing can lead to desertification, fossil fuel use alters atmospheric chemistry); recognizing the possible causes and risks of global climate change; identifying types, sources, and effects of atmospheric pollution (e.g., atmospheric deposition, greenhouse gases, smog, ozone pollution in the troposphere); evaluating techniques and procedures for reducing air pollution; and relating ozone layer destruction and the amount of ultraviolet radiation reaching the earth's surface.

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V. ASTRONOMY

021 Understand the characteristics of the sun-earth-moon system.

Includes identifying the motions of the earth and moon; describing the history of the sun-earth-moon system (e.g., changes in orbit and rotation over time); recognizing the effects of the gravitational fields of the sun and moon on tides; identifying the effects solar energy has on the earth (e.g., solar cycle, cycling of energy, atmospheric phenomena, health effects); and analyzing the effects of the earth's motion and orientation on physical phenomena (e.g., the diurnal cycle, seasons, phases of the moon, eclipses).

022 Recognize the components of the solar system.

Includes identifying the characteristics of the different types of objects in the solar system (e.g., comets, asteroids, planets, moons) and their locations; recognizing the physical laws controlling the motions of objects in the solar system; analyzing apparent motions of objects in the solar system as viewed from the earth (e.g., retrograde motion of Mars); and explaining current scientific theories on the origin and development of the solar system.

023 Understand stellar evolution and the formation of the universe.

Includes analyzing the evolution of stars (e.g., H-R diagrams, production of elements); identifying characteristics of different types of stars (e.g., white dwarfs, neutron stars, binary stars) and stellar phenomena (e.g., supernovae, black holes, star clusters); analyzing evidence for the layered composition, temperature, and motion of stars; recognizing factors that affect the absolute and apparent magnitude of stars; identifying types and characteristics of galaxies, including the Milky Way; and recognizing scientific theories and evidence relating to the origin of the universe (e.g., big bang theory, inflationary models, dark matter).

024 Demonstrate knowledge of the history of astronomy.

Includes recognizing major events in the history of astronomy and space exploration; identifying the ideas and accomplishments of individuals (e.g., Galileo, Copernicus, Kepler) involved in the history of astronomy; and recognizing the technology used to advance knowledge of space (e.g., radio telescopes, infrared telescopes, optical telescopes, manned space craft, space probes).

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