

# Massachusetts Tests for Educator Licensure® (MTEL®)

## FIELD 64: GENERAL SCIENCE TEST OBJECTIVES

Subarea	Multiple-Choice	Range of Objectives	Approximate Test Weighting*
I.	Technology / Engineering	01–03	20%
II.	Earth and Space Science	04–07	20%
III.	Life Science	08–11	20%
IV.	Physical Science	12–16	<u>20%</u>
			<b>80%</b>
	<b>Open-Response</b>		
V.	Integration of Knowledge and Understanding		
	Earth and Space Science and Life Science	17	10%
	Physical Science	18	<u>10%</u>
			<b>20%</b>

\*Final decisions regarding the proportion of the multiple-choice and open-response sections of the test will be made by the Department of Elementary and Secondary Education. If the proportions of the multiple-choice and open-response sections change, the proportions for the multiple-choice sections for each subarea will remain relative to the proportions indicated above.

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**DRAFT**

**Massachusetts Tests for Educator Licensure® (MTEL®)  
Test Objectives  
Field 64: General Science**

**SUBAREAS:**

TECHNOLOGY / ENGINEERING  
EARTH AND SPACE SCIENCE  
LIFE SCIENCE  
PHYSICAL SCIENCE  
INTEGRATION OF KNOWLEDGE AND UNDERSTANDING

**TECHNOLOGY / ENGINEERING [20%]**

**0001 Apply knowledge of engineering design.**

For example:

- Apply knowledge of engineering design practices to define a problem and to identify the criteria and constraints associated with the problem, including the following: materials; time; cost; and societal, scientific, and engineering restrictions.
- Apply knowledge of the iterative design process, including constructing a prototype, testing a prototype, comparing design solutions, and modifying design solutions to improve a prototype.
- Demonstrate knowledge of the systematic process used to evaluate an engineering design or interpret results, including the use of models (e.g., mathematical, physical, computer simulations).
- Demonstrate knowledge of the relationship between the components of a product or device to its function, including addressing the design features and limitations of the product or device.

**Field 064: General Science  
Test Objectives**

**0002 Demonstrate knowledge of tools, materials, and manufacturing.**

For example:

- Apply knowledge of scientific concepts to the development and general functioning of tools, materials, and manufacturing processes in a real-world context.
- Demonstrate knowledge of the selection and appropriate use of tools in a variety of contexts, including manufacturing processes, engineering projects, and classroom activities.
- Demonstrate knowledge of how products are created using basic processes in manufacturing systems (e.g., forming, separating, conditioning, assembling, finishing), quality control, and safety.
- Demonstrate knowledge of the composition of different materials and the effect of manufacturing processing (e.g., magnetization, heating, cutting) on a material's composition.
- Demonstrate knowledge of the relationship between the use of a material (e.g., metal, plastic, wood) and the material's physical and chemical properties (e.g., flexibility, ductility, thermal conductivity, electrical conductivity, melting point).
- Apply knowledge of safety procedures and hazards associated with a workspace or classroom setting (e.g., practices and requirements related to the safe use and storage of tools and equipment, the use and proper disposal of materials, procedures for preventing or responding to accidents and injuries).

**Field 064: General Science  
Test Objectives**

**0003 Demonstrate knowledge of technological systems.**

For example:

- Analyze the interdependence of science, engineering, and technology, including the use of scientific principles and engineering design to explain the development, production, general functioning, and improvement of various technologies (e.g., radio, air conditioner, internal combustion engine).
- Demonstrate knowledge of the principles and technological applications of heat, mechanics, electricity, magnetism, and electromagnetism, including information transfer by waves.
- Demonstrate knowledge of the functioning of different components of a communication system, including source, encoder, transmitter, receiver, decoder, and storage, and the benefits and drawbacks of different communication systems (e.g., radio, television, print, Internet).
- Demonstrate knowledge of structural and transportation systems, including the relationship of the components and design of a structure to its intended use; how transportation systems are designed to move people and goods; and the design of subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control.
- Apply knowledge of the concepts of systems engineering to model components of a communication, structural, or transportation system.

**Field 064: General Science  
Test Objectives**

**EARTH AND SPACE SCIENCE [20%]**

**0004 Demonstrate knowledge of the components of the solar system and universe and their interactions.**

For example:

- Demonstrate knowledge of the Big Bang theory of the origin and evolution of the universe and supporting evidence (i.e., expansion of the universe, cosmic microwave background radiation, hydrogen-helium ratio).
- Demonstrate knowledge of the types and characteristics of celestial objects, including galaxies and stars.
- Demonstrate knowledge of the formation and structure of the solar system, including the types and characteristics of objects in the solar system (e.g., planets, moons, comets, asteroids) and the movement of celestial objects relative to Earth.
- Demonstrate knowledge of the role of gravity in the universe, in the solar system, and on Earth and of the concepts of Kepler's laws of planetary motion.
- Apply knowledge of the movements and interactions of the sun, the moon, and Earth (e.g., seasons, moon phases, tides, eclipses).
- Apply knowledge of the use of science practices in exploring and understanding content related to the solar system and universe, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

**Field 064: General Science  
Test Objectives**

**0005 Apply knowledge of Earth's geosphere, geologic history, and processes.**

For example:

- Demonstrate knowledge of the geologic timescale and the history of Earth, including supporting evidence (e.g., relative and absolute dating, stratigraphy, distribution of fossils).
- Demonstrate knowledge of the structure and composition of Earth, including evidence that supports the current model of Earth's structure (e.g., seismic waves, meteorites, magnetic field).
- Apply knowledge of the theory of plate tectonics and supporting evidence (e.g., continental and ocean floor features, crustal rock age, distribution of fossils), including processes that drive plate movement.
- Demonstrate knowledge of the characteristics of and the processes that form minerals, soils, and rocks (igneous, sedimentary, and metamorphic).
- Apply knowledge of constructive and destructive processes (e.g., weathering, erosion, deposition) that shape Earth's geologic features, including interpreting the processes involved in the formation of topographic features of Earth.
- Apply knowledge of the use of science practices in exploring and understanding content related to Earth's geosphere, geologic history, and processes; such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

**Field 064: General Science  
Test Objectives**

**0006 Demonstrate knowledge of Earth's hydrosphere, atmosphere, weather, and climate.**

For example:

- Demonstrate knowledge of the processes that transfer energy within and between Earth's systems; the effects (e.g., ocean circulation, Coriolis effect) of these processes; and the interrelationships among Earth's geosphere, biosphere, hydrosphere, and atmosphere.
- Apply knowledge of the physical and chemical properties of sea water and fresh water; the physical processes that drive the hydrologic cycle; and the characteristics of, distribution of, and interrelationships between surface and subsurface water reserves (e.g., aquifers, watersheds, lakes, rivers, glaciers, oceans).
- Apply knowledge of how the sun's energy affects weather and climate.
- Demonstrate knowledge of the structure of the atmosphere and characteristics of its different layers, the movement of air in the atmosphere, air pressure, and factors that affect cloud formation.
- Demonstrate knowledge of atmospheric and geographic factors that produce different types of weather, including factors that control regional climate conditions.
- Demonstrate knowledge of weather maps, data, equipment, and techniques to predict and explain weather events.
- Apply knowledge of the use of science practices in exploring and understanding content related to Earth's hydrosphere, atmosphere, weather, and climate; such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

**Field 064: General Science  
Test Objectives**

**0007 Demonstrate knowledge of natural resources, natural hazards, and human impacts on the environment.**

For example:

- Demonstrate knowledge of the characteristics, origins, and uses of renewable and nonrenewable energy resources (e.g., geothermal, solar, fossil fuels) and the benefits and risks associated with the extraction, use, and management of these resources.
- Demonstrate knowledge of the sources, limits, and uses of natural resources; the patterns of global distribution of natural resources due to geologic processes; and how human activity (e.g., deforestation, agriculture) affects the availability and quality of natural resources.
- Demonstrate knowledge of the causes and consequences of hazardous weather, tsunamis, volcanoes, and earthquakes; factors contributing to the extent of damage caused by hazardous events (e.g., distance, air quality, epicenter, geologic substrate); methods used to forecast hazardous events; and measures taken to limit their damage.
- Apply knowledge of the anthropogenic and natural causes, scientific evidence, and potential impacts of global climate change, including the greenhouse effect and the roles of Earth systems in producing and absorbing greenhouse gases (e.g., methane sources, buffering capacity of oceans, photosynthesis).
- Analyze the impact on society and the environment that can result from the use of natural and synthetic materials (e.g., plastics, fertilizers, antibiotics, pesticides).
- Demonstrate knowledge of the ways in which science and technology can be used to solve natural and societal problems, including strategies to reduce human impacts on the environment and to maintain or increase standards of living.
- Apply knowledge of the use of science practices in exploring and understanding content related to natural resources, natural hazards, and human impacts on the environment; such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.



## Field 064: General Science Test Objectives

### LIFE SCIENCE [20%]

#### 0008 Demonstrate knowledge of the characteristics and processes of living organisms.

For example:

- Demonstrate knowledge of the characteristics of life, cell theory, and the structure and function of basic chemical components of life, including nucleic acids, lipids, carbohydrates, and proteins.
- Demonstrate knowledge of basic cell structures and their functions, including comparisons among cell types (e.g., plant and animal, prokaryotic and eukaryotic).
- Demonstrate knowledge of the processes of cellular division, including binary fission, mitosis, and meiosis, and of the role of each of these processes in the differentiation of cells and the growth and reproduction of organisms.
- Analyze the processes of photosynthesis and cellular respiration (anaerobic and aerobic), including how organisms obtain, use, and store matter and energy.
- Demonstrate knowledge of the levels of biological organization (molecules, cells, tissues, organs, organ systems, and organisms), including the influence of environmental and genetic factors on the growth and development of organisms.
- Apply knowledge of the structures and functions of major systems in plants and animals and of interactions among the systems, including how the systems are involved in the processes of homeostasis and metabolism.
- Apply knowledge of the use of science practices in exploring and understanding content related to the characteristics and processes of living organisms, such as developing and using models, planning and safely conducting investigations, ethically using caring for living organisms, applying mathematical concepts, and communicating and evaluating data and conclusions.

**Field 064: General Science  
Test Objectives**

**0009 Apply knowledge of the characteristics of populations, communities, ecosystems, and biomes.**

For example:

- Demonstrate knowledge of the biotic and abiotic factors, as well as of the interactions between them, that affect populations, communities, ecosystems, and biomes (e.g., resource availability, habitat requirements, predation, competition, disease).
- Demonstrate knowledge of the interrelationships among organisms—including humans—in ecosystems (e.g., symbiotic, competitive, predatory) and the strategies used by organisms to obtain basic requirements for life (e.g., food, shelter, water).
- Apply knowledge of matter and energy transfers in ecosystems, including the processes involved in biogeochemical cycles and the relationships among producers, consumers, and decomposers in food webs.
- Apply knowledge of the responses of ecosystems to change, including the process of ecological succession and the short- and long-term impacts of natural and anthropogenic phenomena (e.g., flooding, continental drift, construction) on ecosystems and species diversity.
- Apply knowledge of the use of science practices in exploring and understanding content related to populations, communities, ecosystems, and biomes; such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

## **Field 064: General Science Test Objectives**

### **0010 Apply principles related to the inheritance of characteristics.**

For example:

- Apply knowledge of animal behavioral characteristics and specialized plant structures that increase the probability of successful reproduction.
- Apply knowledge of the advantages and disadvantages of asexual and sexual reproductive strategies, including their impacts on genetic and phenotypic variation and population growth.
- Apply knowledge of genetic and phenotypic variation and the inheritance of traits that are determined by one or more genes (e.g., dominant, recessive, incomplete dominance, sex-linked).
- Demonstrate knowledge of the structure and function of DNA, genes, and chromosomes, including the basic processes of DNA replication and protein synthesis.
- Demonstrate knowledge of the influence of environmental factors on genetic material and of types of mutations and their effects, including effects on protein function.
- Apply knowledge of the use of science practices in exploring and understanding content related to the inheritance of characteristics, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

### **0011 Demonstrate knowledge of principles related to the theory of biological evolution.**

For example:

- Demonstrate knowledge of the theories and processes associated with the origin (e.g., RNA world, primordial soup) of macromolecules and cells.
- Demonstrate knowledge of the evidence for evolution (e.g., the fossil record, homologies) and the principles and methods used to investigate evolution and evolutionary processes (e.g., population studies, artificial selection, genetic engineering).
- Apply knowledge of the principles of biological evolution (e.g., natural selection, gene flow, genetic drift), including the roles of genetic and phenotypic variation and environmental factors in speciation.
- Demonstrate knowledge of the diversity of life and the principles of biological classification, including its connection to anatomical, embryological, and genetic evidence.
- Apply knowledge of the use of science practices in exploring and understanding content related to biological evolution, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

**Field 064: General Science  
Test Objectives**

**PHYSICAL SCIENCE [20%]**

**0012 Apply knowledge of the structure and properties of matter.**

For example:

- Demonstrate knowledge of how the model of the structure of the atom has progressed over time.
- Apply knowledge of the development and organization of the periodic table and trends in the physical and chemical properties of elements, including atomic structure.
- Apply knowledge of the properties of atoms, elements, molecules, compounds, and mixtures, including how to classify matter.
- Demonstrate knowledge of types and characteristics of chemical bonds (e.g., covalent, ionic, hydrogen), including the effects of these bonds on the characteristics of matter.
- Demonstrate knowledge of physical and chemical properties of matter, physical and chemical changes, and factors that affect rates of reaction and chemical equilibrium (e.g., concentration, temperature, state of matter, catalysts).
- Apply knowledge of types and properties of mixtures and solutions and the characteristics and properties of acids and bases (e.g., pH, buffers, ion movement).
- Apply the concept of mass, the principle of conservation of matter, and knowledge of chemical formulas to balance chemical equations.
- Apply knowledge of the use of science practices in exploring and understanding content related to the structure and properties of matter, such as developing and using models, planning and safely conducting investigations, safely storing and disposing of hazardous materials, applying mathematical concepts, and communicating and evaluating data and conclusions.

**Field 064: General Science  
Test Objectives**

**0013 Apply knowledge of the states of matter, particle motion, and heat.**

For example:

- Demonstrate knowledge of the different states of matter and their characteristics, changes of state and related changes in energy, and the use of models to represent states of matter.
- Apply knowledge of the relationships between pressure, temperature, and volume in gaseous systems, including the concept of the kinetic molecular theory.
- Demonstrate knowledge of energy transfer resulting from physical processes (heating and cooling, calorimetry) and chemical processes (endothermic and exothermic reactions).
- Apply knowledge of heat transfer through conduction, convection, and radiation, including using models of each mode of heat transfer and system designs that maximize or minimize thermal energy transfer.
- Apply knowledge of the use of science practices in exploring and understanding content related to the states of matter, particle motion, and heat; such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

**0014 Apply knowledge of different forms of energy and the conservation of energy.**

For example:

- Apply knowledge of the classification and the calculation of potential and kinetic energy.
- Apply knowledge of the conservation of mechanical energy, including the processes of energy transfer (e.g., collisions, free fall, projectiles).
- Apply knowledge of forms of energy (e.g., mechanical, light, thermal, electrical, nuclear) and the transformation of energy from one form to another.
- Demonstrate knowledge of the laws of thermodynamics and the concept of entropy.
- Apply knowledge of the use of science practices in exploring and understanding content related to different forms of energy and the conservation of energy, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

**Field 064: General Science  
Test Objectives**

**0015 Apply knowledge of the concepts of force, motion, work, and power.**

For example:

- Apply knowledge of Newton's laws of motion and universal gravitation, including how objects interact through gravitational fields.
- Apply knowledge of scalar and vector quantities and the vector nature of force, displacement, velocity, and acceleration.
- Analyze separate forces that act on a system (e.g., gravity, friction), the effect of separate forces on the stability of a system, and the net force acting on an object or system.
- Analyze the motion of an object in terms of distance and speed, displacement and velocity, acceleration, inertia, and momentum, including through graphs.
- Apply knowledge of the relationships among force, work, and power.
- Apply knowledge of the use of science practices in exploring and understanding content related to force, motion, work, and power; such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

## Field 064: General Science Test Objectives

### 0016 Apply knowledge of the characteristics and properties of waves, electricity, magnetism, and electromagnetism.

For example:

- Demonstrate knowledge of the characteristics of transverse and longitudinal waves (e.g., amplitude, wavelength, frequency), changes in these properties during wave interactions, and the relationship between wave characteristics and properties of sound (e.g., loudness, pitch) and light (e.g., color, intensity).
- Apply knowledge of the effects of mirrors, lenses, and prisms on the behavior of light (e.g., reflection, refraction, diffraction, dispersion), including the behavior of sound and light waves in various media (e.g., air, water, vacuum, steel).
- Demonstrate knowledge of the characteristics and properties of the electromagnetic spectrum, including the relationships among the characteristics of electromagnetic waves (e.g., energy, wavelength, speed, frequency).
- Apply knowledge of how objects interact through electric and magnetic fields, including application of Coulomb's law.
- Demonstrate knowledge of the characteristics of electric charge and electron flow, including the properties and formation of static electricity and electric current.
- Analyze characteristics and components of simple electric circuits (e.g., power, current, batteries, resistors), including interpretation of series and parallel circuit diagrams.
- Apply knowledge of the characteristics of magnetic materials and magnetic fields, including the properties of permanent magnets.
- Apply knowledge of the use of science practices in exploring and understanding content related to waves, electricity, magnetism, and electromagnetism; such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

**Field 064: General Science  
Test Objectives**

**INTEGRATION OF KNOWLEDGE AND UNDERSTANDING [20%]**

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

**0017 Prepare an organized, developed analysis of a topic related to key concepts in earth and space science and/or life science.**

For example:

- Describe the key scientific concepts that relate to a given topic.
- Use a representative graph, formula, and/or diagram with all proper labels to model the presented topic.
- Discuss how the topic relates to the concept of structure and function or cause and effect.

**0018 Prepare an organized, developed analysis of a topic related to key concepts in physical science that emphasizes the application of the principles of science practices.**

For example:

- Form a testable scientific claim that addresses a given topic.
- Outline a specific scientific procedure to investigate the proposed claim, including identifying variables and controls.
- Describe a possible result provided by collected data.
- Provide reasoning of how the collected data provides evidence that supports or refutes the tested claim.