Massachusetts Tests for Educator Licensure™
Test Objectives
Field 11: Physics

SUBAREAS:

SCIENTIFIC INQUIRY
MECHANICS AND HEAT ENERGY
ELECTRICITY AND MAGNETISM
WAVES, SOUND, AND LIGHT
QUANTUM THEORY AND THE ATOM

SCIENTIFIC INQUIRY

0001 Understand the historical and contemporary contexts of the study of physics and the applications of physics to everyday life.

For example: the significance of key events, theories, and individuals in the history of physics; and the societal implications of developments in physics (e.g., nuclear technology, solid state technology).

0002 Understand the nature of scientific inquiry, scientific processes, and the role of observation and experimentation in science.

For example: processes by which new scientific knowledge and hypotheses are generated; ethical issues related to scientific processes (e.g., accurately reporting experimental results); the appropriateness of a specified experimental design to test a given physics hypothesis; and the role of communication among scientists and between scientists and the public in promoting scientific progress.

0003 Understand the processes of gathering, organizing, reporting, and analyzing scientific data in the context of physics investigations.

For example: the appropriateness of a given method or procedure for collecting data for a specified purpose; appropriate and effective graphic representations (e.g., graph, table, diagram) for organizing and reporting experimental data; procedures and criteria for formally reporting experimental procedures and data to the scientific community; and relationships between factors (e.g., linear, direct, inverse, direct squared, inverse squared) as indicated by experimental data.

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0004 Understand principles and procedures of measurement and the use of mathematics in physics (e.g., vector analysis, calculus).

For example: SI units; measuring devices; proper methods of measurement for given situations; analyzing uncertainty in measurements; applying dimensional analysis; deriving equations; and applying principles of graphing, trigonometry, vector analysis, and calculus to analyze, model, and solve problems.

0005 Understand the interrelationships among physics, society, technology, and other sciences and disciplines.

For example: the impact of physics and technology on society; similarities and differences between science and technology (e.g., science as investigating the natural world, technology as solving human adaptation problems); the technological design process; ethical considerations related to science and technology; and the application of scientific and technological decision making at the community, state, national, and international level.

0006 Understand safe and proper use of equipment, materials, and chemicals used in physics investigations.

For example: the principles upon which given laboratory instruments are based (e.g., oscilloscopes, Geiger counters); hazards associated with given laboratory materials (e.g., projectiles, lasers, radioactive materials, heat sources); safety rules for electricity and electrical equipment; and proper procedures for dealing with accidents and injuries in the physics laboratory.

MECHANICS AND HEAT ENERGY

0007 Understand concepts related to motion in one and two dimensions, and apply this knowledge to solve problems that require the use of algebra, calculus, and graphing.

For example: the terminology, units, and equations used to describe and analyze one- and two-dimensional motion; the movement of freely falling objects near the surface of the earth; solving problems involving distance, displacement, speed, velocity, and constant acceleration; and interpreting information presented in one or more graphic representations related to distance, displacement, speed, velocity, and constant acceleration.

0008 Understand characteristics of forces and methods used to measure force, and solve algebraic problems involving forces.

For example: identifying forces acting in a given situation; experimental designs for measuring forces; and solving problems involving gravitational and frictional forces.

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0009 Apply knowledge of vectors and trigonometric functions to solve problems involving concurrent, parallel, resultant, equilibrant, and component forces and torque.

For example: applying graphic solutions to solve problems involving concurrent and equilibrant forces; and solving problems involving torque.

0010 Understand the laws of motion (including relativity) and conservation of momentum.

For example: the characteristics and examples of each of Newton's laws of motion; applying Newton's laws of motion and the conservation of momentum in solving problems; and the implications of special relativity for the laws of motion.

0011 Understand the characteristics of circular motion and simple harmonic motion, and solve problems involving these types of motion.

For example: applying vector analysis to describe uniform circular motion in radians; determining the magnitude and direction of the force acting on a particle in uniform circular motion; the relationships among displacement, velocity, and acceleration in simple harmonic motion (e.g., simple pendulum); and solving involving springs and force constants.

0012 Understand Kepler's laws and the law of universal gravitation, and apply them to satellite motion.

For example: the geometric characteristics of planetary orbits; applying Kepler's law of equal areas to solve problems involving satellite motion; applying Kepler's laws to relate the radius of a planet's orbit to its period of revolution; and using the law of universal gravitation to interpret the relationship among force, mass, and the distance between masses.

0013 Apply the principle of conservation of energy and the concepts of energy, work, and power.

For example: analyzing mechanical systems in terms of work, power, and conservation of energy; using the concept of conservation of energy to solve problems; and determining power, mechanical advantage, and efficiency as they relate to work and energy in operations such as simple machines.

0014 Understand the dynamics of rotational motion, including torque, angular momentum, motion with constant angular acceleration, rotational kinetic energy, center of mass, and moment of inertia.

For example: the principles of motion with constant angular acceleration; the law of conservation of angular momentum; and the concepts of center of mass, moment of inertia, and rotational kinetic energy.

0015 Understand the statics and dynamics of fluids.

For example: the concepts of force, pressure, and density; using Bernoulli's principle to analyze fluid dynamics; and applying Archimedes' principle to solve problems involving buoyancy and flotation.

0016 Understand the principles of the first and second laws of thermodynamics, the relationship between temperature and heat, and the principles of thermal expansion, thermal contraction, and heat transfer.

For example: solving calorimetry problems involving heat capacity, specific heat, heat of fusion, and heat of vaporization; analyzing methods of heat transfer (i.e., conduction, convection, radiation) in practical situations; solving problems involving thermal expansion and thermal contraction of solids; and using the principle of entropy to analyze the operation of heat engines (e.g., Carnot cycle).

0017 Understand the kinetic-molecular theory and its relationship to thermodynamics and the characteristics of solids, liquids, and gases.

For example: analyzing the behavior of a gas in terms of the kinetic-molecular theory (i.e., ideal gas law); and analyzing phase changes in terms of kinetic-molecular theory and molecular structure.

ELECTRICITY AND MAGNETISM

0018 Understand characteristics and units of electric charge, electric fields, electric potential, and capacitance; and apply principles of static electricity to solve problems involving Coulomb's law and electric field intensity.

For example: analyzing the behavior of an electroscope in given situations; applying Coulomb's law to determine the forces between charges; applying principles of electrostatics to determine electric field intensity; and the relationships between capacitance, charge, and potential difference.

0019 Understand characteristics of electric current and components of electric circuits.

For example: analyzing a DC circuit in terms of conservation of energy and conservation of charge (i.e., Kirchhoff's law, Ohm's law); factors that affect resistance; schematic diagrams of electric circuits; and applying principles of DC circuits to reduce a complex circuit to a simpler equivalent circuit.

0020 Understand magnets, electromagnets, and magnetic fields; the effects of magnetic fields on moving electric charges; and the applications of electromagnetism.

For example: factors that affect the strength of an electromagnet; the orientation and magnitude of a magnetic field; the magnitude and direction of the force on a charge or charges moving in a magnetic field; and the use of electromagnetism in technology (e.g., motors, generators, meters).

0021 Understand and apply the principles of electromagnetic induction and AC circuits.

For example: factors that affect the magnitude of an induced electromotive force (EMF); analyzing an AC circuit, including relationships involving impedance and reactance; determining the direction of an induced current; and the functions of transformers and generators.

0022 Understand the principles of conductors, semiconductors, and superconductors.

For example: analyzing current-voltage characteristics of typical solid state diodes and zener diodes; the function of a diode in a given electric circuit; comparing NPN and PNP transistors and identifying correct terminal connections in a given circuit; and the function of a transistor in a given electrical circuit.

WAVES, SOUND, AND LIGHT

0023 Understand waves and wave motion, and solve problems involving wave motion.

For example: types (e.g., longitudinal, transverse) and characteristics (e.g., frequency, period, amplitude, wavelength) of waves; and applying the wave equation to determine a wave's velocity, wavelength, or frequency.

0024 Apply the principles of wave reflection, refraction, diffraction, interference, polarization, dispersion, and the Doppler effect.

For example: applications of wave reflection, refraction, diffraction, interference, polarization, dispersion, and the Doppler effect (e.g., radar, sonar, polarizers); applying Snell's law to determine index of refraction, angle of incidence, angle of refraction, or critical angle; solving problems involving diffraction and interference in single and multiple slits; and applying the superposition principle to determine characteristics of a resultant wave.

0025 Understand the characteristics of sound waves and the means by which sound waves are produced and transmitted.

For example: the physical nature of sound waves (including intensity and intensity level); factors that affect the speed of sound in different media; and solving problems involving resonance, harmonics, and overtones.

0026 Understand the production and characteristics of electromagnetic waves.

For example: the properties (e.g., energy, frequency, wavelength) of components (e.g., visible light, ultraviolet radiation) of the electromagnetic spectrum; and applications of the components of the electromagnetic spectrum (e.g., infrared detectors, solar heating, x-ray machines).

0027 Understand the principles of lenses and mirrors.

For example: types and characteristics of lenses and mirrors; using a ray diagram to locate the focal point or point of image formation of a lens or mirror; applying the lens and mirror equations to solve problems involving lenses and mirrors; and applications of lenses and mirrors (e.g., telescopes, compound microscopes, eyeglasses).

QUANTUM THEORY AND THE ATOM

0028 Understand the principles and concepts of the photoelectric effect, quantum theory, and the dual nature of light and matter.

For example: applying the laws of photoelectric emission to explain photoelectric phenomena; analyzing bright-line spectra in terms of electron transitions; the principles of stimulated emission of radiation as applied to lasers and masers; and the dual nature of light and matter.

0029 Understand physical models of atomic structure and the nature of elementary particles.

For example: historic and contemporary models of atomic structure (e.g., Bohr, Schrödinger, Heisenberg, Mayer, Bhabha); notation used to represent elements, molecules, ions, and isotopes; and the relationship between the design of particle accelerators and elementary particle characteristics.

0030 Understand the principles of radioactivity and types and characteristics of radiation, and the process of radioactive decay.

For example: applying principles of the conservation of mass-energy and charge to balance equations for nuclear reactions; analyzing radioactive decay in terms of the half-life concept; analyzing the nuclear disintegration series for a given isotope; and the basic operation of types of radiation detectors.

0031 Understand types and characteristics of nuclear reactions, methods of initiating and controlling them, and applications of nuclear reactions to the generation of electricity.

For example: characteristics of fission and fusion reactions; the operation of components of a nuclear reactor (e.g., moderator, fuel rods, control rods); calculating nuclear mass defect and binding energy; the isotopes commonly used to fuel nuclear reactors; and the problems associated with the waste products generated by nuclear reactions.