ILLINOIS CERTIFICATION TESTING SYSTEM

FIELD 116 SCIENCE: PHYSICS

TEST FRAMEWORK

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Science and Technology
Life Science
Physical Science
Earth Systems and the Universe
Physics Skills, Motion, Forces, and Waves
Heat, Electricity, Magnetism, and Modern Physics

SUBAREA I—SCIENCE AND TECHNOLOGY

0001 Understand and apply knowledge of science as inquiry.

- Recognize the assumptions, processes, purposes, requirements, and tools of scientific inquiry.
- Use evidence and logic in developing proposed explanations that address scientific questions and hypotheses.
- Identify various approaches to conducting scientific investigations and their applications.
- Use tools and mathematical and statistical methods for collecting, managing, analyzing (e.g., average, curve fit, error determination), and communicating results of investigations.
- Demonstrate knowledge of ways to report, display, and defend the results of an investigation.

0002 Understand and apply knowledge of the concepts, principles, and processes of technological design.

- Recognize the capabilities, limitations, and implications of technology and technological design and redesign.
- Identify real-world problems or needs to be solved through technological design.
- Apply a technological design process to a given problem situation.
- Identify a design problem and propose possible solutions, considering such constraints as tools, materials, time, costs, and laws of nature.
- Evaluate various solutions to a design problem.

0003 Understand and apply knowledge of accepted practices of science.

- Demonstrate an understanding of the nature of science (e.g., tentative, replicable, historical, empirical) and recognize how scientific knowledge and explanations change over time.
- Compare scientific hypotheses, predictions, laws, theories, and principles and recognize how they are developed and tested.
- Recognize examples of valid and biased thinking in reporting of scientific research.
- the basis for and application of safety practices and regulations in the study of science.

0004 Understand and apply knowledge of the interactions among science, technology, and society.

- Recognize the historical and contemporary development of major scientific ideas and technological innovations.
- Demonstrate an understanding of the ways that science and technology affect people's everyday lives, societal values and systems, the environment, and new knowledge.
- Analyze the processes of scientific and technological breakthroughs and their effects on other fields of study, careers, and job markets.
- Analyze issues related to science and technology at the local, state, national, and global levels (e.g., environmental policies, genetic research).
- Evaluate the credibility of scientific claims made in various forums (e.g., the media, public debates, advertising).

0005 Understand and apply knowledge of the major unifying concepts of all sciences and how these concepts relate to other disciplines.

- Identify the major unifying concepts of the sciences (e.g., systems, order, and organization; constancy, change, and measurement) and their applications in real-life situations.
- Recognize connections within and among the traditional scientific disciplines.
- Apply fundamental mathematical language, knowledge, and skills at the level of algebra and statistics in scientific contexts.
- Recognize the fundamental relationships among the natural sciences and the social sciences.

SUBAREA II—LIFE SCIENCE

0006 Understand and apply knowledge of cell structure and function.

- Compare and contrast the structures of viruses and prokaryotic and eukaryotic cells.
- Identify the structures and functions of cellular organelles.
- Describe the processes of the cell cycle.
- Explain the functions and applications of the instruments and technologies used to study the life sciences at the molecular and cellular levels.

0007 Understand and apply knowledge of the principles of heredity and biological evolution.

- Recognize the nature and function of the gene, with emphasis on the molecular basis of inheritance and gene expression.
- Analyze the transmission of genetic information (e.g., Punnett squares, sex-linked traits, pedigree analysis).
- Analyze the processes of change at the microscopic and macroscopic levels.
- Identify scientific evidence from various sources, such as the fossil record, comparative anatomy, and biochemical similarities, to demonstrate knowledge of theories about processes of biological evolution.

0008 Understand and apply knowledge of the characteristics and life functions of organisms.

- Identify the levels of organization of various types of organisms and the structures and functions of cells, tissues, organs, and organ systems.
- Analyze the strategies and adaptations used by organisms to obtain the basic requirements of life.
- Analyze factors (e.g., physiological, behavioral) that influence homeostasis within an organism.
- Demonstrate an understanding of the human as a living organism with life functions comparable to those of other life forms.

0009 Understand and apply knowledge of how organisms interact with each other and with their environment.

- Identify living and nonliving components of the environment and how they interact with one another.
- Recognize the concepts of populations, communities, ecosystems, and ecoregions and the role of biodiversity in living systems.
- Analyze factors (e.g., ecological, behavioral) that influence interrelationships among organisms.
- Develop a model or explanation that shows the relationships among organisms in the environment (e.g., food web, food chain, ecological pyramid).
- Recognize the dynamic nature of the environment, including how communities, ecosystems, and ecoregions change over time.
- Analyze interactions of humans with their environment.
- Explain the functions and applications of the instruments and technologies used to study the life sciences at the organism and ecosystem levels.

SUBAREA III—PHYSICAL SCIENCE

0010 Understand and apply knowledge of the nature and properties of energy in its various forms.

- Describe the characteristics of and relationships among thermal, acoustical, radiant, electrical, chemical, mechanical, and nuclear energies through conceptual questions.
- Analyze the processes by which energy is exchanged or transformed through conceptual questions.
- Apply the three laws of thermodynamics to explain energy transformations, including basic algebraic problem solving.
- Apply the principle of conservation as it applies to energy through conceptual questions and solving basic algebraic problems.

0011 Understand and apply knowledge of the structure and properties of matter.

- Describe the nuclear and atomic structure of matter, including the three basic parts of the atom.
- Analyze the properties of materials in relation to their chemical or physical structures (e.g., periodic table trends, relationships, and properties) and evaluate uses of the materials based on their properties.
- Apply the principle of conservation as it applies to mass and charge through conceptual questions.
- Analyze bonding and chemical, atomic, and nuclear reactions (including endothermic and exothermic reactions) in natural and man-made systems and apply basic stoichiometric principles.
- Apply kinetic theory to explain interactions of energy with matter, including conceptual questions on changes in state.
- Explain the functions and applications of the instruments and technologies used to study matter and energy.

0012 Understand and apply knowledge of forces and motion.

- Demonstrate an understanding of the concepts and interrelationships of position, time, velocity, and acceleration through conceptual questions, algebra-based kinematics, and graphical analysis.
- Demonstrate an understanding of the concepts and interrelationships of force (including gravity and friction), inertia, work, power, energy, and momentum.
- Describe and predict the motions of bodies in one and two dimensions in inertial and accelerated frames of reference in a physical system, including projectile motion but excluding circular motion.
- Analyze and predict motions and interactions of bodies involving forces within the context of conservation of energy and/or momentum through conceptual questions and algebra-based problem solving.
- Describe the effects of gravitational and nuclear forces in real-life situations through conceptual questions.
- Explain the functions and applications of the instruments and technologies used to study force and motion in everyday life.

0013 Understand and apply knowledge of electricity, magnetism, and waves.

- Recognize the nature and properties of electricity and magnetism, including static charge, moving charge, basic RC circuits, fields, conductors, and insulators.
- Recognize the nature and properties of mechanical and electromagnetic waves (e.g., frequency, source, medium, spectrum, wave-particle duality).
- Describe the effects and applications of electromagnetic forces in real-life situations, including electric power generation, circuit breakers, and brownouts.
- Analyze and predict the behavior of mechanical and electromagnetic waves under varying physical conditions, including basic optics, color, ray diagrams, and shadows.

SUBAREA IV—EARTH SYSTEMS AND THE UNIVERSE

0014 Understand and apply knowledge of Earth's land, water, and atmospheric systems and the history of Earth.

- Identify the structure and composition of Earth's land, water, and atmospheric systems and how they affect weather, erosion, fresh water, and soil.
- Recognize the scope of geologic time and the continuing physical changes of Earth through time.
- Evaluate scientific theories about Earth's origin and history and how these theories explain contemporary living systems.
- Recognize the interrelationships between living organisms and Earth's resources and evaluate the uses of Earth's resources.

0015 Understand and apply knowledge of the dynamic nature of Earth.

- Analyze and explain large-scale dynamic forces, events, and processes that affect Earth's land, water, and atmospheric systems, including conceptual questions about plate tectonics, El Niño, drought, and climatic shifts.
- Identify and explain Earth processes and cycles and cite examples in real-life situations, including conceptual questions on rock cycles, volcanism, and plate tectonics.
- Analyze the transfer of energy within and among Earth's land, water, and atmospheric systems, including the identification of energy sources of volcanoes, hurricanes, thunderstorms, and tornadoes.
- Explain the functions and applications of the instruments and technologies used to study the earth sciences, including seismographs, barometers, and satellite systems.

0016 Understand and apply knowledge of objects in the universe and their dynamic interactions.

- Describe and explain the relative and apparent motions of the sun, the moon, stars, and planets in the sky.
- Recognize properties of objects (e.g., comets, asteroids) within the solar system and their dynamic interactions.
- Recognize the types, properties, and dynamics of objects external to the solar system (e.g., black holes, supernovas, galaxies).

0017 Understand and apply knowledge of the origins of and changes in the universe.

- Identify scientific theories dealing with the origin of the universe (e.g., big bang).
- Analyze evidence relating to the origin and physical evolution of the universe (e.g., microwave background radiation, expansion).
- Compare the physical and chemical processes involved in the life cycles of objects within galaxies.
- Explain the functions and applications of the instruments, technologies, and tools used in the study of the space sciences, including the relative advantages and disadvantages of Earth-based versus space-based instruments and optical versus nonoptical instruments.

SUBAREA V—PHYSICS SKILLS, MOTION, FORCES, AND WAVES

0018 Understand and apply the knowledge and skills needed to practice physics and understand the broad applicability of its principles to real-world situations.

- Demonstrate knowledge of the safe and proper use of equipment and materials commonly used in physics classrooms and laboratories.
- Design appropriate laboratory investigations to study the principles and applications of physics.
- Demonstrate knowledge of the uses of basic equipment to illustrate physical principles and phenomena.
- Use mathematical concepts, strategies, and procedures, including graphical and statistical methods and differential and integral calculus, to derive and manipulate formal relationships between physical quantities.
- Demonstrate an understanding of the growth of physics knowledge from a historical perspective.
- Recognize examples of the applicability of physics in daily life, including career opportunities and avocations in physics and technology.

0019 Understand and apply knowledge of planar motion.

- Analyze the relationship between vectors and physical quantities and perform a variety of vector algebra operations.
- Use algebra and calculus methods to determine the rectilinear displacement, velocity, and acceleration of particles and rigid bodies, given initial conditions.
- Use algebra and calculus methods to determine the angular displacement, velocity, and acceleration of rigid bodies in a plane, given initial conditions.
- Use algebra and calculus methods to determine the displacement, velocity, and acceleration of particles and rigid bodies undergoing periodic motion, given initial conditions.
- Analyze and solve problems involving the relationships of linear and angular displacement, velocity, and acceleration.
- Analyze and solve problems involving periodic motion and uniform circular motion.

0020 Understand and apply knowledge of force, momentum, and energy as they apply to planar motion.

- Apply Newton's laws of motion to analyze and solve problems involving translational, rotational, and periodic motion.
- Apply the law of universal gravitation to solve problems involving free fall, projectile motion, and planetary motion.
- Analyze and solve problems involving the relationships between linear quantities and their rotational analogues.
- Solve problems involving the conservation of linear and angular momentum.
- Use the relationship between work and energy, in algebraic and calculus forms, to solve problems involving the motions of physical systems acted upon by conservative and nonconservative forces.

0021 Understand and apply knowledge of the nature, properties, and behavior of mechanical waves.

- Apply the relationships among wave speed, wavelength, period, and frequency to analyze and solve problems related to wave propagation.
- Analyze the interference and reflection of waves and wave pulses.
- Describe and analyze the nature, production, and transmission of sound waves in various uniform media.
- Describe how the perception of sound depends on the physical properties of sound waves.

0022 Understand and apply knowledge of the nature, properties, and behavior of electromagnetic radiation.

- Classify the regions of the electromagnetic spectrum relative to their frequency or wavelength.
- Analyze and predict the behavior of various types of electromagnetic radiation as they interact with matter.
- Analyze and predict the behaviors of light, including interference, reflection, diffraction, polarization, and refraction.
- Use ray diagrams to analyze systems of lenses and mirrors.

SUBAREA VI—HEAT, ELECTRICITY, MAGNETISM, AND MODERN PHYSICS

0023 Understand and apply knowledge of the principles of thermodynamics.

- Apply basic concepts of heat and temperature as they relate to temperature measurement and temperature-dependent properties of matter.
- Apply the laws of thermodynamics to problems involving temperature, work, heat, energy, and entropy.
- Demonstrate knowledge of the kinetic-molecular theory and apply it to describe thermal properties and behaviors of solids, liquids, and gases.
- Analyze and solve problems involving energy, temperature, heat, and changes of state.

0024 Understand and apply knowledge of static and moving electric charges.

- Predict the interactions between electric charges.
- Interpret electric field diagrams and predict the influence of electric fields on electric charges.
- Determine the electric potential due to a charge distribution and calculate the work involved in moving a point charge through a potential difference.
- Determine the electric field due to a charge distribution and calculate the force on a point charge located in that electric field.
- Describe the flow of charge through different media and interpret circuit diagrams.
- Analyze AC and DC circuits composed of basic circuit elements.

0025 Understand and apply knowledge of the principles of magnetism and induced electric fields.

- Analyze the motion of a charged particle in a magnetic field and determine the force on a current-carrying conductor in a magnetic field.
- Analyze the characteristics of magnetic fields produced by straight and coiled current-carrying conductors.
- Describe and analyze the processes of electromagnetic induction.
- Demonstrate an understanding of the operating principles of electric generators, motors, and transformers.
- Identify applications of magnets and magnetic fields in technology and daily living.

0026 Understand and apply knowledge of the basic concepts and applications of modern physics.

- Demonstrate knowledge of a quantum model of atomic structure (e.g., the Bohr model), including the relationship between changes in electron energy levels and atomic spectra.
- Describe types, properties, and applications of radioactivity and the effects of radioactivity on living organisms.
- Balance particle equations and solve radioactive decay problems involving half-life, energy, mass, and charge.
- Describe the quantum mechanical nature of the interaction between radiation and matter.
- Describe the wave-particle duality of radiation and matter.
- Describe the quantum mechanical electron properties of conductors, semiconductors, and insulators.
- Apply the concepts of special relativity as they relate to time, space, and mass.