National Evaluation Series

Test Framework

Physics (822)

December 2024

Multiple Choice

Subarea	Range of Objectives	Approximate Percentage of Test Score
I. Matter and Its Interactions	0001–0002	11%
II. Motion and Stability: Forces and Interactions	0003–0005	17%
III. Motion and Stability: Forces and Interactions in Fields and Circuits	0006–0009	23%
IV. Energy	0010–0011	12%
V. Waves and Their Applications in Technologies for Information Transfer	0012–0014	17%
Total	0001–0014	**80%**

Open Response

Subarea	Range of Objectives	Approximate Percentage of Test Score
VI. Integration of Knowledge and Understanding		
Key Scientific Concepts	0015	10%
Application of Science and Engineering Practices	0016	10%
Total	0015–0016	**20%**

MATTER AND ITS INTERACTIONS

0001: Apply knowledge of atomic and nuclear physics.

- Apply knowledge of the quantum mechanical model of the atom, including discrete energy levels, characteristics of the nucleus, and the historical development of the atomic model.
- Demonstrate knowledge of radioactivity and the types, relative energies, and biological effects of ionizing radiation, specifically alpha particles, beta particles, and gamma rays.
- Interpret basic nuclear reactions (e.g., fusion, fission, radioactive decay) and interpret the mass–energy interactions in these reactions.
- Apply knowledge of nuclear physics to a variety of technological applications (e.g., nuclear medicine, imaging technology, power generation).
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to atomic and nuclear physics, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

0002: Demonstrate knowledge of the basic principles of modern physics.

- Demonstrate knowledge of wave-particle duality in the context of its historical development (e.g., blackbody radiation, photoelectric effect, de Broglie wavelength).
- Demonstrate knowledge of characteristics of the double-slit experiment and how the Heisenberg uncertainty principle relates to situations involving the position and momentum of a particle.
- Demonstrate knowledge of applications of quantum mechanics in modern technologies (e.g., lasers, diodes, transistors).
- Demonstrate knowledge of the theory of relativity (e.g., speed of light is constant, time dilation, equivalence of mass and energy).
- Apply knowledge of the fundamental forces to explain how gravitational forces dominate over large distance scales (as in astronomy), but strong, weak, and electromagnetic forces dominate on much smaller distance scales.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to modern physics, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

MOTION AND STABILITY: FORCES AND INTERACTIONS

0003: Apply knowledge of kinematics to interpret motion.

- Apply knowledge of vector and scalar quantities to solve problems, using vectors to represent directional quantities (e.g., displacement, velocity, acceleration).
- Interpret multiple representations (e.g., graphs, equations, descriptions) of the motion of an object in one dimension.
- Apply knowledge of kinematics to solve problems involving displacement, velocity, time, and constant acceleration in one dimension.
- Analyze situations and solve problems involving two-dimensional motion (e.g., projectile motion, relative velocity).
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to kinematics, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

0004: Apply knowledge of forces and Newton's laws.

- Analyze forces that act on objects (e.g., normal, gravitational, frictional, elastic) and determine the effects of the forces on the motion of systems.
- Apply knowledge of vectors and trigonometry to free-body diagrams.
- Apply knowledge of mass and inertia with respect to Newton's first law.
- Apply knowledge of Newton's second law to solve problems involving motion and stability.
- Apply knowledge of Newton's third law to physical situations.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to forces and Newton's laws, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

0005: Apply knowledge of linear momentum, angular momentum, and rotational dynamics.

- Apply knowledge of momentum and the impulse-momentum theorem to solve problems involving momentum changes and impact forces (e.g., to minimize forces during collisions).
- Apply knowledge of linear momentum conservation in a closed and isolated system to solve problems involving systems in one and two dimensions.
- Apply knowledge of angular displacement, angular velocity, and angular acceleration to describe rotational motion.
- Apply knowledge of rotational dynamics to problems involving torque, moment of inertia, and angular momentum.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to momentum and rotational dynamics, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

MOTION AND STABILITY: FORCES AND INTERACTIONS IN FIELDS AND CIRCUITS

0006: Apply knowledge of gravitational forces and circular motion.

- Apply knowledge of Newton's law of universal gravitation to solve problems involving masses and gravitational forces.
- Compare and contrast Newton's law of universal gravitation to Coulomb's law and other inverse-square law relationships.
- Apply knowledge of uniform circular motion, centripetal acceleration, and centripetal force to solve problems involving objects moving in circular paths.
- Demonstrate knowledge of applications of Newton's law of universal gravitation to motion in orbital systems described by Kepler's laws.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to gravity and circular motion, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

0007: Apply knowledge of electrostatics, electric fields, and electric potential.

- Demonstrate knowledge of the characteristics of electric charge, including the properties of static electricity.
- Apply knowledge of Coulomb's law to predict the effects of attractive and repulsive electrostatic forces between charges, and on a test charge in an electric field.
- Demonstrate knowledge of the methods by which objects can gain, lose, or redistribute charge (e.g., conduction, induction, polarization).
- Apply knowledge of the electric field concept to analyze the electric field for various charge distributions (e.g., electric dipole, infinite wire).
- Apply knowledge of electric potential to solve problems involving work, electrical potential energy, and potential difference.
- Apply knowledge of force, motion, and energy to describe the behavior of electric charges in electric fields and in electric potentials.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to electrostatics, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

0008: Apply knowledge of magnetic fields and electromagnetism.

- Demonstrate knowledge of the structure, properties, and characteristics of ferromagnetic materials at the macroscopic and microscopic scales.
- Demonstrate knowledge of the source and characteristics of magnetic fields produced by current-carrying conductors and moving charges.
- Analyze factors that affect the magnitude and direction of forces on current-carrying conductors and charged particles in magnetic fields.
- Demonstrate knowledge of how electric motors produce mechanical movement.
- Apply knowledge of Lenz's law and Faraday's law of induction in a variety of situations (e.g., determining induced electromotive forces and the direction of induced currents, describing the operation of generators and transformers).
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to electromagnetism, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

0009: Apply knowledge of electric circuits.

- Demonstrate knowledge of conductivity, electric current, and electric circuit concepts (e.g., closed circuit, voltage source, conducting path, load).
- Apply knowledge of Ohm's law to solve problems involving voltage, current, and resistance in DC circuits.
- Interpret schematics of series and parallel circuits and apply Kirchhoff's laws to analyze the voltage, current, and resistance throughout a circuit.
- Apply concepts of energy and power to analyze energy transformations in electric circuits and devices (e.g., resistors, capacitors, inductors).
- Demonstrate knowledge of alternating current and circuits (e.g., AC frequency, root mean square [RMS] power).
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to electric circuits, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

ENERGY

0010: Apply knowledge of energy, power, and the conservation of energy.

- Apply knowledge of various forms of energy and transformations from one form to another.
- Apply the concept of work to analyze kinetic, gravitational potential, and elastic potential energy, and analyze energy transformations involving the conservation of energy.
- Apply knowledge of power to solve problems involving rates of energy transfer and related applications.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to energy and power, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

0011: Apply knowledge of the basic laws of thermodynamics and the kinetic molecular theory.

- Demonstrate knowledge of energy, temperature, and heat on the macroscopic and microscopic scales.
- Apply knowledge of the first law of thermodynamics to analyze energy transfers within closed and open systems.
- Apply knowledge of entropy and the second law of thermodynamics in a closed system.
- Apply knowledge of thermodynamic principles to analyze situations involving heat, temperature changes, thermal expansion, specific heat, latent heat, and phase changes.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to thermodynamics, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

WAVES AND THEIR APPLICATIONS IN TECHNOLOGIES FOR INFORMATION TRANSFER

0012: Apply knowledge of simple harmonic motion and wave properties and characteristics.

- Apply knowledge of simple harmonic motion to solve problems involving oscillating systems.
- Apply knowledge of types of waves (e.g., transverse, longitudinal) and wave properties (e.g., amplitude, wavelength, frequency, speed) to explain how waves transfer energy through various media.
- Apply knowledge of waves to analyze the production, transmission, and properties of sound waves (e.g., speed of sound, decibel scale, intensity) in various media.
- Demonstrate knowledge of how technological devices use the principles of wave properties to transmit, transform, and capture energy and information.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to wave properties, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

0013: Apply knowledge of wave interactions and phenomena.

- Analyze wave reflection and refraction at boundaries between different media.
- Analyze interactions involved in constructive and destructive interference, wave superposition, and the formation of standing waves.
- Demonstrate knowledge of resonance, harmonics, and overtones in oscillating systems.
- Apply knowledge of wave properties and behavior to explain wave diffraction, polarization, and the Doppler effect.
- Demonstrate knowledge of how technological devices use the principles of wave interactions (e.g., reflection, refraction, interference, polarization) to transmit, transform, and capture energy and information.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to wave phenomena, 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 electromagnetic waves and the electromagnetic spectrum.

- Demonstrate knowledge of the production and propagation of electromagnetic waves.
- Demonstrate knowledge of various regions within the electromagnetic spectrum.
- Apply properties of electromagnetic waves to explain properties of visible light (e.g., color, intensity) and optical phenomena.
- Evaluate the strengths and limitations of the wave and particle models of light.
- Apply knowledge of the effects of mirrors, lenses, and prisms on the behavior of light (e.g., reflection, refraction, dispersion).
- Demonstrate knowledge of how technological devices (e.g., solar cells, medical imaging, communication technology) use properties of electromagnetic waves to transmit, transform, and capture energy and information.
- Apply knowledge of the use of science and engineering practices in exploring and understanding content related to electromagnetic waves, such as developing and using models, planning and safely conducting investigations, applying mathematical concepts, and communicating and evaluating data and conclusions.

INTEGRATION OF KNOWLEDGE AND UNDERSTANDING

0015: Prepare an organized, developed analysis of a key topic in physics related to Matter and Its Interactions, Energy, or Waves and Their Applications in Technologies for Information Transfer.

- Describe the key scientific concepts that relate to a given topic.
- Use appropriate graphs, tables, formulas, and/or diagrams (with all proper labels) to model the presented topic.
- Discuss how a specific science and engineering practice (e.g., developing and using models, constructing explanations, designing solutions) could be used to help students understand phenomena related to the given topic.

0016: Prepare an organized, developed analysis of a key topic in physics related to Motion and Stability: Forces and Interactions or Motion and Stability: Forces and Interactions in Fields and Circuits that emphasizes the application of science and engineering practices in a classroom setting.

- Form a testable claim that addresses a given topic.
- Outline a specific scientific procedure to investigate the proposed claim, including identifying independent, dependent, and control variables.
- Describe a possible result, and explain how the data collection and analysis would support or refute the tested claim.
- Discuss how a specific science and engineering practice (e.g., developing and using models, planning and carrying out investigations) could be used to help students make sense of phenomena related to the given topic.