Science | Physics

1. **Scientific processes. The student conducts investigations, for at least 40% of instructional time, using safe, environmentally appropriate, and ethical practices. These investigations must involve actively obtaining and analyzing data with physical equipment but may also involve experimentation in a simulated environment as well as field observations that extend beyond the classroom. The student is expected to:**
   - A. demonstrate safe practices during laboratory and field investigations; and
   - B. demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials.
2. **Scientific processes. The student uses a systematic approach to answer scientific laboratory and field investigative questions. The student is expected to:**
   - A. know the definition of science and understand that it has limitations, as specified in subsection (b)(2) of this section;
   - B. know that scientific hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence;
   - C. know that scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well established and highly reliable explanations, but may be subject to change;
   - D. design and implement investigative procedures, including making observations, asking well defined questions, formulating testable hypotheses, identifying variables, selecting appropriate equipment and technology, evaluating numerical answers for reasonableness, and identifying causes and effects of uncertainties in measured data;
   - E. demonstrate the use of course apparatus, equipment, techniques, and procedures, including multimeters (current, voltage, resistance), balances, batteries, dynamics demonstration equipment, collision apparatus, lab masses, magnets, plane mirrors, convex lenses, stopwatches, trajectory apparatus, graph paper, magnetic compasses, protractors, metric rulers, spring scales, thermometers, slinky springs, and/or other equipment and materials that will produce the same results;
   - F. use a wide variety of additional course apparatus, equipment, techniques, materials, and procedures as appropriate such as ripple tank with wave generator, wave motion rope, tuning forks, hand-held visual spectroscopes, discharge tubes with power supply (H, He, Ne, Ar), electromagnetic spectrum charts, laser pointers, micrometer, caliper, computer, data acquisition probes, scientific calculators, graphing technology, electrostatic kits, electroscope, inclined plane, optics bench, optics kit, polarized film, prisms, pulley with table clamp, motion detectors, photogates, friction blocks, ballistic carts or equivalent, resonance tube, stroboscope, resistors, copper wire, switches, iron filings, and/or other equipment and materials that will produce the same results;
   - G. make measurements with accuracy and precision and record data using scientific notation and International System (SI) units;
   - H. organize, evaluate, and make inferences from data, including the use of tables, charts, and graphs;
   - I. communicate valid conclusions supported by the data through various methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports; and
   - J. express relationships among physical variables quantitatively, including the use of graphs, charts, and equations.
3. **Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:**
   - A. analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, so as to encourage critical thinking by the student;
   - B. communicate and apply scientific information extracted from various sources such as current events, news reports, published journal articles, and marketing materials;
   - C. explain the impacts of the scientific contributions of a variety of historical and contemporary scientists on scientific thought and society;
   - D. research and describe the connections between physics and future careers; and
   - E. express, manipulate, and interpret relationships symbolically in accordance with accepted theories to make predictions and solve problems mathematically.
4. **Science concepts. The student knows and applies the laws governing motion in a variety of situations. The student is expected to:**
   - A. generate and interpret graphs and charts describing different types of motion, including investigations using real-time technology such as motion detectors or photogates;
   - B. describe and analyze motion in one dimension using equations and graphical vector addition with the concepts of distance, displacement, speed, average velocity, instantaneous velocity, frames of reference, and acceleration;
   - C. analyze and describe accelerated motion in two dimensions, including using equations, graphical vector addition, and projectile and circular examples; and
   - D. calculate the effect of forces on objects, including the law of inertia, the relationship between force and acceleration, and the nature of force pairs between objects using methods, including free-body force diagrams.
5. **Science concepts. The student knows the nature of forces in the physical world. The student is expected to:**
   - A. describe the concepts of gravitational, electromagnetic, weak nuclear, and strong nuclear forces;
   - B. describe and calculate how the magnitude of the gravitational force between two objects depends on their masses and the distance between their centers;
   - C. describe and calculate how the magnitude of the electric force between two objects depends on their charges and the distance between their centers;
   - D. identify and describe examples of electric and magnetic forces and fields in everyday life such as generators, motors, and transformers;
   - E. characterize materials as conductors or insulators based on their electric properties; and
   - F. investigate and calculate current through, potential difference across, resistance of, and power used by electric circuit elements connected in both series and parallel combinations.
6. **Science concepts. The student knows that changes occur within a physical system and applies the laws of conservation of energy and momentum. The student is expected to:**
   - A. investigate and calculate quantities using the work-energy theorem in various situations;
   - B. investigate examples of kinetic and potential energy and their transformations;
   - C. calculate the mechanical energy of, power generated within, impulse applied to, and momentum of a physical system;
   - D. demonstrate and apply the laws of conservation of energy and conservation of momentum in one dimension; and
   - E. explain everyday examples that illustrate the four laws of thermodynamics and the processes of thermal energy transfer.
7. **Science concepts. The student knows the characteristics and behavior of waves. The student is expected to:**
   - A. examine and describe oscillatory motion and wave propagation in various types of media;
   - B. investigate and analyze characteristics of waves, including velocity, frequency, amplitude, and wavelength, and calculate using the relationship between wavespeed, frequency, and wavelength;
   - C. compare characteristics and behaviors of transverse waves, including electromagnetic waves and the electromagnetic spectrum, and characteristics and behaviors of longitudinal waves, including sound waves;
   - D. investigate behaviors of waves, including reflection, refraction, diffraction, interference, resonance, and the Doppler effect; and
   - E. describe and predict image formation as a consequence of reflection from a plane mirror and refraction through a thin convex lens.
8. **Science concepts. The student knows simple examples of atomic, nuclear, and quantum phenomena. The student is expected to:**
   - A. describe the photoelectric effect and the dual nature of light;
   - B. compare and explain the emission spectra produced by various atoms;
   - C. calculate and describe the applications of mass-energy equivalence; and
   - D. give examples of applications of atomic and nuclear phenomena using the standard model such as nuclear stability, fission and fusion, radiation therapy, diagnostic imaging, semiconductors, superconductors, solar cells, and nuclear power and examples of applications of quantum phenomena.