Physics
6–12

Section 32

Physics 6–12

1 Knowledge of the nature of scientific investigation and instruction in physics

1. Identify the characteristics and processes of scientific inquiry.

2. Identify potentially hazardous situations in a physics laboratory and classroom, methods of prevention, and corrective actions.

3. Select the appropriate laboratory equipment for specific scientific investigations.

4. Relate the historical development of the major concepts, models, and investigations in physics to current knowledge (e.g., force and motion, conservation principles, fields, quantum theory).

5. Distinguish between scientific theories and laws in terms of their specific roles and functions.

6. Identify elements of guided inquiry (e.g., engaging through questioning, eliciting prior knowledge, engaging in thoughtful discussion, engaging in exploration, fostering data-based argumentation, providing for application) in the physics classroom and laboratory.

7. Identify the areas of teacher liability and responsibility in science-related activities, including accommodations for diverse student populations.

2 Knowledge of the mathematics of physics

1. Determine the validity of a formula based on dimensional analysis.

2. Combine vectors using graphic and trigonometric methods.

3. Determine the dot product and cross product of two vectors.

4. Convert between units of a given quantity (e.g., length, area, volume, mass, time, temperature).

5. Identify prefixes in the metric system and standard units of measure (e.g., newtons, meters, kilowatt-hours, teslas, electron volts, calories, horsepower).

6. Estimate the order of magnitude of a physical quantity.

7. Interpret the slope of a graph or area under the curve in relation to physical concepts.

8. Apply the concepts of accuracy, precision, uncertainty, and significant figures to measurements and calculations.

3 Knowledge of thermodynamics

1. Relate changes in length, area, or volume of a system to changes in temperature.

2. Distinguish between the three methods of heat transfer (i.e., conduction, convection, radiation).

3. Determine the amount of heat transferred by conduction or radiation.

4. Interpret segments of graphs of temperature versus heat added or removed (e.g., latent heats, specific heats).

5. Analyze pressure, volume, and temperature relationships using the ideal gas law.

6. Apply the first law of thermodynamics (i.e., energy conservation) to physical systems.

7. Calculate work done by or on a gas from pressure versus volume diagrams.

8. Interpret pressure versus volume diagrams (e.g., identify isobaric, isothermal, and adiabatic processes).

9. Determine the specific heat, latent heat, or temperatures of a substance, given appropriate calorimetric data.

10. Apply the second law of thermodynamics (i.e., entropy increase) to physical processes.

11. Relate temperature or pressure to kinetic molecular theory.

4 Knowledge of mechanics

1. Analyze the motion of an object moving in one dimension, given a graph (e.g., displacement versus time, velocity versus time, acceleration versus time).

2. Determine distance traveled, displacement, speed, velocity, acceleration, or time of travel for objects moving in one dimension.

3. Determine distance traveled, displacement, speed, velocity, acceleration, or time of travel for objects moving in two dimensions (e.g., projectile motion).

4. Apply Newton's laws of motion to problems involving linear motion of a body.

5. Apply Newton's laws of motion to problems involving circular motion of a body.

6. Identify action-reaction pairs of forces between two bodies.

7. Apply conservation of momentum to problems in one or two dimensions.

8. Analyze problems using the impulse-momentum theorem.

9. Analyze problems using Newton's universal law of gravitation (e.g., orbital motion).

10. Analyze problems involving static or kinetic frictional forces.

11. Apply conservation of mechanical energy.

12. Use Newton's second law to analyze problems involving two connected masses (e.g., Atwood machine, Atwood machine on inclined plane, blocks, massless pulley).

13. Analyze problems involving torque (e.g., equilibrium, rotational dynamics).

14. Apply conservation of angular momentum and conservation of energy to problems involving rotational motion.

15. Analyze problems involving work done on mechanical systems (e.g., power, work-energy theorem).

16. Analyze problems involving the relationships between depth, density of fluid, and pressure.

17. Analyze problems involving the buoyant force on a submerged or floating object (i.e., Archimedes' principle).

18. Analyze problems involving moving fluids (e.g., mass conservation, Bernoulli's principle).

19. Analyze problems involving center of mass.

20. Use free-body diagrams to analyze static or dynamic problems in two or three dimensions.

21. Analyze characteristics and examples of simple harmonic motion (e.g., oscillating springs, vibrating strings, pendula).

5 Knowledge of waves and optics

1. Identify characteristics of waves (e.g., velocity, frequency, amplitude, wavelength, period, pitch, intensity, phase, nodes, antinodes, transverse waveforms, longitudinal waveforms).

2. Analyze the motion of particles in a medium in the presence of transverse and longitudinal waves.

3. Identify factors that affect wave propagation and wave speed.

4. Analyze problems involving the superposition, or interference, of waves (e.g., beats, standing waves, interference patterns).

5. Analyze problems involving standing waves (e.g., open or closed tube, vibrating string).

6. Analyze the Doppler effect due to the motion of a source or receiver.

7. Analyze waves, using either graphical or mathematical representations.

8. Analyze reflection and refraction problems using the law of reflection and Snell's law).

9. Interpret the relationships between wavelength, frequency, and speed of light.

10. Analyze the effects of linear polarizing filters on the polarization and intensity of light.

11. Analyze the geometric optics of thin lenses and mirrors.

12. Analyze patterns produced by diffraction and interference of light (e.g., single-slit, double-slit, diffraction gratings).

13. Identify the use and characteristics of various optical instruments (e.g., eye, spectroscope, camera, telescope, microscope, corrective lenses).

14. Apply the relationship between intensity and distance from a point source (i.e., inverse-square law).

15. Compare qualitative features of the ranges of the electromagnetic spectrum.

6 Knowledge of electricity and magnetism

1. Determine the electric force on a point charge due to one or more other charges.

2. Determine the electric potential difference between two points in an electric field.

3. Analyze problems involving capacitance, with or without dielectrics.

4. Analyze the electric field due to a charge distribution.

5. Apply Gauss's law to determine or characterize an electric field.

6. Analyze charge distributions in conductors and nonconductors.

7. Simplify series and parallel combinations of resistors or capacitors.

8. Solve problems using Ohm's law.

9. Apply Kirchhoff's laws to analyze DC circuits.

10. Determine the power dissipated through one or more elements of a DC circuit.

11. Relate the resistance of a conductor to its geometry and resistivity.

12. Analyze problems involving the direction and magnitude of the magnetic force acting on moving charges (e.g., mass spectrometer).

13. Apply the laws of electromagnetic induction (i.e., Faraday's law, Lenz's law).

14. Analyze problems involving AC circuits (e.g., transformers, peak current, root-mean-square voltage, frequency, reactance, resonant frequency, impedance).

15. Identify principles and components involved in the operation of motors and generators.

16. Predict the magnetic fields associated with current-carrying conductors (e.g., long straight wires, loops, solenoids).

7 Knowledge of modern physics

1. Analyze problems based on the energy of a photon (e.g., photoelectric effect, E = hf).

2. Apply Einstein's theory of special relativity (e.g., light postulate, length contraction, time dilation).

3. Apply Einstein's mass-energy equivalence ($E = mc^2$).

4. Determine the allowed energies of quantum atomic states or of transitions between such states.

5. Compare the characteristics of alpha, beta, and gamma radiation.

6. Predict outcomes of radioactive decay processes (e.g., balancing a nuclear equation).

7. Calculate the age of a radioactive source, given data (e.g., half-life, activity, remaining mass, decayed fraction).

8. Differentiate between fission and fusion processes and their applications.

9. Analyze problems involving Heisenberg's uncertainty principle (e.g., momentum versus position, energy versus time).

10. Differentiate between historical models of the atom (e.g., Thomson's plum pudding, Rutherford, Bohr, electron cloud).

11. Identify characteristics of subatomic and elementary particles (e.g., protons, neutrons, electrons, photons, neutrinos, quarks, antiparticles).

12. Distinguish between the four fundamental forces of nature in terms of the particles they act upon, the relative distances over which they act, and their relative strengths.

13. Identify characteristics of the dual (i.e., wave and particle) nature of light and matter.