| **Required Course Numbers** | | | | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test Content Categories** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **I. Mechanics (32%)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **A. Vectors and Scalars** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Vector and scalar quantities in describing motion and forces. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Scalars (e.g., mass, speed, time, energy) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Vectors (e.g., displacement, velocity, acceleration, force, momentum) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Vector components |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Addition of vectors |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Resultant vector |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B. Kinematics** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Motion in terms of displacement, velocity, and acceleration. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Linear motion |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Simple harmonic motion (e.g., pendulums, spring oscillation) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Circular motion |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Projectile motion |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Rotational kinematics (e.g., angular displacement, angular velocity, angular acceleration) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Frames of reference and their applications. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Frames of reference (e.g., coordinate systems, inertial reference frames) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Relative velocity |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **C. Dynamics and Fluid Mechanics** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Newton’s three laws of motion. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Newton’s first law of motion (e.g., mass, inertia, inertial reference frame) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Newton’s second law of motion (net force, mass, acceleration) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Newton’s third law of motion (action-reaction forces) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Applications (e.g., inclined planes, pendulums, Atwood machine) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Static equilibrium. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Sum of forces |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Sum of torques |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Friction, including forces and coefficients. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Normal force |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Frictional force |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Coefficients of static and kinetic friction |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4. Circular motion. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Centripetal acceleration |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Centripetal force |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5. Simple harmonic motion. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Restoring force (e.g., Hooke’s law) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Properties of simple harmonic motion (e.g., period, frequency, amplitude) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Pendulums |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Spring oscillation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6. Work, mechanical energy, and power, and how they are related to one another. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Mechanical energy (e.g., kinetic energy, potential energy, conservation of energy) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Work |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Work and energy |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Power |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Simple machines and mechanical advantage |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7. Linear momentum and impulse and how they are related to one another. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Linear momentum |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Impulse |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Impulse and momentum |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 8. Rotational motion. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Center of mass |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Angular momentum |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Conservation of angular momentum |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Torque |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Rotational inertia (moment of inertia) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 9. Differences between elastic and inelastic collisions. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Elastic collisions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Inelastic collisions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Conservation of momentum |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Conservation of kinetic energy |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Collisions in one dimension |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Collisions in two dimensions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 10. Laws of conservation of energy and conservation of linear momentum. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Conservation of energy |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Conservation of linear momentum |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Energy transformations |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 11. Newton’s law of universal gravitation. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Newton’s law of universal gravitation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Satellites and orbital motion |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Gravitational acceleration |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 12. Difference between weight and mass. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Weight and mass |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Difference between weight and mass |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Relationship between density and mass |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 13. Kepler’s three laws of orbital motion. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Kepler’s first law (law of ellipses) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Kepler’s second law (law of equal areas) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Kepler’s third law (relationship between orbital period and mean orbital radius) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 14. Fluid mechanics. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Archimedes’ principle |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Bernoulli’s principle |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Pascal’s principle |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Properties of fluids (e.g., density, pressure, viscosity) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **II. Electricity and Magnetism (19%)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Electrostatics. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Electric charge |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Induced charge |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Coulomb’s law |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Electrostatic forces |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Electric field |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Electric flux |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| g. Electric potential |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| h. Electric potential energy |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| i. Potential difference |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| j. Gauss’s law |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Electrical properties of conductors, insulators, and semiconductors. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Conductors |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Insulators |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Semiconductors |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Material examples (e.g., metals, ceramics, superconductors) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Electrical current, resistance, potential difference, energy, power, and the relationships between them. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Electric current |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Potential difference |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Resistance |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Resistivity |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Ohm’s law |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Energy |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| g. Power |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| h. Energy and power (e.g., kilowatt-hours vs. kilowatts) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4. Capacitance and inductance. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Capacitance and capacitors |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Inductance and inductors |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5. Differences between alternating and direct current. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Direct current |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Alternating current |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6. How to analyze simple series, parallel, and combination circuits. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Series circuits |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Parallel circuits |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Combination circuits |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Ohm’s law |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Equivalent resistance |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Equivalent capacitance |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| g. Kirchhoff’s laws |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| h. Measurement devices within circuits (e.g., ammeters, voltmeters) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7. How sources generate electric potential. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Batteries |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Photocells |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Generators |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Electromotive force (EMF) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 8. Magnetic fields, magnetic forces, and properties of magnetic materials. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Magnetic field |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Magnetic flux |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Magnetic force |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Magnets (e.g., bar magnets and poles, permanent magnets, electromagnets) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Transformers, motors, and generators |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Direction of fields and forces (e.g., right-hand rule) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| g. Magnetic field generated by a steady current (e.g., Biot-Savart law) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| h. Ampere’s law |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| i. Lorentz force law (force on a moving charge) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| j. Force between current-carrying wires |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 9. How a changing electric field produces a magnetic field and how a changing magnetic field produces an electric field. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Ampere’s law |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Lenz’s law (direction of induced current) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Faraday’s law of induction |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Motional EMF |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **III. Optics and Waves (13%)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Types of waves and their characteristics. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Transverse and longitudinal |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Wave motion and propagation (mechanical vs. electromagnetic) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Amplitude, wavelength, frequency, period, speed, energy |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Superposition and phase |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Intensity and inverse square law |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Standing waves |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Wave phenomena such as reflection, refraction, interference, and diffraction. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Reflection, refraction, Snell’s law, dispersion, total internal reflection |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Diffraction, interference, superposition, Young’s double-slit interference experiment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Polarization |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Scattering, absorption, transmission |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Resonance and natural frequencies, harmonics |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Fundamentals of the Doppler effect. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Doppler effect |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Apparent frequency |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Moving source |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Moving observer |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Redshift, blueshift |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4. Characteristics of sound. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Compression waves |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Speed of sound (e.g., sonic boom, sound barrier) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Pitch (frequency), loudness (intensity) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Beats |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Air columns (open and closed pipes) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5. Electromagnetic waves and the electromagnetic spectrum. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Electromagnetic waves (e.g., electric and magnetic fields, speed of light, energy) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Electromagnetic spectrum (radio waves, microwaves, infrared, visible, ultraviolet, x-rays, gamma rays) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6. Geometric optics. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Ray tracing |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Focal point, image distance, image size and magnification, real vs. virtual image, image orientation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Lenses (converging, diverging) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Mirrors (plane, convex, concave, spherical, parabolic) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Lens and mirror equations |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Simple instruments (e.g., magnifying glass, telescope, microscope) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| g. Prisms |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **IV. Heat, Energy, and Thermodynamics (12%)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Temperature, temperature scales, heat, and heat capacity. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Temperature (measure of average kinetic energy) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Temperature scales |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Heat and thermal energy |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Difference between temperature and thermal energy |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Heat capacity and specific heat |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Calorimetry |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| g. Thermal expansion |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Mechanisms of heat transfer. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Conduction |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Convection |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Radiation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Different forms of energy and transformations between them. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Forms of energy (e.g., kinetic, potential, mechanical, electrical, electromagnetic, chemical, nuclear) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Energy transformations |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4. Energy involved in phase transitions between the various states of matter. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Phase transitions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Phase diagrams |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Heating/cooling diagrams |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Heats of vaporization, fusion, and sublimation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5. Kinetic molecular theory and the ideal gas laws. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Kinetic molecular theory (e.g., assumptions of the theory, temperature, pressure, average molecular speeds) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Ideal gases and the ideal gas law |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6. Laws of thermodynamics. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. First law (e.g., internal energy, conservation of energy, work, heat) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Second law (entropy) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Third law (absolute zero) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Zeroth law (thermal equilibrium) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. P-V diagrams |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Thermodynamic processes (e.g., isothermal, adiabatic, reversible/irreversible) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| g. Heat engines and efficiency (e.g., ideal vs. actual efficiency, temperature differences) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **V. Modern Physics, and Atomic and Nuclear Structure (12%)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Organization, structure and states of matter. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Atoms, molecules, ions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Solids, liquids, gases, plasmas |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Chemical/physical properties and changes |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Nature of atomic and subatomic structure including various models of the atom. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Atomic and subatomic structure (e.g., electrons, protons, neutrons, and isotopes) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Models of the atom (e.g., Bohr model, quantum model) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Experimental basis of models (e.g., Rutherford experiment, Millikan oil-drop experiment, Thomson experiment) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Relationship of atomic spectra to electron energy levels. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Electron energy transitions in atoms |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Absorption and emission spectra |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4. Characteristics, processes, and effects of radioactivity. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Radioactivity and radioactive decay processes |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Alpha particles, beta particles, and gamma radiation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Half-life |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Radioisotopes |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Fission and fusion |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5. Topics in modern physics. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Wave-particle duality |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Photoelectric effect |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Special relativity |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Heisenberg uncertainty principle |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. de Broglie’s hypothesis |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Nuclear forces (strong and weak) and binding energy |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **VI. Scientific Inquiry, Processes, and Social Perspectives (12%)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **A. History and Nature of Scientific Inquiry** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Processes involved in scientific inquiry. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Identifying problems |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Forming and testing hypotheses |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Development of theories, models, and laws |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Process skills, including observing, comparing, inferring, categorizing, generalizing, and concluding |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Experimental design. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Experimental procedures used to test hypotheses |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Reproducible procedures |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Significance of controls |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Dependent and independent variables |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Determining what data need to be collected |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Nature of scientific knowledge. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Is subject to change |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Is consistent with evidence |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Is based on reproducible evidence |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Includes unifying concepts and processes (e.g., systems, models, constancy and change, equilibrium, form and function) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4. How major principles in physics developed historically and the contributions of major historical figures. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. How current principles and models developed over time |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Major developments (e.g., atomic model, Newtonian mechanics, Rutherford experiment) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Major historical figures in the development of physics |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **B. Scientific Procedures and Techniques** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. How to collect, process, analyze, and report data including sources of error. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Organization and presentation of data |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Units of measurement including SI, SI derived, and others (e.g., meter, newton, mile) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Unit conversion and dimensional analysis |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Scientific notation and significant figures |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Measurement equipment, including applications |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Basic error analysis, including precision and accuracy |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| g. Identifying sources of error |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| h. Interpreting and drawing valid conclusions from data presented in tables, graphs, and charts (e.g., trends in data, relationships between variables, predictions based on data) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Appropriate use of materials, equipment, and technology in the high school physics laboratory and classroom. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Appropriate use and storage |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Appropriate prelab setup and classroom demonstrations |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Safety procedures and precautions |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **C. Science, Technology, and Society** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Impact of physics and technology on society and the environment. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Space exploration, communications, etc. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Climate change, ozone layer depletion, noise pollution, etc. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Production, storage, and disposal issues associated with consumer products |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Major issues associated with energy use and production. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Renewable and nonrenewable energy resources |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Conservation and recycling |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Power generation based on various sources, such as fossil and nuclear fuel, hydropower, wind power, solar power, and geothermal power |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Storage and distribution of renewable energy (e.g., alternative fuels, fuel cells, rechargeable batteries) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Applications of physics in daily life. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Communications (e.g., wireless devices, fiber optics, satellites) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Research tools (e.g., space telescopes, lasers, super colliders) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Medicine (e.g., medical imaging, lasers) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Transportation (e.g., superconductors, magnetic levitation) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Other applications |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |