Indiana Science

Physics II: Grades 9, 10, 11, 12

Adopted 2022

Energy and Momentum in Two Dimensions

1. For a system consisting of a single object with a net external force applied, qualitatively and quantitatively predict changes in its linear momentum using the impulse-momentum theorem and in its translational kinetic energy using the work-energy theorem. HS-PSII-1.1
2. For a system consisting of two objects with no net external forces applied, qualitatively and quantitatively analyze a two-dimensional interaction (i.e., collision or separation) to show that the total linear momentum of the system remains constant HS-PSII-1.2
3. For a system consisting of two objects moving in two dimensions with no net external forces applied, apply the principles of conservation of linear momentum and of mechanical energy to quantitatively predict changes in the linear momentum, velocity, and kinetic energy after the interaction between the two objects. HS-PSII-1.3
4. Classify interactions between two objects moving in two dimensions as elastic, inelastic, and completely inelastic. HS-PSII-1.4

Temperature and Thermal Energy Transfer

1. Develop graphical and mathematical representations that describe the relationship among the temperature, thermal energy, and thermal energy transfer (i.e., heat) in the kinetic molecular theory and apply those representations to qualitatively and quantitatively describe how changing the temperature of a substance affects the motion of the molecules. HS-PSII-2.1
2. Describe the process of the transfer of thermal energy (i.e., heat) that occurs during the heating cycle of a substance from solid to gas and relate the changes in molecular motion to temperature changes that are observed. HS-PSII-2.2
3. Cite evidence from everyday life to describe the transfer of thermal energy by conduction, convection, and radiation. HS-PSII-2.3
4. Develop graphical and mathematical representations that describe the relationship among the volume, temperature, and number of molecules of an ideal gas in a closed system and the pressure exerted by the system and apply those representations to qualitatively and quantitatively describe how changing any of those variables affects the others. HS-PSII-2.4

5. **Describe the slope of the graphical representation of pressure vs. the product of: the number of particles, temperature of the gas, and inverse of the volume of the gas in terms of the ideal gas constant.** `HS-PSII-2.5`
6. **Using PV graphs, qualitatively and quantitatively determine how changes in the pressure, volume, or temperature of an ideal gas allow the gas to do work and classify the work as either done on or done by the gas.** `HS-PSII-2.6`

Fluids

1. **For a static, incompressible fluid, develop and apply graphical and mathematical representations that describe the relationship between the density and the pressure exerted at various positions in the fluid, and apply those representations to qualitatively and quantitatively describe how changing the depth or density affects the pressure.** `HS-PSII-3.1`
2. **Qualitatively and quantitatively determine how the density of fluid or volume of fluid displaced is related to the force due to buoyancy acting on either a floating or submerged object as described by Archimedes' principle of buoyancy.** `HS-PSII-3.2`
3. **Develop and apply the principle of constant volume flow rate to determine the relationship between cross-sectional area of a pipe and the velocity of an incompressible fluid flowing through a pipe.** `HS-PSII-3.3`
4. **Develop and apply Bernoulli's principle and continuity equations to predict changes in the speed and pressure of a moving incompressible fluid.** `HS-PSII-3.4`
5. **Describe how a change in the pressure of as static fluid in an enclosed container is transmitted equally in all directions (Pascal's Principle) and apply Pascal's Principle to determine the mechanical advantage of a hydraulic system.** `HS-PSII-3.5`

Electricity

1. **Describe the methods of charging an object (i.e., contact, induction, and polarization) and apply the principle of conservation of charge to determine the charges on each object after charge is transferred between two objects by contact.** `HS-PSII-4.1`
2. **For a single isolated charge, develop and apply graphical and mathematical representations that describe the relationship between the amount of charge, the distance from the charge and the strength of the electric field created by the charge and apply those representations to qualitatively and quantitatively describe how changing either the amount of charge or distance from the charge affects the strength of the electric field.** `HS-PSII-4.2`
3. **Using Coulomb's law, pictorially and mathematically describe the force on a stationary charge due to other stationary charges. Understand that these forces are equal and opposite as described by Newton's third law and compare and contrast the strength of this force to the force due to gravity.** `HS-PSII-4.3`

4. **For a single isolated charge, develop graphical and mathematical representations that describe the relationship between the amount of charge, the distance from the charge and the electric potential created by the charge and apply those representations to qualitatively and quantitatively describe how changing either the amount of charge or distance from the charge affects the electric potential.** HS-PSII-4.4
5. **Map electric fields and equipotential lines, showing the electric field lines are perpendicular to the equipotential lines, and draw conclusions about the motion of a charged particle either between or along equipotential lines due the electric field.** HS-PSII-4.5
6. **Distinguish between electric potential energy and electric potential (i.e., voltage).** HS-PSII-4.6
7. **Apply conservation of energy to determine changes in the electric potential energy, translational kinetic energy, and speed of a single charged object (i.e., a point particle) placed in a uniform electric field.** HS-PSII-4.7

Simple and Complex Circuits

1. **Relate the idea of electric potential energy to electric potential (i.e., voltage) in the context of electric circuits.** HS-PSII-5.1
2. **Develop graphical and mathematical representations that describe the relationship between the between the amount of current passing through an ohmic device and the amount of voltage (i.e., EMF) applied across the device according to Ohm's Law. Apply those representations to qualitatively and quantitatively describe how changing the current affects the voltage and vice versa for an ohmic device of known resistance.** HS-PSII-5.2
3. **Describe the slope of the graphical representation of current vs. voltage or voltage vs. current in terms of the resistance of the device.** HS-PSII-5.3
4. **Define and describe a device as ohmic or non-ohmic based on the relationship between the current passing through the device and the voltage across the device based on the shape of the curve of a current vs. voltage or voltage vs. current graphical representation.** HS-PSII-5.4
5. **Explain and analyze simple arrangements of electrical components in series and parallel DC circuits in terms of current, resistance, voltage, and power. Use Ohm's and Kirchhoff's laws to analyze DC circuits.** HS-PSII-5.5

Magnetism

1. **Describe the magnetic properties of ferromagnetic, paramagnetic, and diamagnetic materials on a macroscopic scale and atomic scale.** HS-PSII-6.1
2. **Develop and apply a mathematical representation that describes the relationship between the magnetic field created by a long straight wire carrying an electric current, the magnitude of the current, and the distance to the wire.** HS-PSII-6.2

	3. Describe the motion of a charged or uncharged particle through a uniform magnetic field. HS-PSII-6.3
	4. Determine the magnitude of the magnetic force acting on a charged particle moving through a uniform magnetic field and apply the right hand rule to determine the direction of either the magnetic force or the magnetic field. HS-PSII-6.4
	5. Describe the practical uses of magnetism in motors, electronic devices, mass spectroscopy, MRIs, and other applications. HS-PSII-6.5
Electromagnetic Induction	**1. Given the magnitude and direction of a uniform magnetic field, calculate the flux through a specified area in terms of the field magnitude and the size and orientation of the area with respect to the field.** HS-PSII-7.1
	2. Develop graphical and mathematical representations that describe the relationship between the rate of change of magnetic flux and the amount of voltage induced in a simple loop circuit according to Faraday's Law of Induction and apply those representations to qualitatively and quantitatively describe how changing the voltage across the device affects the current through the device. HS-PSII-7.2
	3. Apply Ohm's Law, Faraday's Law, and Lenz's Law to determine the amount and direction of current induced by a changing magnetic flux in a loop of wire or simple loop circuit. HS-PSII-7.3
Geometric Optics	**1. Develop graphical, mathematical, and pictorial representations (e.g., ray diagrams) that describe the relationships between the focal length, the image distance, and the object distance for planar, converging, and diverging mirrors and apply those representations to qualitatively and quantitatively describe how changing the object distance affects the image distance.** HS-PSII-8.1
	2. Develop graphical, mathematical, and pictorial representations (e.g., ray diagrams) that describe the relationship between the angles of incidence and refraction of monochromatic light passed between two different media and apply those representations to qualitatively and quantitatively describe how changing the angle of incidence affects the angle of refraction. HS-PSII-8.2
	3. Develop graphical, mathematical, and pictorial representations (e.g., ray diagrams) that describe the relationships between the focal length, the image distance, and the object distance for both converging and diverging lenses and apply those representations to qualitatively and quantitatively describe how changing the object distance affects the image distance. HS-PSII-8.3
	4. Describe an image as real or virtual for both a curved mirror and lens system based on the position of the image relative to the optical device. HS-PSII-8.4

Particle and Wave Nature of Light

1. **Develop the relationship among frequency, wavelength, and energy for electromagnetic waves across the entire spectrum.** HS-PSII-9.1
2. **Explain how electromagnetic waves interact with matter both as particles (i.e., photons) and as waves and be able to apply the most appropriate model to any particular scenario.** HS-PSII-9.2
3. **Develop graphical and mathematical representations that describe the relationship between the frequency of a photon and the kinetic energy of an electron emitted through the photoelectric effect and apply those representations to qualitatively and quantitatively describe how changing the frequency or intensity of light affect the current produced in the photoelectric effect.** HS-PSII-9.3
4. **Describe the slope of the graphical representation of the kinetic energy of a photoelectron vs. frequency in terms of Planck's constant.** HS-PSII-9.4
5. **Develop graphical and mathematical representations that describe the relationship between the wavelength of monochromatic light, spacing between slits, distance to screen, and interference pattern produced for a double-slit scenario and apply those representations to qualitatively and quantitatively describe how changing any of the independent variables affects the position of the bright fringes.** HS-PSII-9.5
6. **Develop graphical and mathematical representations that describe the relationship between the angle between two polarizing filters and the intensity of light passed through the filters from an unpolarized light source and apply those representations to qualitatively and quantitatively describe how changing the angle between polarizing filters affects the intensity of light passing through both filters.** HS-PSII-9.6

Modern Physics

1. **Describe the Standard Model and explain the composition and decay of subatomic particles using the Standard Model and Feynman diagrams.** HS-PSII-10.1
2. **Explain the stability of the nucleus considering the electromagnetic repulsion in the nucleus and how forces govern binding energy and radioactive decay for different elements.** HS-PSII-10.2
3. **Qualitatively compare and contrast how particle interactions, fission, and fusion can convert matter into energy and energy into matter and calculate the relative amounts of matter and energy in such processes.** HS-PSII-10.3
4. **Apply the conservation of mass, conservation of charge, and conservation of linear momentum principles to describe the results of a radioactive particle undergoing either alpha or beta decay.** HS-PSII-10.4

5. **Know and describe how a particle accelerator functions and how current high energy particle physics experiments are being used to develop the Standard Model.** HS-PSII-10.5