# East Penn School District
**Curriculum and Instruction**

## Curriculum for: Science Department

**Course(s): STEM Physics Honors**

**Grades: 9-10**

**Department: Science** | **Length of Period (average minutes): 42**

**Periods per cycle: 6** | **Length of Course (yrs): 1**

**Type of offering: ______ required __X__elective** | **Credit(s) awarded: 1.0** | **Weighting: 4.5/4.0**

**Developed by: Brent Ohl and Edward Anthony**

**ADOPTED:**

| Enduring Understanding | Essential Questions | Content | Standard | Skills |
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| Scientific conventions are used in all topics and concepts of physics. | How do I use the scientific method in everyday life?<br><br>How are facts different than hypothesis and different from a theory?<br><br>What is studied in Physics?<br><br>What is the main reason for using scientific notation?<br><br>Why do scientists use the metric system in science?<br><br>What are base units and how are prefixes used to modify base units?<br><br>What is dimensional consistency, and how does it apply to physics equations?<br><br>Why is the validity of a hypothesis based solely on its ability to account for known observations and to correctly predict new observations?<br><br>What are the conventional graphing techniques? | Use of the scientific method<br>Fact versus hypothesis (theory)<br>Metric system-use of<br>Use of correct units scientifically, mathematically, and graphically.<br><br>**Vocabulary**<br>density<br>Mass<br>Volume weight<br>dimensional analysis<br>Accuracy<br>Precision<br>time<br>Scientific method<br>Variables<br>hypothesis<br>Theory<br>Law<br>quantitative<br>qualitative<br>significant figures<br>Metric units<br>Scientific notation<br>slope | **HS-PS2-6.. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.***[Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.]<br><br>**HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.**[Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [Assessment Boundary: Assessment is limited to systems containing two objects.]<br><br>**HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*** [Clarification Statement: Examples could include solar cells capturing light and | The student will be able to:<br><br>a. Modify or affirm preexisting scientific conceptions through experimentation and using other evidence.<br><br>c. Identify the independent and dependent variables in any experiment.<br><br>d. Graph data properly using axes labeled with appropriate quantities, appropriate units on axes, axes labeled with appropriate intervals, and an appropriate title.<br><br>e. Identify trends and sources of error using experimental data.<br><br>f. Analyze data by re-expressing data to determine the correct proportional relationship among variables, determining the value, units, and physical significance of the slope of the graph, and writing the equation derived from the analysis.<br><br>g. Predict and explain everyday phenomena using equations and graphs derived from data. |

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| | | | converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.] | h. Use math skills, including unit conversions, manipulating and solving algebraic equations, scientific notation, and proportional relationships.<br><br>i. Use computers or graphing calculators to perform calculations for tables and graphs.<br><br>j. Solve problems methodically by making a diagram of the problem, identifying known and unknown quantities, identifying appropriate equations, and judging the reasonableness of an answer. |
| Motion can be represented by a position-time graph. | How do forces combine?<br><br>How does an object in mechanical equilibrium behave?<br><br>How do we observe forces? What is inertia?<br><br>How do distance and displacement differ?<br><br>What distinguishes velocity from speed? | Speed, Velocity, Graphs and Equations<br><br>**Vocabulary…**<br>coordinate system<br>distance<br>displacement<br>average speed<br>average velocity | | The student will be able to:<br><br>a. Define position as a signed number relative to an origin.<br><br>b. Calculate displacement ($\Delta x$) as the change in position of an object.<br><br>c. Identify the frame of reference used in any problem.<br><br>d. Calculate speed as the distance traveled divided by the elapsed time.<br><br>e. Calculate velocity as the change in position divided by the elapsed time. |

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| | | | | f. Identify cases where average speed does not equal average velocity.<br><br>g. Describe a situation when the velocity is negative. |
| All objects in free fall move with the same constant acceleration | What is the difference between acceleration and velocity?<br><br>What cause accelerations?<br><br>What is the difference between average, instantaneous and constant acceleration?<br><br>What is free fall?<br><br>What kind of motion results in an acceleration?<br><br>What determines whether an acceleration causes an increase or a decrease in speed? | Constant acceleration, graphing constant acceleration & free fall<br><br>**Vocabulary:**<br><br>acceleration average acceleration instantaneous acceleration constant acceleration free fall | **HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.**[Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.] | The student will be able to:<br><br>a. Define and calculate acceleration as the change in velocity divided by the elapsed time.<br><br>b. Describe how the physics definition of acceleration differs from the everyday definition of acceleration.<br><br>c. Interpret position versus time and velocity versus time graphs for motion at constant velocity and for motion at constant acceleration.<br><br>d. Solve and interpret situations of constant acceleration. |
| The horizontal and vertical motions of an object are independent of one another. | How do we analyze the motion of objects?<br><br>How can vectors be used to aid in the analysis of motion in multiple dimensions? | Vectors, relative & projectile motion<br><br>**Vocabulary:**<br><br>vector<br>resultant | **HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.[**Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the | The student will be able to:<br><br>a. Identify a projectile as an object which has been launched and whose motion is affected only by gravity (ignoring air resistance). |

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| | How are vector quantities different from scalar quantities?<br><br>How do the vertical and horizontal components of a projectile effect each other?<br><br>How are vector components used to determine the resultant vector?<br><br>How are relative velocity vectors related to each other?<br><br>What is the shape of the path followed by an ideal projectile? | relative motion<br>projectile range | qualitative meaning of this principle.] [Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.] | b. Analyze the motion of a projectile by breaking its velocity and acceleration vectors into horizontal and vertical components.<br><br>c. Identify scalar and vector quantities.<br><br>d. Perform vector addition geometrically.<br><br>e. Determine the components of a vector using a geometric method.<br><br>f. Apply vector concepts to physical situations involving forces, projectile motion |
| All motion is governed by Newton's Laws. | How do scientists relate forces and motion?<br><br>What is a Newton?<br><br>How does friction effect motion of an object?<br><br>How is net force related to mass and acceleration?<br><br>How are action and reaction forces related?<br><br>How are free-body diagrams used to solve problems?<br><br>How is the weight of an object related to its mass? | Newton's Laws and Applications<br><br>**Vocabulary:**<br><br>force<br>net force<br>inertia<br>Newton<br>free-body diagram<br>normal force<br>apparent weight<br>Hooke's Law<br>spring constant<br>tension<br>equilibrium<br>friction<br>kinetic friction<br>static friction | **HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.**[Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.] | The student will be able to:<br><br>a. Explain that objects change their motion only when a net force is applied.<br><br>b. Apply the relationship, a = F/m, to physical situations in order to explain qualitatively and quantitatively how any one variable is affected by a change in another.<br><br>c. Use a = F/m in conjunction with motion equations to solve problems involving motion in one dimension. |

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| | What is the condition for an object to be in equilibrium?<br><br>How do the coefficients of static friction and kinetic friction compare? | | | d. Explain that force is not something that an object "has", but is characteristic of the action between objects.<br><br>e. Explain that when one object applies a force to a second object, the second object simultaneously applies an equal and opposite force to the first object. |
| Energy can change form one form to another, but the total amount of energy in the universe stays the same. | How is work done?<br><br>How does the work done on an object affect its kinetic energy?<br><br>What determines how much potential energy an object has?<br><br>When is mechanical energy conserved?<br><br>How is power related to the rate at which work is done and how is it related to speed?<br><br>How is work in Physics different from work in ordinary life (for example biological work)?<br><br>How does everyday life relate to the Conservation of Energy?<br><br>What is the relationship between potential and kinetic energy?<br><br>Where does "most" energy end up after its final transformation? | Conservation of Energy & Power<br><br>**Vocabulary:**<br><br>work<br>Joule<br>kinetic energy<br>potential energy<br>mechanical energy<br>Conservation of Energy | **HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.**[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]<br><br>**HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).**[Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two | The student will be able to:<br><br>a. Define energy in terms of work.<br><br>b. Calculate work and illustrate that simple machines do not decrease work, rather, they decrease application force by increasing the distance that the force is applied.<br><br>c. Define and calculate kinetic energy, and gravitational potential energy.<br><br>d. State and apply the relationship that work done with no opposing force equals the change in kinetic energy.<br><br>e. State and apply the relationship that work done against gravity equals the change in gravitational potential energy. |

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| | | | electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]<br><br>**HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy**.*[Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.] | f. Define and calculate mechanical energy as the sum of the kinetic and potential energy.<br><br>g. Identify the different forms of energy in simple systems such as a swinging pendulum or a car on a frictionless roller coaster.<br><br>h. Describe the law of conservation of energy for a system and apply it to problems where friction and air resistance are ignored. |
| Momentum is conserved in all collisions, as long as external forces do not act on the system. | What is the direction of momentum?<br><br>What happens to momentum & energy during and after a collision?<br><br>What is the difference between impact and impulse?<br><br>What determines the direction of an impulse?<br><br>How is impulse related to momentum?<br><br>How do internal and external forces affect a system's momentum? | Impulse, Conservation of Momentum & Collisions<br><br>**Vocabulary:**<br><br>momentum<br>impulse<br>elastic collision<br>inelastic collision<br>internal force<br>external force | **HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.**[Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.]<br><br>**HS-PS2-2. Use mathematical representations to support the claim that** | The student will be able to:<br><br>a. Calculate the momentum of an object.<br><br>b. Define and calculate impulse and apply it to the change in momentum of an object.<br><br>c. Use the concept of impulse to explain and demonstrate mathematically why it is safer in a collision to take a longer time to come to a stop.<br><br>d. Analyze a problem and choose a system to determine if |

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| | | | **the total momentum of a system of objects is conserved when there is no net force on the system**.[Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.]<br><br>**HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.***[Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.] | the forces are internal or external to that system.<br><br>e. Explain that a conserved quantity is a quantity that remains numerically constant.<br><br>f. Define and identify situations involving elastic and inelastic collisions and explosions.<br><br>g. State the law of conservation of momentum and use it to solve one - dimensional explosion and collision problems |
| Forces can produce torques, and torques can produce rotation. | What causes torque and how is torque defined in terms of a moment arm?<br><br>What effect does a torque have on an object?<br><br>What is the difference between center of mass and center of gravity?<br><br>How is an object's moment of inertia related to changes in its rotation?<br><br>What two kinds of motion are combined in a rolling circular object? | Angular motion, moment of inertia, torque & static equilibrium<br><br>**Vocabulary:**<br><br>angular position<br>radian<br>average angular velocity<br>center of mass<br>angular speed<br>average angular acceleration | **HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration**.[Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.] | The student will be able to:<br><br>a. Explain the relationship of torque and moment of inertia.<br><br>b. Analyze situations of objects rolling as opposed to sliding down a hill.<br><br>c. Calculate the forces on a system in equilibrium.<br><br>d. Explain the difference between center of mass and gravity. |

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| | | moment of inertia<br>moment arm<br>rotational kinetic energy<br>angular momentum torque | **HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.**[Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.]<br><br>**HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.**[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]<br><br>**HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy**.*[Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment | e. Explain the relationship between moment of inertia and angular velocity.<br><br>f. Demonstrate the relationship of torque and angular acceleration. |

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| | | | Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.] | |
| Heat is a form of energy that is transferred because of temperature differences. | How is heat related to thermal energy?<br><br>What is heat and how does it interact with matter?<br><br>How does temperature relate to the potential and kinetic energies of molecules?<br><br>What is the difference between temperature and heat?<br><br>How does the specific heat capacity describe a substance's response to heat?<br><br>What is the key characteristic of phase equilibrium?<br><br>What happens to the temperature when heat is added to convert a substance from on phase to another?<br><br>What are the three types of thermal energy transfer?<br><br>How is temperature change related to length/volume change of objects? | Temperature, Energy, Heat, Thermal Expansion, Energy Transfer, Specific Heat Capacity, Phase Change & Latent Heat<br><br>**Vocabulary:**<br>temperature<br>thermal energy<br>thermal equilibrium<br>heat<br>absolute zero<br>coefficient of thermal expansion<br>conduction<br>conductor<br>insulator<br>convection<br>radiation<br>kilocalorie<br>specific heat capacity<br>calorimeter<br>phase change<br>pressure<br>equilibrium<br>vapor pressure<br>boiling point<br>evaporation<br>latent heat<br>internal energy | **HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.**[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]<br><br>**HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects)**.[Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.] | The student will be able to:<br><br>a. Distinguish between conduction, convection, and radiation with real life examples.<br><br>b. Explain the differences in specific heats and latent heats.<br><br>c. Explain kinetic theory as it relates to gases and internal energy.<br><br>d. Distinguish the relationships with energy transfer and temperature. |

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| | | | **HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.***[Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]<br><br>**HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics)**.[Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.] | |
| Energy conservation applies to thermal energy and heat | How does heat relate to average kinetic molecular energy? | Thermal processes & 3 laws of thermodynamics | **HS-PS3-1 Create a computational model to calculate the change in the energy of one** | The students will be able to: |

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| | How do a material's insulating properties affect the transfer of energy?<br><br>How do temperature differences of two of the same materials effect heat flow?<br><br>How does the first law of thermodynamics relate heat, work, energy conservation and internal energy?<br><br>How is the efficiency of a heat engine related to the amount of work it does?<br><br>What are the key characteristics of thermal processes?<br><br>What does Carnot's theorem say about the efficiency of an ideal engine?<br><br>What is the direction of entropy change in the universe? | **Vocabulary:**<br>heat engine<br>thermal reservoir<br>efficiency<br>isothermal<br>adiabatic<br>entropy<br>Isobaric<br>isometric | **component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.**[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]<br><br>**HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects)**.[Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the 219 energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]<br><br>**HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.***[Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable | a. Apply the three laws of thermodynamics to an ideal gas.<br><br>b. Explain the four processes of thermodynamics.<br><br>c. Explain heat engines and their efficiency. |

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| | | | energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]<br><br>**HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics)**.[Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.] | |
| Gases, Liquids and Solids: Fluids flow and change shape easily, whereas solids maintain a definite shape unless acted on by a force. | How does change in the cross-sectional area through which a fluid is flowing affect its speed?<br><br>How does a change in the speed of a fluid affect its pressure?<br><br>How is fluid viscosity related to work?<br><br>What causes the permanent deformation of a solid? | Gases, Fluids at rest & Fluids in motion, Solids<br><br>**Academic Vocabulary:**<br>fluid<br>ideal gas<br>mole<br>molar mass<br>atomic mass density<br>buoyant force<br>Bernoulli's Principle<br>lift<br>viscosity | **HS-PS3-1**<br>**Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.**<br>[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model. Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to | The students will be able to:<br><br>a. Explain the relationships of a moving ideal fluid and viscous fluid.<br><br>b. Explain fluid flow to Bernoulli's Principle.<br><br>c. Analyze examples that vary the buoyant force and determines whether an object will float. |

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| | What is the significance of the surface tension of a fluid and how is the arrangement of the surface atoms different from other atoms of that fluid?<br><br>What factors affect the pressure of a gas?<br><br>How are the concepts of moles and molar mass useful when measuring quantities of matter?<br><br>What does it mean to say one substance in more dense than another?<br><br>How does an external applied pressure affect an enclosed fluid?<br><br>What determines the buoyant force acting on an object in fluid? | surface tension<br>Hooke's law | thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.<br><br>**HS-PS3-2.**<br>**Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).**<br>[Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.<br><br>**HS-PS3-3.**<br>**Design, build, and refine a device that work s within given constraints to convert one form of energy into another form of energy.***<br>[Clarification Statement:<br>Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency. Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students. | d. Explain the relationship of restoring force to the stretch of the spring, aka Hooke's Law.<br><br>e. Explain and apply the relationship between the Force, Area, and pressure. |

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| | | | **HS-PS3-4.**<br>**Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).**<br>[Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.]<br>[Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.<br><br>**HS-PS4-1.**<br>**Use mathematical representations to support a claim regarding relationship s among the frequency, wavelength, and speed of waves traveling in various media.**<br>[Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.<br>Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively. | |

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| | | | **HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.**<br>[Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.<br>Assessment Boundary: Assessment is limited to qualitative descriptions. | |
| Matter is made of electric charges, and electric charges exert forces on the other.<br><br>Electric charges produce fields that exert forces and store energy.<br><br>Electrons flow through electric circuits in response to differences in electric potential. | Can you calculate the magnitude and direction of the electric force between two charged objects?<br><br>What amount of charge can an object have?<br><br>How is the electrostatic force between two charges related to the magnitude of the charges and the distance between them?<br><br>What is the electric field inside a charged conductor?<br><br>How is the total electric potential for two or more charges determined?<br><br>In what ways are static charges displayed in nature? | **Vocabulary:**<br><br>positive charge<br>negative charge<br>neutral<br>ohmmeter<br>resistor<br>coulomb<br>charge<br>quantization<br>ion<br>diode<br>magnetic domain<br>insulator<br>conductor<br>semi-conductor<br>solenoid<br>plasma<br>mass spectrometer<br>galvanometer | **HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.**[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]<br><br>**HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy** | The student will be able to:<br><br>a. Identify two kinds of electric charges and describe the interaction of like and unlike charges.<br><br>b. Describe the acquisition of net charge in terms of the gain or loss of electrons by friction, conduction, and induction, and explain that connecting objects to the ground discharges them.<br><br>c. Explain why an electrically charged object can attract an electrically neutral object.<br><br>d. Differentiate between conducting and insulating |

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| | What is the nature of electric force?<br><br>How are electrical energy, current and resistance related?<br><br>What conditions create current in an electric circuit?<br><br>What are the benefits of a parallel circuit and a series circuit?<br><br>How do electrons flow through a DC circuit? | Coulomb's law<br>electric field<br>electric dipole<br>capacitor<br>charging by induction<br>electric potential energy<br>electric potential (voltage)<br>volt<br>capacitance<br>electric current<br>electric circuit battery<br>electromotive force<br>resistance<br>Ohm's Law<br>series circuit<br>parallel circuit<br>ammeter<br>voltmeter | **associated with the relative positions of particles (objects).**[Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]<br><br>**HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy**.*[Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]<br><br>**HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction**.[Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [Assessment Boundary: | materials in terms of the ease that electrons flow in them.<br>e. Identify and apply the proportional relationships involved in Coulomb's law of electric force<br><br>f. Describe the concepts in an electrical circuit including electric potential energy, electric potential, voltage, current, and resistance.<br><br>g. Use each concept to explain the flow of charge through a simple circuit and to illustrate the electric circuit/water analogy.<br><br>h. Use Ohm's law (V = IR) to calculate circuit variables.<br><br>i. Explain that current is not "used up" in an electric circuit, rather, the electric potential energy of a charge is converted to heat energy as the charge flows through a resistor.<br><br>j. Identify the characteristics of simple series circuits including that the total resistance is equal to the sum of the resistances of the resistors, the current is constant throughout the circuit, and the sum of the voltages across the resistors equals the voltage across the voltage source. |

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| | | | Assessment is limited to systems containing two objects.]<br><br>**HS-PS4-5 the damage to living tissue from electromagnetic radiation depends on the energy of the radiation.** Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.] [Assessment Boundary: Assessment is limited to qualitative descriptions.] Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.* [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.] | k. Identify the characteristics of simple parallel circuits including the inverse of the total resistance is equal to the sum of the inverses of the resistors, the voltage across each resistor is the same as the voltage source, and the sum of the currents in the branches equals the current output by the voltage source.<br><br>l. Explain why houses are wired in parallel and describe short circuits and the function of circuit breakers.<br><br>m. Define power as the amount of energy transferred (work) divided by the elapsed time.<br><br>n. Define electrical power as the product of voltage and current and apply this to simple circuits. |
| Properties of Light<br>Light is a small but important part of the electromagnetic spectrum. Everything you see, either emits or reflects light | What are the properties of light?<br><br>Can you solve for the frequency or wavelength given the other?<br><br>Can you describe various uses for the different wavelengths/frequencies of the electromagnetic spectrum? | Nature of Light, Color & the Electromagnetic Spectrum, Polarization & Scattering of light<br><br>**Vocabulary:**<br>photon<br>electromagnetic wave<br>visible light<br>electromagnetic spectrum<br>primary colors of light<br>primary colors of pigment<br>subtractive primary colors<br>polarization | **HS-PS4-1.**<br>**Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).** [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two | The student will be able to:<br><br>a. Compare and contrast light waves to water and sound waves.<br><br>b. Explain the electromagnetic spectrum.<br><br>c. Explain the difference between the primary colors of light and pigments with color addition/subtraction. |

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| | What are the differences between primary and complementary colors of light?<br><br>How do the primary colors of light relate to the colors we see?<br><br>How does pigment produce its characteristic color?<br><br>What determines the direction of polarization and how is a beam of light effected by the polarizer? | polarizer | electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]<br><br>**HS-PS4-1.**<br>**Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.**<br>[Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air<br>and water, and seismic waves traveling through the Earth.<br>Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.<br><br>**HS-PS4-2.**<br>**Evaluate questions about the advantages of using a digital transmission and storage of information.**<br>[Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.<br><br>**HS-PS4-3.**<br>**Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.**<br>[Clarification Statement: Emphasis is on ho | d. Explain how the electromagnetic waves relate polarizers. |

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| | | | w the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.<br>Assessment Boundary: Assessment does not include using quantum theory.<br><br>**HS-PS4-4.**<br>**Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.**<br>[Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.<br>Assessment Boundary: Assessment is limited to qualitative descriptions.<br><br>**HS-PS4-5.**<br>**Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.***<br>[Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative | |

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| | | | information. Assessments do not include band theory | |
| Sound carries energy in the form of traveling waves of compression and expansion. | How is a sound wave produced?<br><br>What determines the pitch of a sound?<br><br>What causes beats? x How is the frequency of a sound you hear related to the motion of the source?<br><br>How does sound relate to the properties of waves?<br><br>How does the frequency of a sound change as the direction or speed of the source changes?<br><br>What is resonance and how does it occur in a sound wave?<br><br>How are intensity, decibel level and perceived loudness related?<br><br>What is the speed of sound at various temperatures and mediums?<br><br>Why does loudness of a sound decrease as you move away from it? | Sound waves & Beats, standing waves, Doppler Effect, Perception of Sound<br><br>**Vocabulary:**<br><br>Doppler Effect<br>decibel<br>intensity<br>frequency<br>pitch<br>medium | **HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.**[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.<br><br>**HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).**[Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.<br><br>**HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.***[Clarification Statement: Emphasis is on both qualitative and | The student will be able to:<br><br>a. Describe the motion of the wave and of the wave medium for transverse and longitudinal waves.<br><br>b. Define wave characteristics including amplitude, wavelength (λ), and frequency (f).<br><br>c. Solve problems using the wave equation ($v = f\lambda$).<br><br>d. Cite examples of the transportation of energy in waveform and describe that wave energy can be converted to other forms of energy.<br><br>e. Sketch and describe how wave fronts reflect off of plane and concave barriers.<br><br>f. Sketch and describe how wave fronts refract when crossing a boundary, how the change in wave speed at the boundary produces refraction, and how refraction is affected by the wavelength of the wave.<br><br>g. Sketch and describe how the crests and troughs of two transverse waves can interfere (add or subtract) while passing |

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| | | | quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for 232 quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.] Students who demonstrate understanding can:<br><br>**HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media**.[Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.<br><br>**HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter**.[Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, | through one another, and produce a pattern by two in-phase point sources.<br><br>h. Sketch and describe how wave fronts are diffracted when traveling through small apertures, and explain how diffraction varies with wavelength.<br><br>i. Illustrate that the wavelength of an approaching or receding wave source is different from the wavelength of a stationary wave source (i.e., explain the Doppler Effect). |

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| | | | videos, and other passages that may reflect bias.] [Assessment Boundary: Assessment is limited to qualitative descriptions. | |
| Waves are traveling oscillations that carry energy. | How are the period and the frequency of a periodic motion related?<br><br>What type of restoring force produces simple harmonic motion?<br><br>What factors affect the period of a pendulum?<br><br>What conditions produce resonance?<br><br>What determines the speed of a wave?<br><br>How does a standing wave form?<br><br>What are the properties of transverse and longitudinal waves?<br><br>What are some everyday examples of wave interference?<br><br>What is the behavior of a wave as it travels through different media? | Periodic motion, Pendulums, Wave properties & Interacting Waves<br><br>**Vocabulary:**<br>periodic motion period<br>frequency<br>destructive interference<br>resultant wave<br>Hertz<br>simple harmonic motion<br>restoring force<br>node<br>principle of superposition<br>amplitude<br>simple pendulum<br>natural frequency<br>standing wave<br>constructive interference<br>resonance<br>wave<br>transverse wave<br>oscillation<br>mechanical wave<br>longitudinal wave<br>crest<br>trough<br>antinode<br>medium<br>wavelength | **HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.**[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]<br><br>**HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).**[Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]<br><br>**HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.***[Clarification Statement: 228 | The student will be able to:<br><br>a. Describe the motion of the wave and of the wave medium for transverse and longitudinal waves.<br><br>b. Define wave characteristics including amplitude, wavelength (λ), and frequency (f).<br><br>c. Solve problems using the wave equation ($v = f\lambda$).<br><br>d. Cite examples of the transportation of energy in waveform and describe that wave energy can be converted to other forms of energy.<br><br>e. Sketch and describe how wave fronts reflect off of plane and concave barriers.<br><br>f. Sketch and describe how wave fronts refract when crossing a boundary, how the change in wave speed at the boundary produces refraction, and how refraction is affected by the wavelength of the wave.<br><br>g. Sketch and describe how the crests and troughs of two transverse waves can interfere |

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| | | | Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]<br><br>**HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media**.[Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.]<br><br>**HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.**[Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] | (add or subtract) while passing through one another, and produce a pattern by two in-phase point sources.<br><br>h. Sketch and describe how wave fronts are diffracted when traveling through small apertures, and explain how diffraction varies with wavelength.<br><br>i. Illustrate that the wavelength of an approaching or receding wave source is different from the wavelength of a stationary wave source (i.e., explain the Doppler Effect). |

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| | | | [Assessment Boundary: Assessment does not include using quantum theory.]<br><br>**HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter**.[Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.] [Assessment Boundary: Assessment is limited to qualitative descriptions.] | |
| Gravity acts on everything in the universe. | How do gravitational forces add together?<br><br>What is the defining characteristic of a black hole?<br><br>What is required to move an object along a circular path?<br><br>What are the defining characteristics of the centripetal force?<br><br>What is the law of gravity?<br><br>How can an object moving at constant speed be accelerating?<br><br>How can Newton's Law of Universal Gravitation be used to investigate satellite motion? | Universal Law of Gravitation, Gravity, Circular motion, Orbits<br><br>**Vocabulary:**<br>gravity<br>centripetal acceleration<br>centripetal force<br>spring tides<br>neap tides<br>Universal Law of Gravitation<br>tangential velocity | **HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.**[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]<br><br>**HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.***[Clarification Statement: Emphasis is on both qualitative and | The student will be able to:<br><br>a. Identify uniform circular motion.<br><br>b. Identify the type of force supplying the centripetal force that acts on any object in uniform circular motion.<br><br>c. Identify a centrifugal force as a fictitious force and explain how it results from an accelerated frame of reference.<br><br>d. Determine the directions of the velocity, acceleration, and net force vectors for an object in uniform circular motion. |

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| | How can the orbits of satellites be described? | | quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]<br><br>**HS-PS2-1. HS-PS2-2 Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration**.[Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.] Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.[Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.]<br><br>**HS-PS2-4 Use mathematical representations of Newton's Law of** | e. Apply the proportional relationship of the law of universal gravitation<br><br>f. Explain why a spaceship in a stable circular orbit is in free fall and why a person in that spaceship experiences weightlessness.<br><br>g. Use Newton's second law and the law of universal gravitation to show why all objects near the surface of the earth fall with the same constant acceleration. |

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| | | | **Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects**. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.] | |

**NOTE**: All of the topics listed above may not be covered every year.  Topics throughout the year will be determined in accordance with the integration of the PLTW topics.

**Materials and Resources:**

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Serway, Raymond and Faughn, Jerry.  Holt Physics.  Holt, Rinehart, and Winston, 2012.  (Same as CP Physics 1 and 2 Textbook)