| PSCI.PS3: Energy | | | |
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| Time Frame | Learning Outcomes | Online Resources | Crosscutting Concepts & Science and Engineering Practices |
| PSCI.PS3.1 Identify and give examples of various forms of energy (kinetic, gravitational potential, elastic potential) and solve mathematical problems regarding the work-energy theorem and power.<br>McGraw Hill: Chapter 4 (pp.106-127) | | | |
| Quarter 2<br>2 Weeks of Quarter | DOK 1:<br>1. Identify everyday phenomena that relate to various types of energy (kinetic, gravitational potential, elastic potential).<br>2. State the work-energy theorem.<br>DOK 2:<br>3. Solve for kinetic energy, mass, or velocity given two of the three variables in situational phenomena or math problems.<br>4. Given a data set, develop and use a mathematical model for work and power.<br>5. Solve for work, force, or distance given two of the three variables in situational phenomena or math problems.<br>6. Solve for power, work, or time given two of the three variables in situational phenomena or math problems.<br>DOK 3:<br>7. Solve for force, work, or power in situational phenomena or math problem requiring multiple steps and equations.<br>8. Solve for the appropriate quantity by applying the correct formula of power, work, or force that best matches the requirements of a given scenario.<br>DOK 4:<br>9. Apply the work-energy theorem to mathematically synthesize common phenomena. | Physics Classroom: notes, lessons, videos, and practice problems for energy<br><br>Khan Academy: notes, lessons, videos, and practice problems for energy<br><br>Better Lesson: multiple NGSS lesson plans (and other non-pertinent ones) | CCC:<br>Systems and System Models<br><br>SEP:<br>Developing and Using Models<br>Using Mathematics and Computational Thinking |

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<tr><th>Time Frame</th><th>Learning Outcomes</th><th>Online Resources</th><th>Crosscutting Concepts & Science and Engineering Practices</th></tr>
<tr><td colspan="4">PSCI.PS3.3 Design, build, and refine a define within design constraints that has a series of simple machines to transfer energy and/or do mechanical work.<br>PSCI.PS3.4 Collect data and present your findings regarding the law of conservation of energy and the efficiency, mechanical advantage, and power of the refined device.<br>McGraw Hill: Chapter 4, Sections 1 (pp.106-112)</td></tr>
<tr><td>Quarter 2<br>2 Weeks of Quarter</td><td>DOK 1:<br>1. Identify the six simple machines and their uses.<br>2. State the law of conservation of energy.<br>DOK 2:<br>3. Calculate the mechanical advantage, work, and efficiency of an inclined plane, a wedge, a pulley system, a lever (all classes), and a wheel and axel (mechanical advantage of screw not required) in math problems.<br>4. Identify the simple machines used in common mechanical devices.<br>DOK 3:<br>5. Design, build, and refine a mechanical device using three or more simple machines to complete work (i.e. Rube Goldberg machine).<br>6. Calculate the amount of work, efficiency, mechanical advantage, and power of each simple machine used in the designed mechanical device.<br>DOK 4:<br>7. Analyze other mechanical devices created in class or used in everyday applications for areas of inefficient energy transfer and recommend possible solutions.</td><td>cK-12: notes, lessons, videos, and practice problems for simple machines<br><br>Digital Trends: cool Rube Goldberg machine videos</td><td>CCC:<br>Structure and Function<br>Energy and Matter<br><br>SEP:<br>Using Mathematical and Computational Thinking<br>Designing Solutions</td></tr>
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| Time Frame | Learning Outcomes | Online Resources | Crosscutting Concepts & Science and Engineering Practices |
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| PSCI.PS3.5 Investigate the relationship among kinetic, potential, and total energy within a closed system (the law of conservation of energy).<br>McGraw Hill: Chapter 4, Sections 2 & 3 (pp.114-127) | | | |
| Quarter 2<br>.5 Weeks of Quarter | DOK 1:<br>1. Define kinetic energy, potential energy, and mechanical energy.<br>2. Identify examples of kinetic energy and potential energy in everyday phenomena.<br>3. Identify locations of greatest kinetic and greatest potential energy in a closed system.<br>4. State the relationship of kinetic and potential energy in a closed system.<br>DOK 2:<br>5. Calculate gravitational potential energy, height, or mass given three of the four variables in situational phenomena or math problems.<br>6. Calculate the height, gravitational potential energy, and kinetic energy in a closed system in situational phenomena or math problems.<br>DOK 3:<br>7. Calculate the velocity, height, mass, or acceleration of an object in free fall or travelling down a ramp when given three of the four variables.<br>DOK 4:<br>8. Analyze the law of conservation of energy in relation to its application of everyday phenomena such as meteorites, rockets, and other systems with potential and kinetic energy communicating instances of “lost” energy in the system. | Physics Classroom: notes, lessons, videos, and practice problems for kinetic, potential, and mechanical energy<br><br>Khan Academy: notes, lessons, videos, and practice problems for kinetic, potential, and mechanical energy | CCC:<br>Energy and Matter<br>Systems and System Models<br><br>SEP:<br>Using Mathematical and Computational Thinking<br>Constructing Explanations |

| Time Frame | Learning Outcomes | Online Resources | Crosscutting Concepts & Science and Engineering Practices |
|---|---|---|---|
| PSCI.PS3.2 Plan and conduct an investigation to provide evidence that the thermal energy will move as heat between objects of two different temperatures, resulting in more uniform energy distribution (temperature) among objects.<br>PSCI.PS3.6 Determine the mathematical relationship among heat, mass, specific heat capacity, and temperature change using the equation Q= mCp^T.<br>McGraw Hill: Chapter 5, Sections 1 & 2 (pp.136-150) | | | |
| Quarter 2<br>1 Week of Quarter | DOK 1:<br>1. Define heat, temperature, thermal energy, and specific heat.<br>2. Identify everyday phenomena involving energy transfer in the form of heat.<br>3. Define the three ways thermal energy is transferred.<br>DOK 2:<br>4. Describe the effect of mass on thermal energy.<br>5. Describe the influence of materials on heat.<br>6. Calculate heat, specific heat capacity, mass, or temperature change in situational phenomena or math problems when given three of the four variables.<br>DOK 3:<br>7. Plan and carry out an investigation to provide evidence that thermal energy will move as heat between objects of two different temperatures, resulting in more uniform energy distribution among the objects.<br>DOK 4:<br>8. Apply understanding about the principles and variables of thermal energy transfer and materials to connect, critique, or create designs meant to control thermal transfer. | worksheet: math calculations<br><br>Physics Classroom: notes, lessons, videos, and practice problems around thermal energy<br><br>PBS Learning: animation and examples of thermal energy transfer | CCC:<br>Energy and Matter<br><br>SEP:<br>Constructing Explanations<br>Using Mathematical and Computational Thinking<br>Planning and Carrying Out Investigations<br>Analyzing and Interpreting Data |

| Time Frame | Learning Outcomes | Online Resources | Crosscutting Concepts & Science and Engineering Practices |
|---|---|---|---|
| PSCI.PS3.8 Plan and conduct an experiment using a controlled chemical reaction to transfer thermal energy and/or do mechanical work.<br>PSCI.PS3.9 Demonstrate the impact of the starting amounts of reacting substances upon the energy released. | | | |
| Quarter 2<br>1 Week of Quarter | DOK 1:<br>1. Identify the role of energy in chemical reactions.<br>DOK 2:<br>2. Conduct a designed experiment to identify the type of reaction occurring and relate the results to the ability of the reaction to complete work.<br>3. Identify chemical reactions that people use that involve chemical reactions to complete work or transfer thermal energy.<br>DOK 3:<br>4. Design a demonstration that illustrates the impact of starting amounts of reactants upon the energy released in a chemical reaction.<br>5. Define a problem that can be solved with the application of chemical reactions and formulate possible solutions based on your understanding of the types of chemical reactions.<br>DOK 4:<br>6. Plan and carry out an investigation based on the possible problem and solutions proposed to actually complete the transfer of thermal energy or complete mechanical work. | LibreTexts: advanced application of chemical reactions doing work (combustion engine)<br><br>Lumen Learning: explanation of thermodynamics and how chemical reactions can do work with examples | CCC:<br>Energy and Matter<br>Scale, Quantity, and Proportion<br><br>SEP:<br>Constructing Explanations and Designing Solutions<br>Asking Questions and Defining Problems<br>Planning and Carrying Out Investigations |

| Time Frame | Learning Outcomes | Online Resources | Crosscutting Concepts & Science and Engineering Practices |
|---|---|---|---|
| PSCI.PS3.7 Demonstrate Ohm's Law through the design and construction of simple series and parallel circuits.<br>McGraw Hill: Chapter 6 (pp.168-199) | | | |
| Quarter 2<br>1 Week of Quarter | DOK 1:<br>1. Define voltage, resistance, circuit, and electric current.<br>2. Identify symbols used in a basic electric schematic.<br>3. Identify common energy conversion in circuits.<br>DOK 2:<br>4. Differentiate between a simple series and parallel circuit and the impact on appliances within those circuits in terms of available current.<br>5. Calculate amperes (current), voltage, or resistance (ohms) when given two of the three variables in situational phenomena or math problems.<br>6. Construct an explanation about ways to increase the resistance in a circuit.<br>DOK 3:<br>7. Construct a schematic for simple series and parallel circuits used in common applications, and calculate the current, resistance, and voltage for each part of the circuit.<br>8. Build simple series and parallel circuits using lights to demonstrate Ohm's Law and gather evidence of the relationship among voltage, current, and resistance.<br>DOK 4:<br>9. Design a schematic using an appropriate circuit for a practical household application using 120 volts and 20amps, calculating the electric needs in terms of current to ensure the circuit can support all the appliances in the circuit. | Khan's Academy: videos and notes about circuits and Ohm's Law.<br><br>Physics Classroom: notes and practice problems with audio explanations about circuits<br><br>All About Circuits: notes, worksheets, and schematics on circuits<br><br>Power Consumption: list of power consumption of common household appliances (for use with #7-9) | CCC:<br>Systems and System Models<br>Cause and Effect<br><br>SEP:<br>Using Mathematic and Computational Thinking<br>Constructing Explanations and Designing Solutions |
| PSCI.PS4: Waves and Their Applications in Tecchnologies for Information Transfer | | | |

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<tr><td colspan="4">PSCI.PS4.1 Use scientific reasoning to compare and contrast the properties of transverse and longitudinal waves and give examples of each type.<br>McGraw Hill: Chapter 9 (pp.272-285)</td></tr>
<tr><td>Quarter 2<br>1 Week of Quarter</td><td>DOK 1:<br>1. Draw, label, and define the parts of a transverse wave.<br>2. Draw, label, and define the parts of a longitudinal wave.<br>DOK 2:<br>3. Differentiate the transfer of energy and motion in a transverse and a longitudinal wave.<br>4. Identify the phenomena that result in a transverse or a longitudinal wave.<br>DOK 3:<br>5. Cite evidence of the transfer of energy through space or matter by collecting data through observation of everyday phenomena.<br>DOK 4:<br>6. Applying your understanding of transverse and longitudinal waves, analyze why humankind uses transverse or longitudinal waves in various applications.</td><td>Physics Classroom: Lesson 1 includes notes, lessons, videos, and practice problems about waves<br><br>Khan Academy: video and questions about waves</td><td>CCC:<br>Energy and Matter<br>Structure and Function<br><br>SEP:<br>Constructing Explanations and Designing Solutions</td></tr>
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Supporting Document for Curriculum Guide

2nd Quarter

This nine-week period focuses on energy and on the ability of energy to do work. There is a number of formulas students will use to calculate energy, work, and power to quantify and better describe these phenomena. Students will be expected to complete various projects that require the application of their understanding of energy and work and to calculate the results of those projects mathematically. All scientists and engineers are limited by the tools used for measuring results, and that will be no different for our students. Much of the unit hints around some of the laws regarding thermodynamics, especially PS 3.2, PS3.6, PS3. 8, and PS3.9. However, students are not expected to learn these laws as that will be covered in advanced science classes if taken. They may come across these laws in their internet research. Circuits are quickly explored and relates to the transfer of electrical energy. Waves, the transfer of energy, are introduced at the end of the quarter and fully explored in the 3rd quarter.

PSCI.PS3.1

1. Work-energy theorem: the net force acting on an object are equal to the change in kinetic energy
2. Kinetic energy formula: $KE = .5mv^2_f - .5mv^2_i$, kinetic energy is measured in Joules ($J = kgxm^2/s^2$)
3. Work formula: W=fd; kinetic energy = work; measured in Joules
4. Power formula: P = w/t, measured in watts (J/s)
5. Kinetic energy and work are used to measure the same quantity. Power is good for comparing the energy expended over time between different machines or people (power rating).
6. Students can simulate the amount of energy or power involved in various scenarios like car accidents and rocket launches, or work completed by simple machines.

PSCI.PS3.3 & PS3.4

1. The law of conservation of energy states that energy cannot be created nor destroyed. Energy can only be transformed.
2. Generic mechanical advantage formula: $MA = F_{out}/F_{in}$
3. Simple Machines:
    a. Lever (1st, 2nd, and 3rd class), MA = (distance of effort to fulcrum)/(distance of load to fulcrum)
    b. Wheel and axle, MA = (radius of wheel)/(radius of axle)
    c. Pulley, MA = # of ropes that support load
    d. Inclined plane, MA = (length of hypotenuse)/(height of plane)
    e. Wedge, MA = length/width
    f. Screw, smaller the pitch (distance between threads) the greater the mechanical advantage
4. Machines either increase speed, change direction of force, or increase force.
5. Work is the transfer of energy, thus when machines perform work they are simply transferring energy from one object to another.
6. No machine is 100% efficient. Energy is lost from a system in the forms of heat, light, sound, or other type of energy.

7. Efficiency = $W_{out}/W_{in}$ x100

PSCI.PS3.5

1. Kinetic energy: energy of motion
2. Potential energy: stored energy
3. Mechanical energy: total energy (kinetic and potential) in a closed system
4. Students can determine the potential energy of an object given its height using the acceleration of gravity. When the object is dropped, students can determine the potential and kinetic energy at specific heights. By subtracting the new potential energy from the original potential energy, since the energy is only transformed, then the remaining energy is kinetic. Furthermore, students can calculate the speed of the object at different heights by using the kinetic energy formula.
5. Since no system is truly closed, students need to understand how the law of conservation of energy applies to everyday phenomena and in the design of various systems. Natural phenomena such as meteorites striking the Earth lose energy from within a system to exterior forces such as friction. The overall energy is not lost, as it is just transferred to another form such as heat or sound, but the total energy within a system can be changed as that energy transfer occurs. Thus, a meteor entering the atmosphere does not convert all potential energy directly into kinetic energy as some of the energy is converted into light, sound, and heat. This also occurs in manmade systems such as rockets and vehicles. The interaction of outside forces, namely friction, result in the system losing energy.

PSCI.PS3.2 & PS3.6

1. Heat is the transfer of thermal energy. Temperature is a measure of the average kinetic energy of a substance. Thermal energy is the total potential and kinetic energy of the particles in a substance. Specific heat is the amount of heat needed to raise the temperature of 1kg of material by 1*C. The unit for specific heat is J/(kgx*C).
2. Heat transfer occurs as conduction (collisions between materials), convection (fluids), and radiation (transfer as electromagnetic waves).
3. The mass of a substance is directly proportional to the thermal energy of the material. For example, two cups of water have twice the thermal energy as one cup of water at the same temperature.
4. Specific heat of a material is influenced by the properties of that matter including density, type of chemical bonds, and intermolecular forces to name a few. As such, some materials are capable of absorbing more heat before the temperature of the material is raised.
5. The relationship between heat, mass, specific heat capacity and temperature is represented by the mathematical model Q=mCp^T where Q is heat, m mass, Cp specific heat, and ^T the change in temperature. The model is good at explaining the amount of heat required to change the temperature in a substance. For example, metals have low specific heat capacities. Since specific heat and mass and temperature are multiplied (directly related), metals do not require as much heat to change the temperature in comparison to substances such as air or water. That is why metals are classified as

conductors and are used in cooking applications. You can also see how the mass of an object would increase the amount of heat required to change the temperature.

6. There are a number of common applications that demonstrate the transfer of thermal energy as heat. In connecting, critiquing, or creating designs of systems meant to control thermal transfer, students need to consider the implications of the mathematical model. By considering the specific heat of different materials, students should be able to identify materials that are efficient at thermal energy transfer and when that would be desired, and also identify materials that are good at reducing thermal energy transfer and when that would be desired. Other considerations beyond the math include cost of the material and impact on the environment.

PSCI.PS3.8 & PS3.9

1. These standards are the equivalent of the engineering, technology, and applications of science standards present in other science courses. It requires the use of acquired knowledge from previous lessons to complete a project-based or design task. The students have not learned about chemical reactions at this point in physical science. However, the standard is included here because of the emphasis on thermal energy and mechanical energy and students were taught chemical reactions in $7^{th}$ grade science.
2. All chemical reactions are either endothermic (absorbs energy) or exothermic (release energy). However, some reactions result in greater energy exchange than others. Some are nearly imperceptible.
3. Students can complete simple reactions (baking soda and vinegar or Calcium chloride and water) to get a real sense of endothermic and exothermic reactions. Using a thermometer will provide more accurate data if wanted. Once students note that energy can be released or absorbed, they should consider that the change in energy can be used to complete work or change the thermal energy in another substance. Identifying everyday examples of humankind's application of chemical reactions can help solidify their understanding. Examples include the conversion of energy in gas to expand air and push pistons which power a car (mechanical work). People also use that same idea to in thermal energy transfer to melt ice (calcium chloride), cook food (gas stove), and treat bruises (ice pack).

*The online resources are mainly for teachers. Students will need to complete their own online research to identify examples and consider possibilities of using chemical reactions to transfer thermal energy and complete work. Combustion reactions are commonly considered for completing work. Any reaction that is very endothermic or exothermic are used for thermal energy transfer, including combustion reactions again.

PSCI.PS3.7

1. Voltage difference is measured in volts and is a measure of the difference between in charges between two points. Resistance is measured in ohms and is the tendency of a material to resist the flow of electrons. A circuit is a closed path that allows electricity to flow. Electric current is measured in amperes and is the net movement of electric charges in a single direction.
2. Basic symbols needed in an electric schematic are resistor, conductor, and battery.

3. Energy in circuits are often converted into heat, light, sound, or mechanical energy.
4. Simple circuits have all resistors on a single path and result in an increase in resistance and a decrease in current. Lights in a series circuit will appear dimmer with the greater number of lightbulbs in the circuit. Furthermore, if one light goes out then all lights go out. Parallel circuits have separate branches for resistors. This means that there is less resistance in each branch and thus more current. Lightbulbs in a parallel circuit will usually appear at the same brightness. Sometimes when using batteries this may not actually occur and the furthest lightbulb will be dimmer. However, this is the result of weak batteries and increased resistance in the circuit furthest from the battery due to the wire length.
5. V=IR where V is voltage, I current, and R resistance. In a parallel circuit, each branch must be calculated separately. The total resistance in a parallel circuit is calculated using $R_T=1/(1/R_1) + (1/R_2) +\ldots$ Total current is simple the current from each branch added together. In a parallel circuit the total resistance is less than the resistance on any single line. In a simple series circuit, the resistance on the line is added together to complete the calculations.
6. Resistance increases with the length of the wire, gauge of wire (thinner = greater resistance), and temperature. Lights burn out when the filament gets too hot and the resistance too great resulting in the breakage of the filament. Semi-conductors are used in dimmable switches because the resistance along the dial changes dramatically over a short distance.
7. Most household circuits are parallel circuits. The standard voltage in a household is 120V (240V for dryers and stoves) and the common breaker is for 20amps. Often a set of lights, receptacles, and major appliances will be placed on different circuits. Circuits are designed to support the most common appliances within the circuit. Sometimes circuits are overwhelmed (liking running an air fryer and a crock pot simultaneously) and causes the breaker to flip. Using the power consumption list, students can backward design circuits most likely found in their homes (i.e. oven, fridge, kitchen receptacles, media room, etc.). The appliances are listed in watts which is current times voltage (P=IV). Given the wattage, students can infer that higher wattage means more current since voltage is fixed at 120V. If a breaker only has a total of 20amps of current to provide, too many appliances requiring high current will result in the breaker flipping.

PSCI.PS4.1

1. A transverse wave transfers energy through space or matter and the molecules travel perpendicular to the direction of the wave.
   a. resting position: arrangement of molecules when no energy is flowing through it
   b. amplitude: amount of displacement of a molecule from the resting position (determined by amount of energy)
   c. wavelength: distance from one part to another corresponding part on the wave (i.e. crest to crest)
   d. crest: maximum displacement of a molecule above the resting position
   e. trough: maximum displacement of a molecule below the resting position

2. A longitudinal wave transfers energy through matter only and the molecules travel parallel to the direction of the wave.
    a. wavelength: distance from one part to another corresponding part on the wave (i.e. compression to compression)
    b. compression: dense region of a longitudinal wave where molecules are pushed together
    c. rarefaction: region where the molecules are pulled apart from each other
3. Examples of transverse waves include all electromagnetic waves (because they travel through space) such as light, s-waves in an earthquake, and waves along a rope. Longitudinal waves include sound, p-waves in an earthquake, and waves in a slinky.
4. Transfer of energy can be noted by the movement of materials or its heating. For example, sound waves can be detected in the movement of water or even the vibration of other objects depending on the amplitude of the sound. Transverse waves are detected as light from the sun (travels through space) and also heating objects from the sunlight such as sidewalks or sand.
5. Humankind uses different waves depending on the application and the property of the wave. For example, electromagnetic waves travel at the speed of light and are used in telecommunications. They can also travel through space allowing for the use of satellites to transport information across the world. Longitudinal waves are created by speakers to allow for sound to be produced. The vibrations of longitudinal waves are detected by ears. Longitudinal waves are used to help concrete settle as the vibrations of the matter cause more dense materials to sink and less dense to rise. The vibration can also be transferred into kidney stones that are sensitive to vibrations because of weak crystal bonds and resonance that result in the stone being shattered.