Physical Universe

Quarter 1

Unit 1: Forces and Motion

Guiding Questions

How can Newton's Laws be used to explain how and why things move?

How can mathematical models of Newton's Laws be used to test and improve engineering designs?

Students who demonstrate understanding can:

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.]

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Students who demonstrate understanding can:

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.]

	Performance Tasks	Skill/Assessments/Activities	Materials/Resources
Disciplinary Core Ideas ● PS2.A : Forces and Motion **Science and Engineering Practices** ● Mathematics	**Topic: Distance, Speed and Acceleration** **Phenomena/Observations - use video:** (1) Show Car Race, Sprint running, swimmers, etc - What makes one a winner? *(one who moves fastest, covers the same distance in least time,..)* ***1.*** Show videos or realia and have students describe, then compare and contrast the motions of a (b1) battery operated toy car and a (b2) pull back car. *(b1 . constant or uniform motion or speed, and b2 is one that speeds up)* **2.** Elicit other examples of uniform motion, non uniform motion from students. ***Part A. Concepts: Position and Speed*** Have students: **3.** Gather distance and time data of an object that moves with constant speed like a battery operated toy car or a person walking at constant speed and organize them in a distance-time table. (Distance here is measured from the origin to where the	Speed Unit: Skill Development: ● Writing verbal descriptions of observed phenomena ● Collecting data from observed phenomena ● Representing data in a graphical form ● Interpreting graphical data ● Developing mathematical models from graphical	•**<u>Flexbook Topics:</u>** First Quarter 1. The World of Science 2. World of Science and Technology 2.1. What is Science 2.2. Scientific investigation 2.3.Science skills 2.4. Technology 3. Motion-Observable Phenomena 4. Motion 4.1. Distance and displacement 4.2. Speed and Velocity 4.3 Acceleration **<u>Phenomena Identification Links</u>**: https://www.youtube.com/watch?v=wDITJkDV1nk

and Computational Thinking ● Developing and Using Models ● Planning and Carrying Out Investigations ● Defining Problems **Crosscutting Concepts** ● Cause and Effect: Mechanism and Explanation ● Systems and System Models ● Structure and Function	object is at that time) **4.** Construct distance-time graph for an object moving with constant speed. Describe trend of graph and relate to verbal description of phenomena **5.** Determine the slope of the graph. Discuss the physical meaning of the slope of a distance-time graph. Develop mathematical model of the phenomena from the graph. (speed/velocity, $v = \Delta d/\Delta t$) **6.** Do steps #3 and 4 with an object that speeds up like pull back car or a lab cart moving down a ramp ***7.*** Compare the distance- time graphs obtained for a uniform and a nonuniform (speeding up) motions. Focus on what happens with the slope of the graphs between two time intervals as time progresses. *(For Uniform motion the slope of the graph remains the same, while the slope of the distance-time graph of the object that speeds up increases as time goes on).* **8.** Apply the mathematical model (speed/velocity, $v = \Delta d/\Delta t$) to other observed phenomena like speed records at Bonneville Salt Flats or other daily examples. ***Part B. Accelerated Motion - Speeding Up Concept: Positive Acceleration*** ***1.*** Use the motion detector. First set it to gather and graph distance - time for a lab cart moving down the ramp. Record the graph shown on the monitor. Compare the graph on the monitor with what you got in Part A #7. *(The graphs should be similar)*	representations ● Using Google Sheets to analyze data make graphs ● Using motion detectors and other probeware to collect and analyze data ● Applying mathematical models to other observed phenomena Activities: ● Day 1: Observe a constant velocity vehicle - describe its motion, determine what data could be collected from the phenomena and collect data ● Day 2: Analyze data by	**<u>Suggested Labs:</u>** 1. Investigating Motion- Investigating constant velocity with a motion detector (vernier). 2. Graph Matching- plot graphs of position (vernier) 3. Mousetrap Car - Investigating motion Note: Get copy of the procedures from Vernier.com

	2. Roll the cart again, with nothing changed except the setting on the motion detector. This time collect speed/velocity-time. Have students describe the speed/velocity-time graph. *(Linear - speed increases as time goes on.)*		

●	**http://www2.vernier.com/sample_labs/MSV-33-CALC-graph_motion.pdf** **3.** Analyze the slope of a speed/velocity-time graph. *(The slope of the v-t graph is equal to the acceleration of the object; that is, acceleration = change in speed/time interval.)* In equation form: $a = \Delta v/\Delta t$; or $a = \frac{v_f - v_i}{t}$ Based on the above relationship and the speed/velocity-time graph obtained for the cart rolling down the ramp, predict what kind of acceleration-time graph you will obtain with the cart rolling down the ramp. (Straight - horizontal line). Calculate for the acceleration of the cart using the above relationship. **4.** Roll the cart again, with nothing changed except the setting on the motion detector. This time collect acceleration-time data. Compare the graph on the monitor with your prediction done in #6. Explain your observation. **5.** Have the cart roll down ramp at different angles of incline (Vary angle at least 5 times with increment of 5 degrees). Determine the relationship between the angle of the incline and the acceleration of the cart. Discuss what limits maximum acceleration. **6.** Determine the acceleration due to gravity using Vernier	constructing graph of data, describe trend of graph and relate to verbal description of phenomena ● Day 3: Develop mathematical model of the phenomena from the graph by finding slope ● Day 4: Use Google Sheets to graph and analyze the data collected ● Day 5: Apply the mathematical model to other observed phenomena like speed records at Bonneville Salt Flats Acceleration Unit: Skill	

	Motion Detector or Picket fence and Photogates. ***Part C. Accelerated Motion - Slowing Down Concept: Negative Acceleration*** **1.** Show the distance-time graph, then the speed/velocity-time graph of an object that slows down using the motion detector (Example: block pushed to move on the floor/table). **2.** Compare the distance-time graph and the speed/velocity-time graph of this object with one that speeds up (Part B). Have them predict the kind of acceleration-time graph the object has. Compare their prediction with the actual one gathered using the motion detector. ***Summarize, compare/contrast the (a) distance-time, (b) speed/velocity-time, and (c) acceleration - time graphs of the different types of motion investigated by filling up the table below:***	Development: ● Describing accelerated motion verbally ● Graphing and analyzing nonlinear data ● Using photogates ● Predicting trends in data Activities: ● Day 1: Observe and describe accelerated motion or cart on ramp, determine what data could be collected to develop model of motion and method of collecting data ● Day 2: Collecting data on cart rolling down ramp from varying	

	Topic: Newton's **Second Law *Part A.*** ***Force and acceleration*** Have students: **Phenomena:** Describe the motion of a. Ball tossed up b. Roller coaster ride - down, up, down **1.** Sketch path taken by the moving object, divide the sections of the path and label each portion "speeds up" or "slows down" **2.** Make a claim as to what causes an object speed up or slow down ***3.*** Observe the motion of Lab Cart on table/pulley that is pulled with small weight. *(For the teacher: Make the length of the string half the entire distance the lab cart will travel. Push the cart away from the pulling weight. Students should see the cart speeding up then slowing down)* **4.** Describe the motion of cart; sketch the path of the cart then label portions with "speeding up" and "slowing down". Draw the direction of motion using arrows, and label arrows "v". The hanging weight exerts force on the cart. Draw the direction of	distances, graph data and describe graph • Day 3: Show cart rolling down ramp at different angles of incline and have students determine relationship between angle and acceleration, what limits maximum acceleration, what causes the acceleration • Day 4: Collecting data on acceleration due to gravity directly (dropping picket fence with photo gates) graphing with google sheets.	<u>**Flexbook Topics:**</u> 5. Forces in the Universe- Observable Phenomena (p.58) 6.Forces (p.59) 6.1 What is Force(60-64) 6.2 Newton's First Law (p.65-68) 6.3 Newton's Second Law (p.69-73)

	the force (arrows) on the cart and label it “F”. Relate the direction of “v” and “F” while the cart was speeding up and while it was slowing down. *(Their sketch should show that the arrows of v and F are opposite when the cart was slowing down and the v and F are in the same direction when the object was speeding up)* **5.** Revisit your claim made in # 1 and 2 above. Identify the force (/forces) that could have caused the tossed ball and the roller coaster to slow down and speed up. *(Gravitational force*). Have them complete the CER process. **6.** Summarize the important concept the students should have learned: ● Force opposite the direction of an object’s motion causes object to slow down and force in the direction of the object’s motions causes the object to speed up. In other words force cause an object to change speed or accelerate. **7.** Think or other examples of nonuniform motion and identify the forces acting on them (friction, gravitational force, air friction, buoyant force, etc) ***Part B. Relating Force and Acceleration*** **1.** Use the Lab Cart on table/pulley that is pulled with varied force. Keep mass (of cart) constant. Make the force the independent variable. For varying the force you may increase the hanging mass by 20-g mass each time, at least 5 different values. (Remember, Force = Weight of hanging mass = mass in kilograms x acceleration due to gravity, F = m x 9.8 m/s^2). Make the length of the string about 10 cm less the height of the table. Pull the cart away from the pulley, them simply release. Use the Vernier Motion Detector to determine the acceleration of the cart. Have students tabulate the acceleration of the cart for each force acting on it then graph force versus acceleration.	Newton’s Second Law Unit:	Phenomena Identification Links: Suggested Labs: 1. Newton’s second Law- Experiment 9 on physics with vernier.- This experiment uses an accelerometer to directly measure the acceleration. (Use vernier Equipments)

Disciplinary Core Ideas • ETS1.A: Defining and Delimiting Engineering Problems • ETS1.B: Developing Possible Solutions	**2.** Based on the graph, have students relate Force (F) and Acceleration (a). That is, $F \alpha a$ (Force is directly proportional to acceleration). The proportionality constant is the mass of the cart so in equation form: $F = ma$, which is Newton's second law. ***Part C. Solution to an Engineering Problem:*** ***Choose*** *from available materials, design a car that is moving the fastest at the 2-m mark from starting point. Car will be launched with a constant force launcher.* *Explain your choice of material and design before car is launched.* ***Materials for the car (get only what you need):*** *bottle caps (different widths will be available), straw, barbeque stick, masking tape, washers, balloon (not to be inflated), cardboard or thin balsa wood* ***Other Materials:*** *Constant force launcher, hot glue gun, pair of scissors*		

Unit 2: Momentum, Impulse and Collisions

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.]

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.]

Disciplinary Core Ideas	Topic: Momentum		Flexbook Topic::
• Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved. (HS-PS2-2) • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3)	**Phenomena:** 1. Show pictures/videos of a truck and a car traveling side by side on a highway. Ask why trucks are given a lower speed limit than cars. Ask further question: Suppose that these vehicles are running with the same speed and they run unto a similar barrier, which vehicle would result to a greater damage on the barrier? 2. Show a second video of two similar cars one moving slow and another one moving faster. Suppose that these vehicles are running with the same speed and they run unto a similar barrier, which vehicle would result to a greater damage on the barrier? **Lesson Proper:** 1. Have the class do an activity to simulate Phenomena 1 above. Ask students to write their observations. You may use: (a) two Vernier dynamics carts, one with two loads and the other none. Have the carts move with the same speed down their respective tracks and have similar barriers that crumples/folds permanently at the end of their tracks. You can make the carts move with same speed if the tracks are tilted with the same small angle. (b) a big and a small steel ball that will roll down on a (an aluminum) track tilted with the same angle. First show that the two balls move with equal speeds at the foot of the inclined track. Have the barrier at the foot of the incline. 2. Have students explain their observations on the effect of the two objects on the barrier. Guide the discussion until you elicit the idea that the different effects on the barrier is caused by the objects' difference in **mass.** 3. Simulate Phenomena 2 by using carts of the same mass or similar balls one moving faster (moving on a steeper incline) than the other. Put a barrier at the end of each track. Have students explain their observations, then guide the class to have a discussion and a summary - that the different effects on the barrier is caused by the objects' difference in **speed.** 4. Introduce the word momentum. To minimize misconception on		6.4 Newton's Third Law (P.74-7) Suggested Labs: 1. Two objects (Vernier dynamics carts or a big and a small steel ball of different masses on an aluminum track) moving with the same speed 2. To objects

momentum later on, it is good to have students describe “momentum”as it is used in daily language, then move on to describe momentum in science. Connect momentum to your earlier discussions of the above phenomena. The objects produced different degree of effect on objects placed along their way. A greater effect on the barrier indicates that the moving object is more difficult to stop, hence greater momentum. In Activity 1a, the difference in momentum is due to their different in masses, and in Activity 1b, the difference is caused by their different speeds. Putting the two observations together will lead you to the concept of momentum, that is:

Momentum(p) = mass (m) x velocity(v), or $p = mv$
The SI unit of momentum is kg.m/s

5. Check for understanding: Have students answer some questions and word problems.

Topic: Collision and Impulse

Phenomena:

1. Have them do a long jump and observe what they do with their knees when they land. -- flex knees or make knees rigidly straight? Why?

3. Have them catch baseball on the side of their body - do try to catch the ball with straight, rigid hand or sway you hand backward as you catch the ball? Why?

4. You may use other phenomena/daily connection: Have students talk about their ideas about the use of a helmet, seat belt, airbag. have them think about some connections between the phenomena they talked about in #1 - 3.

Lesson Proper:

1. Discuss:
(a) that when an object collides with an object, its velocity decreases or increases, or in other words the velocity of the object changes. Have students give examples of situations where the velocity of an object decreases/increases at impact.
(b) When an object collides it is acted on with a force. Do the activity

<u>Flexbook Topic:</u>
9. Momentum and Collision (p.163)

10. Momentum and Impulse (p. 164-167)

11. Conservation of momentum in one dimension(168-171)

using the Vernier dynamics cart and observe the force that acts on the car during collision. Discuss: the force that acts on the car happens within a period of time and this changes the velocity of the car. In other words:

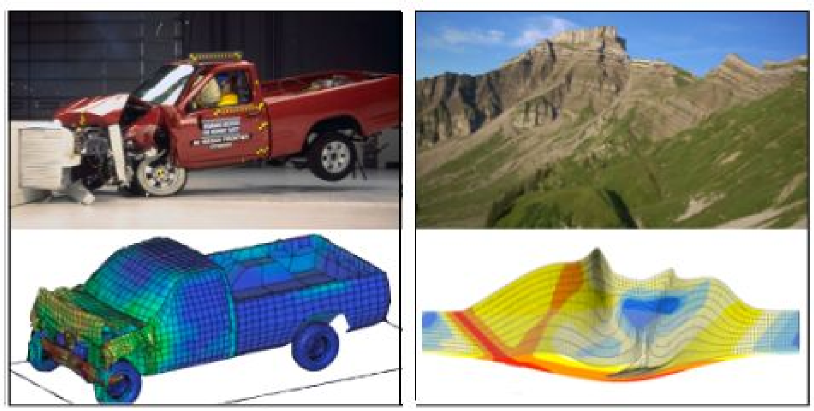
Force x Time of Collision = Change in Momentum

2. Discuss with the students the implication of the above relationship to sports and with their daily lives.

(a) Catching a ball - A ball going toward a catcher has a certain momentum. Whether the catcher catches the ball with swaying hand or not, the ball has to stop, so the change in momentum will be the same in any situation. You hand will experience a greater force (and will hurt more) if the catcher will not sway his/her hand because the time of collision is much shorter. Swaying the hand makes the time of collision much longer, reducing the force.

(b) Helmet, airbag, seatbelt all make collision time of the part of the body much longer making the force experienced by the passenger much less.

3. Connect collision with mountain building. During collision of a car onto a concrete, the front of the car crumples. This is also of true when two land masses collide. The lighter one crumples just like the formation of the Himalayas as India collided with Eurasia.



Solution to an Engineering Problem:

	Given *one page of newspaper, 1 -m string and 1-m of 1-inch wide masking tape, create a container for a raw egg that will be dropped from a height of 2 - 3 meters and and must not break.*		

Unit 3: Forces at a Distance

Guiding Questions

How can different objects interact when they are not even touching?

How do interactions between matter at the microscopic scale affect the macroscopic properties of matter that we observe?

How do satellites stay in orbit?

Students who demonstrate understanding can:

HS-PS2-4 Use mathematical representations of Newton's Law of 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.]

HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.]

Science and Engineering Practices • Analyzing and Interpreting Data • Mathematics and Computational Thinking	**Topic: Circular Motion** **Phenomena:** 1. Show videos of objects undergoing circular motion. Ask what makes the object move around in circle. **Lesson Proper:** 1. Whirl a rubber object at the end of a string. Again, ask what makes the object move around in circle. (Force exerted by the string on the object.) 2. Show that if the Force (string is let go) is remove, the object no longer moves in a circle.		**<u>Flexbook Topic:</u>** 8.1. Circular Motion (p. 84-88)

• Developing and Using Models • Planning and Carrying Out Investigations • Constructing Explanations (For Science) and Designing Solutions (For Engineering) • Obtaining, Evaluating, and Communicating Information **Crosscutting Concepts** • Cause and Effect • Structure and Function • Scale, Proportion, and Quantity **Disciplinary Core Ideas** • ETS1.A: Defining and Delimiting Engineering Problems • ETS1.B:Developing Possible Solutions	**Topic: Gravitation and Orbiting objects** **Phenomena:** 1. Students will be introduced to the phenomenon that planets stay in their orbits due to the gravitational force. 2. Students will be shown a short video showing the planets orbiting around the sun 3. teacher will ask students what they have observed in the video and formulate questions about planetary motion **Lesson Proper:** 1. Essential Questions: a. Why do planets go around the sun? b. How can we describe the planetary motion? c. Why do planets stay in orbit? 2. Corresponding Idea: Using a simulation model for planetary motion, students will understand the Newton's Law of Gravitation.It states that the force of gravitational attraction between Earth and other objects is inversely proportional to the distance separating the Earth's center to the object's' center . The force of gravity acting between the earth and any object is directly proportional to the mass of the earth and to the mass of the object. 3. Students will individually explore about planetary motion using the Phet Simulation- Gravity and orbits http://phet.colorado.edu/en/ simulation/gravity-and-orbits .They will follow the procedures in the gravity and orbits worksheet. They will have to draw the motion of the planets, moon and satellite. they will explore and draw diagrams to show that gravitational force controls the motion of our solar system. They will also identify the factors and variables that affect the strength of the gravitational force. Students must predict how motion would change if the force is stronger or weaker. 4. Students understanding will be evaluated based on their answers and drawings . (see attached gravity and orbits worksheet)		**Flexbook Topics:** 7. Gravitation and Orbiting Objects. (p.81) 8. Gravitation and Orbiting Objects (p.82-83). 8.1.Circular Motion (p.84-88) 8.2.Universal Law of Gravity (p.89-91) 8.3. Gravity (93-100) 8.4. Introduction to the Solar System (101-113) 8.5. Planet Earth (p.114-120) 8.6. Inner Planets (121-132) 8.7. Outer Planets (p.133-143) 8.8. Kepler's Laws of PLanetary Motion (144-147)

Quarter 2

Unit 3: Energy Conversion and Renewable Energy

Guiding Questions

How do power plants generate electricity?

What engineering designs can help increase the efficiency of our electricity production and reduce the negative impacts of using fossil fuels?

Students who demonstrate understanding can:

HS-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. **[Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.]**

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.]

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 position 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.]

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.]

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.]

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 converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative information.
Assessments do not include band theory.]

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.]

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

	Performance Tasks	Skill/Assessment s/Activities	Materials/Resources.
Highlighted Science and Engineering Practices **Developing and Using Models** **Highlighted Disciplinary Core Ideas**	**Topic 1: Describing Energy and its Forms** **Phenomenon:** **Lesson:** **1.** Describe energy using examples so students are able to state that "Energy is the ability to do work and to make other things hotter". **2.** Use examples to describe the different forms of energy: **(a)** Mechanical Energy: (a1) Kinetic Energy - (a2) Potential Energy: (a2i) Gravitational Potential Energy (a2ii) Elastic Potential Energy **(b)** Chemical Energy **(c)** Electrical Energy **(d)** Thermal or Internal Energy **(e)** Nuclear Energy **(f)** Electromagnetic Energy **(g)** Sound Energy **3.** Discuss the Nature of Energy		Flexbook Topics: Unit 6. Energy and Energy transfer p. 172 13.1. Types of energy. p 174-181 13.2 Forms of Energy. p.182-188 13.3 Energy resources p. 189-199 13.4 Energy resources. p. 200-204 13.5. Renewable Energy Resources p.205- 215 13.6. Non-renewable Energy Resources p.216-229

PS3.D: Energy in Chemical Processes and Everyday Life **PS3.A: Definitions of Energy** **PS3.B: Conservation of Energy and Energy Transfer** **PS3.C: Relationship Between Energy and Forces** **Highlighted Crosscutting Concepts** **Energy and Matter: Flows, Cycles, and Conservation**	**(a)** Energy is always conserved **(b)** Energy can be transformed from one form to another **(c)** Energy can be transferred from one object to another **Question:** If energy is conserved why are we still encouraged to conserve energy? **4.** How can energy be transferred from one object to another? **(a)** Work = Force x distance **(b)** Heat = transfer of energy from a hotter to a colder body through (b1) conduction, (b2) convection, (b3) radiation **5.** Energy transfer and transformation - Nature has given us vast amount of energy in forms we can not directly use or in places that is not accessible. → In changing energy from one form to another that is useable for us, several devices were discovered and made as science and technology advanced over a long period of time. Give examples of devices used for energy transfer and transformation: (a) Electric generator (b) Car (heat) engine **Topic: Electromagnetic Induction** **Phenomenon:** Electrical Energy Generation **Hook:** What do you think your life would be like without electricity **Lesson Proper:** **Part 1: Magnetic field around a current carrying conductor** **1. Demonstration Activities** (a) Sprinkle iron filings around a bar magnet. Say that the iron filings align as it is seen because the magnetic field around the bar magnet is affecting them.		Chapter 14. Thermal Energy p.233 14.1 Temperature and Heat. p.234-238 14.2.Transfer of Thermal energy p.239-244 14.3 Heat, Temperature, and Thermal Energy transfer. p.245-248

	(b) Move a magnet around a compass needle or vice versa to show that a compass needle deflects from its usual Northward orientation. Explain that the compass needle is a small magnet and that it is affected by the magnetic field of the bar magnet. (c) Connect a long connecting wire (about 1 m) to a battery (3 - 6 volts) and a switch. Move the compass around the wire while the circuit is still open. Now switch on and again move the compass needle around the current-carrying wire. (d) Coil the wire (about 3 cm diameter) and orient it along west-east orientation. Put the compass at one end of the coil so that its needle is parallel to the place of the face of the coil. Have the students note that the compass needle is still along its northward orientation. Connect the coil to a battery. Note that compass needle now deflects and aligns itself with the axis of the coil. Also move the compass around the coil and have students observe what happens with the direction of the needle. 2. **Summarize the students' observation:** Electric current produces magnetic field. **Part 2: Electromagnetic Induction** 1. **Ask:** If current produces magnetic field, can magnetic field produce current. 2. **Demonstration Activities:** (a) Use a bicycle dynamo (or a genecon) to light up a flashlight bulb. Show that there is no battery connected to the bulb. Ask where the electricity (electric current) is coming from. (b) Say that small amount of electric current can be measured with a galvanometer. Show different setups where electricity can be generated using a galvanometer (galvanometer is an "ammeter" that measures a small amount of current) as detector of the presence of electric current.		

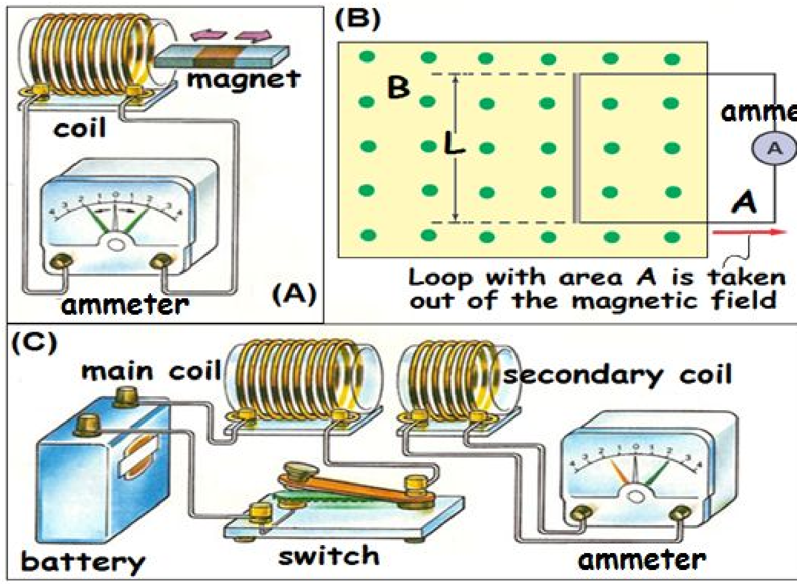


Fig 1. (a) Moving the coil and magnet relative to each other - either the coil moves and the magnet stationary, or the coil is stationary and the magnet moves or both of them are moving near each other, (b) the conductor is pulled out of the magnetic field, or a straight conductor is moved perpendicular to the magnetic field; (c) the current in a nearby coil is switched on and off

3. **Summarize students' observation:** A changing magnetic field near a conductor produces current in the conductor. Whenever there is a relative movement (rotate, move away/nearer) of a conductor in a magnetic field, current is produced or generated.

Topic: Electricity Generation in Power Plants

Phenomenon: Go back to the small dynamo demonstration or a genecon - Elicit students' opinions as to what makes the bulb light up.

Lesson Proper:

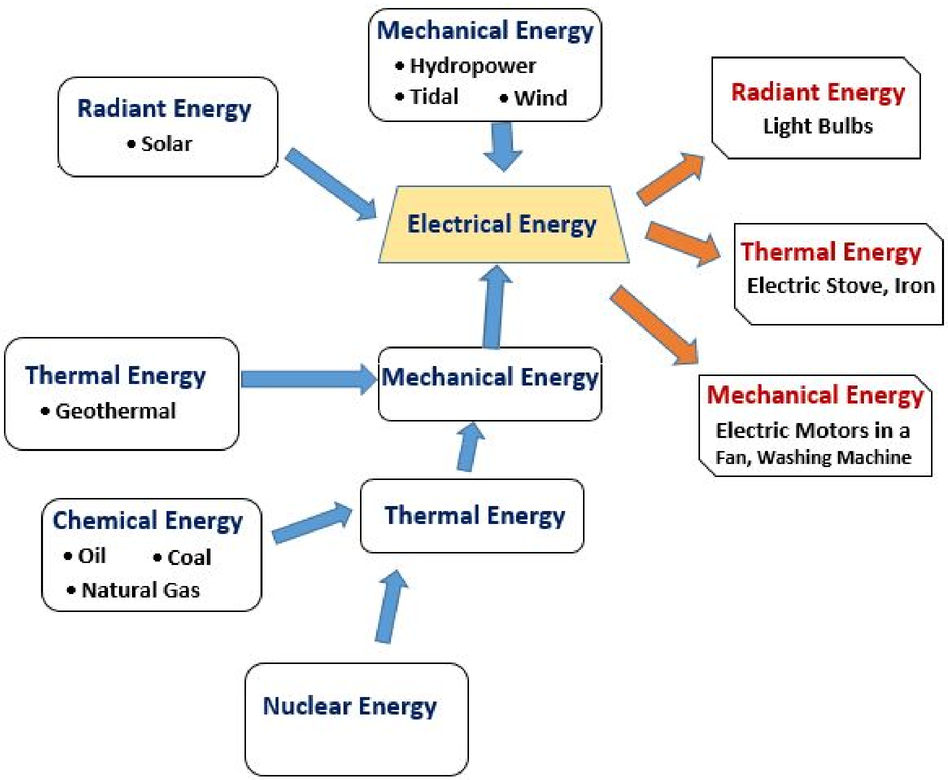
1. Show an animation of a hydropower plant and show that it is the mechanical energy of moving water that rotates the turbine (in our

genecon model- the handle of the genecon) that in turn rotates the generator (coils of wire near a magnet/electromagnet): https://youtu.be/q8HmRLCgDAI

2. You can now discuss that in the case of wind power, it is the mechanical energy of the wind that rotates the turbine.

3. You can now show the following **Concept Map** to show how else electrical energy is generated.

Concept Map: Energy Transformations from the energy sources to the usable form of energy – Electricity



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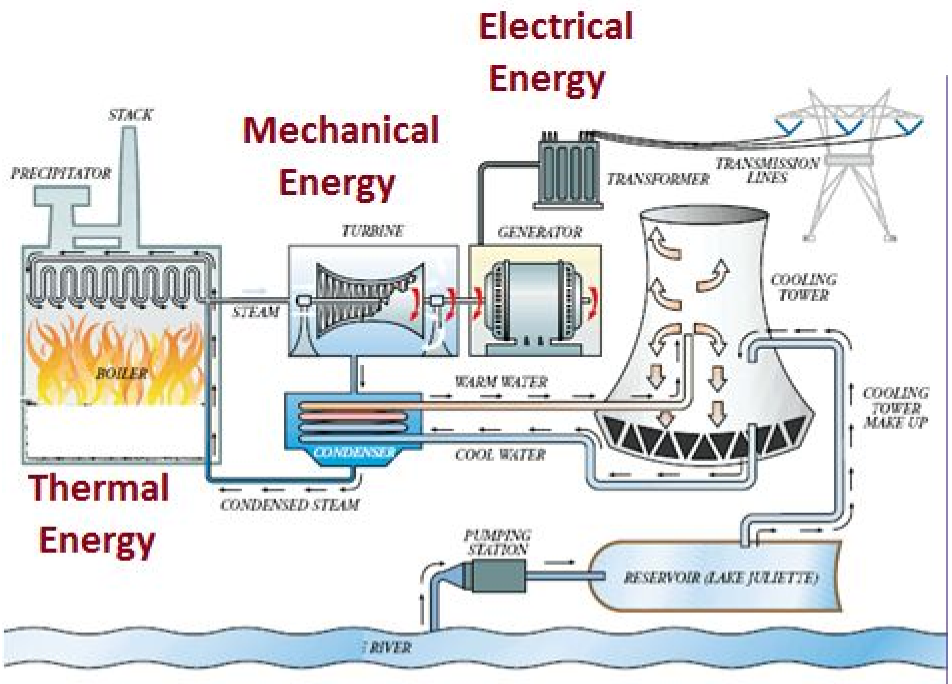
4. Show a picture of a power plant where thermal energy in a boiler is converted to mechanical energy of a turbine and the generation of electrical energy in a generator.



or an animation of a thermal power plant:
https://youtu.be/IdPTuwKEfmA

5. Discuss that in a fossil-fired (coal, oil, natural gas) the chemical energy released in burning the fuel is used in heating up water in the steam engine. Same is true in a nuclear power plant, where the nuclear energy released in nuclear fission is used in heating water in the steam generator. The expanding steam rotates the turbine.

6. In a geothermal power plant, the heated water from drawn underground is used directly or indirectly in rotating the turbine that rotates the generator of the power plant.

7. Discuss how solar energy is harnessed to generate electrical energy.

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Class project:
Energy Conversion Suggested Laboratory Activities:

5. Generation of electricity using solar panels
6. Generation of electricity using wind turbines
7. Generation of electricity using hydrogen fuel cells
8. Generation of electricity using hydropower
9. Computation of carbon footprints

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	8. Have students research on the pros and cons of the different energy sources for electrical energy generation - use varied strategies in the way students discuss their researches - jigsaw strategy, debate, panel of experts. Make sure that students will include not only the economic cost but also the environmental costs of mining/extracting the fuel and also in burning/using them. 9. You may have the students calculate their carbon footprints 10. Have the class do their assigned projects: <u>Class project:</u> Energy Conversion Suggested Laboratory Activities: 1. Generation of electricity using solar panels 2. Generation of electricity using wind turbines 3. Generation of electricity using hydrogen fuel cells 4. Generation of electricity using hydropower		

Quarter 3

Unit 4: Nuclear Processes and Earth History

Guiding Questions

What does E=mc2 mean?

How do nuclear reactions illustrate conservation of energy and mass? How do we determine the age of rocks and other geologic features?

Students who demonstrate understanding can:

HS-PS1-8 Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.]

HS-PS2-4 ~~Use mathematical representations of Newton's Law of 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.]

HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the

theory of plate tectonics to explain the ages of crustal rocks. [Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions).] (Also addressed in the High School Chemistry in the Earth System course)

HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.] (Also addressed in the High School Living Earth course)

HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).] [Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.] (Also addressed in the High School Living Earth course)

Highlighted Science and Engineering Practices

Developing and Using Models

Highlighted Disciplinary Core Ideas

PS1.C: Nuclear Processes

PS1.A Structure and Properties of Matter

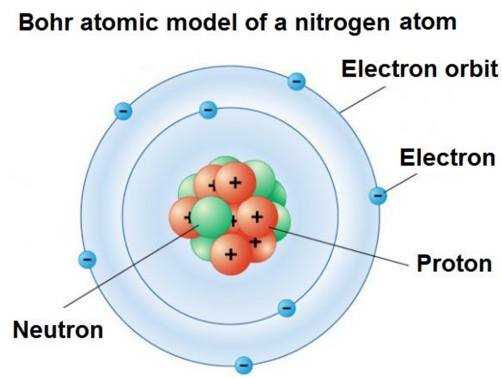
ESS1.C: The History of Planet Earth

Topic: Radioactive Decay

Phenomenon:

Lesson Proper:

1. Review with the students the structure of the atom - that it has a central small sized nucleus made up of the neutral neutrons and the positive protons. Around the atom are the negatively charged electrons. Show a model of an atom (Fig 1)



2. Demonstrate the interactions of the like and unlike poles of a magnet and come up with the observation: Like poles repel and unlike poles attract.

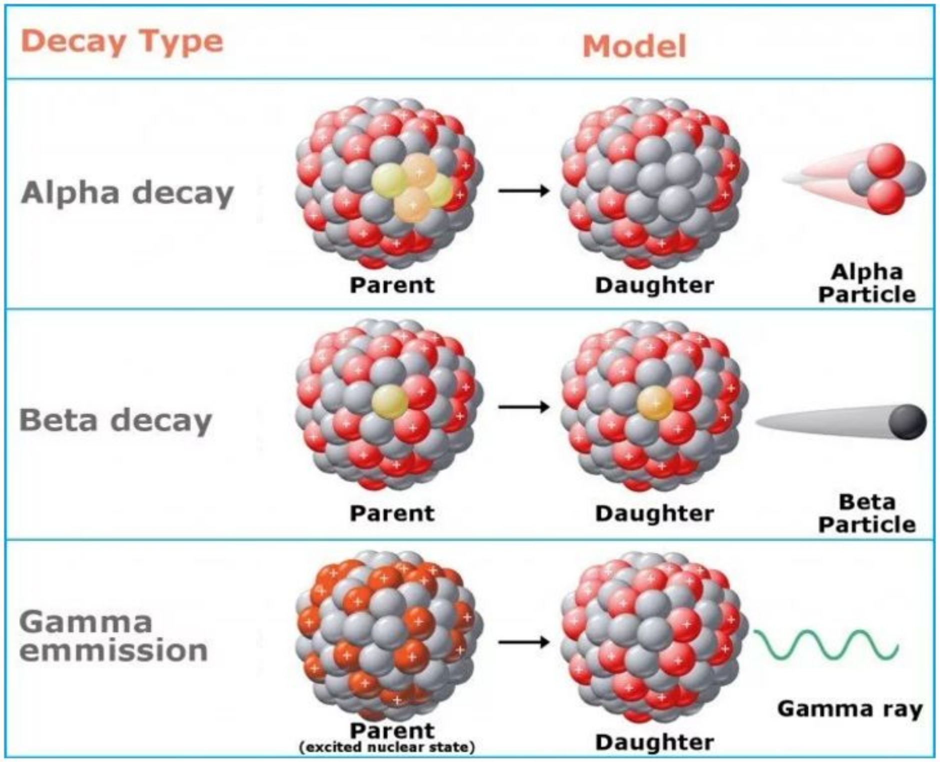
3. Demonstrate the interaction between like charges and unlike charges with the use of a fur and two plastic (quart size ziploc bag cut into two along the folds) sheets. Show that there is no interaction between the plastic sheets when they are not rubbed yet so they hang vertically when held side by side as shown in Fig 2A. When both of them are rubbed with fur and again hang side by side as before, the sheets already repel each other as shown in Fig 2B. This is because both acquired a negative charge when rubbed with fur. When the fur is brought near the plastic sheet, the sheet is attracted toward the fur. These show negatively (or similarly) charged objects repel while objects with opposite charges, attract.

(Insert Fig 2 A and B here)

4. Go back to your atom model. Discuss that within the very small nucleus are positively charged protons that are closely packed. If only the electrostatic force exists between the protons, they should be repelling each other. However, they stay together in the nucleus because of a much stronger force that exists between them - the strong nuclear force. In bigger atoms like uranium (point at the big elements in the Periodic Table, the strong nuclear

force is no longer sufficient to hold the protons together so that the atoms undergo a radioactive decay, a process that happens spontaneously. Atoms that undergo radioactive decay are called radioactive elements.

5. Describe briefly the three types of radioactive decays: alpha, beta and gamma. (You may not include what happens with the atomic and mass number of the nuclei as they undergo decay)



6. Discuss that when a parent nucleus emits alpha or beta particle, it transforms into a new element (daughter nucleus). Show an example of what happens with Uranium 238 and the transformation it goes through. See the figure of Uranium 238 Decay Chain at https://pubs.usgs.gov/of/2004/1050/uranium.htm . Use this same figure to discuss briefly what half life is.

7. Connecting to Previous Unit: Recall that radioactive decay is a spontaneous process. When a big radioactive element as Uranium 238 is bombarded with a neutron, it splits into two smaller atoms

	(https://www.google.com/search=fission) plus 2 - 3 neutrons to initiate fission in other U-238 atoms and a large amount of nuclear energy. This is the nuclear energy mentioned in the previous unit that is used to generate electrical energy in a Nuclear Power Plant.		

ESS2.B: Plate Tectonics and Large-Scale System Interactions **Highlighted Crosscutting Concepts** **Energy and Matter: Flows, Cycles, and Conservation**	**Topic: Plate Tectonics** **Phenomenon: Show a picture of the** **Lesson Proper:** **Plate Tectonics -** **1. Rock Evidence - age of Rock** **2. Other Evidences** **Continental Drift**		

Unit 5: Stars and the Origins of the Universe

Guiding Questions

How do we know what are stars made out of?

What fuels our Sun? Will it ever run out of that fuel?

Do other stars work the same way as our Sun?

How do patterns in motion of the stars tell us about the origin of our Universe?			
Students who demonstrate understanding can: **HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation.** [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11- year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.] **HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.** [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).] **HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements.** [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]			
Highlighted Science and Engineering Practices **Developing and**			

Using Models **Constructing Explanations** **Highlighted Disciplinary Core Ideas** **ESS1.A: The Universe and Its Stars** **PS1.C: Nuclear Processes** **Highlighted Crosscutting Concepts** **Energy and Matter** **Cause and Effect** **Patterns** **Scale, Proportion, and Quantity**			
Quarter 4			

Unit 6: Waves and Electromagnetic Radiation

Guiding Questions

How do we know what is inside the Earth?

Why do people get sunburned by UV light?

How do can we transmit information over wires and wirelessly?

Students who demonstrate understanding can:

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.]

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.] [Assessment Boundary: Assessment does not include using quantum theory.]

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.]

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 converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.]

HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information. [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.]

Highlighted Science and Engineering Practices **Asking Questions** **Using**			

Mathematics and Computational Thinking **Engaging in Argument from Evidence** **Obtaining, Evaluating and Communicating Information** **Highlighted Disciplinary Core Ideas** **PS4.A: Wave Properties** **PS4.B: Electromagnetic Radiation** **PS4.C: Information Technologies and Instrumentation**			

PS3.D: Energy in Chemical Reactions **ETS1.A: Defining and Delimiting Engineering Problems** **Highlighted Crosscutting Concepts** **Energy and Matter** **Systems and System Models** **Stability and Change** **Interdependence of Science, Engineering, and Technology** **Influence of Science, Engineering, and**			

Technology on Society and the Natural World			