Energy and Waves

4th grade
Teacher's Guide

Transfer of Energy

Lesson 1: Moving Pennies
Lesson 2: Colored Paper
Lesson 3: Light Bulbs
Lesson 4: Golf Ball / Ping Pong Ball

NGSS Lesson Planning: Fourth Grade-Moving Pennies

<table>
<tr><td>Grade: 4th</td><td>Topic: Transfer of Energy</td><td>Lesson 1: Moving Pennies</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Using pennies, students will demonstrate how energy can be transferred from one object to another.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS3-1.Use evidence to construct an explanation relating the speed of an object to the energy of that object.
4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will work with pennies to develop questions and predict what happens when objects collide.</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">The faster a penny is moving, the more energy it possesses. When objects collide, energy can be transferred from one object to another, changing their motion.</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">What is energy?</td></tr>
<tr><td>Science & Engineering Practices:

○ Asking questions (science) and defining problems (engineering)
○ Developing and using models
○ Planning and carrying out investigations
○ Analyzing and interpreting data
○ Using mathematics and computational thinking
○ Constructing explanations (science) and designing solutions (engineering)
○ Engaging in argument from evidence
○ Obtaining, evaluating, and communicating information</td><td>Disciplinary Core Ideas:

PS3.A: Definitions of Energy
● The faster a given object is moving, the more energy it possesses. (4-PS3-1)
● Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)
PS3.B: Conservation of Energy and Energy Transfer
● Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3)
PS3.D: Energy in Chemical Processes and Everyday Life
● The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)</td><td>Crosscutting Concepts:

○ Patterns
○ Cause and effect: Mechanism and explanation
○ Scale, proportion, and quantity
○ Systems and system models
○ Energy and matter: Flows, cycles, and conservation
○ Structure and function
○ Stability and change</td></tr>
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	ETS1.A: Defining Engineering Problems • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	
Possible Preconceptions/Misconceptions		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	Begin by discussing Energy. What do students know about energy? What do they want to learn? Explain to the students that today we will be experimenting with some simple everyday items to demonstrate energy and motion.	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	Have the students get into groups of two or three. Give each group seven pennies. Ask them to work together to demonstrate how energy can be used to create motion. Students record their demonstrations on paper or in their science notebooks.	
EXPLAIN: Concepts Explained and Vocabulary Defined	Introduce the concept of energy (***energy*** – the ability to do work. There are different types of energy. (potential - stored and kinetic - motion) ***Conservation of energy***- energy cannot be created or destroyed, it is transferred from one form to another.) Energy leads to motion. Show Bill Nye Science video on Energy on YouTube 8 mins.) http://www.youtube.com/watch?v=zTXW9aRO23Y	
ELABORATE: Applications and Extensions	After watching the video and discussing the information above, the students are given the opportunity to refine their demonstrations from earlier. They can keep their previous experiments or alter them. The teacher also poses one more challenge. Since energy can be transferred through collisions, one of the groups demonstrations must show energy transfer through a collision. (If no experiments have done so, demonstrate to the students how you can spread the pennies out on the desk and flick on penny into the others. The movement of the first penny will cause movement of the other pennies. Ask the students what would happen if you were to flick the penny faster or softer?)	
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	After students are given a chance to experiment they present their demonstrations to the class. In their demonstrations they must explain what they have learned about energy. Students also will turn in their notes from the day.	
Elaborate Further / Reflect:	Explain that moving forward the students will have more opportunity to experiment with energy.	

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
100	**pennies**		**$1.00**

NGSS Lesson Planning: Fourth Grade-Colored Paper

<table>
<tr><td>Grade: 4th</td><td>Topic: Transfer of Energy</td><td>Lesson 2: Colored Paper</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Using different colored paper, students will demonstrate how energy can be transferred from one object to another, by melting an ice cube.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will work with ice cubes and different colored paper to develop observations that prove energy can be transferred from the paper to the ice cube.</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">Darker colored paper will be warmer as it absorbs more light.</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">Which colors would you rather wear on a warm day?</td></tr>
<tr><td>Science & Engineering Practices:

● Asking questions (science) and defining problems (engineering)
● Developing and using models
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● Using mathematics and computational thinking
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PS3.A: Definitions of Energy
● Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)
PS3.B: Conservation of Energy and Energy Transfer
● Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3)
● Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-2),(4-PS3-4)
PS3.D: Energy in Chemical Processes and Everyday Life
● The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)

ETS1.A: Defining Engineering Problems</td><td>Crosscutting Concepts:

● Patterns
● Cause and effect: Mechanism and explanation
● Scale, proportion, and quantity
● Systems and system models
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	• Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	
Possible Preconceptions/Misconceptions		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	Begin by discussing Energy. What do students know about energy? What do they want to learn? Explain to the students that today we will be experimenting with some simple everyday items to demonstrate how energy can be used for the purposes we have..	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	Have the students get into groups of two or three. Give each group six different sheets of colored 3in by 3in sheets of paper (white, black, green, red, violet, yellow) and six small ice cubes. Ask them to work together to predict which type of paper will cause the ice cube to melt the quickest. The students then set their paper under heat lamps or in the sun and put an ice cube on each sheet. Students record their observations on paper or in their science notebooks.	
EXPLAIN: Concepts Explained and Vocabulary Defined	Discuss with the students light and absorption. Follow the link. https://spweb.tbaisd.k12.mi.us/sites/home/instructionalresources/science/pk8resources/3rd%20Grade/3rd%20Grade%20Unit%202%20Light%20and%20Sound%20-%20Color%20and%20Heat%20Absorption%20Teacher%20Version.doc Go over the results of the experiments. Did groups arrive at similar results? If so why? If not why not? Watch videos on how light travels and how it is absorbed.	
ELABORATE: Applications and Extensions	After watching the video and discussing the information above, the students are given the opportunity to apply their knowledge to discover how light energy can be transferred into heat energy. The students then experiment with their colored sheets of paper and thermometers to discover the transfer of energy. Follow the link. https://spweb.tbaisd.k12.mi.us/sites/home/instructionalresources/science/pk8resources/3rd%20Grade/3rd%20Grade%20Unit%202%20Light%20and%20Sound%20-%20Color%20and%20Heat%20Absorption%20Student%20Version.doc	
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	The students will reflect on their experiments from today and explain why it was possible for ice cube to melt, and where the energy came from to melt the ice cube.	
Elaborate Further / Reflect:	In the future if we want to use objects to heat objects, what colors would we wish to use?	

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
1	construction paper yellow	Amazon.com	$3.50
1	construction paper red	Amazon.com	$4
1	construction paper black	Amazon.com	$5
1	construction paper white	Amazon.com	$1.50
1	construction paper green	Amazon.com	$3.70
1	construction paper violet	Amazon.com	$5

NGSS Lesson Planning: Fourth Grade-Light Bulbs

<table>
<tr><td>Grade: 4th</td><td>Topic: Transfer of Energy</td><td>Lesson 3: Light Bulbs</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Using batteries, bulbs, wires, motors and hand cranks students will demonstrate how energy can be transferred from one object to another.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS3-1.Use evidence to construct an explanation relating the speed of an object to the energy of that object.
4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will work with various materials to make observations that energy can be transferred from place to place..</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">Batteries and hand cranks can be used to move electrons through a bulb to cause the bulb to light. For a bulb to light, you will need to create a circuit. The circuit must include a bulb, a battery and wire. The wire must connect the plus side of the battery to either the bottom or side metal on the bulb. The other wire must connect the the minus side of the battery and to whichever metal side of the bulb was not touched earlier.</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">What is energy? Energy can be transferred.</td></tr>
<tr><td>Science & Engineering Practices:

● Asking questions (science) and defining problems (engineering)
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
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● The faster a given object is moving, the more energy it possesses. (4-PS3-1)
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● Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3)
● Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-2),(4-PS3-4)
PS3.D: Energy in Chemical Processes and Everyday Life</td><td>Crosscutting Concepts:

● Patterns
● Cause and effect: Mechanism and explanation
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	• The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4) **ETS1.A: Defining Engineering Problems** • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	
Possible Preconceptions/Misconceptions		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	Begin by reviewing Energy. What do students know about energy and its transfer? What do they want to learn? Explain to the students that today we will be experimenting with electrical energy.	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	Have the students get into groups of two or three. Give each group a box of materials that include four wires, two batteries, two bulbs, a hand crank and the appropriate holders. Ask them to work together to light a bulb. Students diagram their findings on paper or in their science notebooks.	
EXPLAIN: Concepts Explained and Vocabulary Defined	Introduce the concept of electrical circuits. What are the parts of the circuits and how do they work? http://www.energyquest.ca.gov/story/chapter04.html Discuss how the energy from the battery is transferred from the battery through the wires and into the bulb. Watch videos on circuits. http://www.youtube.com/watch?v=VnnpLaKsqGU	
ELABORATE: Applications and Extensions	After watching the video and discussing the information above, the students are given the opportunity to refine their systems from earlier. They can keep their previous experiments or alter them. The teacher also poses one more challenge, "Can the groups cause the bulb/bulbs to light up brighter or make them dimmer?"	
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	After students are given a chance to experiment they present their demonstrations to the class. In their demonstrations they must explain what they have learned about energy and how they were able to cause the bulbs to glow brighter and dimmer. Students also will turn in their notes from the day with a write up of their findings.	
Elaborate Further / Reflect:	Students work more the next few days with adding more and fewer bulbs and batteries into the circuits to better their understanding of electrical energy. Teach the students about conductors and insulators using the lesson below.	

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
2	hand cranks	Amazon.com	$24
50	wires	Electrical Supply Set	
20	bulbs	Electrical Supply Set	
20	battery holder	Electrical Supply Set	
	batteries	Local Dollar Store	$10
20	bulb holder	Electrical Supply Set	
	motors	From Wheeled Vehicle Kit	
10	buzzers	Kelvin.com	$9.50

Electricity: Circuits and Conductivity

Scientist's Name: _____

"What is electricity?"

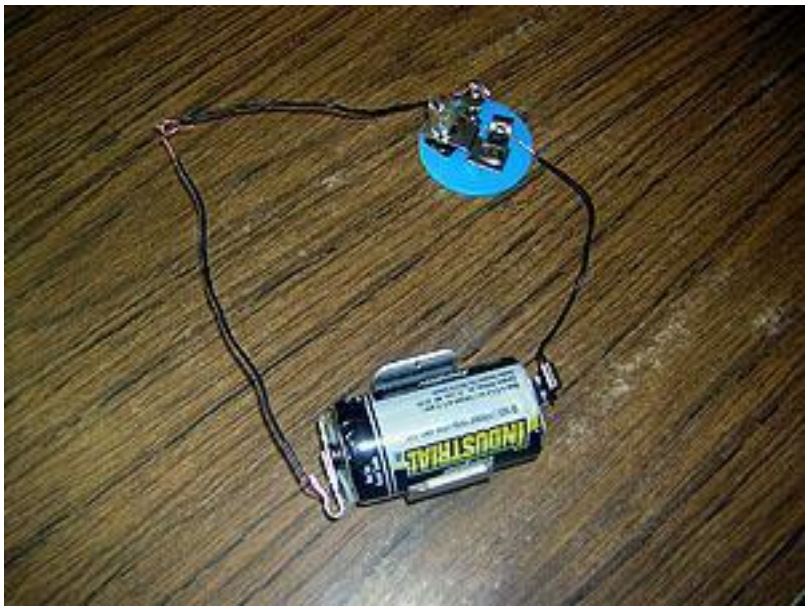
Electricity can be defined simply as the flow of a ***charged particle*** around a loop called a ***circuit.*** The charged particles flow much like water flows through a stream. This flow of charge particles is called ***electrical current*** or ***current.*** The presence of an electrical current through a circuit allows for the circuit to perform ***work.*** Work is a term used by physicists to describe the energy expended when a force is applied over a distance. When a current is created the charged particles which are flowing around the circuit are said to be "doing work." This electrical work can be used to power a light bulb or a simple engine.

"What is conductivity?"

Why are the wires that power your television and toaster made from metal? The reason for this is that some materials called ***conductors*** are able to carry an electrical current while others, ***insulators,*** cannot. The ***conductivity,*** or measure of a materials current carrying ability, is based on properties inherent to that material. Conductors must have an available source of charged particles. As stated earlier, these charged particles are what make up an electrical current.

Experiment 1: The Conductivity of Solids

You will be testing the conductivity of solids. You will build a circuit tester using three wires, a battery and a bulb (see the picture below). You will also get a Ziploc bag containing test materials, a pair of safety glasses, your data collection packet, and a pen or pencil. Check to make sure that you have everything you need.



Instructions

1. Put on your pair of safety glasses!

2. *BEFORE BEGINNING TESTING*, predict whether each item will light the bulb when you connect it to the electrical circuit board. Write down your predictions in the 2nd column of the table below. (Need help deciding? Talk about it with your group members.)

3. *TESTING TIME!*Connect items to the circuit using the red and black alligator clips. Observe what happens to the bulb.

4. *COLLECT DATA* using the 3rd column. Did the bulb light?

5. *ANALYZE IT* . Answer the first two questions in the Observations section. Think about your answers and what they tell you about each material's conductivity, and about your answers to the first two questions.

Test Materials	Predictions	Observations
Nail		
Wood		
Paper Clip		
Penny		
Ping Pong Ball		
Marble		
Aluminum Foil		

Observations

Make a list of the objects the lit the bulb and the ones that did not. What are some of the traits that these materials have in common? What are other items that you know of that you would predict to be conductors and insulators?

NGSS Lesson Planning: Fourth Grade- Golf Ball/ Ping Pong Ball

<table>
<tr><td>Grade: 4th</td><td>Topic: Transfer of Energy</td><td>Lesson 4: Golf Ball / Ping Pong Ball</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Using golf ball and ping pong balls, the students will work to see how energy can be transferred from one object to another.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will work with various materials to make observations that energy can be transferred from one object to another.</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">When two balls are dropped one on top of the other, the ball on the bottom will transfer its energy to the ball on the top, causing the ball on top to bounce higher. This activity is a good example of one of the basic laws of physics; the Conservation of Momentum.
In the collision of the golf ball with the ping pong ball the mass of the golf ball is much greater than the mass of the ping pong ball. In order for momentum to be conserved, the velocity of the ping pong ball will be much greater.
Adapted from: http://www.mcrel.org/whelmers/whelm22.asp</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">What is energy? Energy can be transferred. Students experience conservation of momentum with a baseball and bat. The much more massive bat imparts a greater velocity on the baseball.</td></tr>
<tr><td>Science & Engineering Practices:

● Asking questions (science) and defining problems (engineering)
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● Engaging in argument from evidence
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● Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-2),(4-PS3-4)</td><td>Crosscutting Concepts:

● Patterns
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	PS3.D: Energy in Chemical Processes and Everyday Life ● The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4) PS3.C: Relationship Between Energy and Forces ● When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3) **ETS1.A: Defining Engineering Problems** ● Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	
Possible Preconceptions/Misconceptions		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	Begin by discussing Energy. What do students know about energy? What do they want to learn? Explain to the students that today we will be experimenting with some simple everyday items – a golf ball and a ping pong ball - to demonstrate energy and motion.	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	This activity works best on a concrete or hard tile floor. A large concrete block can be placed on a carpeted floor. Before dropping either of the balls, ask students to predict how high each will bounce. Use tape on the wall to mark the height of each bounce. Have the students get into groups of two or three. Give each group materials that include one golf ball and one ping pong ball. After the initial drop of the ping pong ball, ask students how the ball can be made to bounce higher (e.g. Drop the balls from a higher point). (The balls cannot be thrown down). Students diagram their findings on paper or in their science notebooks. Relate to students that each response is an example of adding more energy to the ping pong ball. Suggest to students that you will transfer energy from the golf ball to the ping pong ball. Ask them if they think it is possible to transfer energy from one thing to another. Ask for examples (kicking a soccer ball, hammering a nail, etc.).	
EXPLAIN: Concepts Explained and Vocabulary Defined	Have the students explain their results. Ask students to explain where the energy came from that caused the ping pong ball to bounce so high (golf ball). Discuss how energy can be transferred from one object to another. Encourage them to experiment with transferring energy from one ball to the other. Ask them to explain what must have happened to the golf ball if it did transfer some of its energy to the ping pong ball (it bounced lower than before). Did any of them observe the lower bounce of the golf ball during the first test? (Most follow the more interesting flight of the ping pong ball.) Relate to students that scientists must learn to be keenly observant. Share this video: http://www.youtube.com/watch?v=XNqUnGT1qDE http://www.youtube.com/watch?v=QfRXBAgIzwY	

	Vocabulary: Momentum, Inertia, Gravity
ELABORATE: Applications and Extensions	After discussing the information above, the students are given the opportunity to refine their systems from earlier. Direct them to make careful observations and measurements as you repeatedly drop both balls. Use tape strips to indicate the height of different bounces. The students can also work with different types of balls and record their results. They can keep their previous experiments or alter them. The teacher also poses one more challenge: Can you drop the same ball from the same height, but make it bounce higher? Collect balls of various sizes and masses. Some balls which could be used are baseballs, large ball bearings, small rubber balls and other ping pong balls. Students should predict which ball will allow the ping pong ball to bounce higher when the activity is repeated. Repeat the activity and compare the predictions to the outcomes.
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	After students are given a chance to experiment they present their demonstrations to the class. In their demonstrations they must explain what they have learned about energy and how they were able to cause the ball to bounce higher. Students also will turn in their notes from the day with a write up of their findings.
Elaborate Further / Reflect:	Students work more the next few days with trying to get balls to bounce higher by only dropping them.

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
	Golf Balls	**From other experiments**	
	Ping Pong Balls	**From other experiments**	
	Tennis Balls	**From other experiments**	

Speed and Energy

NGSS Lesson Planning: Fourth Grade-Dropper Poppers

<table>
<tr><td>Grade: 4th</td><td>Topic: Speed and Energy</td><td>Lesson 5: Dropper Poppers</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Using dropper poppers, the students will work to see how speed and energy are related.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.
4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will work with various materials to make observations that speed is related to the amount of energy in an object..</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">Dropping the poppers from different heights will cause them to bounce to different levels.</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">What is energy? Energy can be transferred.</td></tr>
<tr><td>Science & Engineering Practices:

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PS3.C: Relationship Between Energy and Forces
● When objects collide, the contact forces transfer energy so as to change the objects’ motions. (4-PS3-3)

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</table>

	a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	
Possible Preconceptions/Misconceptions		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	Begin by discussing Energy. What do students know about energy? What do they want to learn? Explain to the students that today we will be experimenting with some simple everyday items to demonstrate energy and motion.	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	Remind the students of the work with the ping pong ball and golf ball from yesterday. Today we will continue our experiments with Dropper Poppers. Have the students get into groups of two or three. Give each group materials that include one dropper popper. Ask them to work together to experiment to cause the popper to bounce higher. (The poppers cannot be thrown down). Students diagram their findings on paper or in their science notebooks.	
EXPLAIN: Concepts Explained and Vocabulary Defined	Have the students explain their results. Discuss where the energy for the bounce comes from. (Stored energy from turning the popper inside out.) Bring back out the balls from yesterday. Demonstrate how an object will not bounce higher than the point you dropped it from. We have discussed previously how energy cannot be created or destroyed.	
ELABORATE: Applications and Extensions	After discussing the information above, the students are given the opportunity to refine their thoughts from earlier. The students can also work with the poppers and the balls from yesterday to see if they can transfer the energy from the popper to the balls. The teacher also poses one more challenge: Why does the popper bounce higher than the point that you dropped it from?	
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	Students also will turn in their notes from the day with a write up of their findings. Teacher also has the chance to move around the room to evaluate the learning.	
Elaborate Further / Reflect:		

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
	Golf Balls	**local golf course**	
	Ping Pong Balls	**Use from Earlier Experiments**	
3	**Tennis Balls**	**Amazon.com**	**$9**
2	**Dropper Poppers**	**Amazon.com**	**$10.50**

NGSS Lesson Planning: Fourth Grade-Energy of the Playground

<table>
<tr><td>Grade: 4th</td><td>Topic: Speed and Energy</td><td>Lesson 6: Energy of the Playground</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Using playground equipment, the students will work to see how speed and energy are related.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.
4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will work with various materials to make observations that speed is related to the amount of energy in an object.</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">Energy can be transferred from object to object.</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">What is energy? Energy can be transferred.</td></tr>
<tr><td>Science & Engineering Practices:

● Asking questions (science) and defining problems (engineering)
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations (science) and designing solutions (engineering)
● Engaging in argument from evidence
● Obtaining, evaluating, and communicating information</td><td>Disciplinary Core Ideas:

PS3.A: Definitions of Energy
● The faster a given object is moving, the more energy it possesses. (4-PS3-1)
● Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)
PS3.B: Conservation of Energy and Energy Transfer
● Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3)
PS3.D: Energy in Chemical Processes and Everyday Life
● The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)
PS3.C: Relationship Between Energy and Forces
● When objects collide, the contact forces transfer energy so as to change the objects’ motions. (4-PS3-3)</td><td>Crosscutting Concepts:

● Patterns
● Cause and effect: Mechanism and explanation
● Scale, proportion, and quantity
● Systems and system models
● Energy and matter: Flows, cycles, and conservation
● Structure and function
● Stability and change</td></tr>
</table>

	ETS1.A: Defining Engineering Problems • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	
Possible Preconceptions/Misconceptions		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	Begin by discussing Energy. What do students know about energy? What do they want to learn? Explain to the students that today we will be experimenting with some simple everyday items to demonstrate energy and motion.	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	Tell the students that we will be doing science outside today. Encourage students to test out the different equipment outside and think about how the amount of energy they use affects speed. Students diagram their findings on paper or in their science notebooks (including drawings and notes).	
EXPLAIN: Concepts Explained and Vocabulary Defined	Bring the class back together, go to the different spots on the playground and allow students to demonstrate how energy and speed are related. Discuss with the students why some smaller students may not be able to use certain equipment on the playground. Where do students get the energy to do these activities? We have discussed previously how energy cannot be created or destroyed.	
ELABORATE: Applications and Extensions	After discussing the information above, the students are taken to the swing set. Instruct them to work in groups to explain how a swing works. In their notebooks they should include a diagram of the swing and an explanation of how it works. They should experiment on different ways to safely swing high and low.	
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	Students will turn in their notes from the day with a write up of their findings. The diagrams in the notebooks and their explanation of what they learned will help to show student understanding. Teacher also has the chance to move around the room to evaluate the learning.	
Elaborate Further / Reflect:		

NGSS Lesson Planning: Fourth Grade-Let's Build a Balloon Rocket

<table>
<tr><td>Grade: 4th</td><td>Topic: Speed and Energy</td><td>Lesson 7: Let's Build a Rocket</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Using balloons and string, students will deepen their understanding of speed and energy.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.
4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will work in partnerships to explore how the number of breaths and different types of string effect the movement of the balloon.</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">Energy can be transferred</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">What is energy? Energy isn't created or destroyed. Energy can be transferred.</td></tr>
<tr><td>Science & Engineering Practices:

● Asking questions (science) and defining problems (engineering)
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations (science) and designing solutions (engineering)
● Engaging in argument from evidence
● Obtaining, evaluating, and communicating information</td><td>Disciplinary Core Ideas:

PS3.A: Definitions of Energy
● The faster a given object is moving, the more energy it possesses. (4-PS3-1)
● Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)

PS3.B: Conservation of Energy and Energy Transfer
● Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3)
PS3.D: Energy in Chemical Processes and Everyday Life
● The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)

ETS1.A: Defining Engineering Problems
● Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a</td><td>Crosscutting Concepts:

● Patterns
● Cause and effect: Mechanism and explanation
● Scale, proportion, and quantity
● Systems and system models
● Energy and matter: Flows, cycles, and conservation
● Structure and function
● Stability and change</td></tr>
</table>

	solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	
Possible Preconceptions/Misconceptions		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	Explain that earlier in the unit we have learned what energy is and that it can transfer from object to object. We also learned that energy can be transferred from one form to another. Today we will be experimenting with how energy affects speed.	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	When given balloons, straws, string, tape and two chairs, can the students create a device that gets the balloon from one side of the room 5 meters away? Give the students the materials and time to develop a system that would work.	
EXPLAIN: Concepts Explained and Vocabulary Defined	Students take time to share with the class what they have discovered. Reintroduce the concept of energy (***energy*** – the ability to do work. There are different types of energy. ***Conservation of energy***- energy cannot be created or destroyed, it is transferred from one form to another.) Discuss with the class how varying the amount of energy might change the process. Also talk with them about how changing the type of string might change the outcomes.	
ELABORATE: Applications and Extensions	Students experiment with different number of breaths into the balloon to see the results. They also practice with different types of strings. (Use the sheet attached.)	
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	Students turn in the sheet that accompanies this project. Their numbers and explanation will help to show understanding.	
Elaborate Further / Reflect:	Students will be provided the opportunity to share their new experiment ideas and continue their investigations.	

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
1	10 Balloons	Kelvin.com	$14
1	5 meters Yarn	Walmart.com	$2
1	5 meters Twine	Walmart.com	$4
1	5 meters Fishing Line	Walmart.com	$1
2	Plastic Tape	Kelvin.com	$2
	Straws	Use straws from Wheeled Vehicle project	

Let's Build a Rocket

Performance Based Assessment – 4th Grade

This is a whole class demonstration, but students will collect data during the experiment and make a bar graph with the results.

Materials:

9" Balloons
500 cm (5 meters) of each of the following "strings": fishing line, yarn, and twine
Tape
6 chairs or 6 students
3 straws
Up to 3 stopwatches

Directions:

Teachers builds one balloon/string model for each type of "string" for the class demonstration.

1. Feed the string through the straw. Either attach the string to two chairs or have two students hold each end. Make sure the string is taut and level.
2. Blow up the balloon and hold it closed so that the air does not escape. (Do not tie the balloon shut.) Blow up the balloon as large as possible - at least the size of soccer ball. Have help taping the balloon to the straw that is fed through the string.
3. Pull the balloon to the very end of the string.
4. Have a student tell you/volunteer when to release the balloon as the student will time the balloon's travel on the string with a stopwatch. The student will stop timing when the balloon reaches the opposite end of the string.
5. Let go of the balloon when told and let it go.
6. How long does it take the balloon to travel the distance of the string (or at least 400 cm)?
7. Record the data on the table below.
8. Repeat the exact same set up two more times, recording the data below each time.
9. Move on using the different "strings" and repeat steps 1-7.
10. Collect pages #-# or science journals to assess student understanding of this lesson.

Let’s Build A Rocket! PBA 5th Grade

Student Name:_____

String Type	**Distance**	**Time**
Yarn Trial 1	500 cm	
Yarn Trial 2	500 cm	
Yarn Trial 3	500 cm	
Fishing Line Trial 1	500 cm	
Fishing Line Trial 2	500 cm	
Fishing Line Trial 3	500 cm	
Twine Trial 1	500 cm	
Twine Trial 2	500 cm	
Twine Trial 3	500 cm	

Number of breaths	**Distance**	**Time**
1		
2		
3		
4		
5		
6		
7		
8		
9		

1. What are some observations you have about today's class demonstration? Make sure to include which type of string had the fastest balloon travel time.

2. How does different number of breaths affect this experiment? Why?

3. Describe an experiment you would like to try to further our understanding of this topic?

NGSS Lesson Planning: Fourth Grade-Marble Mountains

<table>
<tr><td>Grade: 4th</td><td>Topic: Speed and Energy</td><td>Lesson 8: Marble Mountains</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Using marbles and clear plastic tubing, the students will work to see how speed and energy are related.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.
4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will work with various materials to make observations that speed is related to the amount of energy in an object.</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">The potential energy of the marble at the top of the track will turn into kinetic energy as the marble rolls down the tube. The second hill of the roller coaster will need to be lower than the first hill, as the potential energy of the marble will not be able to carry the marble up a hill that is higher than the first hill (conservation of energy).</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">What is energy? Energy can be transferred.</td></tr>
<tr><td>Science & Engineering Practices:

● Asking questions (science) and defining problems (engineering)
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations (science) and designing solutions (engineering)
● Engaging in argument from evidence
● Obtaining, evaluating, and communicating information</td><td>Disciplinary Core Ideas:

PS3.A: Definitions of Energy
● The faster a given object is moving, the more energy it possesses. (4-PS3-1)
● Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)
PS3.B: Conservation of Energy and Energy Transfer
● Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3)
PS3.D: Energy in Chemical Processes and Everyday Life
● The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)
PS3.C: Relationship Between Energy and Forces
● When objects collide, the contact forces transfer energy so as to change the objects’ motions. (4-PS3-3)

ETS1.A: Defining Engineering Problems</td><td>Crosscutting Concepts:

● Patterns
● Cause and effect: Mechanism and explanation
● Scale, proportion, and quantity
● Systems and system models
● Energy and matter: Flows, cycles, and conservation
● Structure and function
● Stability and change</td></tr>
</table>

	• Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	
Possible Preconceptions/Misconceptions		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	Begin by reviewing Energy. What do students know about energy and transfer? Explain to the students that today we will be creating their own roller coasters with some simple everyday items to demonstrate energy and motion.	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	Introduce the idea of roller coasters. Discuss what students know about roller coasters and how they work. Ask the students to use what we've learned over the past few lessons to help to explain how the roller coaster operate. Have the students get into groups of four or five. Give each group materials that include one five feet of vinyl tubing, and a marble. Ask them to work together to build a roller coaster in the classroom. Tell them to build two different roller coasters and draw the models in their science notebooks. Students diagram their findings on paper or in their science notebooks.	
EXPLAIN: Concepts Explained and Vocabulary Defined	Have the students explain their results. They are given a chance to demonstrate their roller coasters to the class. Draw the students' attention to any roller coasters who used a hill. The marble will never climb a hill higher than the first hill. Show videos of different roller coasters to demonstrate that the first hill is always the highest. Why is this? We have discussed previously how energy cannot be created or destroyed. Watch video on roller coaster science http://search.yahoo.com/search;_ylt=A0oG7jlstM1R3CkAsBFXNyoA;_ylc=X1MDMjc2NjY3OQRfcgMyBGJjawMwc3NwMzY5OHNyNjRiJTI2YiUzRDMlMjZzJTNEYmsEY3NyY3B2aWQDSTZvNEhVZ2V1ckFPY3lNeVVjMllpd2FHREdIMkExSE50R3dBRFRPUwRmcgN5ZnAtdC05MDAEZnIyA3NiLXRvcARncHJpZANDb1h1SW1TeVRELjZEcmdGT2t0Z19BBG5fcnNsdAMxMARuX3N1Z2cDMARvcmlnaW4Dc2VhcmNoLnlhaG9vLmNvbQRwb3MDMARwcXN0cgMEcHFzdHJsAwRxc3RybAMzMwRxdWVyeQNzY2llbmNlIG9mIHJvbGxlciBjb2FzdGVycyB2aWRlb3MEdF9zdG1wAzEzNzI0MzU2NTYxNTUEdnRlc3RpZANBQ0JNMDM-?p=science+of+roller+coasters+videos&fr2=sb-top&fr=yfp-t-900	
ELABORATE: Applications and Extensions	After discussing the information above, the students are given the opportunity to refine their roller coasters from earlier. The students are given different types of marbles to experiment with (wood, metal, glass). The teacher also poses one more challenge: Can you create a roller coaster with a loop?	
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	Students will turn in their notes from the day with a write up of their findings. The diagrams in the notebooks and their explanation of what they learned will help to show student understanding.) Teacher also has the chance to move around the room to evaluate the learning.	
Elaborate Further / Reflect:	Have the students experiment to find the tallest height of the second hill that the marble can still climb.	

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
	Marble **or** **Steel ball bearings**	**From Previous lessons** **VXB Ball Bearings**	
	Vinyl Tubing	**Home Depot**	

The following picture can be used to help get an idea of what the roller coaster should look like. The large hill on the right would be where the students start the marble. The loop would be the second hill. The groups of students will work to hold the track in place.

NGSS Lesson Planning: Fourth Grade-Stomp Rockets

Grade: 4th	**Topic: Speed and Energy**	**Lesson 9: Stomp Rockets**
Brief Lesson Description:	Using classroom-made rockets, students will deepen their understanding of speed and energy.	
Performance Expectation(s):	4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object. [Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.] 4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. [Assessment Boundary: Assessment does not include quantitative measurements of energy.] 4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide. [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [Assessment Boundary: Assessment does not include quantitative measurements of energy.] 4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.* [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.]	
Specific Learning Outcomes:	Students will work in partnerships to explore: Rocket design, attributes of cause and effect in design	
Narrative / Background Information	Energy can be transferred from Sun to food to humans to a stomp to propel a rocket	
Prior Student Knowledge:	**What is energy? Energy isn't created or destroyed. Energy can be transferred.**	

Science & Engineering Practices:	Disciplinary Core Ideas:	Crosscutting Concepts:
○ ***Asking questions (science) and defining problems (engineering)*** ○ ***Developing and using models*** ○ ***Planning and carrying out investigations*** ○ Analyzing and interpreting data ○ Using mathematics and computational thinking ○ ***Constructing explanations (science) and designing solutions (engineering)*** ○ ***Engaging in argument from evidence*** ○ ***Obtaining, evaluating, and communicating information***	PS3.A: Definitions of Energy ● The faster a given object is moving, the more energy it possesses. (4-PS3-1) ● Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3) PS3.B: Conservation of Energy and Energy Transfer ● Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3) PS3.D: Energy in Chemical Processes and Everyday Life ● The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4) **ETS1.A: Defining Engineering Problems** ● Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	○ ***Patterns*** ○ ***Cause and effect: Mechanism and explanation*** ○ ***Scale, proportion, and quantity*** ○ ***Systems and system models*** ○ ***Energy and matter: Flows, cycles, and conservation*** ○ ***Structure and function*** ○ ***Stability and change***
Possible Preconceptions/Misconceptions		

LESSON PLAN – 5-E Model	
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	Explain that earlier in the unit we have learned what energy is and that it can transfer from object to object. We also learned that energy can be transferred from one form to another. In this lesson, we will be experimenting with designing, testing and observing the flight of a paper rocket.
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	After a very brief demonstrations, allow students to design, build, and test paper stomp rockets.
EXPLAIN: Concepts Explained and Vocabulary Defined	Students take time to share with the class what they have discovered. Reintroduce the concept of energy (***energy*** – the ability to do work. There are different types of energy. ***Conservation of energy***- energy cannot be created or destroyed, it is transferred from one form to another.) Discuss with the class how varying the amount of energy might change the process. Also talk with them about how changing the design by adding or removing certain attributes may effect flight.
ELABORATE: Applications and Extensions	Students experiment with different designs: fins, nose cones, diameter of fuselage, Students to explore existing designs based on designs. NASA, Boeing, Jet Propulsion Laboratory/NASA
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	Students compete with other teams in a Stomp Rocket contest: ● Distance ● Accuracy
Elaborate Further / Reflect:	Make assumptions regarding current air and space travel and exploration vehicle design. NASA, Boeing, Jet Propulsion Laboratory/NASA

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
1	Ream of 8 ½ x 11" notebook paper	school supplies	
6	roll of plastic tape	school supplies	
8 ft	8 x 12" section of 1" inch PVC pipe	Home Depot, Lowes, etc	$35.00
1 bag	8" Zip Ties	Home Depot, Lowes, etc	$4.00
1	4 ft. 2x4	Home Depot	$5.00
1	12" x 12" x ½ " plywood piece	Home Depot	$12.00
	Assorted screws, washers	Home Depot	$5.00
2	26 x 2.0" or 29 x 2.0" bike tube	local bike shops	$6.00

Stomp Rocket

Data Sheet Ideas

Team Members: _____

Date: _____

Stomp Rocket Data Table

Test Flight	Distance Traveled Feet or Meters	Time to Travel Distance Seconds	Speed (Distance/Time) Feet/second or Meters/second

Diagraming and work area:

Sample Stomp Rocket

1-8 ½ x 11 inch paper

plastic tape

roll tube

Optional Fins

NGSS Lesson Planning: Fourth Grade-Sound and Movement

<table>
<tr><td>Grade: 4th</td><td>Topic: Speed and Energy</td><td>Lesson 10: Sound and Movement</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Using various materials, the students will work to see how sound energy can create movement.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.
4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will work with various materials to make observations that speed is transferred from place to place by sound.</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">The energy in an object determines the speed of the object.</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">What is energy? Energy can be transferred.</td></tr>
<tr><td>Science & Engineering Practices:

● Asking questions (science) and defining problems (engineering)
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations (science) and designing solutions (engineering)
● Engaging in argument from evidence
● Obtaining, evaluating, and communicating information</td><td>Disciplinary Core Ideas:

PS3.A: Definitions of Energy
● The faster a given object is moving, the more energy it possesses. (4-PS3-1)
● Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)
PS3.B: Conservation of Energy and Energy Transfer
● Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3)
PS3.D: Energy in Chemical Processes and Everyday Life
● The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)
PS3.C: Relationship Between Energy and Forces
● When objects collide, the contact forces transfer energy so as to change the objects’ motions. (4-PS3-3)</td><td>Crosscutting Concepts:

● Patterns
● Cause and effect: Mechanism and explanation
● Scale, proportion, and quantity
● Systems and system models
● Energy and matter: Flows, cycles, and conservation
● Structure and function
● Stability and change</td></tr>
</table>

	ETS1.A: Defining Engineering Problems • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	
Possible Preconceptions/Misconceptions		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	This lesson should take place after the class has had the chance to work with sound. What do we know about sound and how it travels? Relate sound to energy. Tell the class that today we will experiment with sound and energy. Challenge the class to develop demonstrations that show how sound energy can be used to transfer energy. Remind students of some of the activities we've done previously.	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	Get out materials for this activity (borrow instruments from the music room), rubber bands, rulers, other devices that can be used to make sound. Encourage the class to find interesting ways to produce sounds. See if they can use those sounds to transfer energy to other objects. Record any observations that demonstrate the transfer of sounds.	
EXPLAIN: Concepts Explained and Vocabulary Defined	Bring the class back together, and demonstrate what students have discovered. Allow them to use their own words to describe their findings. Were we able to show sound can move objects? Do some demonstrations or show videos that demonstrate sound and energy transfer. This can be done with speakers covered in plastic wrap and placing salt on the speaker to make it dance.	
ELABORATE: Applications and Extensions	After discussing the information above, the students are given a task. They are to use sound to move an object 20 cm. Instruct them to work in groups to choose an object to move and develop a system to use sound to move that object. In their notebooks they should include a diagram their system and an explanation of how it works.	
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	Students will turn in their notes from the day with a write up of their findings. The diagrams in the notebooks and their explanation of what they learned will help to show student understanding. Teacher also has the chance to move around the room to evaluate the learning.	
Elaborate Further / Reflect:		

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
	rubber bands	**From previous lessons**	
	rulers	**From previous lessons**	
	cardboard boxes	**Local**	
	reflective mirrors	**From the front table**	
	instruments from music class or home		

Name_____

Data Transfer Performance Assessment

4-PS4-3.	Generate and compare multiple solutions that use patterns to transfer information.*[Clarification Statement: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, and using Morse code to send text.]

Using the materials provided students will need to develop **more than one** system to transfer a message to a partner. You must send the message across the room to your partner using patterns.

Take time to plan and discuss with your partner the systems you will use to send your message. Look through the materials and brainstorm how you could use these items to send the same message in more than one way.

Once you have developed your systems, test them out. Practice sending short messages across the room to each other. Decide who will be sending the messages and who will be receiving them.

When you are ready, the sender will ask the teacher for the message that will be sent across the room. The other partner should remain on the other side of the room and be prepared to receive the message. Once the message has been sent using all the delivery systems, the receiver partner will bring the message they received right to the teacher.

When the message has been given to the teacher each partner will need to reflect and answer the following questions:

A. How did you decide which systems you would use to send your information for this experiment?
B. What patterns did you use?
C. Which of your systems did you prefer? Why?
D. Were you successful in sending your message? Why or why not?

Data Transfer Rubric

	4	3	2	1
Systems	Students developed two or more systems to deliver their message. The message was delivered successfully.	Students developed two or more systems to deliver their message. The message was transferred mostly correctly.	Students developed only one system and the message was sent correctly. The students developed more than one system, but the message was decoded incorrectly.	Students only developed a single system. The message was not sent or was decoded incorrectly.
Patterns	The students developed two patterns and clearly describe each pattern.	The students develop two patterns, but only clearly describe one of the patterns.	The students developed only one pattern and clearly described it, or they developed two patterns, but do not describe them well.	There was no pattern developed.
Preference	Students clearly compare and contrast their systems and give reasons on which system they liked best.	The students give their preference, they attempt to explain, but do not clearly explain why it was the best.	The students say what their preference was, but give no reasons why.	The students did not explain which system they preferred.

_____ out of 12 points

Collision of Objects

Lesson 12: Marble Collisions
Lesson 13: Sudden Stop
Lesson 14: Sports and Collisions
Lesson 15: Collision (Assessment)

NGSS Lesson Planning: Fourth Grade-Marble Collisions

<table>
<tr><td>Grade: 4th</td><td>Topic: Collisions of Objects</td><td>Lesson 12: Marble Collisions</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Using marbles of various sizes, the students will work to see how collisions can transfer energy from one object to another.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will work with various materials to create and answer questions about what happens with energy when objects collide.</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">Energy is not created. It can be transferred from one object to the next.</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">What is energy? Energy can be transferred.</td></tr>
<tr><td>Science & Engineering Practices:

● Asking questions (science) and defining problems (engineering)
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations (science) and designing solutions (engineering)
● Engaging in argument from evidence
● Obtaining, evaluating, and communicating information</td><td>Disciplinary Core Ideas:

PS3.A: Definitions of Energy
● The faster a given object is moving, the more energy it possesses. (4-PS3-1)
● Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)
PS3.B: Conservation of Energy and Energy Transfer
● Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3)
PS3.D: Energy in Chemical Processes and Everyday Life
● The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)
PS3.C: Relationship Between Energy and Forces
● When objects collide, the contact forces transfer energy so as to change the objects’ motions. (4-PS3-3)

ETS1.A: Defining Engineering Problems
● Possible solutions to a problem are limited by available materials and</td><td>Crosscutting Concepts:

● Patterns
● Cause and effect: Mechanism and explanation
● Scale, proportion, and quantity
● Systems and system models
● Energy and matter: Flows, cycles, and conservation
● Structure and function
● Stability and change</td></tr>
</table>

	resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	
Possible Preconceptions/Misconceptions		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	We know that objects in motion have energy, but what happens to that energy when two things collide? Today we will be experimenting with marbles to answer questions about what happens when these collisions occur.	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	Get out materials for this activity which are marbles. Encourage the class to practice with the marbles and observe what happens when the marbles collide. Record any observations that demonstrate the transfer of sounds.	
EXPLAIN: Concepts Explained and Vocabulary Defined	Bring the class back together, and demonstrate what students have discovered. Allow them to use their own words to describe their findings. What do you think happens to the energy in the first item when it collides with the second? Discuss with the students the idea of collisions and energy. Stream videos.	
ELABORATE: Applications and Extensions	After discussing the information above, the students are given a task. Tell the class that they are to set up a ramp using the ruler and books. Make sure that each group has two to three books, one ruler and marbles of different sizes. Tell the students that they are to experiment with putting one marble resting at the bottom of the ramp and to release the second marble from the top of the ramp. Use the divot in the center of the plastic ruler to help control the movement of the marble. Ask them to experiment with having the large marble at rest and having the large marble at the top of the ramp. Instruct them to experiment with adding more books to increase the height of the ramp. On each experiment they should record the distance each marble traveled from the end of the ramp. (See attached worksheet.) When they are finished student need to explain what they have found from this experimentation about collisions.	
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	Students will turn in their notes from the day with a write up of their findings. The diagrams in the notebooks and their explanation of what they learned will help to show student understanding. Teacher also has the chance to move around the room to evaluate the learning.	
Elaborate Further / Reflect:		

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
1	marbles	Amazon.com	$13.07
	ramps from wheeled car activity		

Name_____

Marble at the top	Marble at the bottom	Number of books for ramp	Distance top marble travels	Distance bottom marble travels

NGSS Lesson Planning: Fourth Grade-Sudden Stop

<table>
<tr><td>Grade: 4th</td><td>Topic: Collisions of Objects</td><td>Lesson 13: Sudden Stop</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Using cars and pennies, the students will work to see how collisions can transfer energy from one object to another.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will work with various materials to create and answer questions about what happens with energy when objects collide.</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">Energy is not created, but can be transferred from one object to the next.</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">What is energy? Energy can be transferred.</td></tr>
<tr><td>Science & Engineering Practices:

● Asking questions (science) and defining problems (engineering)
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations (science) and designing solutions (engineering)
● Engaging in argument from evidence
● Obtaining, evaluating, and communicating information</td><td>Disciplinary Core Ideas:

PS3.A: Definitions of Energy
● The faster a given object is moving, the more energy it possesses. (4-PS3-1)
● Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)
PS3.B: Conservation of Energy and Energy Transfer
● Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3)
PS3.D: Energy in Chemical Processes and Everyday Life
● The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)
PS3.C: Relationship Between Energy and Forces
● When objects collide, the contact forces transfer energy so as to change the objects’ motions. (4-PS3-3)

ETS1.A: Defining Engineering Problems
● Possible solutions to a problem are limited by available materials and resources (constraints). The success of</td><td>Crosscutting Concepts:

● Patterns
● Cause and effect: Mechanism and explanation
● Scale, proportion, and quantity
● Systems and system models
● Energy and matter: Flows, cycles, and conservation
● Structure and function
● Stability and change</td></tr>
</table>

	a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	
Possible Preconceptions/Misconceptions		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	We know that objects in motion have energy, but what happens to that energy when two things collide? Today we will be experimenting with cars to answer questions about what happens when these collisions occur. What happens when two objects are traveling together and one of those two objects collide with another?	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	Get out materials for this activity which are small cars, pennies, and blocks of wood. Encourage the class to practice with the materials and observe what happens when objects collide. Record any observations that demonstrate the results of collisions.	
EXPLAIN: Concepts Explained and Vocabulary Defined	Bring the class back together, and demonstrate what students have discovered. Allow them to use their own words to describe their findings. Were you able to find a way to move two objects at once and have one collide? What happened? Discuss with the students the idea of collisions and energy.	
ELABORATE: Applications and Extensions	After discussing the information above, the students are given a task. What happens to the penny when you place it on the top of the car and let the car roll down a ramp? Give the students a ramp and ask them to get out three books. Place the penny on the car and roll it down the ramp. Alter the height of the ramp. Each time record what happens to the penny. Record any distance. How does changing the height of the ramp affect the penny? (Use the table that is attached.)	
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	Students will turn in their notes from the day with a write up of their findings. The diagrams in the notebooks and their explanation of what they learned will help to show student understanding. Teacher also has the chance to move around the room to evaluate the learning.	
Elaborate Further / Reflect:		

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
	Student constructed cars from "Wheeled Vehicles" or hot wheels, matchbox cars, Lego cars, etc	Amazon.com	$22
1	Pennies		$1

Name_____

Number of books for ramp	Observations	Distance penny travels

NGSS Lesson Planning: Fourth Grade-Sports and Collisions

<table>
<tr><td>Grade: 4th</td><td>Topic: Collisions of Objects</td><td>Lesson 14: Sports and Collisions</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Using balls, bats and racquets, the students will work to see how collisions can transfer energy from one object to another.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will work with various materials to create and answer questions about what happens with energy when objects collide.</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">Energy is not created. It can be transferred from one form to the next.</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">What is energy? Energy can be transferred.</td></tr>
<tr><td>Science & Engineering Practices:

● Asking questions (science) and defining problems (engineering)
● Developing and using models
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● Analyzing and interpreting data
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● Constructing explanations (science) and designing solutions (engineering)
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● Obtaining, evaluating, and communicating information</td><td>Disciplinary Core Ideas:

PS3.A: Definitions of Energy
● The faster a given object is moving, the more energy it possesses. (4-PS3-1)
● Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)
PS3.B: Conservation of Energy and Energy Transfer
● Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3)
PS3.D: Energy in Chemical Processes and Everyday Life
● The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)
PS3.C: Relationship Between Energy and Forces
● When objects collide, the contact forces transfer energy so as to change the objects’ motions. (4-PS3-3)

ETS1.A: Defining Engineering Problems
● Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by</td><td>Crosscutting Concepts:

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● Stability and change</td></tr>
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	considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	
Possible Preconceptions/Misconceptions		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	We know that objects in motion have energy, but what happens to that energy when two things collide? Today we will be experimenting with sports to answer questions about what happens when these collisions occur.	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	Tell the students that we will be doing science outside today. Have them get into groups of two or three. Get out materials for this activity which are whiffle balls, bats, playground balls, birdies and badminton racquets. Encourage the class to practice with the materials and observe what happens when objects collide. Record any observations that demonstrate the results of collisions.	
EXPLAIN: Concepts Explained and Vocabulary Defined	Bring the class back together, and demonstrate what students have discovered. Allow them to use their own words to describe their findings. What do you think happens to the energy in the first item when it collides with the second? Discuss with the students the idea of collisions and energy.	
ELABORATE: Applications and Extensions	After discussing the information above, the students are given a task. Can you get an object to travel a set distance using collisions? The students are shown that they have two distance they will try to make their objects move. One distance is five feet away, the other is twenty feet away (can be further). Allow the students to experiment with different ways to make this happen. Show them the starting line that they cannot cross and explain that each group will get one chance to move their object to each of the targets. After giving each group 10 to 20 minutes to practice, bring the class back together and give each group a chance to hit the target. When they are finished student need to explain what they have found from this experimentation about collisions. What did they have to do with each example to try to get the object to move a shorter distance vs. a further distance?	
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	Students will turn in their notes from the day with a write up of their findings. The diagrams in the notebooks and their explanation of what they learned will help to show student understanding. Teacher also has the chance to move around the room to evaluate the learning.	
Elaborate Further / Reflect:		

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
2	build two targets with bulletin board paper (3 foot by 3 foot)	schools	
1	Whiffle Balls	Amazon.com	5.95
3	Whiffle Ball Bats	Walmart.com	9.00
1	Badminton Racquets	Walmart.com	16.71
6	Playground balls	schools	

Collisions Performance Task

Name: Date:

A collision occurs when a baseball bat hits a baseball, or a tennis racket hits a tennis ball. What would happen if you hit a baseball with a table-tennis paddle, or a table-tennis ball with a baseball bat? How do the masses of colliding objects change the results of collisions?

What You'll Investigate (Problem):

How does changing the size and number of marbles in a collision affect the momentum?

What do you think will happen? (Hypothesis):

_____

_____

_____

_____

Materials:

Small marbles (5) Meter sticks (2)

Large marbles (2) Tape

Goals:

Be able to compare and contrast different collisions.

Be able to determine how the speeds after a collision depend on the masses of the colliding objects.

Procedure:

1. Tape the meter sticks next to each other, slightly farther apart than the width of the large marbles. This limits the motion of the marbles to nearly a straight line.
2. Place a target marble in the center of the track formed by the meter sticks. Place a small marble at one end of the track. Shoot this marble at one end of the track. Shoot this marble toward the target marble by flicking it with your finger. Describe the collision.
3. Repeat step 2, replacing the two small marbles with the two large marbles.
4. Repeat step 2, replacing the small shooter marble with a large marble, the target marble will be small.

5. Repeat step 2, replacing the small target marble with a large marble, the shooter marble should be small.
6. Repeat step 2, replacing the small target marble with four small marbles that are touching, the shooter marble should be small.
7. Place two small marbles at opposite ends of the meter sticks. Shoot the marbles toward each other and describe the collision.
8. Place two large marbles at opposite ends of the meter sticks. Shoot the marbles toward each other and describe the motion.
9. Place a small marble and a large marbles at opposite ends of the meter sticks. Shoot the marbles toward each other and describe the collision.

Data: Table 1: Marble Collisions

Trial Number	Shooter Marble (Moving)	Target Marble (Stationary)	Before Collision Drawing	After Collision Drawing
1				
2				
3				
4				
5				
6				
7				
8				

Conclude and Apply:

1. Compare and contrast the results of the various types of collisions.

1. In which collisions did the shooter marble change direction? How did the mass of the target marble compare with the shooter marble in these collisions?

Converting Energy

Lesson 16: Catapults
Lesson 17: Solar Ovens
Lesson 18: Wheeled Vehicles (Assessment)
Lesson 19: Natural Resources and Energy

NGSS Lesson Planning: Fourth Grade-Catapults

<table>
<tr><td>Grade: 4th</td><td>Topic: Converting Energy</td><td>Lesson 16: Catapults</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Using ping pong balls and a variety of materials, the students will work in teams to design, test and refine a device that can launch the ping pong ball across the room.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.
4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will work with various materials to create a catapult.</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">There are many types of Catapult. In modern times, the word catapult can be used to describe any machine that hurls a projectile.</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">What is energy? Energy can be transferred.</td></tr>
<tr><td>Science & Engineering Practices:

● Asking questions (science) and defining problems (engineering)
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations (science) and designing solutions (engineering)
● Engaging in argument from evidence
● Obtaining, evaluating, and communicating information</td><td>Disciplinary Core Ideas:

PS3.A: Definitions of Energy
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● The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)
PS3.C: Relationship Between Energy and Forces
● When objects collide, the contact forces transfer energy so as to change the objects’ motions. (4-PS3-3)

ETS1.A: Defining Engineering Problems</td><td>Crosscutting Concepts:

● Patterns
● Cause and effect: Mechanism and explanation
● Scale, proportion, and quantity
● Systems and system models
● Energy and matter: Flows, cycles, and conservation
● Structure and function
● Stability and change</td></tr>
</table>

	• Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	
Possible Preconceptions/Misconceptions		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	We know that objects in motion have energy. We have spent time working to develop an understanding of energy transfer and collisions. Today we will be working to design a device to transfer energy to this ping pong ball and move it across the room. We will be building catapults.	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	Start out by getting out materials for the students to use (ping pong balls, spoons, rubber bands, and craft sticks). Encourage the students to work in partnerships to use these items to build a catapult. In their science notebooks they should record diagrams of any catapults they build.	
EXPLAIN: Concepts Explained and Vocabulary Defined	Bring the class back together, and demonstrate what students have discovered. Allow them to use their own words to describe their findings. Take the class to the lab to research catapults. In their notebooks they should record information they feel would be beneficial. They should save sites to their favorites that they might want to access later. The students and their partners should discuss the changes they would like to make to their catapult.	
ELABORATE: Applications and Extensions	After discussing the information above, the students are given a task. Each of you will refine your catapults in an attempt to build a catapult that will propel the ping pong ball the furthest distance. Each group will be provided with more rubber bands, craft sticks, and cardboard. We will test out the catapults to see which group moved the ball the furthest.	
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	Students will turn in their notes from the day with a write up of their findings. The diagrams in the notebooks and their explanation of what they learned will help to show student understanding. Teacher also has the chance to move around the room to evaluate the learning.	
Elaborate Further / Reflect:	Encourage students to build their own catapults outside of school to bring in and share with the class.	

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
2 boxes of 300 Jumbos	craft sticks	on-line supplier	$8.60 ea./$18.00 for two boxes
1 box of 144	ping pong balls (can be split between all fourth grade kits - 24 per kit)	Amazon.com	$8.75
3 bag/box	rubber bands	Shop let.com	$3.78
15-30	spoons	school cafeteria	

NGSS Lesson Planning: Fourth Grade-Solar Oven

<table>
<tr><td>Grade: 4th</td><td>Topic: Converting Energy</td><td>Lesson 17: Solar Ovens</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">The students will build solar ovens to demonstrate how light energy is transferred into heat energy.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will observe how light transports energy into heat energy through the construction of solar ovens.</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">Light absorption with different colors- Darker (absorbs) lighter (reflects). Light is not energy but rather a transporter of energy through space.</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">Knowledgeable of what colors absorb more light than others and the concepts regarding energy. It cannot be created or destroyed.</td></tr>
<tr><td>Science & Engineering Practices:

○ Asking questions (science) and defining problems (engineering)
○ Developing and using models
○ Planning and carrying out investigations
○ Analyzing and interpreting data
○ Using mathematics and computational thinking
○ Constructing explanations (science) and designing solutions (engineering)
○ Engaging in argument from evidence
○ Obtaining, evaluating, and communicating information</td><td>Disciplinary Core Ideas:

PS3.A: Definitions of Energy
● Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)
PS3.B: Conservation of Energy and Energy Transfer
● Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3)
● Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-2),(4-PS3-4)
PS3.D: Energy in Chemical Processes and Everyday Life
● The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)

ETS1.A: Defining Engineering Problems</td><td>Crosscutting Concepts:

○ Patterns
○ Cause and effect: Mechanism and explanation
○ Scale, proportion, and quantity
○ Systems and system models
○ Energy and matter: Flows, cycles, and conservation
○ Structure and function
○ Stability and change</td></tr>
</table>

	• Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	
Possible Preconceptions/Misconceptions	Light is not energy but a transporter of energy through space.	
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	Begin by reviewing Energy. What do students know about light energy and heat energy? What are they? What does "solar" mean and what are some examples of things that are solar powered. Explain to the students that today we will be talking about solar ovens.	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	Split the students into groups of two or three. Give the students different materials to use to make a solar oven. They will work together to construct a solar oven using what they know about light and heat energy.	
EXPLAIN: Concepts Explained and Vocabulary Defined	Explain how light energy converts to heat energy. Explain that light is not energy but a transporter of energy through space. Watch video to show students how to make the solar ovens. going-green-challenge.com www.youtube.com	
ELABORATE: Applications and Extensions	After watching the video and discussing the information above, the students are given the opportunity to refine their solar ovens built earlier. They can keep their previous experiments or alter them. The teacher also poses one more challenge. Since energy can be transferred from light energy to heat energy, one of the group's demonstrations must show energy transfer from light to heat.	
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	After students are given a chance to experiment they present their demonstrations to the class. They must explain what is happening throughout the demonstration.	
Elaborate Further / Reflect:		

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
2	Aluminum Foil	Walmart	$12
	Pizza Boxes	Local Pizza store	------
3	Clear Plastic Wrap	Walmart	$7
	Scissors	Normal Classroom Supplies	$0
	All Purpose Glue	Normal Classroom Supplies	$0
1	X-acto knife/Box Cutter	Walmart	$2
	Ruler	Normal Classroom Supplies	$0
	Black Marker	Normal Classroom Supplies	$0
	Tape	Normal Classroom Supplies	$0
1- 50pk	Black Construction Paper	Walmart	$4
2 packs of 10 ea.	Thermometers	Amazon.com	$20/ea. $40

NGSS Lesson Planning: Fourth Grade-Wheeled Vehicle

Grade: 4th	**Topic: Energy**	**Lesson 18: Wheeled Vehicles**
Brief Lesson Description:	Using wheeled vehicles to design, test, and refine a device that converts energy from one form to another. First, students will build a simple ramp car, powered only by gravity. Next, students will add a small fan motor. This will require **circuit** to become part of the lesson. Depending on student progressions, teacher may add **switches**. Students race, showcase and utilize their vehicles for demonstration of learning target mastery	
Performance Expectation(s):	4-PS3-1.Use evidence to construct an explanation relating the speed of an object to the energy of that object. 4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. 4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	
Specific Learning Outcomes:	Students will work in partnerships to design and test a variety of vehicles that demonstrate how energy can be transferred from one place to another. They will be able to identify how the energy changes forms and how with more energy there is a greater speed.	
Narrative / Background Information	The faster a car is moving, the more energy it possesses. When objects collide, energy can be transferred from one object to another, changing their motion.	
Prior Student Knowledge:	**Asking questions, taking a poll or survey, administering a pretest on learning targets**	
Science & Engineering Practices: ● ***Asking questions (science) and defining problems (engineering)*** ● ***Developing and using models*** ● ***Planning and carrying out investigations*** ● ***Analyzing and interpreting data*** ● ***Using mathematics and computational thinking*** ● ***Constructing explanations (science) and designing solutions (engineering)*** ● ***Engaging in argument from evidence*** ● ***Obtaining, evaluating, and communicating information***	**Disciplinary Core Ideas:** PS3.A: Definitions of Energy ● The faster a given object is moving, the more energy it possesses. (4-PS3-1) ● Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3) PS3.B: Conservation of Energy and Energy Transfer ● Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3) ● Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-2),(4-PS3-4) PS3.D: Energy in Chemical Processes and Everyday Life	**Crosscutting Concepts:** ● Patterns ● ***Cause and effect: Mechanism and explanation*** ● ***Scale, proportion, and quantity*** ● ***Systems and system models*** ● ***Energy and matter: Flows, cycles, and conservation*** ● ***Structure and function*** ● Stability and change

	• The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4) **ETS1.A: Defining Engineering Problems** • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*	
Possible Preconceptions/Misconceptions		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	Give an opening act or show of a completed vehicle going down a ramp. Set up ahead of time material distribution stations.	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	**Students to be in teams of two** Provide basic materials: 15-20 cardboard chassis (precut) 100 dowels for Axles (precut) 50 plastic wheels (pre-purchased) 2-3 rolls Duct tape (pre-purchased)	
EXPLAIN: Concepts Explained and Vocabulary Defined	Introduce the concept of energy (***energy*** – the ability to do work. There are different types of energy. ***Conservation of energy***- energy cannot be created or destroyed, it is transferred from one form to another.)	
ELABORATE: Applications and Extensions	Races, collisions, iPad recording (Documentary) (iMovie) demonstrations	
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	**Formative**: observation of vehicles planning, design, testing **Summative**: Completion of vehicle, fulfillment of distance to travel,	
Elaborate Further / Reflect:	Careers in engineering design, race cars, automotive-Ford, GM, Chrysler,	

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
200	Wheels- item number 990168	Kelvin.com	$18
20	Wood Dowels item number 850628	Kelvin.com	$4
1 Box	Straws	Walmart, Amazon, School kitchen	$4
1 per student	Sturdy Cardboard- 3 ¼" x 6"	Warehouse	$0
3 rolls	(Gray or Black or other) Duct Tape	Walmart	$15
2	Grand Prix Pinewood Derby Practice Track	Boy Scout Shop	$32
6	Empty Water Bottles		
2	3 in Propellers 3 blades (pack of 8) item number 990175	Kelvin.com	$12
20 @ $1.50/ea.	6.0-12.0 volt motors	Kelvin.com	$30
3 sets of 10	Wire w/alligator clips	Kelvin.com	$7.95/ea.
15	Blade switch	Kelvin.com	$1.59/ea

Wheeled Vehicle

Data Sheet Ideas

Team Members: _____

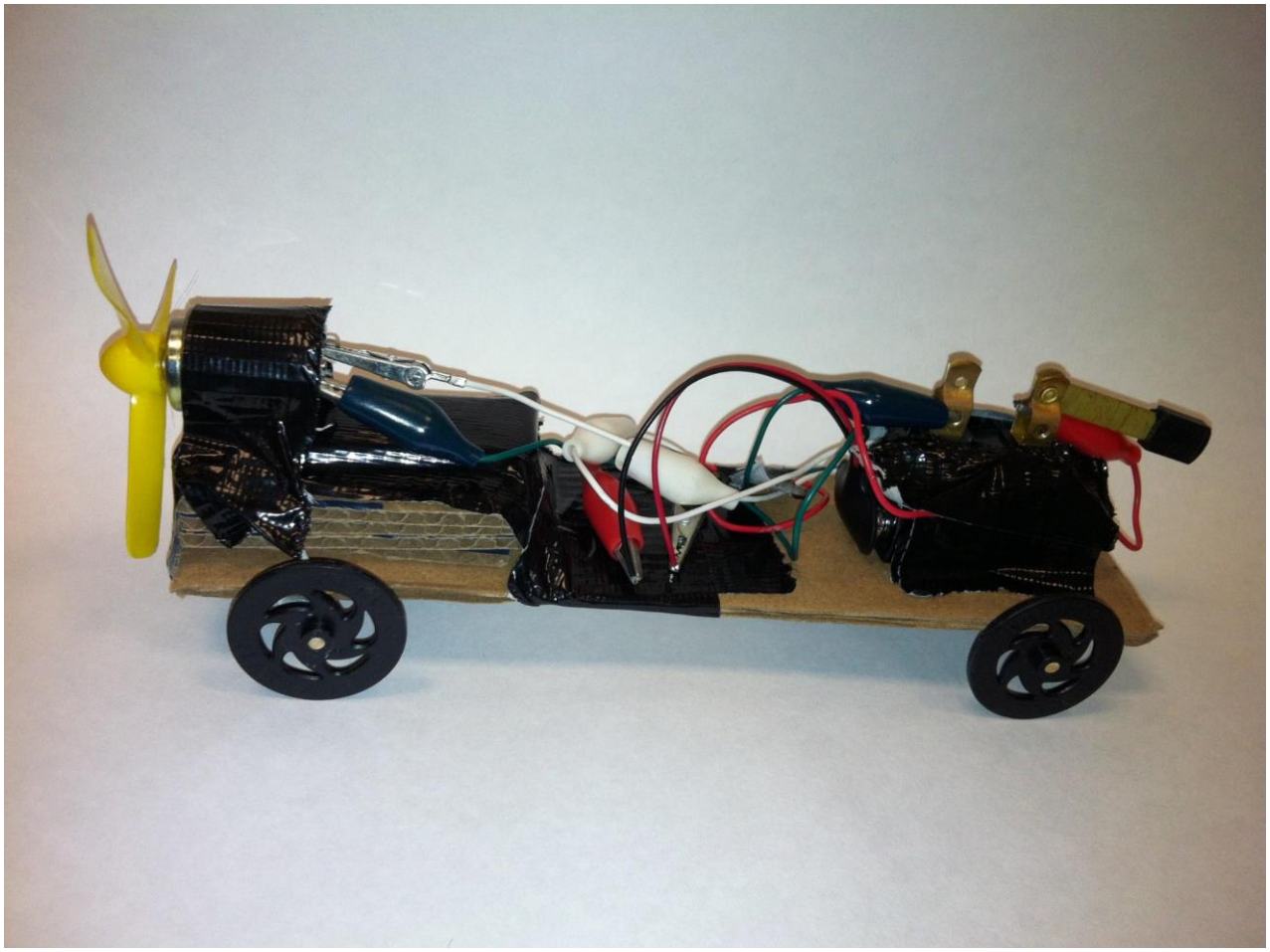
Date: _____

Ramp Car Data Table

Test Run	Distance Traveled Feet or Meters	Time to Travel Distance Seconds	Speed (Distance/Time) Feet/second or Meters/second

Diagramming and work area:

Completed Fan Car Sample



Resources for Fourth Grade Science 4-ESS3-1 Energy (Natural Resources, Non-renewable, renewable energy)

Website: www.ecokids.ca

What it has:

Find out how Canada's environment could change if we produce more carbon dioxide.

Errand Run: An alternative transportation game. Complete your errands while polluting as little as possible.

Contains quizzes on energy resources, climate change,

Fossil Fuel eco-stats: Get all of the facts and figures about fossil fuels.

Learn about energy and where it comes from.

Website: www.kidzworld.com (if this doesn't come up, Google fossil fuels for kids☺

What it has: kid friendly information and research on fossil fuels, hydropower, solar power, geothermal energy, wind power

Website: Discoveryeducation.com

What it has:

Video: Powering the Future: The Green Revolution: Modern society relies on fossil fuels to power everything from cars to food processors. However, experts believe we have already used more than 50 percent of the world's recoverable oil. Natural gas and coal supplies are not endless. Today, the race is on to find renewable, cleaner sources of energy. Discusses alternative energy resources.

Website: Discoveryeducation.com

What it has:

Video: Greatest Inventions with Bill Nye: Energy

Reveals new advances in oil drilling and coal mining, as well as considers the impact of burning fossil fuels on the environment.

Website: **Discoveryeducation.com**

What it has:

Video: Power Up: Energy in our Environment (grades 3-5)

Fossil fuels (oil, coal, and natural gas) are formed from the remains of living things that died millions of years ago and were gradually buried by layers of rock and soil. Fossil fuels are used to produce energy in order to generate electricity, run our cars, and heat our homes.

Website: **brainpop.com** (if you don't have an account, you can sign up for a free trial)

What it has:

Video: Fossil fuels – 3 minutes video with quiz, activities

Video: Conserving Energy – minute video with quiz, activities

Other resources:

Powerpoint by Sean and Anne ☺

What is has: Natural Resources and Energy: Has graphics, student discussion questions, i.e.-global coal, gas, oil reserves, how to read and interpret information in graphs, tables, and charts.

Natural Resources and Energy

Strand 4-ESS3-1

4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. [Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. **Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]**

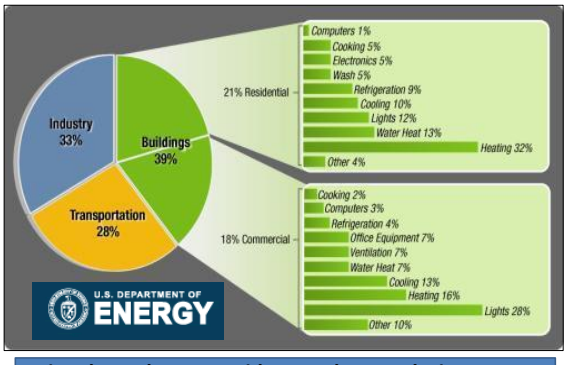
What are some of the natural resources from which we get our ENERGY?

Energy That Powers the United States

NONRENEWABLE		RENEWABLE	
PETROLEUM	35.10% *Uses: transportation, manufacturing*	BIOMASS	4.39% *Uses: heating, electricity, transportation*
NATURAL GAS	25.17% *Uses: heating, manufacturing, electricity*	HYDROPOWER	2.56% *Uses: electricity*
COAL	21.26% *Uses: electricity, manufacturing*	WIND	0.94% *Uses: electricity*
URANIUM	8.62% *Uses: electricity*	GEOTHERMAL	0.22% *Uses: heating, electricity*
PROPANE	1.63% *Uses: heating, manufacturing*	SOLAR	0.11% *Uses: heating, electricity*

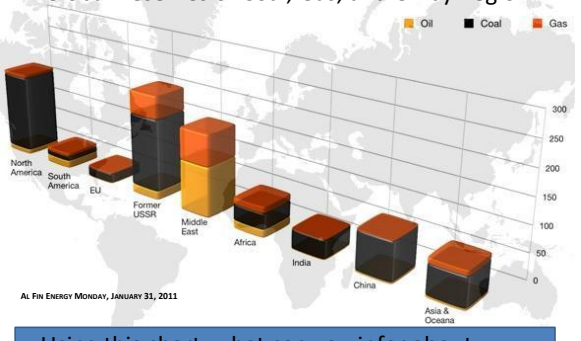
Data: Energy Information Administration

Using this evidence, what conclusions can you draw about US energy usage?

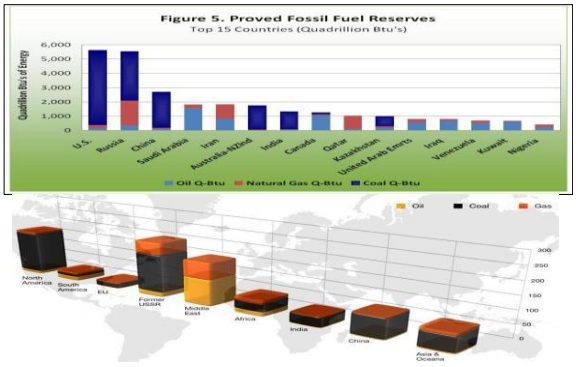


Using these charts as evidence, what conclusion can you reach about U.S. Energy usage?

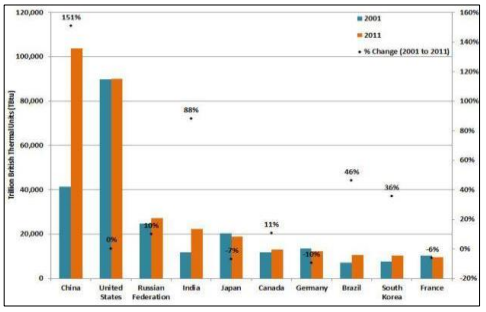
Global Reserves of Coal, Gas, and Oil by Region



Using this chart, what can you infer about energy reserves across the world?



Both of these charts are meant to contain similar information. In your opinion, which of the two is better and why? Does teh evidence int he two charts agree? Support you answer with evidence.



Source: BP Statistical Review of World Energy June 2012

Using this chart, what does it appear is happening to energy consumption inside and outside the United States? Why might this be? What might this chart look like in 10 or 20 years?

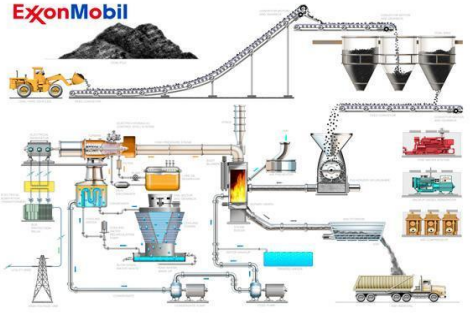
Possible Environmental Consequences of Renewable Resources

Think as you view these videos and websites.

On each source, do you believe that the information can be trusted?

Who made these information sources?
Why were they made? (Author's Purpose)

Mining Coal



coal mining

What are some of the possible effects in the mining and burning of coal?

Obtaining Uranium, a Fissile Substance

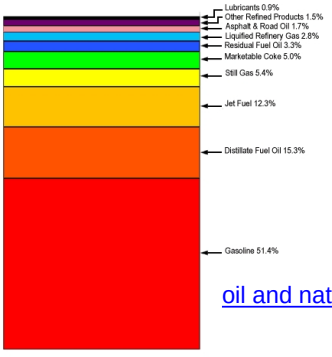
uranium mining

Using Uranium, a Fissionable Substance

What are some of the possible effects in the mining and use of fissile materials?

Drilling for Oil and using its many Products

Petroleum Products Yielded from One Barrel of Crude Oil in California



Product	Percent of Total
Finished Motor Gasoline	51.4%
Distillate Fuel Oil	15.3%
Jet Fuel	12.3%
Still Gas	5.4%
Marketable Coke	5.0%
Residual Fuel Oil	3.3%
Liquefied Refinery Gas	2.8%
Asphalt and Road Oil	1.7%
Other Refined Products	1.5%
Lubricants	0.9%

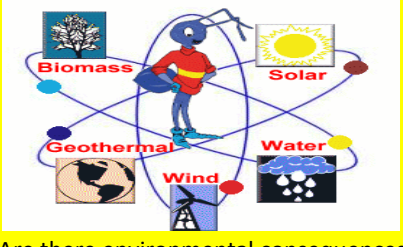
oil and natural gas production

Possible Environmental Effects

- What kind of effects are there on the environment from the collecting and use of natural gas, petroleum, and the other fossil fuels?

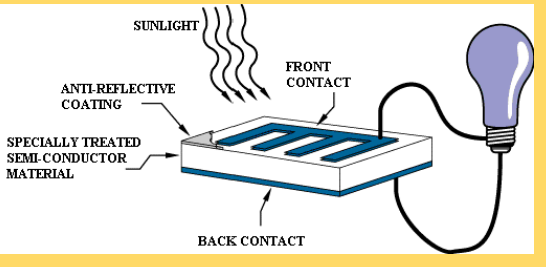
Renewable Energy

- What are some of the more common types of renewable energy?



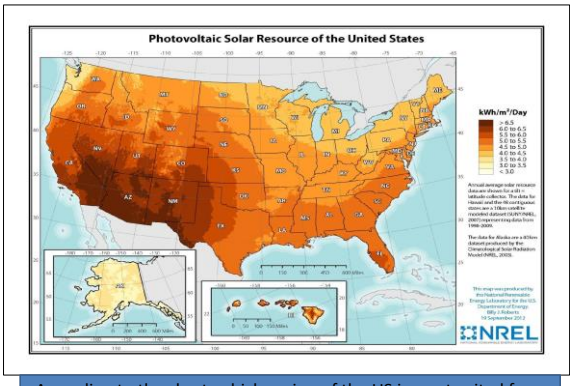
- Are there environmental consequences with using renewable resources to produce energy?
- Is it clean energy or just cleaner?

Solar Photovoltaic Cell Converts Light to Electricity

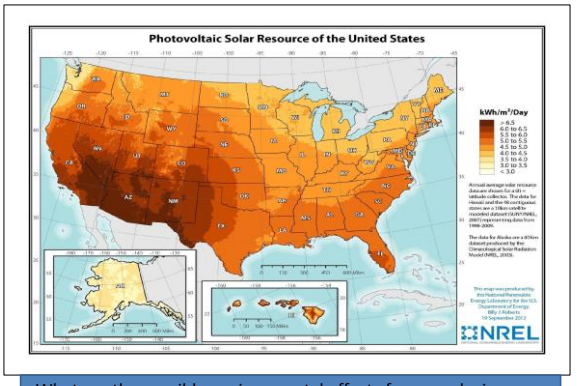


NASA.gov

Solar Energy

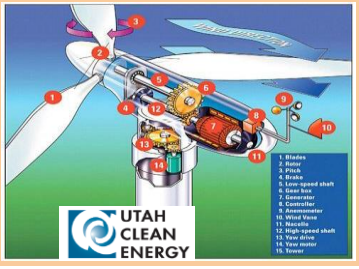


According to the chart, which region of the US is most suited for to use solar energy? What do you know about this region?



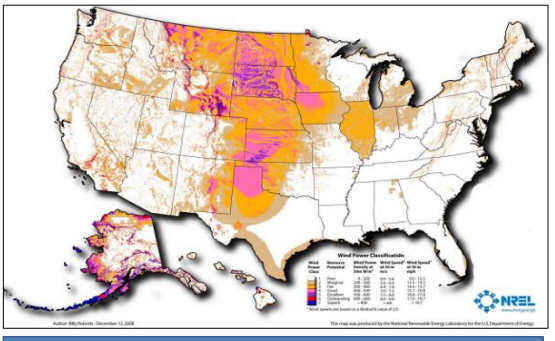
What are the possible environmental effects from producing energy using the sun as a natural resource?

Moving air molecules push the blades of the windmill, at which point the generator uses the motion of the blades to make electricity.



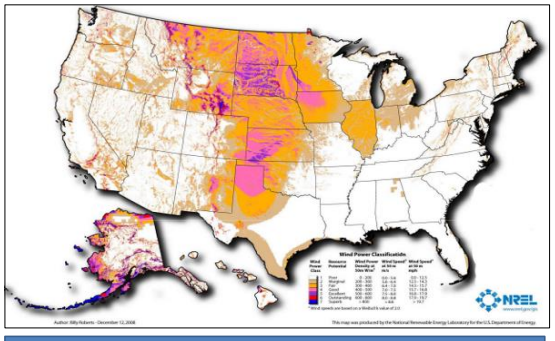
Solar Farm in Michigan

U.S. Wind Resources



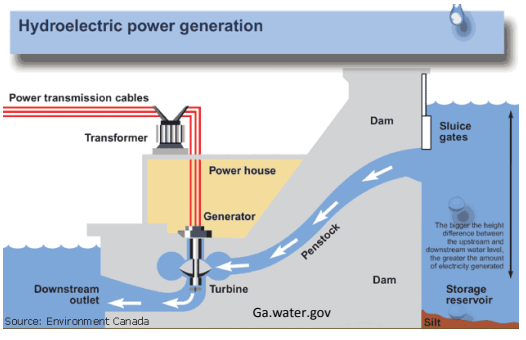
According to the chart, which region of the US is most suited for wind energy? What do you know about this region?

U.S. Wind Resources



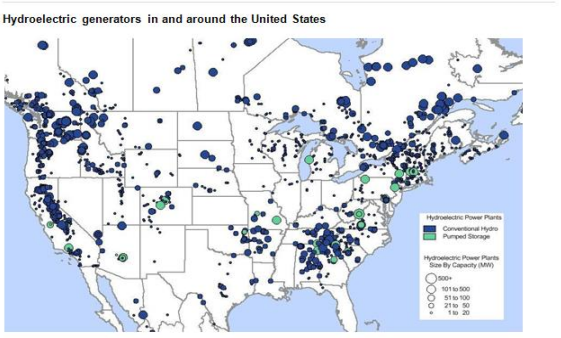
What are the possible environmental effects from producing energy using the wind as a natural resource?

Moving water is changed into electricity

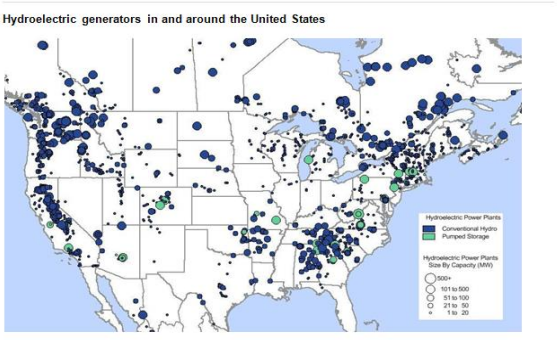


Interesting Website

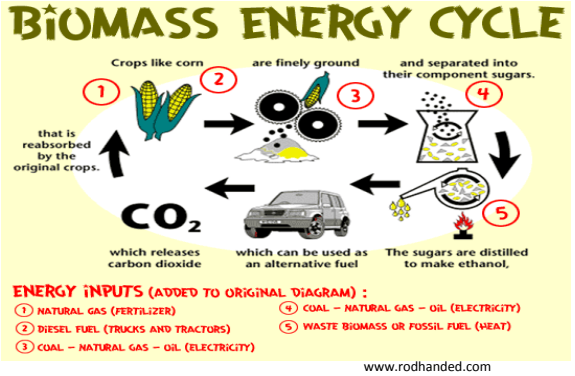
Hydroelectric Energy



According to the chart, which region of the US is most suited for the use of hydroelectric energy? What can you infer about these areas?

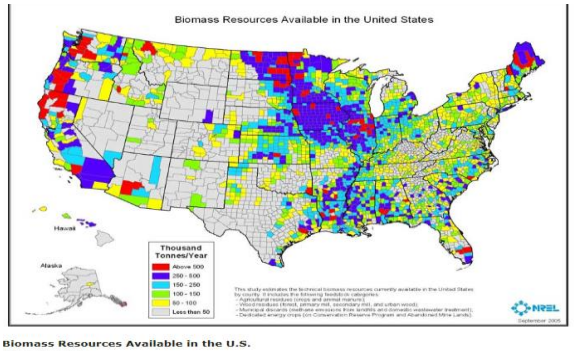


What are some possible environmental effects from producing energy using water as a natural resource?



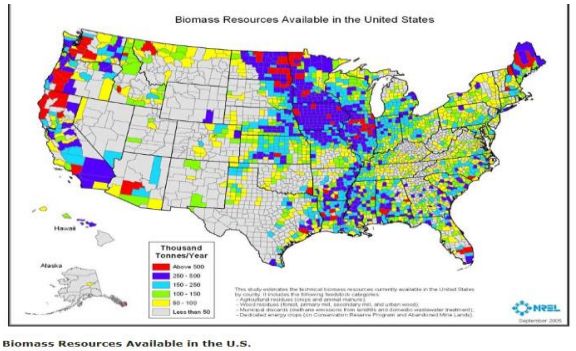
www.rodhanded.com

Biomass



Biomass Resources Available in the U.S.
Source: NREL

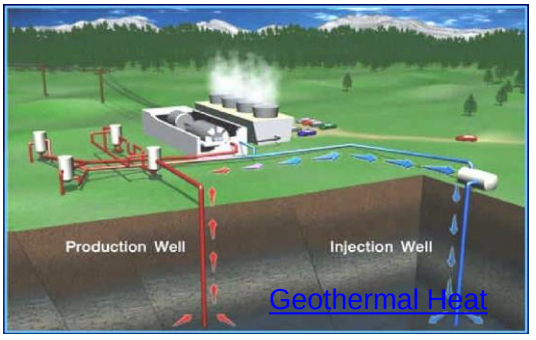
According to the chart, which region of the US is most suited for the use of biomass energy? Why do you believe this is true?

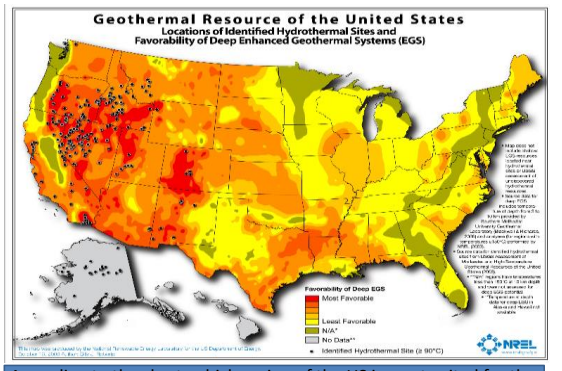


Biomass Resources Available in the U.S.
Source: NREL

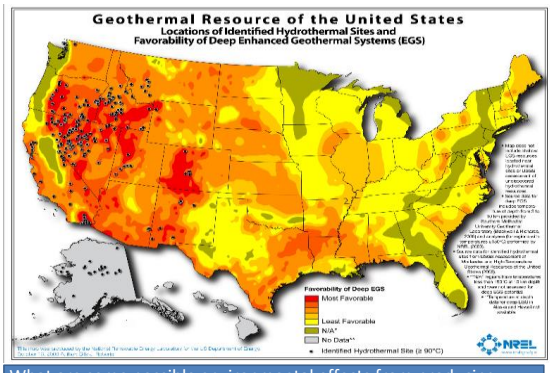
What are some possible environmental effects from producing energy using wood and other biomass as a natural resource?

The energy from the ground water is harvested and then the waste water is returned to the ground.

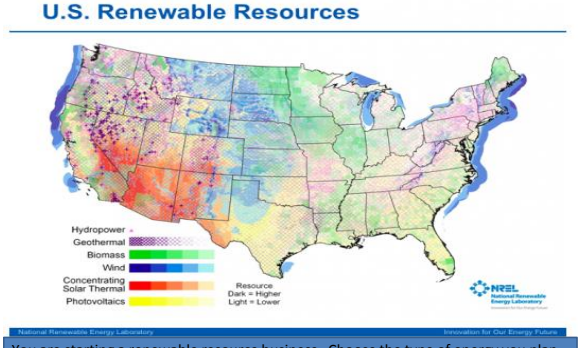




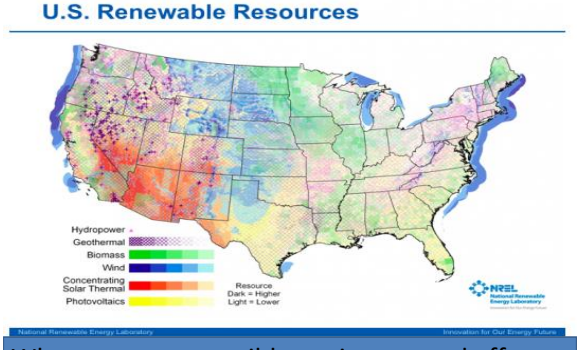
According to the chart, which region of the US is most suited for the use of geothermal energy? Why do you believe this is true?



What are some possible environmental effects from producing energy using geothermal energy as a natural resource?



You are starting a renewable resource business. Choose the type of energy you plan to produce and the region of the United States in which you would choose to start your company. Record evidence to support both your decisions. Describe the natural resources available in this area.



What are some possible environmental effects from producing energy in your company?

Companion to Energy PowerPoint

4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
[Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]

ESS3.A: Natural Resources

- Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. (4-ESS3-1)

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluate the merit and accuracy of ideas and methods.

- Obtain and combine information from books and other reliable media to explain phenomena. (4-ESS3-1)

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluate the merit and accuracy of ideas and methods.

- Obtain and combine information from books and other reliable media to explain phenomena. (4-ESS3-1)

Connections to Engineering, Technology, and Applications of Science
Interdependence of Science, Engineering, and Technology

- Knowledge of relevant scientific concepts and research findings is important in engineering. (4-ESS3-1)

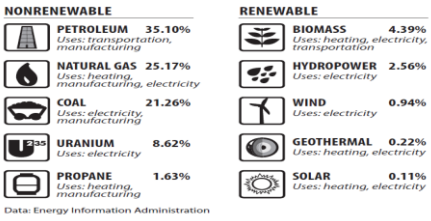
Influence of Engineering, Technology, and Science on Society and the Natural World

- Over time, people's needs and wants change, as do their demands for new and improved technologies. (4-ESS3-1)

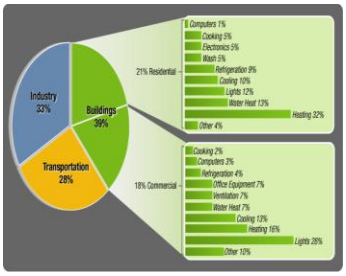
PowerPoint Companion Document

Open all videos thoughtfully, as they link to YouTube.

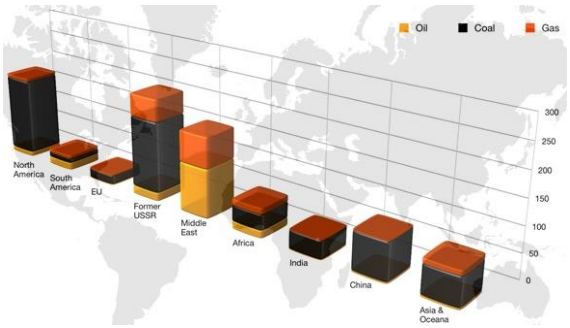
The children brainstorm ideas in partners or small groups to predict the next slide.



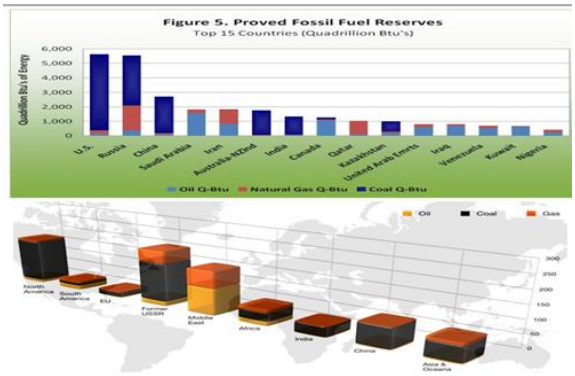
The children should be able to see difference in percent's of nonrenewable and renewable resources, solar being the least, petrol being the most, and many more comparisons.



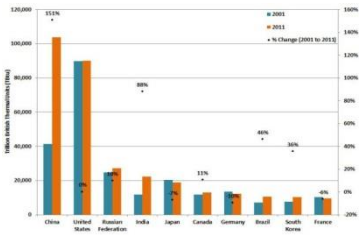
Students will identify areas of most or least use.



Different regions have different amounts of natural resources. North America is rich with coal, while the Middle East has much oil and natural gas.



Comparing deficits and positives about the two graphs.

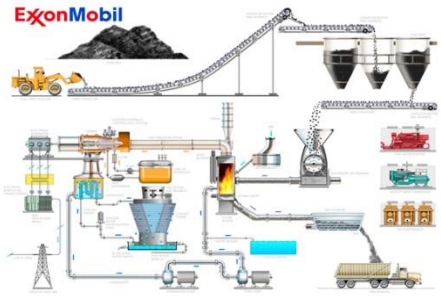


Students will identify trends in energy usage and propose reasons for the trends.

Think as you view these videos and websites.

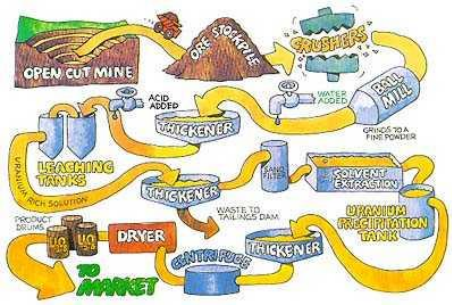
On each source, do you believe that the information can be trusted?

Who made these information sources? Why were they made? (Author's Purpose)
Is it reasonable? Does it agree with the things that we already know?



Children should observe and describe the process of producing coal for use. ***Imbedded Video***

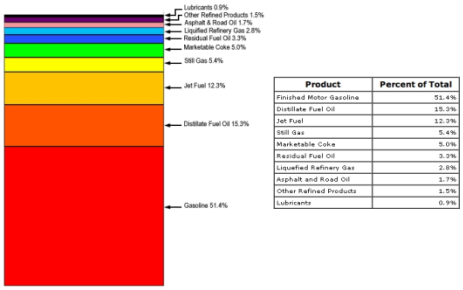
Children should talk about loss of habitat due to surface mining, air pollution, soil pollution, and water pollution.



Children should observe and describe the process of producing uranium for use. ***Imbedded Video***

Children should talk about loss of habitat due to surface mining, air pollution, soil pollution, and water pollution.

Petroleum Products Yielded from One Barrel of Crude Oil in California

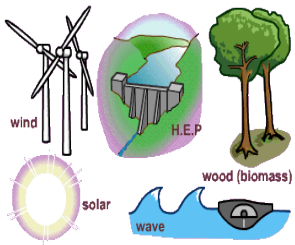


Product	Percent of Total
Finished Motor Gasoline	51.4%
Distillate Fuel Oil	15.3%
Jet Fuel	12.3%
Still Gas	5.4%
Marketable Coke	5.0%
Residual Fuel Oil	3.3%
Liquefied Refinery Gas	2.8%
Asphalt and Road Oil	1.7%
Other Refined Products	1.5%
Lubricants	0.9%

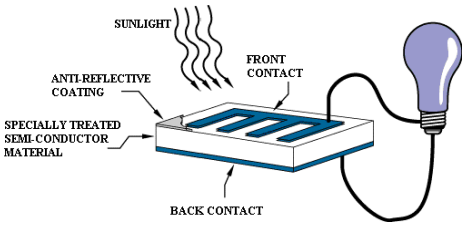
Student discuss the uses of oil.

Children should talk about loss of habitat due to surface mining, air pollution, soil pollution, and water pollution. ***Imbedded Video***

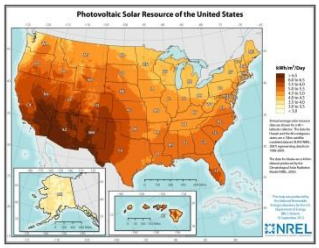
Renewable Energy



Student will brainstorm different sources of renewable energy.

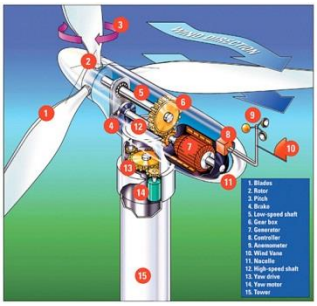


Discuss how the energy in light causes electricity when it hits a photovoltaic panel. ***Imbedded Video***

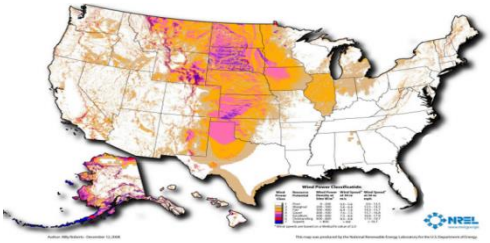


The southwest is dry, has few clouds, and is closer to the equator than much of the US.

Children should talk about loss of habitat due to construction, new roads, air pollution, and soil pollution



Discuss how the motion of the wind pushes the blades of the wind mill and that motion creates electricity in the generator ***Imbedded Video***



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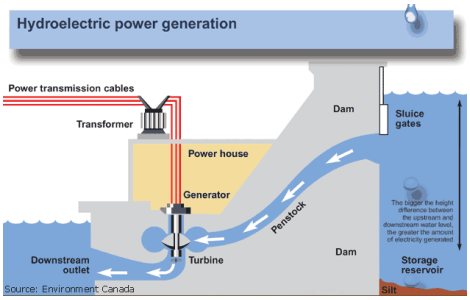
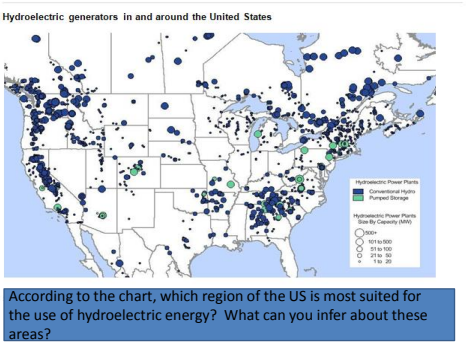
The Midwest is often called tornado alley. It has regular strong winds that unfortunately result in tornados. Discuss possible environmental consequences.

Children should talk about loss of habitat due to construction, new roads, air pollution, and soil pollution



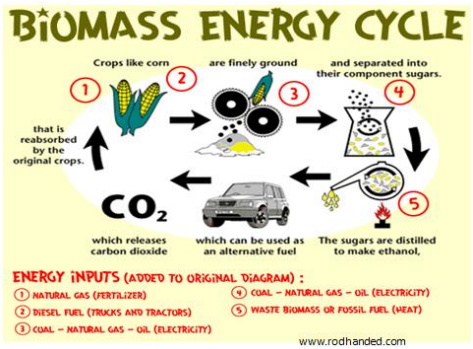
Discuss how the motion of the water pushes the blades of the turbine and that motion creates electricity in the generator. Discuss possible environmental consequences.

Children should talk about loss of habitat due to construction, new roads, air pollution, and soil pollution ***Imbedded Website***

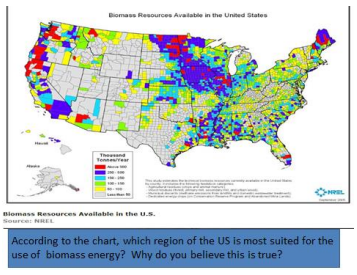


Tie in the location of dams to rivers and the fact that most are neat the mountain chains. Discuss possible environmental consequences.

Children should talk about loss of habitat due to construction, new roads, air pollution, and soil pollution



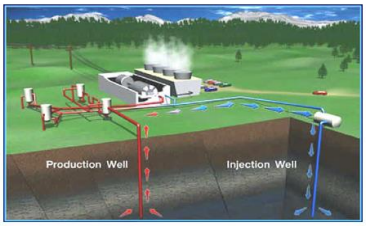
Imbedded Video



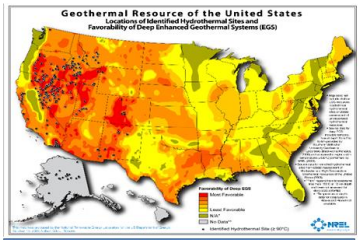
Explain that bio means life and mass is material. Then discuss that most biomass plants are near the Corn Belt, a great area for growing corn. Discuss possible environmental consequences.

Children should talk about loss of habitat due to construction, new roads, air pollution, and soil pollution

The energy from the ground water is harvested and then the waste water is returned to the ground.

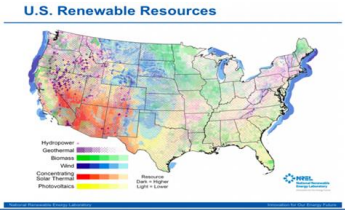


Imbedded Video



According to the chart, which region of the US is most suited for the use of geothermal energy? Why do you believe this is true?

Explain that large scale geothermal production is located near plate boundaries where you also find earthquakes and volcanoes.



You are starting a renewable resource business. Choose the type of energy you plan to produce and the region of the United States in which you would choose to start your company. Record evidence to support both your decisions. Describe the natural resources available in this area.

The children need to use the information that they know to locate a good place for their energy plant. The students need to keep in mind the environmental consequences of their choices.

NGSS Lesson Planning Template

<table>
<tr><td>Grade: Fourth</td><td>Topic: Energy</td><td>Lesson 19: Natural Resources and Energy</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">The students will obtain and combine information to create an informational piece concerning the possible environmental consequences of energy production.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2"></td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">Lead (thesis, topic sentence), closing, reasons, details, citing sources, taking notes, avoiding plagiarism , etc.</td></tr>
<tr><td>Science & Engineering Practices:

● Analyzing and interpreting data

● Obtaining, evaluating, and communicating information

Common Core Correlation

W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1)
W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2),(4-PS3-3),(4-PS3-4),(4-ESS3-1)
W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4),(4-ESS3-1)
W.4.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (4-PS3-1),(4-ESS3-1)</td><td>Disciplinary Core Ideas:

PS3.D: Energy in Chemical Processes and Everyday Life
The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)

ESS3.A: Natural Resources
Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. (4-ESS3-1)

ETS1.A: Defining Engineering Problems
Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (secondary to 4-PS3-4)</td><td>Crosscutting Concepts:

● Cause and effect: Mechanism and explanation

● Energy and matter: Flows, cycles, and conservation
● Structure and function

● Stability and change</td></tr>
<tr><td>Possible Preconceptions/Misconceptions</td><td colspan="2"></td></tr>
<tr><td colspan="3">LESSON PLAN – 5-E Model</td></tr>
<tr><td>ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions</td><td colspan="2">Fossil Fuel Hunt Activity adapted from “Fossil Fuels and the Ticking Clock” at www.powerhousekids.com; show brainpop video “Fossil Fuels”</td></tr>
<tr><td>EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions</td><td colspan="2">I can obtain and combine information from a variety sources (trade books; short articles; internet search engines) to describe that energy and fuels are derived from natural resources. I can explain how using these materials affect the environment. Give student access to a variety of trade books, internet resources, media sources, to examine. Provide a graphic organizer to organize information. Summarize and take notes.</td></tr>
</table>

EXPLAIN: Concepts Explained and Vocabulary Defined	**Pass out the "Natural Resources Writing" along with the rubric to show them expectations. They need to choose an energy source described in the above activities.**
ELABORATE: Applications and Extensions	**Optional elaborations: Students present findings to the class, explaining their essay. The audience then has opportunities to question and comment on the essays. Students show a short video related to their resource. Videos can come from: discoveryeducation.com; brainpop.com; YouTube.**
EVALUATE: **Formative Monitoring (Questioning / Discussion): Teacher questioning should occur throughout the entire process. Teachers examine student notes/journals throughout the lesson.** **Summative Assessment (Quiz / Project / Report): Use the "Natural Resources Rubric" to assess student writing.**	
Elaborate Further / Reflect:	

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
150	**Student journals/notebooks**	**Walmart**	**$75?**
	Energy books		

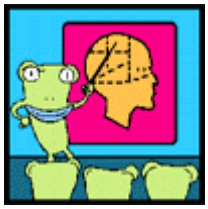
Natural Resources Writing

4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. *(Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to surface mining, and air pollution from the burning of fossil fuels.)*

1. Choose an energy source,
2. **Describe** the natural resource from where the energy was **derived**, and
3. **Discuss the effects** that the use of this energy source has on the environment.

A **student must** choose a minimum of three or more reliable resources for their research. Two or more effects on the environment need to be identified and discussed in their writing. The information must not be **plagiarized**. Credit must be given to the author when text is **lifted** and used in writing.

Natural Resources Rubric



Name: _____ Teacher: _____

Date : _____ Title of Work: _____

	Criteria	Points

	1	2	3	4	
Sources	No sources used	One source used and documented	Two sources used and documented	Three sources used and documented	
Choose an energy source	No **lead** or **conclusion** attempted	Missing either the lead or conclusion	Simple the lead and conclusion.	Contains well developed lead and conclusion.	
Describe the natural resource from where the energy was derived.	Does not attempt to identify the originating natural resource.	Incorrectly identifies the originating natural resource. Attempts to use information from a source.	Identifies the originating natural resource. Uses information from only one of the sources.	Identifies the originating natural resource. Combines the information smoothly from two or more of the sources.	

Discuss the effects that the use of this energy source has on the environment.	Does not attempt to identify the effects that the use of this energy source has on the environment.	Lists one effect that the use of this energy source has on the environment.	Lists two or more effects from more than one source. There are limited example and details.	Explains two or more effects on the environment with **relevant** examples and details.	
Plagiarism				All writing in the student's own words	
				Total---->	

Teacher Comments:

Waves

NGSS Lesson Planning: Fourth Grade- Amplitude of a Wave

<table>
<tr><td>Grade: 4th</td><td>Topic: Waves</td><td>Lesson: Amplitude of a Wave</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Students will use a rope to model and change the amplitude of wave.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will work with a jump rope to develop questions and predict how to change the amplitude of a wave.</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">The faster an object is moving, the more energy it possesses. The higher the amplitude the more energy it has. Higher the waves, the higher the amplitude.</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">Vibrations create sound waves and light waves.</td></tr>
<tr><td>Science & Engineering Practices:
○ Asking questions (science) and defining problems (engineering)
○ Developing and using models
○ Planning and carrying out investigations
○ Analyzing and interpreting data
○ Using mathematics and computational thinking
○ Constructing explanations (science) and designing solutions (engineering)
○ Engaging in argument from evidence
○ Obtaining, evaluating, and communicating information</td><td>Disciplinary Core Ideas:
PS4.A: Wave Properties
● Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. (Note: This grade band endpoint was moved from K–2). (4-PS4-1)
● Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).(4-PS4-1)</td><td>Crosscutting Concepts:
○ Patterns
○ Cause and effect: Mechanism and explanation
○ Scale, proportion, and quantity
○ Systems and system models
○ Energy and matter: Flows, cycles, and conservation
○ Structure and function
○ Stability and change</td></tr>
<tr><td>Possible Preconceptions/Misconceptions</td><td colspan="2"></td></tr>
<tr><td colspan="3">LESSON PLAN – 5-E Model</td></tr>
<tr><td>ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions</td><td colspan="2">The higher the amplitude, the higher the wave. Also, the higher the amplitude the higher the energy of the wave. Can you see why? If the wave has a high amplitude, how must the particles in the wave be moving? A lot, or a little?</td></tr>
<tr><td>EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions</td><td colspan="2">Have the students partner up with another student. They will receive a jump rope and move around the room. The students will create waves with their rope and make observations based on their findings. They will write down their observations on a separate sheet of</td></tr>
</table>

	paper. Ask them to think about the word amplitude and what that means to them. Then have them predict what they think needs to happen to the wave to create a higher amplitude. Record predictions.
EXPLAIN: Concepts Explained and Vocabulary Defined	For a wave to have a high amplitude the particle has to be moving over a large distance (large being a relative term here, the distance may still be miniscule). The more the particle moves, the more work there is being done on the particle (work is force and distance). The more work there is, the more energy there is and so, a wave with a large amplitude has more energy than a wave with a small amplitude. If you've ever been in the ocean this may be more clear. Small little waves don't have the energy to knock you over, but the larger ones...watch out! In sound, amplitude determines the loudness of the sound. In light, amplitude determines the brightness. Use the following video to help. http://www.youtube.com/watch?v=aIcLzDB8NR8
ELABORATE: Applications and Extensions	After talking about energy and the movement of particles, the students are given the opportunity to refine their demonstrations and test their predictions. Students will check to see if their predictions were correct. They will distinguish which amplitude has more energy based on their demonstrations.
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	After students are given a chance to experiment they will present their findings to the class. The students will write a brief summary of their findings for the day and how energy plays a part in waves. Students also will turn in their notes from the day.
Elaborate Further / Reflect:	Explain that moving forward the students will have more opportunity to experiment with energy.

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
1 per group	Jump Rope	PE Class on-line rope supplier	$0
1	tuning forks	From materials on front table	

NGSS Lesson Planning: Fourth Grade- Morse Code

<table>
<tr><td>Grade: 4th</td><td>Topic: Waves</td><td>Lesson: Morse Code</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Students will study Morse code and practice using patterns to send messages.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS4-3. Generate and compare multiple solutions that use patterns to transfer information.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will learn that data can be sent across distances in a variety of different ways.</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">To move information across distances we must use a variety of formats.</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">Vibrations create sound waves and light waves. Sounds and light data can be sent across distances.</td></tr>
<tr><td>Science & Engineering Practices:
Asking questions (science) and defining problems (engineering)
Developing and using models
Planning and carrying out investigations
Analyzing and interpreting data
Using mathematics and computational thinking
Constructing explanations (science) and designing solutions (engineering)
Engaging in argument from evidence
Obtaining, evaluating, and communicating information</td><td>Disciplinary Core Ideas:

<u>PS4.C: Information Technologies and Instrumentation</u>
<u>Digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa. (4-PS4-3)</u>
<u>ETS1.C: Optimizing The Design Solution</u>
<u>Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.</u> <u>(secondary to 4-PS4-3)</u></td><td>Crosscutting Concepts:
Patterns
Cause and effect: Mechanism and explanation
Scale, proportion, and quantity
Systems and system models
Energy and matter: Flows, cycles, and conservation
Structure and function
Stability and change</td></tr>
<tr><td>Possible Preconceptions/Misconceptions</td><td colspan="2"></td></tr>
<tr><td colspan="3">LESSON PLAN – 5-E Model</td></tr>
<tr><td>ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions</td><td colspan="2">In society today information on a variety of topics is right at our fingertips, but how does information get from one place to another? Today we will research and learn about different ways to transmit data.</td></tr>
<tr><td>EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions</td><td colspan="2">Have each student partner up with another student. Students head to the lab to research how data can be transferred across distances. Students will complete a webquest on Morse code.</td></tr>
<tr><td>EXPLAIN: Concepts Explained and Vocabulary Defined</td><td colspan="2">Once the students have had a chance to research, bring the class back together and share their results. What are some different ways to transmit data? How has data transmission</td></tr>
</table>

	changed over time? What methods of data communication do you prefer? Use the following web page to help explain the data transfer. http://www.ehow.com/about_6590474_history-data-communications.html Talk with the class about how things have changed to speed up the data transfer process. Then tell them that we will be focusing on one piece of data transmission technology.
ELABORATE: Applications and Extensions	Students are directed to a website on Morse code. http://www.nsa.gov/kids/games/gameMorse.htm They can practice looking at the pattern of different words. Ask them to write out a few words or phrases in their science journals. Then under the words, write down the Morse code pattern for those words. Ask students to print out the Morse code and hold onto it for tomorrow.
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	After students are given a chance to experiment they will present their findings to the class. The students will write a brief summary of their findings for the day and how energy plays a part in waves. Students also will turn in their notes from the day. www.youtube.com www.enchantedlearning.com http://www.radio-electronics.com
Elaborate Further / Reflect:	On the next day in class set up a circuit tester from the Energy kit. It should include a buzzer, a battery, and three wires. The students will partner up and practice sending their partners on word messages. They can challenge themselves into phrases and sentences when they can send words.

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
30	**wires**	**Energy Kit**	
10	**buzzers**	**Energy Kit**	
10	**batteries**	**Energy Kit**	

Name_____

Data Transfer

1. List at least three different ways that data can be transferred over distances.

2. Why do we need to transmit data over distances? Give one example from your real life where this is important.

3. Which of different methods of data transfer listed above do you think is the most useful? Give two reasons to back up your argument.

4. What are some different methods that were used in the past to transmit data over distances?

NGSS Lesson Planning Template

Grade: 4	Topic: Energy-Waves and vibrations	Lesson: Sound Match

Brief Lesson Description:
In this lesson students see demonstrations of a tuning fork in water causing the water to ripple, sand bouncing on a drum, and rice vibrating on a speaker. They define "vibration." Students match sounds from bags or film canisters with common objects inside. They choose one canister to describe what vibrated to make the sound.

Performance Expectation(s):

4-PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. [Clarification Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.] [Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.]

Specific Learning Outcomes:
Students will:

- Identify sound as a form of mechanical energy (P.EN.03.11).
- Relate sounds to their sources of vibrations (e.g., a musical note produced by a vibrating guitar string, the sounds of a drum made by the vibrating drum head) (P.EN.03.31).
- Construct simple charts and graphs from data and observations (S.IP.03.16).

Narrative / Background Information

Prior Student Knowledge:

Science & Engineering Practices:	Disciplinary Core Ideas:	Crosscutting Concepts:
☐ Asking questions (science) and defining problems (engineering) ☐ Developing and using models ☐ Analyzing and interpreting data ☐ Using mathematics and computational thinking ☐ Constructing explanations (science) and designing solutions (engineering) ☐ Obtaining, evaluating, and communicating information	**4-PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.** [Clarification Statement: Examples of models could include diagrams, analogies, and **physical models** using wire to illustrate wavelength and amplitude of waves.] [Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.]	☐ Patterns ☐ Cause and effect: Mechanism and explanation ☐ Systems and system models

Possible Preconceptions/Misconceptions

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions

Ask students to recall the objects they know of at home that **moved to make sound**. Add some ideas and a picture to the bulletin board.

Explain that a word scientists use for a **fast back and forth movement is "vibration."** (If you have an old fashioned alarm clock or if students can feel the dismissal bell, they may wish to describe the feel of a vibration. A pocket pager (or cell phone) also can be set to vibrate to help students learn this concept.) Move your hand back and forth quickly to illustrate this idea. Remind them of how they made the rubber band make sound by plucking it. The rubber band moved back and forth. Then strike the tuning fork and place the end on a table. "Can you hear the sound?" Repeat until all have heard it.

Ask the students if the tuning fork is vibrating? Explain that you will put the tuning fork into water. **Ask for predictions: "Is the tuning fork vibrating when it makes sound?"**

Again strike the tuning fork. Put the tuning fork into the water in the pan. Ask: "Is the tuning fork vibrating when it makes sound?" Alternate sounding the tuning fork on the table and showing the splash. Add the tuning fork to the class sound chart (bulletin board).

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions

Advance Preparation: Practice using the tuning fork to make vibrations in the water. Strike the tuning fork on your shoe. (Caution: Do not strike it against a hard object such as a table, to avoid damaging the tuning fork.) Then carefully lower the tuning fork into the water in the baking pan or aquarium. You should see a small splash.

You may be able to collect film canisters from your school photographer or a parent with photography as a hobby. Make sets of 16 containers for each group (in film canisters or bags), with pairs of each object. Label eight of each set A, B, C, etc. Label the other eight of the set 1, 2, 3, etc. Record your pairs of objects (For example A, 8 = buttons).

Materials:

- Drum
- Glass baking pan or pie pan
- Overhead projector
- Small opaque containers (i.e., Film canisters or paper bags, 16 per group)
- Tuning fork
- Variety of small objects for containers (rice, beans, bells, buttons, erasers, marbles, paper clips, beads, coins, screws, nuts, washers, centimeter cubes, etc., at least 4 per group)

EXPLAIN: Concepts Explained and Vocabulary Defined

Explain to students that you would like them to work in groups to investigate another way to make vibrations. Show them one of the containers. Shake it. Ask: "Is something vibrating or moving back and forth? What might be making this sound?" Explain that you would like them to find matches between the two sets without opening the containers. They should match each lettered container with one numbered container by the sound it makes while shaken. Show the Student Page "Sound Match". Explain that after they have made their matches they should fill in their record sheet and answer the question.

ELABORATE: Applications and Extensions

Sound helps us recognize many problems; for example, a rattle in a car means something is loose, a jingle in our pocket may mean that's where our change is.

EVALUATE:

Formative Monitoring (Questioning / Discussion): In the final question, students should be able to explain sound as the result of a movement or a vibration.

Elaborate Further / Reflect:

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
6	Tuning forks	Frey scientific	
6	Geoboards		
variety	Rubber bands		
	Drum		
	Glass baking pan or pie pan		
	Overhead projector		
	Small opaque containers (i.e., Film canisters or paper bags, 16 per group)		
	Variety of small objects for containers (rice, beans, bells, buttons, erasers, marbles, paper clips, beads, coins, screws, nuts, washers, centimeter cubes, etc., at least 4 per group)		

Lesson 2: Sound Match

Fill in the table to show the matches.

Container	The Numbered Container that Makes the Same Sound	What I think is inside
A		
B		
C		
D		
E		
F		
G		
H		

Pick one container. Open it and look inside. Tell how it makes sound.

_____

_____

_____

NGSS Lesson Planning: Fourth Grade-Squeaky Balloon

Grade: 4th	**Topic: Waves**	**Lesson: Squeaky Balloon**
Brief Lesson Description:	Students will learn about wavelength and amplitude and model wave patterns through movement.	
Performance Expectation(s):	4-PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.	
Specific Learning Outcomes:	Students will be introduced to and develop a better understanding wavelength and amplitude, by using movements.	
Narrative / Background Information	Stretching the mouth of the balloon makes a very tiny space for the air to flow out of the balloon. The air pressure of the balloon itself forces the air out the mouth, but because of the stretching, that space is limited. The airflow causes the balloon mouth (the stretched part) to vibrate. The vibration makes the noise.	
Prior Student Knowledge:	**How does sound and light travel?**	
Science & Engineering Practices: ● ***Asking questions (science) and defining problems (engineering)*** ● Developing and using models ● Planning and carrying out investigations ● Analyzing and interpreting data ● Using mathematics and computational thinking ● ***Constructing explanations (science) and designing solutions (engineering)*** ● ***Engaging in argument from evidence*** ● ***Obtaining, evaluating, and communicating information***	**Disciplinary Core Ideas:** PS4.A: Wave Properties ● Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. *(Note: This grade band endpoint was moved from K–2.)* (4-PS4-1) ● Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). (4-PS4-1)	**Crosscutting Concepts:** ● Patterns ● ***Cause and effect: Mechanism and explanation*** ● Scale, proportion, and quantity ● ***Systems and system models*** ● Energy and matter: Flows, cycles, and conservation ● ***Structure and function*** ● Stability and change
Possible Preconceptions/Misconceptions		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions	In first grade you learned about light and sound. Both of these travel from one point to the next through waves. We know that sound travels in waves, but how can sound be produced? We will experiment with balloons to see if we can figure it out.	
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions	Give each one of the students a balloon. Instruct them to blow up the balloon and let the air out. Ask them to try to explain why a sound is made when you let the air out. Encourage them to stretch the opening of the balloon and witness the effects. Record your results.	

EXPLAIN: Concepts Explained and Vocabulary Defined	Bring the class back together and demonstrate what students have discovered. Allow them to use their own words to describe their findings. Help the students to understand that the sounds come from the vibrations. By stretching the balloon you can change the wavelength and amplitude of the sound waves coming out of the balloon. Use the following video to help explain. http://www.youtube.com/watch?v=tRzl7Z_VC08
ELABORATE: Applications and Extensions	After discussing the information above, the students are given a task. Ask the students to put their hand under their jaw on the side of their neck. Encourage them to hum and make a variety of sounds, both high and low. At the end of the activity the students should write a reflection of their experience that includes a description of how a balloon and people make sounds in similar ways.
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	Students will turn in their notes from the day with a write up of their findings. The diagrams in the notebooks and their explanation of what they learned will help to show student understanding. Teacher also has the chance to move around the room to evaluate the learning.
Elaborate Further / Reflect:	

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
	balloons	**from previous lessons**	

Wave Properties Lab (Teacher Copy)

Objective:
I can identify the properties of waves and relate them to the energy they carry.

Background Knowledge:
A wave is a disturbance that transmits energy. Vibrations in materials set up wave disturbances that spread away from the source. Waves move energy not matter. In other words, the particles of a medium do not travel with the waves. Mechanical waves require a medium, but electromagnetic waves do not. There are two types of waves: transverse and longitudinal (sometimes called compressional). Transverse waves move perpendicular to the wave disturbance and are made up of crests and troughs. Longitudinal waves move parallel to the wave disturbance and are made up of compressions and rarefactions. Amplitude is the maximum distance that the particles of a medium vibrate from their rest position. The amplitude of a transverse wave is measured from the rest position to the crest or to the trough of the wave. A wave with a large amplitude carries more energy than a wave with a small amplitude. Wavelength is the distance between two adjacent corresponding parts of a wave (e.g.: crest to crest). Frequency is the number of waves that pass a given point in a second. Frequency is measured in hertz (Hz). Wavelength and frequency are related: the shorter the wavelength, the higher the frequency and vice versa. If you are making waves on either a spring or a rope, the rate at which you shake it will determine whether the wavelength is short or long. If you shake it rapidly, you are putting more energy into the wave, and the wavelength will be short and the frequency will be high. If you shake it slowly, you are putting less energy into the wave, and the wavelength will be long and the frequency will be low. Therefore, a shorter wavelength carries more energy than a longer wavelength. Wave speed depends on the medium through which the wave is traveling. For example, a sound wave will travel faster through a solid than a gas. Waves behave in predictable ways. They can reflect, refract, diffract, and interfere with each other. To read more about waves, refer to Chapter 10, Sections 1, 2, and 3 in the *Holt Science and Technology* textbook (blue).

Materials:
For demonstration:
- rope (1-2 meters) or jump rope
- chair
- coiled spring toy (Slinky)
- 1 – short piece of yarn or ribbon (optional)

Per pair or group:
- 1 – piece of yarn (1-2 meters)
- 1 – piece of tape

- 2 – different colored buttons (optional)
- 2 – pipe cleaners (optional)
- 1 – spring toy
- 1 – short piece of yarn or ribbon
- 1 – calculator

Engage:
Have two students volunteer to assist with this demonstration. Provide student volunteers with safety goggles. Give the students a piece of rope (a jump rope will work well) that is approximately 2 meters long. Have the students tie one end of the rope to the back of a chair. Have one student hold the chair steady while the other student holds the free end of the rope in one hand. This student should stand away from the chair so that the rope is almost straight but not pulled tight. Instruct this student to move the rope up and down quickly to create a wave. Repeat this step several times. Students may switch roles. Have the class analyze the results by answering the following questions.

1. In which direction does the wave move? (The wave moves from one end of the rope to the other.) In what direction does the disturbance (student's hand) move? (up and down) What type of wave was created? (transverse) Why? (because the wave moves perpendicular to the wave disturbance)
2. How does the movement of the rope compare with the movement of the wave? (Each piece of rope moves up and down, that is, in a direction different from the wave. If students have difficulty observing this, tie a piece of yarn to the rope, and have students watch only the yarn while waves are being made. The yarn will clearly move only up and down.)
3. Where does the energy of the wave come from? (The energy of the wave comes from shaking the rope. When students stop shaking the rope, the wave eventually stops moving.)

Next, repeat the demonstration, but use a spring toy (Slinky) this time. Have the two student volunteers stretch the spring toy out along the top of a table. One student should move the end of the toy back and forth while the other student holds the other end of the toy still. Have students observe the waves that travel through the coil. Have the students answer the same questions to analyze these waves.

1. In which direction does the wave move? (The wave moves from one end of the spring toy to the other.) In what direction does the disturbance (student's hand) move? (back and forth) What type of wave was created? (longitudinal) Why? (because the wave moves parallel to the wave disturbance)

2. How does the movement of the toy compare with the movement of the wave? (Each coil moves forward and then back into its original place as the wave passes through the toy. If students have difficulty observing this, tie a piece of yarn to one of the coils, and have students watch only the yarn while waves are being made. The yarn will clearly move forward and back again.)
3. Where does the energy of the wave come from? (The energy of the wave comes from moving the toy back and forth. When students stop moving the toy, the wave eventually stops moving.)

Explore:

Procedures:

Part A: Wave Properties

1. Have students work in pairs or in small groups. Provide each group of students with a piece of yarn (about 1-2 meters) and tape.
2. Have them use the yarn to construct a transverse wave. Tell students to leave some excess yarn at the end of their wave to use later. Have the students identify the crest, trough, wavelength, and amplitude. (For a quick check, you can have students place a button on a crest and trough of the wave and use pipe cleaners to identify the wavelength and amplitude of the wave.)
3. Ask them to increase the amplitude of the wave while keeping the frequency constant. (Students will need excess yarn for this step.) Have them explain what increasing the amplitude represents (adding more energy to the wave).
4. Then, have them change the frequency, and ask them what happened to the wavelength when they changed the frequency. (The wavelength decreased with an increase in frequency, and it increased with a decrease in frequency.)

Part B: Relationship between Energy and Amplitude & Frequency and Wavelength

1. Provide each group with a spring toy (Slinky). Have the students hold the spring toy on the floor between two classmates so that the toy is stretched out and straight.
2. Have them move one end of the spring side to side at a constant rate so that they create a transverse wave. Have the students identify the approximate size of the wavelength of the wave they create.
3. Have them increase the amplitude of the waves. Ask them to describe what they had to do to increase the amplitude. How did the change in amplitude affect the wavelength? (To increase the amplitude of the wave, the spring must be shaken farther with bigger motions. That is, the students must provide more energy to the wave. There should be no effect on wavelength when amplitude increases. It may be difficult to increase amplitude without increasing frequency. If students increase frequency significantly, wavelength will change.)

4. Now have them shake the spring side to side about twice as fast as they did before. Which properties of the waves changed? Have students record their observations. (When the students shake the spring faster, the wavelength should become shorter as the frequency is increased.)

Part C: Measuring Frequency

1. Have each group tie a piece of yarn to one of the center coils of the spring toy.
2. Instruct students to move one end of the toy side to side at a constant rate to make a series of transverse waves.
3. Using a stop watch, have them count how many waves pass through the toy in 10 seconds. Explain that they can tell when a wave passes through the toy because the piece of yarn will move up and down. (In other words, the number of times the yarn moves up and down in 10 seconds equals the number of waves that pass through the toy in 10 seconds). Since frequency is the number of waves that pass a given point in one second, students should divide the number of waves by 10 since they timed the waves for 10 seconds. Now they can determine the number of waves that passed through the coil in 1 second. That is the frequency of the wave. Students should repeat this step three times and record their results in the table provided.
4. Remind students that scientists must use units of measure when recording lab data. Frequency in measured in hertz (Hz).

Elaborate:

Have students explore the *Longitudinal Waves* Gizmo module and complete the accompanying student activity guide.

Evaluate:

Challenge students to complete the following task in their science journals: Describe how amplitude, wavelength, and frequency relate to the amount of energy carried by a wave.

Wave Properties Lab (Student Copy)

Objective:
I can identify the properties of waves and relate them to the energy they carry.

Background Knowledge:
A wave is a disturbance that transmits energy. Vibrations in materials set up wave disturbances that spread away from the source. Waves move energy not matter. In other words, the particles of a medium do not travel with the waves. Mechanical waves require a medium, but electromagnetic waves do not. There are two types of waves: transverse and longitudinal (sometimes called compressional). Transverse waves move perpendicular to the wave disturbance and are made up of crests and troughs. Longitudinal waves move parallel to the wave disturbance and are made up of compressions and rarefactions. Amplitude is the maximum distance that the particles of a medium vibrate from their rest position. The amplitude of a transverse wave is measured from the rest position to the crest or to the trough of the wave. A wave with a large amplitude carries more energy than a wave with a small amplitude. Wavelength is the distance between two adjacent corresponding parts of a wave (e.g.: crest to crest). Frequency is the number of waves that pass a given point in a second. Frequency is measured in hertz (Hz). Wavelength and frequency are related: the shorter the wavelength, the higher the frequency and vice versa. If you are making waves on either a spring or a rope, the rate at which you shake it will determine whether the wavelength is short or long. If you shake it rapidly, you are putting more energy into the wave, and the wavelength will be short and the frequency will be high. If you shake it slowly, you are putting less energy into the wave, and the wavelength will be long and the frequency will be low. Therefore, a shorter wavelength carries more energy than a longer wavelength. Wave speed depends on the medium through which the wave is traveling. For example, a sound wave will travel faster through a solid than a gas. Waves behave in predictable ways. They can reflect, refract, diffract, and interfere with each other. To read more about waves, refer to Chapter 10, Sections 1, 2, and 3 in the *Holt Science and Technology* textbook (blue).

Materials:
Per pair or group:
- 1 – piece of yarn (1-2 meters)
- 1 – piece of tape
- 2 – different colored buttons (optional)
- 2 – pipe cleaners (optional)
- 1 – spring toy
- 1 – short piece of yarn or ribbon
- 1 – calculator

Demonstration:
As your teacher and the student volunteers demonstrate two types of waves, analyze the different waves by answering the following questions.

Rope Waves

1. In which direction does the wave move? In what direction does the disturbance (your hand) move? What type of wave was created? Why?

2. How does the movement of the rope compare with the movement of the wave?

3. Where does the energy of the wave come from?

Spring Toy Waves

1. In which direction does the wave move? In what direction does the disturbance (your hand) move? What type of wave was created? Why?

2. How does the movement of the toy compare with the movement of the wave?

3. Where does the energy of the wave come from?

Explore:

Procedures:

Part A: Wave Properties

1. Use the yarn given to you by your teacher to construct a transverse wave. (Leave some extra yarn at the end of the wave to be used later.)
2. Identify the crest, trough, wavelength, and amplitude of the wave that you created.
3. Increase the amplitude of the wave while keeping the frequency constant. (Use the excess yarn for this step.)
4. Explain what increasing the amplitude represents.

5. Change the frequency (make it higher and lower).
6. What happened to the wavelength when you changed the frequency?

Part B: Relationship between Energy and Amplitude & Frequency and Wavelength

1. Obtain a spring toy (Slinky) from your teacher.
2. Sit on the floor facing another student (sit far enough apart so that the spring toy is stretched out and straight).
3. Move one end of the spring toy side to side at a constant rate so that you create a transverse wave. Note the wavelength of the wave you create.
4. Increase the amplitude of the waves.
5. Describe what you had to do to increase the amplitude.

6. How did the change in amplitude affect the wavelength?

7. Shake the spring side to side about twice as fast as they did before.
8. Which properties of the waves changed?

Part C: Measuring Frequency

1. Tie a piece of yarn to one of the center coils of the spring toy.

2. Move one end of the toy side to side at a constant rate to make a series of transverse waves.
3. Using a stop watch, count how many waves pass through the coil in 10 seconds. You will know when a wave passes through the coil because the piece of yarn will move up and down.
4. Since frequency is the number of waves that pass a given point in one second, divide the number of waves by 10 since you timed the waves for 10 seconds. Now you can determine the number of waves that passed through the coil in 1 second. That is the frequency of the wave.
5. Record your results in the chart below.
6. Remember that scientists must use units of measure when recording lab data. Frequency in measured in hertz (Hz).
7. Repeat this portion of the experiment three times.

Trials	**Number of waves that pass through the toy in 10 seconds**	**Frequency (Hz)**

Complete the following task in your science journals: Describe how amplitude, wavelength, and frequency relate to the amount of energy carried by a wave.

NGSS Lesson Planning: Fourth Grade-Wavelength and Amplitude "Simon Says"

<table>
<tr><td>Grade: 4th</td><td>Topic: Waves</td><td>Lesson: Wavelength and Amplitude "Simon Says"</td></tr>
<tr><td>Brief Lesson Description:</td><td colspan="2">Students will learn about wavelength and amplitude and model wave patterns through movement.</td></tr>
<tr><td>Performance Expectation(s):</td><td colspan="2">4-PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.</td></tr>
<tr><td>Specific Learning Outcomes:</td><td colspan="2">Students will be introduced to and develop a better understanding wavelength and amplitude, by using movements.</td></tr>
<tr><td>Narrative / Background Information</td><td colspan="2">Wavelength is the distance between waves. Amplitude it the height of the wave.</td></tr>
<tr><td>Prior Student Knowledge:</td><td colspan="2">How does sound and light travel?</td></tr>
<tr><td>Science & Engineering Practices:

● Asking questions (science) and defining problems (engineering)
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations (science) and designing solutions (engineering)
● Engaging in argument from evidence
● Obtaining, evaluating, and communicating information</td><td>Disciplinary Core Ideas:

PS4.A: Wave Properties
● Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. (Note: This grade band endpoint was moved from K–2.) (4-PS4-1)
● Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). (4-PS4-1)</td><td>Crosscutting Concepts:

● Patterns
● Cause and effect: Mechanism and explanation
● Scale, proportion, and quantity
● Systems and system models
● Energy and matter: Flows, cycles, and conservation
● Structure and function
● Stability and change</td></tr>
<tr><td>Possible Preconceptions/Misconceptions</td><td colspan="2"></td></tr>
<tr><td colspan="3">LESSON PLAN – 5-E Model</td></tr>
<tr><td>ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions</td><td colspan="2">In first grade you learned about light and sound. Both of these travel from one point to the next through waves. Today we are going to delve into how waves move. You will do some research and practice showing wave movements with walking.</td></tr>
<tr><td>EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions</td><td colspan="2">Take the students to the lab and allow them to do some research. The students should bring their journals with them and record their own definition for wavelength and amplitude. Students can use the following sites to help.</td></tr>
</table>

	http://www.classzone.com/books/ml_science_share/vis_sim/wslm05_pg18_graph/wslm05_pg18_graph.html http://www.educationscotland.gov.uk/resources/s/sound/amplitude.asp Once the students have had a chance to explore the web page and have their definitions recorded, they work in groups of three or four to demonstrate wavelength and amplitude through walking.
EXPLAIN: Concepts Explained and Vocabulary Defined	Bring the class back together and demonstrate what students have discovered. Allow them to use their own words to describe their findings. Open the websites above and show the students wavelength and amplitude. Remind the class of different student examples of showing wavelength and amplitude. Wavelength should be the distance of the student's gate. A larger wavelength should be a bigger step, smaller wavelength is a smaller step. Amplitude should be jumping and ducking down. The larger the amplitude the bigger the jump and duck. The smaller the amplitude the smaller the jump and duck.
ELABORATE: Applications and Extensions	After discussing the information above, the students are given a task. We will be playing a game of Simon Says. Using the gym or going outside would probably be best. Here are some examples of things you could say: "Simon says…walk with a really big wavelength." (They should be taking large steps). "Simon says…jump with a tiny amplitude." (They should be taking tiny jumps). "Simon says…walk with a small wavelength and a big amplitude." (They should be taking tiny steps, with a lot of head bobbing or jumping.) Do a variety of different commands to see if the students have an understanding of wavelength and amplitude. At the end of the game the students should write a reflection of their experience that includes a model of waves that is labeled with wavelength and amplitude.
EVALUATE: **Formative Monitoring (Questioning / Discussion):** **Summative Assessment (Quiz / Project / Report):**	Students will turn in their notes from the day with a write up of their findings. The diagrams in the notebooks and their explanation of what they learned will help to show student understanding. Teacher also has the chance to move around the room to evaluate the learning. Watch video: www.ndps.us
Elaborate Further / Reflect:	

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
12	plastic jump ropes or plastic coated clothesline	on line supplier Knot and Rope on-line supplier	