The Evolution of the T2L Science Curriculum

Over the last four years, the Teach to Learn program created 20 NGSS-aligned science units in grades K-5 during our summer sessions. True to our plan, we piloted the units in North Adams Public Schools, and asked and received feedback from our science fellows and our participating teachers. This feedback served as a starting point for our revisions of the units. During year 2 (Summer of 2015), we revised units from year 1 (Summer/Fall 2014) and created new units to pilot. In year 3, we revised units from years 1 and 2 and created new units of curricula, using the same model for year 4. Our understanding of how to create rich and robust science curriculum grew, so by the summer of 2018, our final summer of curriculum development, we had created five exemplar units and established an exemplar unit template which is available in the T2L Toolkit.

We made a concerted effort to upgrade all the existing units with exemplar components. We were able to do much, but not all. So, as you explore different units, you will notice that some contain all elements of our exemplar units, while others contain only some. The fully realized exemplar units are noted on the cover page. We did revise all 20 units and brought them to a baseline of "exemplar" by including the Lessons-At-A-Glance and Science Talk elements.

Grade 4

Energy

A T2L Exemplar Unit

MCLA NAPS Williams

Teach To Learn

A collaboration between MCLA, Williams College, and North Adams Public Schools
Funded by NSF DUE-IUSE Award #1432591

T2L Curriculum Unit

Energy

Physical Science/Grade 4

In this unit, students are introduced to the concept of energy. Throughout this unit, students will gain a deeper understanding of energy, the different forms of energy, and how to move energy from one place to another. The lessons within this unit incorporate hands-on investigations, data collection, and discussion with peers and teachers. This latest revision includes a lesson on renewable and non-renewable energy sources.

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Unit Creation and Revision History

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Unit Plan

Stage 1 Desired Results

ESTABLISHED GOALS **G**

4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.
[State Assessment Boundaries:
State assessment will be limited to analysis of kinetic energy. Accounting for mass, quantitative measures of changes in the speed of an object, or any precise or quantitative definition of energy is not expected in state assessment.]

4-PS3-2. Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents. [Clarification Statement: Evidence of energy being transferred can include vibrations felt a small distance from a source, a solar-powered toy that moves when placed in direct light, warming a metal object on one end and observing the other end getting warm, and a wire carrying electric energy from a battery to light a bulb.] [State Assessment Boundary: Quantitative measurements of energy are not expected in state assessment.]

Meaning

UNDERSTANDINGS **U**

Students will understand that…

- Energy can be described as the capacity to make change.
- Energy comes in different forms.
- Energy can be transferred from one form to another.
- Energy can be transferred from one location to another.
- Energy can be used to send information.
- Energy sources are either renewable or nonrenewable.
- The use of energy resources can harm the Earth.

ESSENTIAL QUESTIONS **Q**

1. What is energy?
2. How can we turn energy from one form to another?
3. How can we move energy from one place to another?
4. What is the best energy source for human use?

Student Learning Targets

Students will know… **K**

1. I can define energy and identify its various forms including potential, kinetic, sound, light, heat, and electric energy.
2. I can create a concept map to demonstrate the understanding of energy.
3. I can measure the time it takes for a marble to roll down a ramp.

4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide. [Clarification Statement: Changes in energy can include a change in the object's motion, position, and the generation of heat and/or sound.] [State Assessment Boundary: Analysis of forces or quantitative measurements of energy are not expected in state assessment.] **4-PS3-4.** Apply scientific principles of energy and motion to test and refine a device that converts motion energy to electrical energy or uses stored energy to cause motion or produce light or sound. [Clarification Statement: Sources of stored energy can include water in a bucket or a weight suspended at a height, and a battery.] **4-ESS3-1.** Obtain information to describe that energy and fuels humans use are derived from natural resources and that some energy and fuel sources are renewable and some are not. (Clarification Statements: Examples of renewable energy resources could include wind energy, water behind dams, tides, and sunlight. Nonrenewable	4. I can draw conclusions about the speed of an object based on the height from which the object was dropped. 5. I can draw conclusions about energy based on observations of the speed of an object. 6. I can explain the transfer of energy that occurs when objects collide. 7. I can recognize the difference between potential and kinetic energy by observing a collision of two marbles. 8. I can name and give examples of the six types of energy (potential, kinetic, light, heat, electric, and sound). 9. I can describe how energy changes from one form to another. 10. I can define nonrenewable and renewable energy. 11. I can name examples of nonrenewable and renewable energy resources. 12. I can explain the harmful effects caused by nonrenewable energy resources. 13. I can build a model power by a renewable energy resource. 14. I can record observations that illustrate the movement of energy across space.

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energy resources are fossil fuels and nuclear materials.) **Math 4.NF. 6**. Use decimal notation for fractions with denominators 10 or 100. For example, rewrite 0.62 as 62/100; describe a length as 0.62 meters; locate 0.62 on a number line diagram.	
Stage 2 – Evidence	
Evaluative Criteria	**Assessment Evidence**
● Clear and detailed plan for a tool (done before any building) that directly answers the following prompts: o What forms of energy are used in your tool? o How does your tool move and change (convert) energy between the different forms? o What message are you sending? ● Actual tool that can transport a message (absolute success is not important). Instead the focus is on making changes to a plan based on testing.	Unit Assessment –CEPA: **Send Your Message** **Summary**: In this task, students will design and then create a tool to send a message across the room using at least two forms of energy. **Details** Drawing upon their knowledge and understanding of the different forms of energy and how energy is transported and converted, students will design (in small groups) a tool to transmit a message across the room. The message can be visual (a picture) or text-based (a written message). They will be able to use materials from earlier lessons. The end products will be the plan, the actual tool, and a (guided) write-up of the tool (including the 2-3 types of energy it uses, how it converts the energy, and how the message is transported). Creativity is encouraged, and the actual tool can be a functional "Rube-Goldberg" type contraption. Students will develop the plan first before doing any building. They can revise their plan after testing the first version of their tool. For groups of students who need additional support, teachers can select their forms of energy for

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	them. On the other hand, for groups who need extensions, the teacher can add in more forms of energy and/or more conversions between different forms of energy.
Optional Pre-unit Assessment- teacher created or use the questions from "Show What You Know"	**OTHER EVIDENCE:** **Show What You Know Worksheets:** Many lessons contain MCAS style multiple choice and open response questions to assess students' understanding of the concepts presented in the lesson. The classroom teacher should administer the questions sometime after the completion of each lesson. The results can be used to plan additional lessons on concepts that students need help mastering. **Science Journals:** Many activities require students to answer questions based on what the learned from or observed in the activities.

Stage 3 – Learning Plan

Summary of Key Learning Events and Instruction

Lesson 1 (Introduction to Energy-bridging lesson): Energy will be addressed for the first time in this lesson, and students will be prompted to think about how energy connects to weathering and erosion.

Lesson 2 (Speedy Marbles): In this lesson, students will do an investigation with ramps and marbles. Students will roll a marble down ramps of varying heights in a series of trials. During these trials, the students will gather data to make conclusions as well as graphic displays at the end of the lesson.

Lesson 3 (Collision Course): In this lesson, students will continue to do an investigation with ramps and marbles. Students will gain a deeper understanding of collisions through discussion, observation, and investigation. Students will also partake in a friendly intra-class competition.

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Lesson 4 (How Can We Change Energy from One Form to Another?): The goal of this lesson is for students to become familiar with different types of energy (potential, kinetic, electrical, sound, light, heat, mechanical, and sound), to be able to describe these types of energy, and to understand how energy may change from one form to another, but never become “lost.” **Lesson 5 (The Energy Dilemma):** In this lesson, students will explore renewable and nonrenewable energy resources through a variety of activities. Students will also learn about the lasting effects of nonrenewable energy and ways for humans to reduce pollution and waste. **Lesson 6 (How Can We Move Energy from One Place to Another?):** The goal of this lesson is for students to find examples of energy in motion in their everyday surroundings and to articulate what forms of energy are being moved/changed.
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Lessons at a Glance

Key

Independent online student research	Tech Integration	YouTube Video (or other video site)	Kinesthetic Learning	Outdoor education	Lab work

Resource and Modalities Chart

Lesson	Core Activities	Extensions	Tools and Modalities
1. From Weathering to Energy	• Recalling Scientists • 8 Scientific Practices • Moving Salt Investigation • Introducing Energy • Explaining Energy • Potential and Kinetic Energy • Energy and Matter • Field Research • Concept Map		
2. Speedy Marbles	• Energy Discussion • Marble Down a Ramp • Marble Discussion	• Marble Averages	
3. Collision Course	• Marble Investigation Discussion • Marble Demonstrations • Playing with Marbles • The Great Marble Competition • Marble Video		

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4. How Can We Change Energy from One Form to Another?	• Marble Collision Discussion • Energy Powerpoint • Presenting Energy • Mass Demonstration • Energy Conversion Stations	• Reading : *Solar Absorbers and the Future of Electricity* • Reading: *"Houston Affects the Earth" (from the binder)*	
5. The Energy Dilemma	• Energy Concept Map • Video Activity • Revisit the Concept Map • Air Pollution Activity • Oil Spill Activity • Solar Water Fountain • Energy Song	• Oil Spill Extension • Solar Water Fountain Extension	
6. How Can We Move Energy from One Place to Another?	• Flashlight Demonstration • Energy Scavenger Hunt • Energy Scavenger Hunt Discussio		

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Lesson Feature Key

Lessons in this unit include a number of features to help instructors. This key is a quick guide to help identify and understand the most important features.

Icons

Talk science icon: Look for this icon to let you know when to use some of the talk science strategies (found in the unit resources of this unit)

Anchor phenomenon icon: Indicates a time when an anchoring scientific phenomenon is introduced or when an activity connects back to this important idea**.**

Text Formatting:[SP#: ….] Any time you see a set of brackets like this, it indicates that students should be engaged in a specific science or engineering practice.

Underlined text in the lesson:

This formatting indicates important connections back to the central scientific concepts and is useful to note these connections as an instructor, as well as for students.

Callouts

Teaching Tip

In these call out boxes, you'll find tips for teaching strategies or background information on the topic.

Student Thinking Alert

Look out for common student answers, ways in which students may think about a phenomenon, or typical misconceptions

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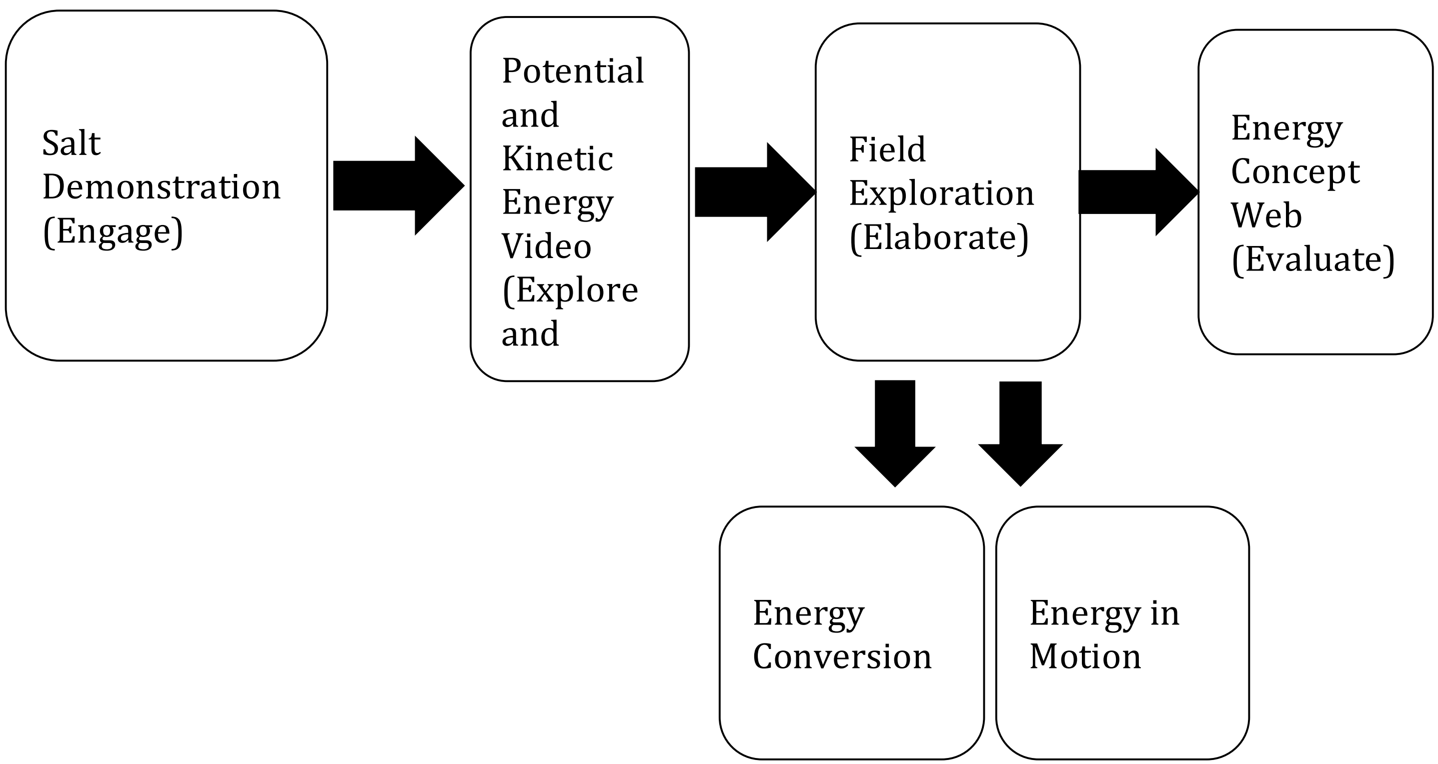
Essential Questions Concept Maps

Essential Question 1: What is energy?



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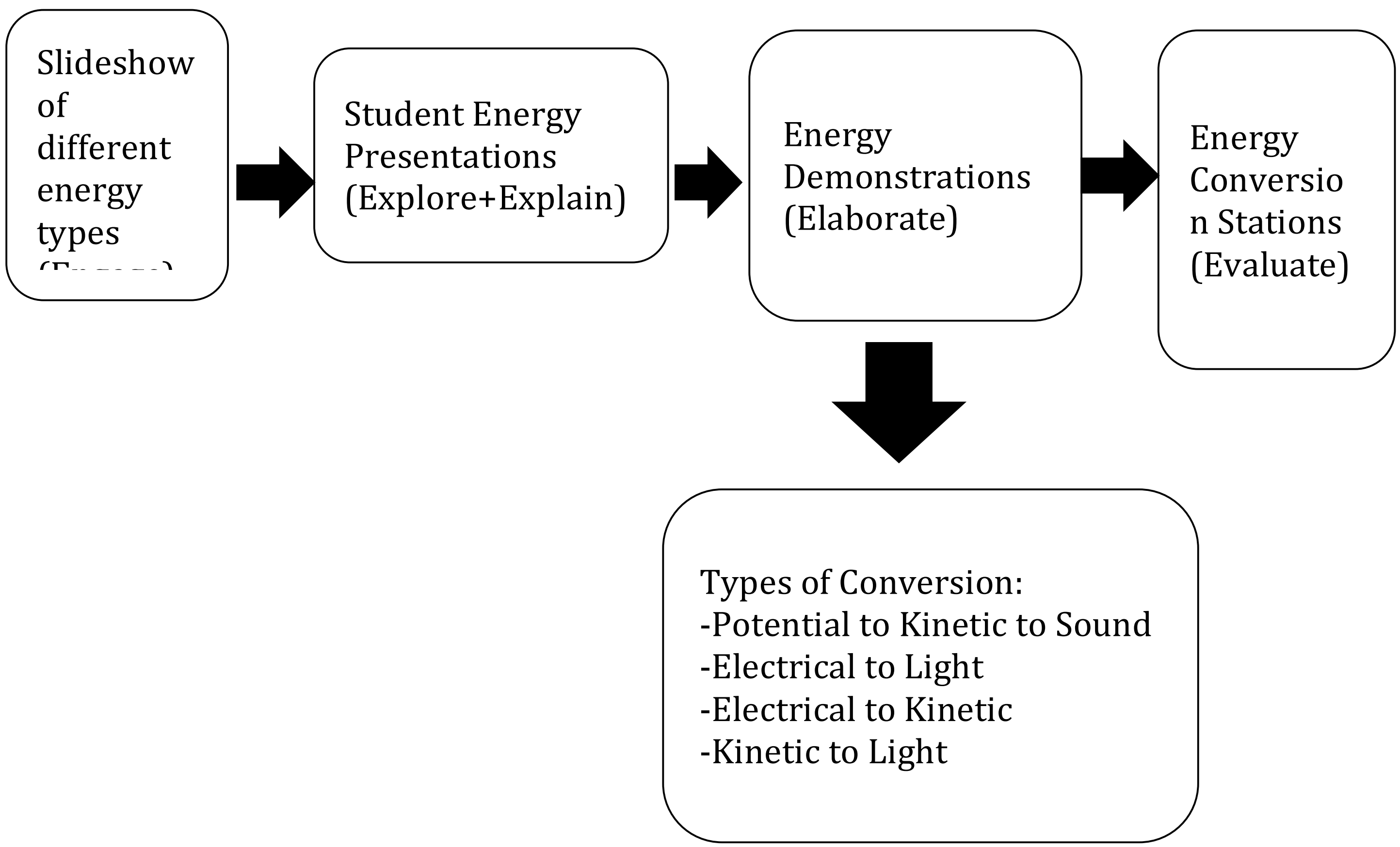
Essential Question 2: How can we turn energy from one form to another?



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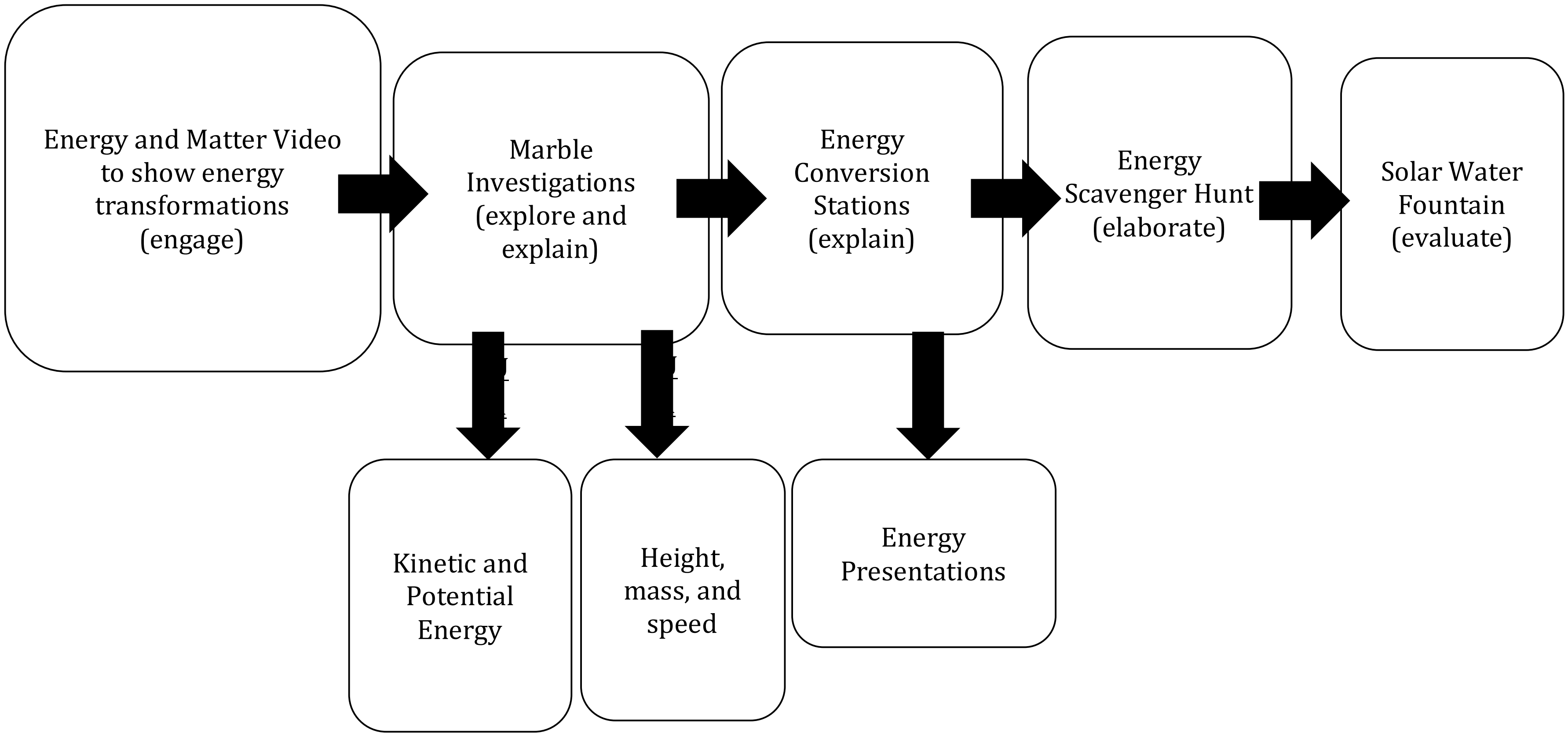
Essential Question 3: How can we move energy from one place to another?



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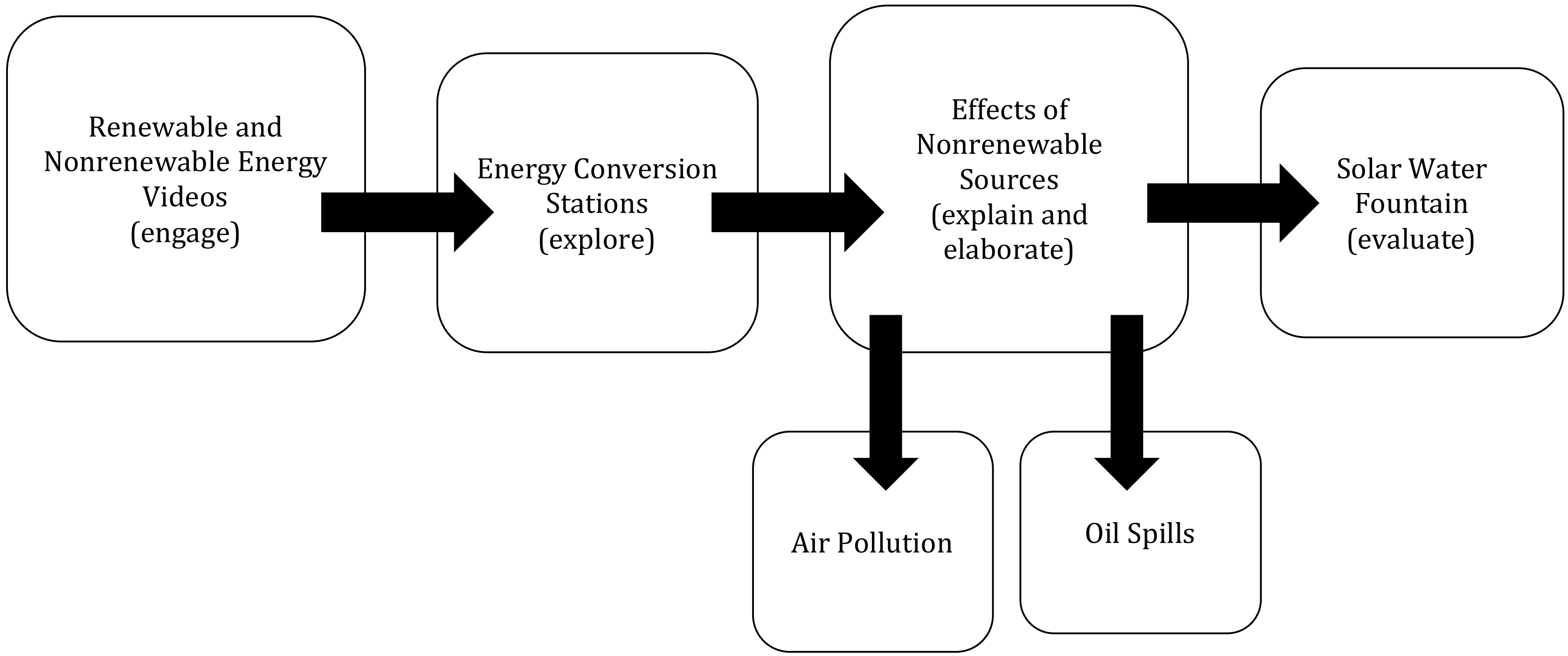
Essential Question 4: What is the best energy source for human use?



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Tiered Vocabulary List

Tier 1	Tier 2	Tier 3
Energy Roll Ramp	Motion Stored Measure Object	Kinetic Potential Angle Transfer Collision Convection Radiation Conduction Renewable Nonrenewable Sustainable Pollution Carbon Dioxide Oil Spill

Science Content Background

Please read through the explanation provided in the next few pages and jot down questions or uncertainties. Consult internet resources to answer your questions, ask colleagues, and work together as a team to grow your own understanding of the science content in this unit. This knowledge primes you to better listen and respond to student ideas in productive ways. Please feel free to revisit this explanation throughout the unit to revise and improve your own understanding of the science content.

Essential Questions:

1.) What is energy?

Energy is defined as the ability to do work, cause change, or move matter. It's important to note that energy cannot be created or destroyed, it can just be transformed (Principle of Energy Conservation). There are two overarching types of energy; potential energy and kinetic energy. Potential energy is the stored energy of an object while kinetic energy is the energy in a moving object. As the unit progresses students learn about types of energy that fall under the two overarching types. Sound energy occurs when an object vibrates causing energy to travel through waves. Light energy is energy that travels through visible waves (the most prevalent example being the light we receive from the Sun). Heat or thermal energy is energy that occurs through the movement of molecules in matter and happens through conduction, convection, and radiation Finally, electric energy occurs when charged particles are conducted through wires, producing electricity.

All energy sources can be categorized as renewable or nonrenewable energy sources. Renewable energy sources are sources that are sustainable and do not harm the Earth. These sources can be easily replenished or are effectively limitless, as they are often created through the Earth's processes. An example of a renewable energy source would be solar power, as it is constantly creating new energy through the Sun's resources. In contrast, nonrenewable energy sources are sources that are not sustainable and can harm the Earth. These sources are limited as they are often derived from resources that are not replenishing themselves. An example of a nonrenewable energy source would be oil, as it is derived through drilling into the Earth and represents the transformation of long ago plant material into hydrocarbons.

2.) How can we turn energy from one form to another?

As mentioned above, energy cannot be created or destroyed. Instead energy is transformed from one type to another when it's acted upon by an outside force (like human intervention). One of the most prevalent types of energy transformation occurs when potential energy shifts into kinetic energy. Students demonstrate this shift as they release the ball from the top of their ramp. The act of letting the ball go releases the potential energy and it transforms into kinetic energy. The kinetic energy is then transformed into sound energy as students hear the marble rolling down the ramp. Another way energy is transformed is through collision. When two objects collide with each other they release kinetic energy as they bounce away from each other. Students also learn about energy transformations that occur in their own lives. For example, they learn about the transformation of electric energy to light energy through conduction. As the energy is conducted through the wires it transforms into the waves of light we see emitting from a light bulb.

3.) How can we move energy from one place to another?

To move energy from one place to another, energy has to change form several times. Oftentimes, renewable energy sources such as windmill farms or solar farms are located far away from highly populated regions where people use large amounts of energy. For this reason, energy has to change form to travel the long distances. For windmill farms, the wind turns wind turbines which produce electric energy to carry electricity to people's homes. For solar farms, the solar energy or radiant energy from the Sun causes the electrons in the solar cells to give off energy and create electric energy which in turns becomes electricity. There are also many types of energy when people utilize nonrenewable resources such as fossil fuels for energy. To draw upon the potential energy within fossil fuels such as coal, people must use kinetic energy, specifically combustion, to burn the coal. The coal in turn creates heat energy in the form of steam. The steam then creates mechanical energy to turn turbines which create electricity. Thus, the journey of energy from one place to another place is a complicated series of steps as energy changes forms.

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4.) What is the best energy source for human use?

Unfortunately, there is not one energy source which is best for humans. Currently, the majority of humans rely on fossil fuels which pollutes the atmosphere with greenhouse gases, causes climate change, and creates air pollution. At the current rate of use, humans will deplete the Earth of its fossil fuels which take millions of years to form. However, renewable energy sources do not solve all the energy problems. There are many aspects to take into consideration when using renewable energy resources such as cost and geographical location. Usually, renewable energy resources are expensive. However, recently, the cost has been slowly decreasing. Even though wind and solar farms can provide electricity for distant locations, these farms need to be set in specific locations with plenty of space. Since wind farms need constant wind to turn the turbines, they are located in high areas with constant winds at least 30 mph. For solar farms, the solar panels need a relatively flat area to catch the sun. In short, renewable energy resources may not be as accessible around the world as fossil fuels. Thus, each energy source has its own pros and cons, so there is not a correct answer for this essential question.

Rationale for Order of Content

In Lesson 1: From Weathering to Energy, students will learn about energy. First, students will learn about the two broad types of energy, kinetic and potential energy. In the second lesson, Speedy Marbles, students will observe examples of potential and kinetic energy. Students will do a marble investigation to learn about the relationship between potential energy and kinetic energy. Furthermore, students will test out several heights to see how height affects kinetic energy. In lesson 3, Collision Course, students will continue to learn about factors such as mass that affect kinetic energy. Besides this, students will learn how an object's kinetic energy can affect another object's kinetic energy through collisions. Since the students learned only about potential and kinetic energy in the first half of the unit, in the fourth lesson, the students will learn about the different types of energy and their energy sources. Similar to the marble investigations in previous lessons, students will conduct an investigation to see how energy transforms in lesson four. In the fifth lesson, the Energy Dilemma, students will expand upon their knowledge of energy sources by learning about renewable and nonrenewable energy resources. Students will then learn how their energy use can harm the Earth. In this way, the unit will become relevant for students because currently, the majority

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of the world's energy relies on fossil fuels which harms the Earth. At the end of the fifth lesson, students will build a solar water fountain, allowing them to utilize their knowledge of energy conversions to create technology powered by renewable energy. In the last lesson, students will conduct a energy scavenger hunt. In this scavenger hunt, students will draw upon their knowledge to locate examples of energy in their surrounding environment. Then, based on what they learned about energy conversions, students will draw a diagram or write about the energy conversions they observed in their school.

Key Science Ideas

OVERARCHING IDEAS

- Energy: the ability to do work, cause change, or move matter
- Principle of Energy Conservation: Energy is neither created or destroyed; it is just transferred or transformed
- Two broad categories of energy: potential and kinetic
  - potential energy: the stored energy of an object
  - kinetic energy: the energy in a moving object
- Potential and kinetic energy affect each other
  - potential energy becomes kinetic energy when a force acts on an object
  - as potential energy increases, kinetic energy decreases and vice versa
- Factors which affect potential and kinetic energy:
  - the greater the height, the greater the potential and kinetic energy
  - the more mass in an object, the more kinetic energy it contains
  - collisions affect kinetic energy:
    - if two objects have the same mass and collide, they go in opposite directions
    - if two objects have different masses and collide, the lighter will go in the same direction as the heavier object

- Other types of energy are either considered potential or kinetic energy
    - sound energy: when an object vibrates, causing energy to travel through waves
    - light energy: travels through visible waves (e.g. light from a light bulb or the Sun)
    - heat or thermal energy: energy caused by the movement of molecules in matter
        - happens through conduction, convection, and radiation
    - electric energy: charged particles moving through wires, producing electricity
- All energy come from energy resources which are either renewable or nonrenewable
    - renewable energy sources: sustainable, limitless, do not harm the Earth
        - there are 6 categories: biomass, hydroelectric, wind, hydrogen, solar, and geothermal
    - nonrenewable energy sources: unsustainable, limited, harms the Earth
        - main fossil fuels are coal, oil/petroleum, and natural gas (propane)
- The Sun is Earth's primary source of energy
    - it provides thermal and radiant energy
- Effects of nonrenewable energy resources:
    - greenhouse gases: increases the amount of carbon dioxide trapped in the atmosphere
    - climate change: the greenhouse gases in the atmosphere trap Earth's heat, increasing the Earth's temperature
    - oil spills: oil suffocates marine life and gets trapped in feathers and fur, so birds cannot fly and marine life cannot maintain their body temperature
- Issues related to renewable energy sources:
    - location dependent: wind and solar farms need to be exposed to a lot of wind and sun on a daily basis
    - land: wind and solar farms need large areas of land because the structures are huge
    - cost: it is expensive to set up solar panels and build windmills
- Converting to renewable energy:
    - Massachusetts government offers tax incentives for people who use renewable energy
    - engineers are making renewable energy sources more accessible and cheaper

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Explanation

This unit is about energy which is the ability to do work, cause change, or move matter. The Principle of Energy Conservation states that energy is never created or destroyed; it is just transformed or transferred. There are two overarching types of energy; they are potential and kinetic energy. Potential energy is the stored energy of an object due to its position. In contrast, kinetic energy is the energy due to the motion of an object. In short, potential energy is when an object is motionless, while kinetic energy is when an object is moving.

There are many variables which affect potential and kinetic energy such as height. The greater the height, the larger the potential energy in an object. Contrary to misconceptions, increasing the potential energy of an object does not increase the object's kinetic energy. In fact, it decreases the object's kinetic energy because potential and kinetic energy are opposite types of energy. For instance, a marble on top of a ramp has more potential energy than kinetic energy because it is still. However, once someone pushes the marble down the ramp, the potential energy is transformed into kinetic energy. Therefore, the marble has more kinetic energy than potential energy. In short, the potential energy was not destroyed; it was just transformed into kinetic energy.

In order for potential energy to transform into kinetic energy, there has to be an acting force. For instance, for a marble, the outside, acting force is someone pushing the marble. As a result of the push or force, the potential energy of the marble is transformed into kinetic energy as it rolls down the ramp. However, the collision of objects can also cause kinetic energy. When two marbles collide, the impact can either cause both marbles to bounce back from each other, so they travel in opposite directions, or for both marbles to travel in the same direction. The direction and force of kinetic energy is influenced by height and mass. The larger the height, the more kinetic energy in an object. This large amount of kinetic energy is demonstrated by the fast rate that the object travels. Similarly, the more mass in an object, the larger the kinetic energy. For instance, when a large marble collides with a small marble, both marbles roll in the same direction as the large marble. In short, the large marble's kinetic energy is larger than the small marble's kinetic energy, so the large marble was not impacted by the small marble's kinetic energy.

There are other types of energy which branch off of the two broad potential and kinetic energy categories. For instance, there is thermal, radiant, and mechanical energy. Students are expected to be able to define sound, light, heat, and electric energy at the end of this unit. Sound energy is when an object vibrates, causing the energy to travel through waves. Similar to sound, light energy travels through waves. However, unlike sound, we cannot hear light energy. In contrast, we can see light energy such as light from a lightbulb or from the Sun, our main light source. Energy from the sun is specifically called solar energy. Heat energy or thermal energy is energy caused by the kinetic energy or movement of molecules in matter. The majority of the heat energy received on Earth comes from the Sun. Thermal energy can be transferred through convection, conduction, and radiation. Electric energy is when charged particles move through wires to provide electricity.

Since energy is neither created or destroyed, energy can change into many types of other energy. In fact, there are many pathways for energy to take. For instance, when a marble is rolled down a ramp and hits a bell, its potential energy is changed into kinetic energy which results in sound energy. Energy transformations happen on a daily basis in people's lives. In fact, energy transformations happen within humans' bodies. In order to gain energy, humans consume food which contains chemical energy. To cook the food, electric energy was transformed into heat energy. During the winter, some people use biomass such as wood to warm their houses by burning the wood. The wood's potential energy then becomes kinetic energy which then results in heat energy. In nature, the largest source of heat, the Sun, powers solar panels. The solar energy from the Sun causes the electrons in the solar cells to give off energy, creating electric energy.

In America, most of the resulting energy such as light or heat energy comes from electric energy. Most of society's technology such as light bulbs or fans are powered by electricity. Even though energy is never created or destroyed, energy is lost whenever it transforms or transfers. A classic example is turning on a light bulb. When a light bulb is on, the electric energy is transformed into two types of energy: radiant and heat energy. The light bulb emits heat or heat energy. Thus, the electric

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energy is not completely transformed into radiant energy. Unfortunately, due to time constraints, students will not learn about the loss of energy in this lesson.

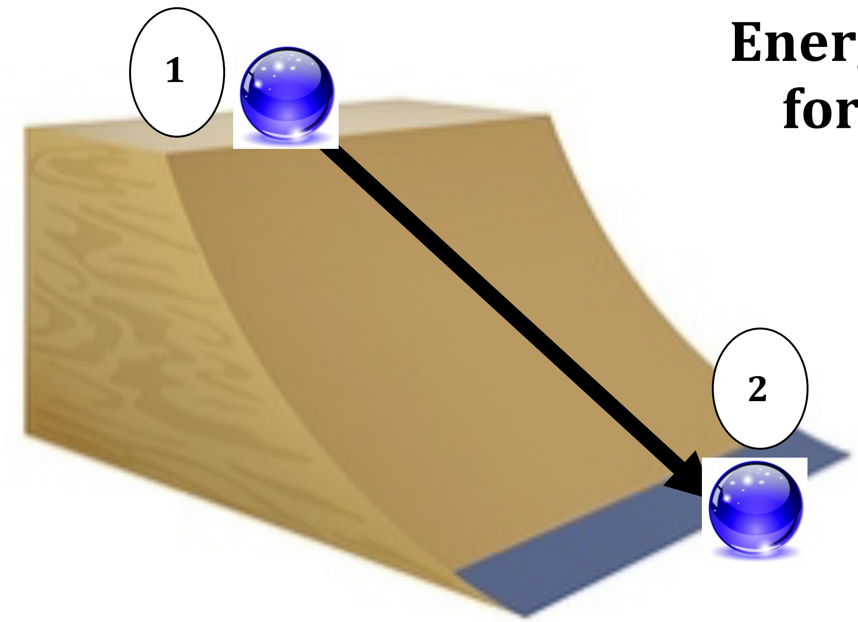
There is not an endless amount of energy resources on Earth. There are two categories that describe how we harness energy: nonrenewable and renewable energy resources. Nonrenewable energy is unsustainable such as fossil fuels and oil. In other words, once we use up all the nonrenewable resources, there will be none left. Unfortunately, fossil fuels also power most of the electricity and transportation in America. Thus, the majority of energy in people's lives come from nonrenewable energy resources. In contrast, renewable energy is sustainable; there is a limitless amount of supply. There are six types of renewable energy: biomass, hydroelectric, wind, hydrogen, solar, and geothermal. Biomass comes from living organisms such as wood and charcoal from trees or corn ethanol from corn. Hydroelectric energy is electricity powered by the movement of water (eg, rivers, tides, and waves. Wind energy comes from wind turning wind turbines. Hydrogen energy is energy taken from fuel cells powered by hydrogen and oxygen molecules. Solar energy is energy taken from the Sun either actively through solar panels or passively through the windows of a house. Finally, geothermal energy is energy powered by the Earth's molten core.

Sadly, the constant use of nonrenewable resources for electricity and transportation has negative effects on the Earth such as contributing to the greenhouse gases in the atmosphere, climate change, and oil spills. When humans burn fossil fuels, they release more carbon dioxide into the atmosphere. Consequently, the carbon dioxide, a greenhouse gas, traps heat in the atmosphere, causing the Earth's temperature to increase. The change in temperature then changes climate, forcing living organisms to adapt to the warmer climate. The use of fossil fuels also results in oil spills which harm marine life. The oil can suffocate marine animals or get caught in fur or feathers, making it difficult to float or maintain body temperature for these animals. For this reason, scientists are trying to find ways to make renewable energy sources accessible for everyone to prevent further damage to Earth. However, there are many aspects to take into consideration before the world can completely rely on renewable energy such as geographic location and cost. Energy resources such as wind energy are primarily available in high, windy areas. The cost can also be expensive to buy and install solar panels. In recent years though, the costs for renewable energy has been decreasing, making it more accessible for everyone. Furthermore, in Massachusetts, the government offers tax incentives to encourage more people to use renewable, sustainable sources instead of nonrenewable sources.

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

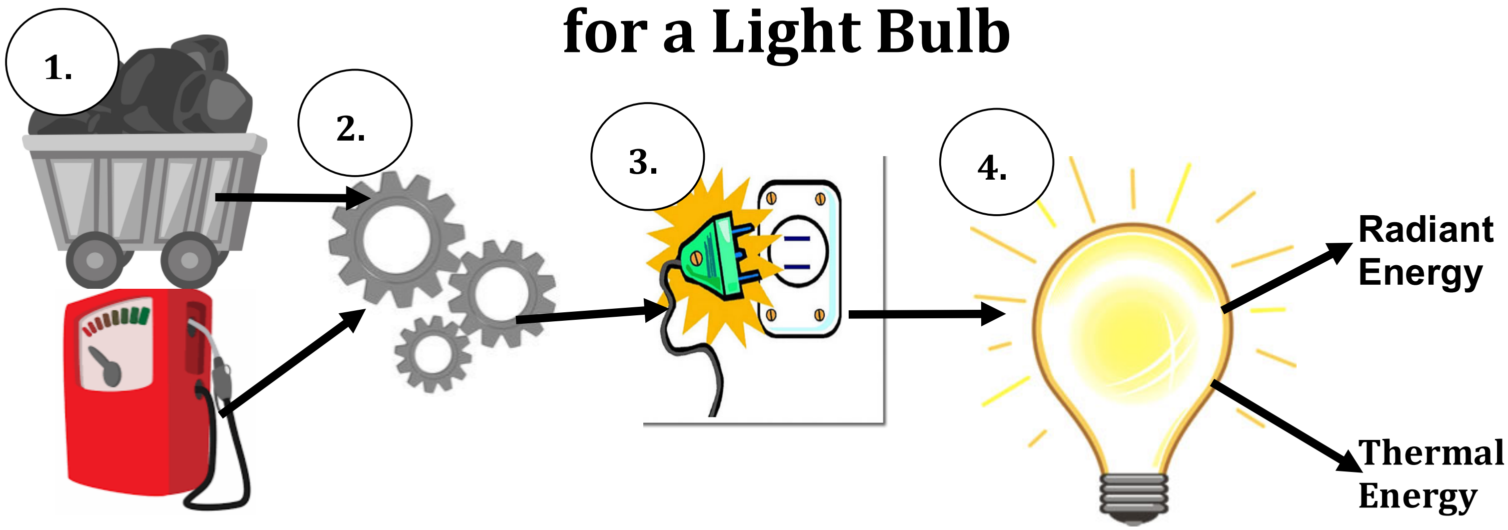
Science Content Background Knowledge Diagrams

Energy Diagram for a Marble



1. The marble on top of the ramp contains potential energy because it is still.
2. Once the marble is pushed down the ramp, it has kinetic energy.

Energy Diagram for a Light Bulb



1. Fossil fuels are burned as the energy source to turn water into steam.

2. The steam turns the turbines, using mechanical energy.

3. This produces electrical energy which travels to the light bulb through wires.

4. The light bulb produces radiant and thermal energy. The thermal energy is "excess energy" because humans only wanted the light energy.

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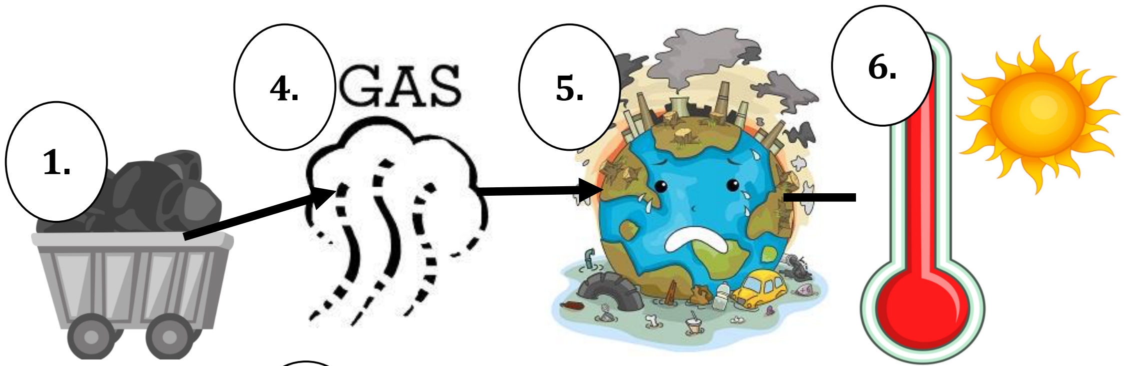
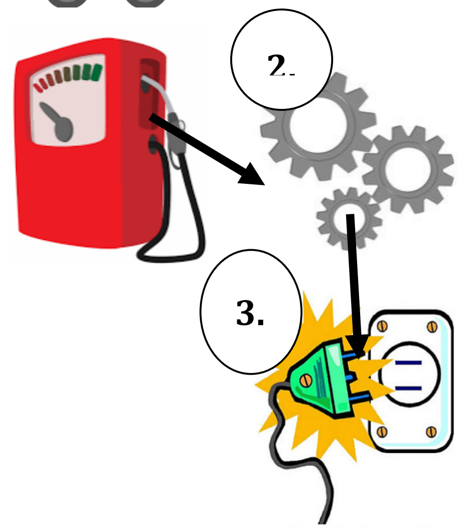
Climate Change





1. First, fossil fuels are burned to produce steam.
2. The steam turns the turbines in factories using mechanical energy.
3. The turning of the turbines produces electrical energy to create electricity.
4. However, the fossil fuels release gas such as carbon dioxide.
5. These greenhouse gases becomes trap in the Earth's atmosphere.
6. Consequently, the Earth cannot maintain its temperature, so it overheats, causing climate change.

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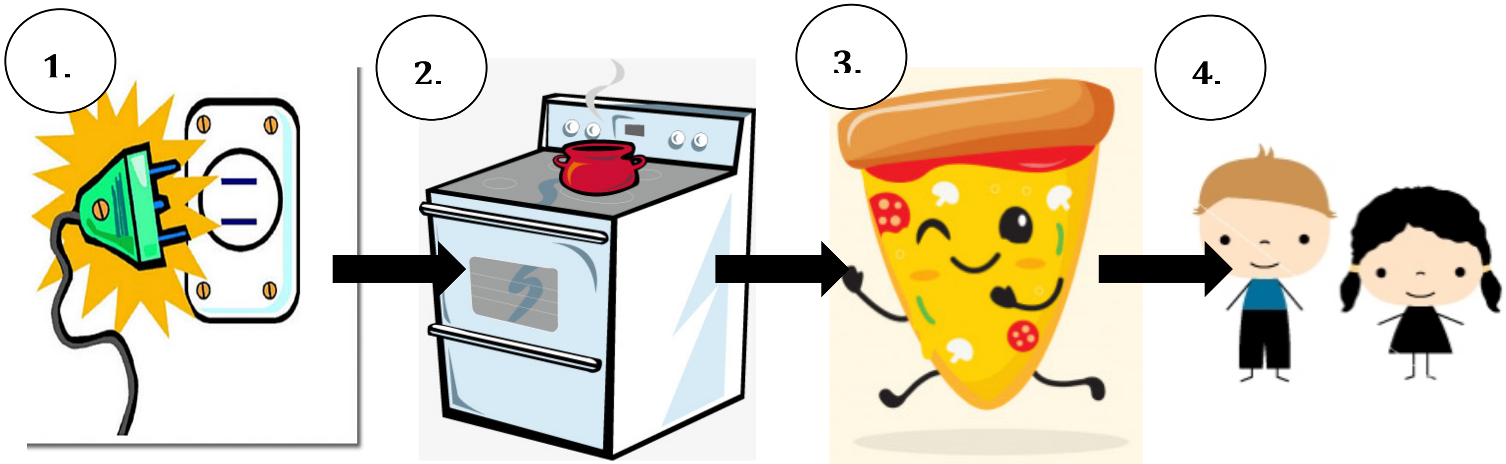
How Humans Receive Energy



1. To cook food, humans use electric energy to power their stoves.
2. Then, the electric energy is converted to thermal energy to bake the pizza.
3. After, the pizza is finished, storing chemical energy.
4. Humans eat the pizza, receiving energy from the pizza.

Lesson 1: Introduction to Energy

LESSON BACKGROUND

In this lesson, students will be introduced to the concept of energy. First, they will learn that energy is the ability to do work, cause change, or move matter. Thus, energy helps people accomplish tasks. Then, students will learn about two broad types of energy, kinetic and potential energy. By first learning about potential energy, students will understand that everything has energy. However, this energy is only evident to humans when it becomes kinetic energy. After learning this, students will learn about types of potential and kinetic energy such as radiant energy and thermal energy.

Science Content Background (for the instructors):

This unit is about energy which is the ability to do work, cause change, or move matter. There are two overarching types of energy; they are potential and kinetic energy. Potential energy is the stored energy of an object due to its position. In contrast, kinetic energy is the energy due to the motion of an object. In short, potential energy is when an object is motionless, while kinetic energy is when an object is moving. There are other types of energy which branch off of these two broad energy categories. For instance, there is thermal, radiant, and mechanical energy. In this lesson, students are expected to learn about sound, light, heat, and electric energy. Sound energy is when an object vibrates, causing the energy to travel through waves. Similar to sound, light energy travels through waves. However, unlike sound, we cannot hear light energy. In contrast, we can see light energy such as light from a lightbulb or the Sun, our main light source. Energy from the Sun is specifically called solar energy. Heat energy or thermal energy is energy caused by the kinetic energy or movement of molecules in matter. The majority of the heat energy received on Earth comes from the Sun. Thermal energy can be transferred through convection, conduction, and radiation. Electric energy is when charged particles move through wires to provide electricity.

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Overview of Lesson

Energy will be introduced for the first time and students will be prompted to think about how energy connects
to weathering and erosion. Students will also be introduced to different types of energy.

Focus and Spiral Standard(s)

Focus Standard: 4-PS3-2. Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents.

Clarification Statement:

- Evidence of energy being transferred can include vibrations felt a small distance from a source, a solar-powered toy that moves when placed in direct light, warming a metal object on one end and observing the other end getting warm, and a wire carrying electric energy from a battery to light a bulb.

State Assessment Boundary:

- Quantitative measurements of energy are not expected in state assessment.

Spiral Standard: K-PS3-1. Make observations to determine that sunlight warms materials on Earth's surface.

Clarification Statements:

- Examples of materials on Earth's surface could include sand, soil, rocks, and water.
- Measures of temperature should be limited to relative measures such as warmer/cooler.

Spiral Standard: 1-PS4-1. Demonstrate that vibrating materials can make sound and that sound can make materials vibrate.

Clarification Statements:

- Examples of vibrating materials that make sound could include tuning forks, a stretched string or rubber band, and a drum head.
- Examples of how sound can make materials vibrate could include holding a piece of paper near a speaker making sound and holding an object near a tuning fork.

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Spiral Standard: 1-PS4-3. Conduct an investigation to determine the effect of placing materials that allow light to pass through them, allow only some light through them, block all the light, or redirect when put in the path of a beam of light.
Clarification Statements:

- Effects can include some or all light passing through, creation of a shadow, and redirecting light.
- Qualitative measures are not expected.

Spiral Standard: 4-ESS3-1. Obtain information to describe that energy and fuels humans use are derived from natural resources and that some energy and fuel sources are renewable and some are not.
Clarification Statements:

- Examples of renewable energy resources could include wind energy, water behind dams, tides, and sunlight.
- Non-renewable energy resources are fossil fuels and nuclear materials.

Spiral Standard: 5-LS1-1. Ask testable questions about the process by which plants use air, water, and energy from sunlight to produce sugars and plant materials needed for growth and reproduction.
State Assessment Boundary:

- The chemical formula or molecular details about the process of photosynthesis are not expected in state assessment.

Spiral Standard: 6.MS-PS1-6. Plan and conduct an experiment involving exothermic and endothermic chemical reactions to measure and describe the release of thermal energy.
Clarification Statements:

- Emphasis is on describing transfer of energy to and from the environment.
- Examples of chemical reactions could include dissolving ammonium chloride or calcium chloride.

Spiral Standard: 7.MS-PS3-6. Use a model to explain how thermal energy is transferred out of hotter regions or objects and into colder ones by convection, conduction, and radiation.

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Spiral Standard: 7.MS-ESS2-4. Develop a model to explain how the energy of the Sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in Earth's hydrosphere.

Clarification Statement:

- Examples of models can be conceptual or physical.

State Assessment Boundary:

- A quantitative understanding of the latent heats of vaporization and fusion is not expected in state assessment.

NGSS Alignment Table

Science/Engineering Practice (SP)	Disciplinary Core Idea (DCI)	Cross Cutting Concepts (CCC)
Planning and Carrying Out Investigations	**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	**Energy and Matter** -Energy can be transferred in various ways and between objects. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4)

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	heated and sound is produced. (4-PS3-2), (4-PS3-3) -Light also transfers energy from place to place. (4-PS3-2) -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)	

Learning Targets

I can define energy and identify its various forms including potential, kinetic, sound, light, heat, and electric energy.
I can create a concept map to demonstrate the understanding of energy.

Assessment

- Do you need energy for weathering and erosion to happen? Could weathering and erosion happen without energy?
- Create a concept map on "energy". Have students work in small groups and then as a class create a concept map. (See the example at the end of this lesson.)

Targeted Academic Language

- Tier 1: energy
- Tier 2: motion, stored
- Tier 3: kinetic, potential

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per student	Science journals	Classroom Teacher
1	Projector	Classroom Teacher
25	**Paper bowls (colored)**	**Bin**
25	Plastic straws	Bin
3 containers	**Salt**	**Bin**
1	Computer	Classroom Teacher
1 per group	iPads (optional)	Classroom Teacher
1	Potential and Kinetic energy video (https://www.youtube.com/watch?v=AYRa8Ismplk&list=PLsAWD8mKKE97b_iwzdzXSijuYpVdxV4qO&index=1)	CMC Website
1	Energy and Matter video (https://www.youtube.com/watch?v=a_JufiBuDzA&list=PLsAWD8mKKE97b_iwzdzXSijuYpVdxV4qO&index=2)	CMC Website

****Items in bold should be returned to the bin for use next year****

LESSON DETAILS

Lesson Opening/ Activator

Recalling Scientists: Ask students how *we* were scientists when we studied rocks and minerals in the Grade 4: Earth's Surface unit. The teacher should then write the answers on the board or on a large piece of paper. The large paper can be hung up on the classroom wall and be used as a "Science Wall of Fame". The science fellow can tell the students that they can keep adding information to it until the end of the unit.

During the Lesson

Student Thinking Alert
Remind students that scientists do not follow the scientific method (a series of steps to attain information), but rely on "ways" of doing and thinking.

1. **Scientific Practices:** Introduce the 8 scientific practices to the students (write them on a large piece of paper which can be kept up on a wall in the classroom for the duration of the semester). Talk through each practice briefly, making sure the students understand why it is important to keep these practices in mind. (See the list of the 8 scientific practices below.) Remind the students that we are scientists and these practices guide all scientists in research and discovery.

The 8 Scientific Practices

1. Ask questions (for science) and define problems (for engineering)
2. Develop and use models
3. Plan and carry out investigations
4. Analyze and interpret data
5. Use mathematics and computational thinking
6. Construct explanations (for science) and design solutions (for engineering)
7. Engage in argument from evidence
8. Obtain, evaluate, and communicate information

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2. Moving Salt Investigation:

> **Teaching Tip**
> To draw upon students' background knowledge of erosion and weathering, ask students what type of erosion they model in this activity. The answer is wind erosion.

Tell the students that they will be doing a small investigation to explore the concept of energy using salt.

1.Give each child a paper bowl and straw. Then, go around to each bowl and pour a pile of salt on one side of the bowl (enough for the students to blow the salt with a straw and see movement).

2.Once all the students have their bowls, salt, and straws, let them experiment and move the salt by blowing into their straws. (Please remind the students to be conscious of those around them and to lightly blow on the salt, so it doesn't get into their eyes.)

(Science Talk: Class Discussion): Once the students have played around with the salt for a bit, try to have them connect what they were doing to the concept of energy. Some probing questions could be: What did you observe? Why is that the case? How did we move the salt? Are there different ways to move the salt? Were we using energy to move the salt? Could we move the salt without energy? **[SP1 - Asking Questions]** After a few minutes, have some of the students share their observations with the class.

3. Introducing Energy: Pose the essential questions (see unit plan) as a way to motivate the tasks ahead and to build awareness among students of the overarching goals for this unit. Be *energetic* in your introduction of this new material; this is your opening pitch and moment to engage them in scientific discovery! You may decide to write the essential questions on a large poster and display them prominently in the class as a reference to use throughout the semester.

4. Explaining Energy: Prompt the students to begin thinking about energy. Think about the words energy and energetic; how do these words relate to us/people? What do we feel like when we have lots of energy? When do we have lots of energy? Where

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does our energy come from? What do we feel like when we have little energy? How do we know how much energy we have? You should consider giving the students a simple definition of energy.

Simple Definition: Energy is the ability to do work, cause change, or move matter.

(Science talk: Small group or class discussion):

5. Potential and Kinetic Energy: Screen the potential and kinetic energy video. After watching the video, discuss other examples of potential and kinetic energy either in small groups or as a whole class. Then, ask the students to explain the kinetic and potential energy of an object based on what they learned in the video and discussion.

6. (Science Talk: Class Discussion) Energy and Matter: Screen the Energy and Matter video (this can be done before or after the next activity). The video moves quickly, so consider pausing frequently or viewing multiple times to ensure the class understands the material. How does the feeling of being "energetic" compare to the scientific definition of energy? (Note: mechanical and chemical energy are mentioned in the video, but are not taught in any lessons in this unit. The teacher does not need to spend time explaining these concepts in great depth).

Student Thinking Alert

Electric energy creates electricity. Electricity is a way of transporting energy; it is not an energy source.

Ask students about the different types of energy. "What are some types of energy that they mentioned in the video? Where can we find these different types of energy? Please name a few examples of energy that are part of our daily lives." If none of the students do not mention the sun as a source of radiant energy, then the teacher should mention it. The teacher should elaborate on this concept by briefly mentioning how the sun is the Earth's primary source of energy. (It provides solar, radiant, and thermal energy.)

7. Field Research: Divide the class in half so that each science fellow can take a group out to do "field research." Have each group take a walk around the school (inside or outside) to see if students can identify examples of *energy conversions* and *energy in motion*. If walking around the school is not feasible, then the students can look for sources of energy within the classroom. If technology is available for student use, then students can record their observations as photos or video clips using iPads or other technology. These "field notes" should be saved in the camera roll to share with the class and for possible use throughout the semester. If iPads are unavailable, then the students can take notes in their science journals. This "field research" should be long enough for the students to see multiple examples of energy in motion/energy conversions; this can take anywhere from 10-30 minutes. **[SP4 - Analyze and interpret data]** Once everyone has had time to explore, bring the whole class back together. Have some of the students share their "field research" and what they observed today.

Lesson Closing:
Concept Map: Create a concept map on "energy" (see the example at the end of this lesson). Explain what a concept map is and tell the students to provide as much information as they can on what they learned about energy. Let the students work in a small group first and then ask them to present their concept maps. At the end, the science fellow should make a concept map on a large piece of paper based on the students' maps . The concept map can be hung on the wall, so students can refer to it throughout the unit. The classroom teacher should appropriately scaffold the creation of the concept map depending on the needs of the class.

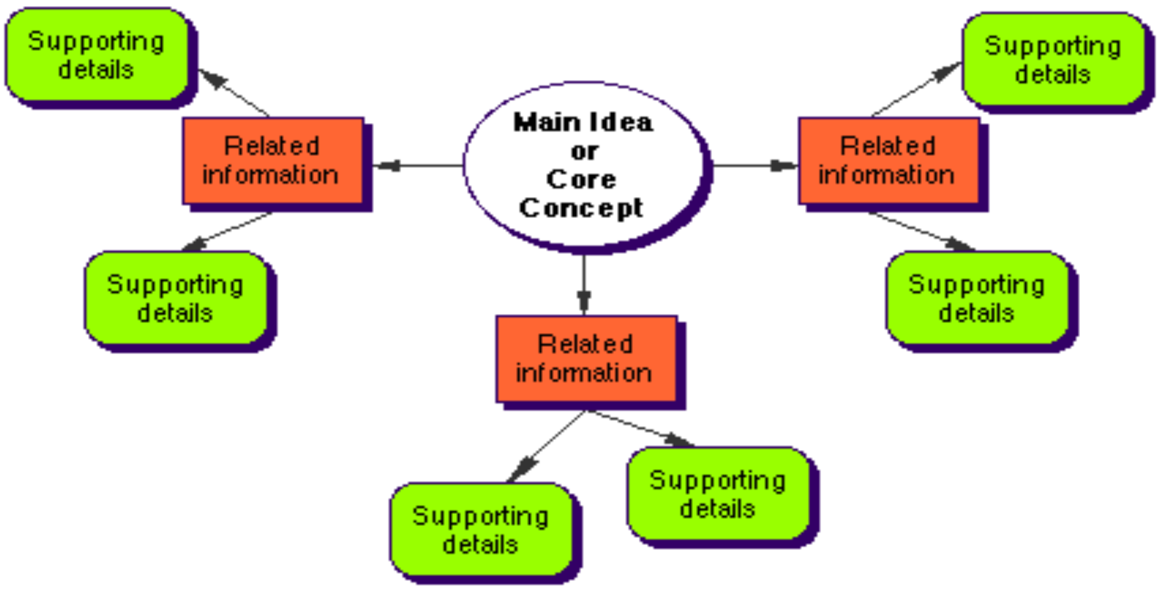
Assessment

- Do you need energy for weathering and erosion to happen? Could weathering and erosion happen without energy?
- Create a concept map on "energy." Have students work in small groups and then as a class create a concept map. (See the example at the end of this lesson.)

***Extension (if students do poorly on the assessment):
If students have difficulty answering the question of whether or not they need energy for weathering and erosion, then have a class discussion during the Moving Salt Investigation activity. Possible questions to ask students are: What type of energy did you use when you were blowing the salt? (The answer should be wind energy.) What kind of erosion carries dirt and minerals such as salt over long distances? (The answer should be wind erosion.) Since blowing the salt represented the wind in nature, what would happen if you were tired? If you are tired, do you have a lot of energy?

For the energy concept map, the whole class should brainstorm ideas together to write on the class concept map. In this way, if students could not come up with ideas in their small groups, the teacher can guide them to possible answers. To guide students' thinking, the teacher should "contribute" to the class concept map by adding potential energy or kinetic energy. This will help the students know what to include on the concept map.

Example of a Concept Map



Lesson 2: Speedy Marbles

LESSON BACKGROUND

Since students learned about potential and kinetic energy in the previous lesson, students will observe examples of potential and kinetic energy in this lesson. This lesson will primarily consist of investigations with marbles and ramps. Students will set marbles at the top of ramps to model potential energy. For kinetic energy, students will roll the marbles down the ramps. This transition from potential energy to kinetic energy in the marbles will help students understand that potential energy decreases as kinetic energy increases and vice versa. To further deepen students' knowledge on kinetic energy, students will test out several heights to see how height affects the marble's kinetic energy.

Science Content Background Knowledge (for the instructors)

This lesson focuses on the difference between potential and kinetic energy. Potential energy is stored energy in an object such as a marble resting at the top of a ramp. In contrast, kinetic energy is the energy of a moving object such as a marble rolling down a ramp. There are many variables which affect potential and kinetic energy. However, in this lesson, students will focus on how height affects potential energy. The greater the height, the larger the potential energy in an object. While this is a common misconception, note that increasing the potential energy of an object does not increase the object's kinetic energy. In fact, it decreases the object's kinetic energy because potential and kinetic energy are opposite types of energy. For instance, a marble on top of a ramp has more potential energy than kinetic energy because it is still. However, once someone pushes the marble down the ramp, the potential energy is transformed into kinetic energy. Therefore, the marble has more kinetic energy than potential energy. In short, the potential energy was transformed into kinetic energy because energy is never created or destroyed.

Overview of Lesson

In this lesson, students will do an investigation with ramps and marbles. Students will roll a marble down ramps of varying heights in a series of trials. During these trials, students will gather data to make conclusions about energy and speed.

Focus and Spiral Standard(s)

Focus Standard: Math 4.NF. 6. Use decimal notation for fractions with denominators 10 or 100. For example, rewrite 0.62 as 62/100; describe a length as 0.62 meters; locate 0.62 on a number line diagram.

Focus Standard: 4-PS3-1 Use evidence to construct an explanation relating the speed of an object to the energy of that object.
State Assessment Boundaries

- State assessment will be limited to analysis of kinetic energy.
- Accounting for mass, quantitative measures of changes in the speed of an object, or any precise or quantitative definition of energy is not expected in state assessment.

Spiral Standard: 7.MS-PS3-1. Construct and interpret data and graphs to describe the relationships among kinetic energy, mass, and speed of an object.

Clarification Statements:

- Examples of could include riding a bike at different speeds and rolling different sized rocks downhill.
- Consider relationships between kinetic energy vs. mass and kinetic energy vs. speed separate from each other; emphasis is on the difference between linear and exponential relationships.

State Assessment Boundary:

- Calculation or manipulation of the formula for kinetic energy is not expected in state assessment.

NGSS Alignment Table

Science/Engineering Practice (SP)	Disciplinary Core Idea (DCI)	Cross Cutting Concepts (CCC)
Constructing explanations and designing solutions	**PS3.A: Definitions of Energy** -The faster a given object is moving, the more energy it possesses. (4-PS3-1)	**Energy and Matter** -Energy can be transferred in various ways and between objects. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4)

Learning Targets

I can measure the time it takes for a marble to roll down a ramp.
I can draw conclusions about the speed of an object based on the height from which the object was dropped.
I can draw conclusions about energy based on observations of the speed of an object.

Assessment

- Have students create a graph with the data collected from the activity. This could be in the form of a line graph with the height of the ramp on one axis and the time it took the marble to roll down the ramp on the other axis.
- Ask the students to write one thing they learned from this activity and one thing they wonder about.
- In small groups, have students discuss the following: How fast does a marble roll down a ramp (without changing the angle)? Would marbles with different weights roll at different speeds? Would it take less time/more time for a larger marble to roll down a 1-meter ramp?

Targeted Academic Language

Tier 1: roll, ramp

Tier 2: measure, object

Tier 3: angle, transfer

Resources and Materials

Quantity	Item	Source
1 per student	Science journals	Classroom Teacher
1 per group (should have at least 5 in your bin)	**1 meter wooden ramp**	**Bin**
4-6 per group	**Marbles**	**Bin**
A bunch per group	Books, blocks, objects to raise one end of a ramp	Classroom Teacher
1 per group	Measuring tape or yardstick	Classroom Teacher
1 per group	**Stopwatch or timer**	**Bin**
1 per group	iPads (optional)	Classroom Teacher
1 per student	Marble speed worksheet	Binder (teacher to make copies)
1 per group	Cardboard or plastic box	Classroom Teacher
1 per group	Calculator (Only for challenge activity)	Classroom Teacher

****Items in bold should be returned to the bin for use next year****

LESSON DETAILS

Lesson Opening/ Activator

(Science talk: Think-Pair-Share): Energy Discussion

Ask students to look back at the concept maps they created in the previous lesson. Then, ask them to pair up with a classmate and talk about the following:

1. One of their ideas regarding the scientific principle of energy conversion.
2. One new idea they recall from the energy video and/or their field research.

Then, ask a few students to share with the class what they discussed with their partners.

During the Lesson

The teacher should explain to the whole class the tools they will use in today's investigation. Describe the group task, which is to measure the time it takes for a marble to roll down a ramp that is placed at different heights.

1. **Marbles down a ramp**
    a. Divide students into small groups and help them find a clear space in the room, so they can set up their experiments and make observations. Tell the students to think of this space as their "lab area" where they will conduct an investigation and collect data. Each group needs ramps, marbles, measuring tape/meter stick, books or blocks to rest their ramp on, and a stopwatch or timer. (**Optional**: Give the students a cardboard or plastic box to set at the bottom of the ramp, so the marbles do not roll all over the classroom. If the marble hits the box, then this will indicate that the students should stop the timer.) The adults can distribute these materials after the transition or groups can come get their materials from a central location. The students should also have their science journals with them.

    b. You can create specific roles for each student if needed such as timekeeper, recorder, and marble roller. Give the students time to practice using the stopwatches correctly. The science fellow should give a demonstration on how the stopwatch works. Then, the classroom teacher or science fellow should review with the students how to read decimals and discuss how to round the answers (to the nearest tenth or hundredth). The science fellow should also give a demonstration on how to measure the height of the ramp from the floor.

c. Ask students to measure the ramps (they should be 1 meter or longer). If the ramps are longer, explain to the students that they must start the ball at the marked line on the ramps and not at the very top of the ramp. Then, give the students time to play with the marbles, ramps, and timers. **[SP5 - Using Mathematics and Computational Thinking]**

d. Now, ask students to find a stable and level surface (e.g. books, blocks, or other materials) on which to prop up one end of the ramp while setting the other end of the ramp on the floor.

e. Ask students to recall how long the ramps are (approximately 1 meter). Now, ask them to measure the vertical height from the top of the ramp to the floor and record that measurement in the height column on the worksheet, which can be found at the end of this lesson. (The distance the marbles will travel on the ramp should always be 1 meter.) **Optional**: The teacher may predetermine heights, so when the class compares results at the end of the lesson, it is easier. Students should have three different heights (example: 1 ft, 2 ft, 3 ft).

f. Instruct students to place a marble at the top of the ramp and set the stopwatches to zero.

g. One student can release the marble while another student simultaneously starts the stopwatch. Students should stop the timer immediately when the marble touches the floor or hits the box at the end of the ramp. A third student can record on the worksheet how long it took for the marble to roll down the ramp. Students should repeat this procedure for a total of three trials at the same height. Later, tell the students that they will find the average of these results to ensure accuracy in the measurement of times. Students should rotate jobs so everyone gets a chance to do each job.

h. **(Science talk: Small group debrief and class discussion)**

Repeat the procedure for two additional heights (three heights total). Make sure that students record all of the heights and times observed. Once all groups are done, ask them to discuss the following questions in their respective groups: What did you observe? What happened as you increased the height of the ramp? What is the relationship between our findings and the concept of energy? Did the marble have potential and kinetic energy? Then, bring the students back together for a class discussion about the data that was collected. Some questions that could be asked include: Did the marble go slower when it was at the taller height or the lower height? When was the marble moving the fastest? When did the marble have potential and kinetic energy? Were the times for the trials all the same or were they different? **[SP4 - Analyzing and Interpreting Data]**

If students have a hard time with the discussion, the science fellow can give them the following sentence frames:

The marble went……… when it was at the tallest height.
The marble went…….. when it was at the lowest height.
The marble moved the fastest when ……..
The marble had potential energy when ………… and it had kinetic energy when……..

Lesson Closing

(Science talk: "turn and talk"): Marble Discussion

Once the students have finished the investigation and the class discussion, ask them to "turn and talk" again with their group about what they observed during their investigation. Did we get the results we expected? Were we surprised by anything? What did we learn?

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Extension: Record each group's data in a whole-class data table or graph. You can use technology (a graphing app projected on screen or project the graph paper using a document camera) or no-technology (chart paper or on board) to create a graph. This may be worthwhile, especially if you notice different groups getting very different answers because that's a good time to talk about how to deal with discrepancy in data and what might have caused this.

Assessment

- Have students create a graph with the data collected from the activity. This could be in the form of a line graph with the height of the ramp on one axis and the time it took the marble to roll down the ramp on the other axis.
- Ask the students to write one thing they learned from this activity and one thing they wonder about.
- In small groups, have students discuss the following: How fast does a marble roll down a ramp (placed at the same angle as the down ramp)? Would marbles that have different weights roll at different speeds? Would it take less time/more time for a larger marble to roll down a 1-meter ramp?

***Extension (if students do poorly on the assessment):
If students have difficulty graphing the data from the marble investigation, then the teacher should model how to create a graph. On the whiteboard or on poster paper, the teacher should draw a X-axis and Y-axis. Then, the teacher should label the Y-axis as time because that was what the students were measuring in the investigation. For the X-axis, the teacher should label it as the heights of the ramps because that was the changing variable students were measuring in the investigation. Afterwards, the teacher should make up times and heights and fill it out accordingly on the graph, so students understand how to graph.

If students have difficulty answering the small group discussion questions, then the teacher should go to each group and ask more guiding questions. Possible guiding questions the teacher can ask are: Which would fall faster? A large rock or small rock? Why do you think they would fall at different speeds? Now, how do you think this situation is similar to a large marble rolling down a ramp versus a small marble rolling down a ramp? Would their speeds also differ? How so?

Lesson Extension (Optional)

We will calculate the average time for each trial by adding the times together and dividing by three. Put the following equation on the projector or board, so students can use the formula to find the average. The science fellow should explain how to use the equation. Afterwards, have a class discussion about the graphs that were made. A potential question to ask the students is: what conclusions about speed can we make from the graphs?

Total of **Trial 1 time + Trial 2 time + Trial 3 time**

$$\frac{\text{Total of Trial 1 time + Trial 2 time + Trial 3 time}}{3}$$

Lesson 3: Collision Course

LESSON BACKGROUND

Since students observed examples of potential and kinetic energy in the previous lesson, this lesson will build upon students' knowledge on potential and kinetic energy. In the last lesson, students learned how the greater the height, the more potential energy a marble contains. In this lesson though, students will learn how mass also affects the amount of potential and kinetic energy contained in an object. Besides this, students will learn how an object's kinetic energy can affect another object's kinetic energy through collisions. For instance, a marble with a heavy mass and a large kinetic energy will affect the direction a small marble travels. This lesson will also provide students with a glimpse of how an object's energy can transfer to another object. However, this concept will be covered more thoroughly in the next lesson.

Science Content Background Knowledge (for the instructors)

In order for potential energy to transform into kinetic energy, there has to be an acting force. In this lesson, the outside, acting force is someone pushing a marble. As a result of the push or force, the potential energy of the marble is transformed into kinetic energy as it rolls down the ramp. However, the collision of objects can also cause kinetic energy.

When two marbles collide, the impact can either cause both marbles to bounce back from each other and travel in opposite directions or for both marbles to travel in the same direction. The direction and force of kinetic energy is influenced by height and mass. The larger the height, the larger the kinetic energy in an object. This large amount of kinetic energy is demonstrated by the fast rate that the object travels. Similarly, the more mass in an object, the larger the kinetic energy. For instance, when a large marble collides with a small marble, both marbles roll in the same direction as the large marble. In other words, the large marble's kinetic energy is larger than the small marble's kinetic energy, so the large marble was not impacted by the small marble's kinetic energy.

Overview of Lesson

In this lesson, students will continue to do an investigation with ramps and marbles. Students will gain a deeper understanding of potential and kinetic energy through discussion, observation, and investigation. Students will also partake in a friendly intra-class competition.

Focus and Spiral Standard(s)

Focus Standard: 4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.
Clarification Statement:

- Changes in energy can include a change in the object's motion, position, and the generation of heat and/or sound.

State Assessment Boundary:

- Analysis of forces or quantitative measurements of energy are not expected in state assessment.

Spiral Standard: 3-PS2-1. Provide evidence to explain the effects of multiple forces, including friction on an object. Include balanced forces that do not change the motion of the object and unbalanced forces that do change the motion of the object.
Clarification Statements:

- Description of force magnitude should be qualitative and relative.
- Force due to gravity is appropriate but only as a force that pulls objects down.

State Assessment Boundary:

- Quantitative force magnitude is not expected in state assessment.
- State assessment will be limited to one variable at a time: number, size, or direction of forces.

Spiral Standard: 7.MS-PS3-5. Present evidence to support the claim that when the motion energy of an object changes, energy is transferred to or from the object.
Clarification Statement:

- Examples of empirical evidence could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of an object.

State Assessment Boundary:

- Calculations of energy are not expected in state assessment.

Focus Standard: 4-PS3-4. Apply scientific principles of energy and motion to test and refine a device that converts motion energy to electrical energy or uses stored energy to cause motion or produce light or sound. *

Clarification Statement:

- Sources of stored energy can include water in a bucket or a weight suspended at a height, and a battery.

Spiral Standard: 4.3-5-ETS1-3. Plan and carry out tests of one or more elements of a model or prototype in which variables are controlled and failure points are considered to identify which elements need to be improved. Apply the results of tests to redesign a model or prototype.*

Spiral Standard: 5-PS3-1. Use a model to describe that the food animals digest (a) contains energy that was once energy from the sun, and (b) provides energy and materials for body repair, growth, motion, body warmth, and reproduction.

Clarification Statement:

- Examples of models could include diagrams and flowcharts.

State Assessment Boundary:

- Details of photosynthesis or respiration are not expected in state assessment.

Spiral Standard: HS-PS3-3. Design and evaluate a device that works within given constraints to convert one form of energy into another form of energy.*

Clarification Statements:

- Emphasis is both on qualitative and quantitative evaluations of devices.
- Examples of devices could include Rube Goldberg devices, wind turbines, solar ovens, and generators.
- Examples of constraints could include use of renewable energy forms and efficiency.

State Assessment Boundary:

- Quantitative evaluations will be limited to total output for a given input in state assessment.

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

NGSS Alignment Table

Science/Engineering Practice (SP)	Disciplinary Core Idea (DCI)	Cross Cutting Concepts (CCC)
Asking Questions and Defining Problems	**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	**Energy and Matter** -Energy can be transferred in various ways and between objects. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4) **Influence of Engineering, Technology, and Science on Society and the Natural World** -Engineers improve existing technologies or develop new ones. (4-PS3-4)

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	electrical energy. (4-PS3-2),(4-PS3-4) **PS3.C: Relationship Between Energy and Forces** -When objects collide, the contact forces transfer energy so as to change the object's' motions. (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)	

Lesson Targets

I can explain the transfer of energy that occurs when objects collide.
I can recognize the difference between potential and kinetic energy by observing a collision of two marbles.

Assessment

After the investigation, have students answer each question in a few sentences in their science journals. The questions are:

- What happens to energy when there is a collision?
- Where does the energy go when two things collide?
- In the marble competition, which marble rolled the farthest? Why do you think it rolled the farthest?

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Targeted Academic Vocabulary

- Tier 3: collision, potential, kinetic

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per student	Science journals	Classroom Teacher
1 per group (should have at least 5)	**1 meter wooden ramp**	**Bin**
2 per group	**Marbles (make sure they are two different color)**	**Bin**
A bunch for each group	Books, blocks, objects to raise one end of a ramp	Classroom Teacher
1 per group	Measuring tape or yardstick	Classroom Teacher
1 per group	**Stopwatch or timer**	**Bin**
1	Marble Lab video (https://www.youtube.com/watch?v=z4e5hOMvmWQ)	CMC Website
1 per group	iPads (optional)	Classroom Teacher
1	Laptop (optional)	Classroom Teacher
1	Projector (optional)	Classroom Teacher

****Items in bold should be returned for use next year****

Teach To Learn
A collaboration between MCLA, Williams College, and North Adams Public Schools
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LESSON DETAILS

Lesson Opening/ Activator

Marble Investigation Discussion: Ask students to recall the marble investigation from the previous lesson. The science fellow may ask them the following questions: What was the investigation about? How did we conduct it?? What did we observe? Why did what we observe happened? What did we learn about energy? Make sure students stay focused and share their scientific discoveries. The aim is for students to grasp and articulate, in their own words, that *the higher the marble starts, the faster its speed*.

During the Lesson

1. **Marble Demonstrations:**
   a. The science fellow should grab 3-5 marbles (of the same size) from the bin and use these marbles to demonstrate simple collisions (two marbles being rolled into one another on a flat surface). Have the students gather around a table, so they may see the experiment clearly. Ask the students to carefully watch the marble collision. After the science fellow has demonstrated a few collisions, ask students to share observations.

   b. Now, the science fellow will demonstrate another type of collision (rolling one marble down a ramp with another marble sitting at the base of the ramp). Before the science fellow demonstrates this collision, have the students make a hypothesis of what will happen when the marble rolls down the ramp and collides with the stationary marble at the base of the ramp. Some questions you can ask are: Will both marbles stop moving? Will both marbles continue to move? Will one marble keep moving while the other marble stops?

   c. Make sure to revisit the vocabulary terms, kinetic and potential energy, and ask the students to think about when the marbles have potential and kinetic energy. It may even be helpful for the students to draw a picture of this in their science journals. The picture could be as simple as using a circle to represent a marble that has potential energy and using a circle with an arrow to represent a marble that has kinetic energy.

d. Now, the science fellow should set up a ramp to demonstrate what happens when marbles collide. Put one of the marbles at the base of a ramp (stationary) and roll another marble down the ramp, allowing the two marbles to collide. The science fellow should hold the ramp at different heights, so the students can see how the speed of the marble impacts the collision; let the students see what happens and ask them if their predictions are correct. You can show this type of collision a few times.

2. **Playing with Marbles**
   a. Divide students into small groups and help them find a clear space in the room where they can set up the investigation. Tell the students to think of this space as the "lab area" where they will conduct an investigation and collect data. Each group will need ramps, marbles, measuring tape/meter stick, books and blocks to rest their ramp on, and a stopwatch or timer. The adults can distribute these materials after the transition or groups can come get materials from a central location. Students should take their science journals with them. Give the students time to play with the marbles and ramps and test out collisions (as demonstrated by the science fellow).

   b. After everyone has had a chance to play with the marbles, have the students test out different collisions and record their observations in their science journals. Some information they could record are number of marbles, the distance stationary marble traveled after collision, what happened to the moving marble after the collision, the height at which the first marble started, and observations about the collisions (sounds, sights).

3. **The Great Marble Competition**

   (Science talk: Small group discussion)
   a. Tell the class that there will be a class competition. Students should remain in their groups and have their original materials. The science fellows and teachers can decide if the students can use additional materials for this competition. If students are allowed additional materials, the teacher should explicitly list other acceptable materials for the competition. Some of these additional materials may include masking tape, rulers, etc. Tell the students they

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will use their new knowledge to see which group can get a marble (after a collision) to travel the farthest. The only requirements are: 1. a collision must take place and 2. the marble must travel down a 1-meter ramp.

b. Allow the students to plan their strategy for a few minutes. Based on the observations in their science journals, each group should devise a strategy to get the marble to travel the longest distance. They should write or draw this plan down in their science journals. Adults should check the plans before students proceed.

c. Once the groups have checked in with an adult, they can build their structure (allow the students to gather additional materials if the science fellows and teachers have decided this is appropriate). Then, let the students implement their strategy; each group will set up their materials as outlined in their plans and then try it out.

d. After testing their strategy, each group can revise their strategy. This revised strategy will be the basis for the competition. Allow 5- 10 minutes for revisions. Encourage students to record revisions in their science journals and explain how scientists continually revise their experiments after each trial. **[SP3 - Planning and Carrying Out Investigations]**

e. Once all the groups have made their revisions, tell them that it is time for the competition. Each group will present their plan and explain their reasoning behind it before doing two trials of the collision. They will use a measuring tape to record the distances. Each group can use the longer of their two measured distances. Be sure to record the distances on the board (or somewhere for the whole class to see). After each group has gone, a winner will be declared.

(Science talk: Class discussion)

4. To end the competition, students should discuss as a class the different strategies they used in the competition, and why some were more successful than others. Try to guide the conversation, so students talk about factors such as height of

the ramp, speed of the marble, distance the marble traveled before the collision etc. **[SP8 - Obtaining, Evaluating, and Communicating Information]**

Lesson Closing

Marble Video: Show the first half of the marble lab video to demonstrate what would happen if two marbles of different sizes were to collide. Next, show the second half of the same video to demonstrate what would happen if two marbles that were both moving collided into each other (instead of one being stationary).

Assessment

After the investigation, have students answer each question in a few sentences in their science journals. The questions are:

- What happens to energy when there is a collision?
- Where does the energy go when two things collide?
- In the marble competition, which marble rolled the farthest? Why do you think it rolled the farthest?

*** Extension (if students do poorly on the assessment):

If students have difficulty answering the questions in their science journals, the teacher should split the class into groups of 4. In their groups, the students should share the answers they wrote in their science journals with each other. The teacher should also ask more guiding questions to the students, so they can rethink the answers to the questions. Some possible questions to ask are: Since we know energy is neither created or destroyed, where does the energy go when two objects collide? How does the collision affect the direction that the marbles roll? Remember potential energy becomes kinetic energy. But, how does potential energy become kinetic energy? How does the mass of an object affect the object's speed? Does an object's speed affect how far an object travels? After the students share in their groups, the teacher should lead a class discussion, so each group can share their answers. The teacher can then guide and correct students if their answers are incorrect.

Lesson 4: How Can We Change Energy from One Form to Another?

LESSON BACKGROUND

In the first half of this unit, the students learned mostly about potential and kinetic energy. However, there are many different types of potential and kinetic energy in the world. In this lesson, the students will learn about these different types of energy and their energy sources. This lesson will build upon students' knowledge on potential and kinetic energy through an investigation. In the energy conversion investigation, students will observe how energy can change forms. Similar to how the students observed the marble's potential energy turning into kinetic energy in the previous lessons, students will observe in the investigation how kinetic energy can create mechanical energy to make a fan spin.

Science Content Background Knowledge (for the instructors)

Energy is found in many forms in the world such as in heat, sound, electricity, etc. Furthermore, energy can change (transform) into many types of other energy. In fact, there are many pathways for energy to take. For instance, when a marble is rolled down a ramp and hits a bell, its potential energy is changed into kinetic energy which results in sound energy. In America, most of the resulting energy such as light or heat energy is from electric energy. In addition, most of the technology such as light bulbs or fans is powered by electricity. Even though energy is never created or destroyed, energy is lost whenever it transforms or transfers. While we don't cover the loss of energy in this unit, it is prime place for an underlying student misconception and teachers should be aware. A classic example of energy loss is turning on a light bulb. When a light bulb is on, the electric energy is transformed into two types of energy; radiant and heat energy. The heat or heat energy from the light bulb is the "lost" energy. Thus, the electric energy is not completely transformed into radiant energy. Unfortunately, due to time constraints, students will not learn about the loss of energy in this lesson.

Overview of Lesson

The goal of this lesson is for students to become familiar with different types of energy (potential, kinetic, light, heat, electric, and sound), to be able to describe these types of energy, and to understand how energy may be changed from one form to another, but never "lost." Before conducting this investigation, the science fellow and classroom teacher should watch the video demonstration on how to setup the solar panel station.

Focus and Spiral Standard(s)

Focus Standard: 4-PS3-2. Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents.
Clarification Statement:

- Evidence of energy being transferred can include vibrations felt a small distance from a source, a solar-powered toy that moves when placed in direct light, warming a metal object on one end and observing the other end getting warm, and a wire carrying electric energy from a battery to light a bulb.

State Assessment Boundary:

- Quantitative measurements of energy are not expected in state assessment.

Spiral Standard: K-PS3-1. Make observations to determine that sunlight warms materials on Earth's surface.
Clarification Statements:

- Examples of materials on Earth's surface could include sand, soil, rocks, and water.
- Measures of temperature should be limited to relative measures such as warmer/cooler.

Spiral Standard: 1-PS4-1. Demonstrate that vibrating materials can make sound and that sound can make materials vibrate.
Clarification Statements:

- Examples of vibrating materials that make sound could include tuning forks, a stretched string or rubber band, and a drum head.

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- Examples of how sound can make materials vibrate could include holding a piece of paper near a speaker making sound and holding an object near a tuning fork.

Spiral Standard: 1-PS4-3. Conduct an investigation to determine the effect of placing materials that allow light to pass through them, allow only some light through them, block all the light, or redirect when put in the path of a beam of light.
Clarification Statements:

- Effects can include some or all light passing through, creation of a shadow, and redirecting light.
- Qualitative measures are not expected.

Spiral Standard: 4-ESS3-1. Obtain information to describe that energy and fuels humans use are derived from natural resources and that some energy and fuel sources are renewable and some are not.
Clarification Statements:

- Examples of renewable energy resources could include wind energy, water behind dams, tides, and sunlight.
- Non-renewable energy resources are fossil fuels and nuclear materials.

Spiral Standard: 5-LS1-1. Ask testable questions about the process by which plants use air, water, and energy from sunlight to produce sugars and plant materials needed for growth and reproduction.
State Assessment Boundary:

- The chemical formula or molecular details about the process of photosynthesis are not expected in state assessment.

Spiral Standard: 6.MS-PS1-6. Plan and conduct an experiment involving exothermic and endothermic chemical reactions to measure and describe the release of thermal energy.
Clarification Statements:

- Emphasis is on describing transfer of energy to and from the environment.
- Examples of chemical reactions could include dissolving ammonium chloride or calcium chloride.

Spiral Standard: 7.MS-PS3-6. Use a model to explain how thermal energy is transferred out of hotter regions or objects and into colder ones by convection, conduction, and radiation.

Spiral Standard: 7.MS-ESS2-4. Develop a model to explain how the energy of the Sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in Earth's hydrosphere.

Clarification Statement:

- Examples of models can be conceptual or physical.

State Assessment Boundary:

- A quantitative understanding of the latent heats of vaporization and fusion is not expected in state assessment.

NGSS Alignment Table

Science/Engineering Practice (SP)	Disciplinary Core Idea (DCI)	Cross Cutting Concepts (CCC)
Planning and Carrying Out Investigations Obtaining, Evaluating, and Communicating Information	**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) **PS3.B: Conservation of Energy and Energy Transfer** -Energy is present wherever 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)	**Energy and Matter** -Energy can be transferred in various ways and between objects (4-PS3-2) **Cause and Effect** Cause and effect relationships are routinely identified and used to explain change. (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 ins important in engineering. (4-ESS3-1)

	-Light also transfers energy from place to place. (4-PS3-2) -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) **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)	**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)

Learning Targets

I can name and give examples of the six types of energy (potential, kinetic, light, heat, electric, and sound).
I can describe how energy changes from one form to another.

Assessment

In their science journals, ask students to record their observations and answers to the following questions:

- What happens when energy is changed from one form to another?

- Can energy be lost?
- Can you list different types of energy?

Targeted Academic Vocabulary

- Tier 2: potential, kinetic
- Tier 3: collide, convection, radiation, conduction

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per student	Science journals	Classroom Teacher
1 per group	iPads (optional)	Classroom Teacher
1 per group	Measuring tape or yardstick	Classroom Teacher
1 per group: 5 total	**Black plastic tube**	**Bin**
1	**Colored slides**	**Bin**
1	**Bouncy ball**	**Bin**
4-6 per group	**Marbles**	**Bin**
2	**Battery holder**	**Bin**
4	**AA batteries**	**Bin**
1	**Multimeter**	**Bin**
4	**Wires with alligator clips**	**Bin**
1	**Motor with fan attached**	**Bin**
1	**Light bulb**	**Bin**
2	**Solar cell**	**Bin**
1-2 pgs. per student	Paper	Classroom Teacher
Enough for all	Coloring Utensils (markers, crayons, pencils)	Classroom Teacher
1	Laptop	Classroom Teacher

1	Projector	Classroom Teacher
1	Electronic version of this lesson	Classroom Teacher
2	**Friction Blocks**	**Bin**
1	**Bell**	**Bin**
1 roll	Tape (clear is preferable)	Classroom Teacher
1 per student	"Solar Absorbers and the Future of Electricity" Reading	Binder
1 per student	"Houston Affects the Earth" Reading	Binder
1 per student	Paired Text Questions	Binder
1	Multimeter Tutorial video (https://www.youtube.com/watch?v=2-px8YQR1_I)	CMC website

****Items in bold should be returned for use next year****

Setup

You will need to set up five stations in advance of this lesson. Screen the multimeter tutorial video to show the kids how to properly set up the solar cells and multimeter.

Stations should be setup as:

1. Marble collides with bell at bottom of ramp (potential -> kinetic -> sound). Materials: 1-meter wood ramp, set of marbles, bell, tape.
2. Simple circuit with two batteries and a light (electrical -> light). Materials: Battery pack, batteries, wires, light bulb
3. Simple circuit with two batteries and a fan (electrical -> kinetic). Materials: Battery pack, batteries, wires, fan (mounted)
4. The multimeter is just to show that electricity is being produced. The specific units and details of how it works are not important.

5. Friction blocks [wood blocks with different materials glued to them] (kinetic -> heat). Materials: small wood blocks with velcro, wool, and plastic attached to them. Students can also use their hands.

Diagrams for the stations are on the next page.

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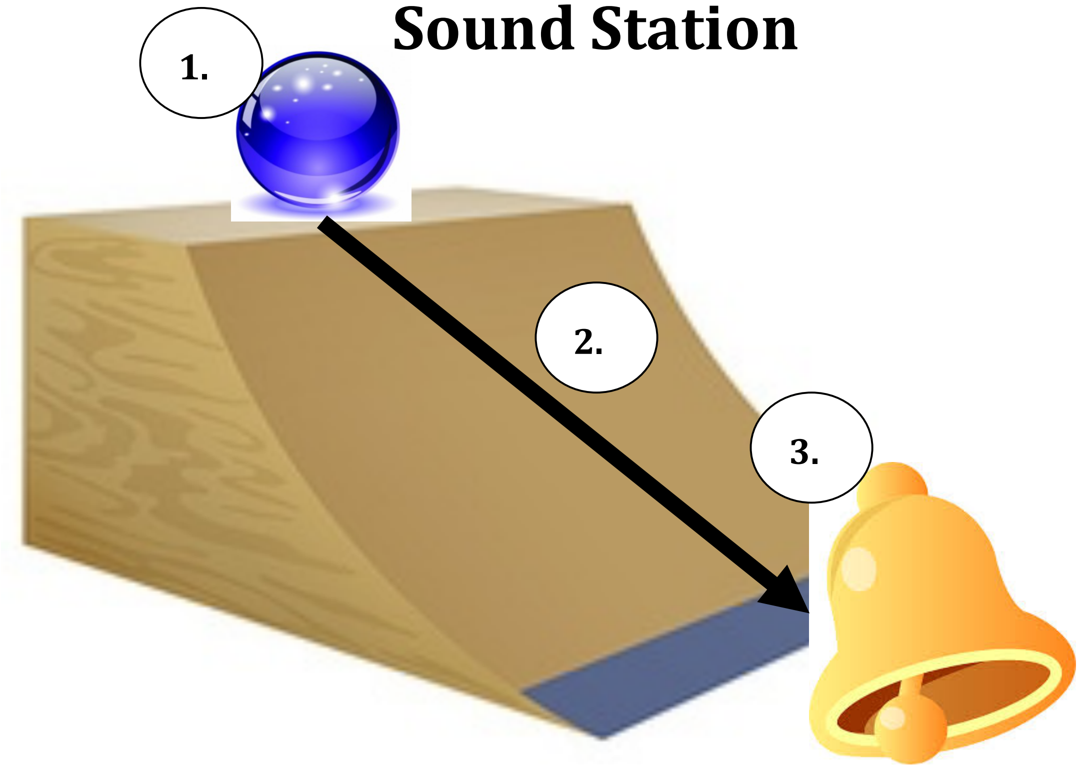
Sound Station



1. The marble has potential energy.
2. This potential energy becomes kinetic energy when the student pushes the marble down the ramp.
3. When the marble goes down the ramp, it hits the bell, creating sound energy.

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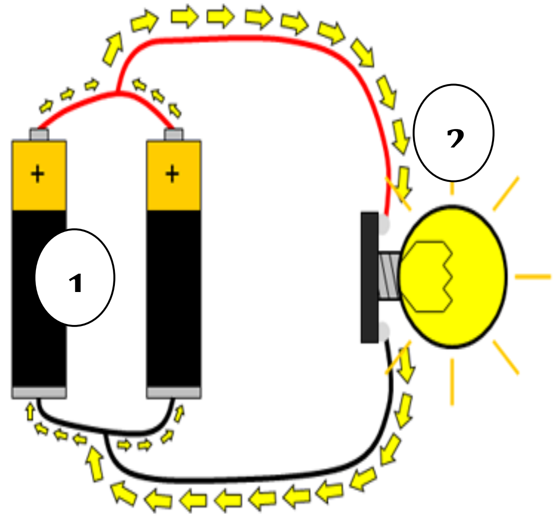
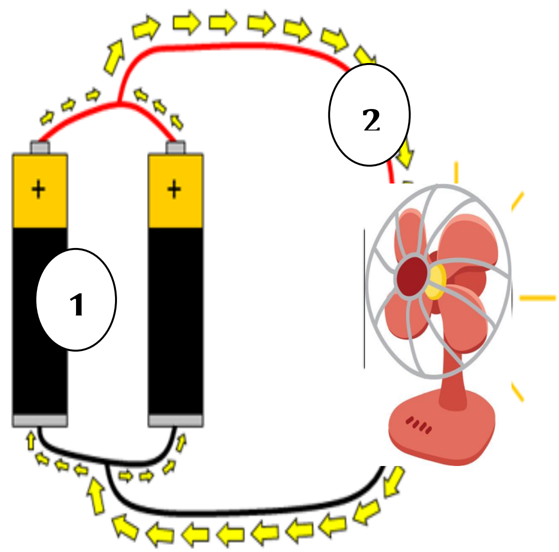
Light Station



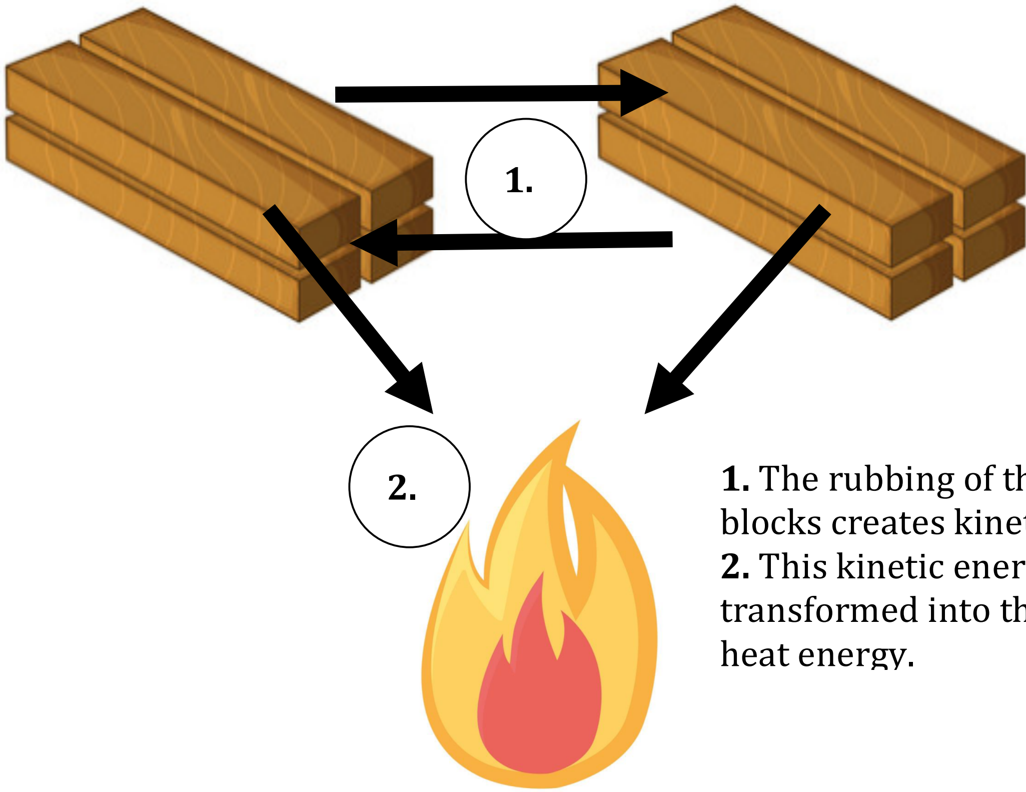
1. The chemical energy from the batteries become electrical energy.
2. The electrical energy then transforms into radiant energy, lighting up the lightbulb.

Kinetic Station



1. The chemical energy from the batteries become electrical energy.
2. The electrical energy then makes the fan rotate, transforming the electrical energy into wind energy.

Heat Station



1. The rubbing of the friction blocks creates kinetic energy.
2. This kinetic energy is then transformed into thermal or heat energy.

LESSON DETAILS

Lesson Opening/ Activator

(Science talk: Think-Pair-Share): Marble Collision Discussion

Ask students to pair up and share with their partner one new idea they learned or an observation they made during the marble collision lesson. Some questions you can prompt the students to think about are: What happened when the marbles collided? Was there energy in these collisions? How could you tell? Then, ask a few students to share with the class what they discussed with their partner.

During the Lesson

1. **Energy Powerpoint:** The classroom teacher needs to set up a laptop/projector so the colored slides located in the bin can be projected on a screen at the front of the classroom (you can find these slides in the electronic version of this lesson). Show each of the six slides and briefly discuss each type of energy. Make sure the students can give examples of each type of energy and understand the difference between each type of energy. The teacher should also elaborate on the importance of the Sun as the primary energy source for the Earth. The Sun provides light energy which allows plants to grow and humans to see. In addition, the Sun gives off heat energy, so living organisms do not freeze to death. Besides this, innovations such as solar panels allow the Sun's solar energy to change into electric energy to supply humans' electricity needs. The science fellow may associate each type of energy with a particular movement of their choice so that students can play with it and remember the association.

2. Break students into five groups; assign each group one type of energy to focus on (Light, Heat, Electric, Potential, Kinetic, and Sound).

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

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(Science talk: Small group discussion)

3. **Presenting Energy:** Now that each group has been assigned a type of energy, they must work together to come up with a way to present their type of energy to the rest of the class. They can use one of the three methods listed below to present their type of energy to the class. Give the students 10-15 minutes to prepare their presentation. Also, ask the students to present the movement associated with the energy type they were assigned. The science fellow can also let the students use the internet to find out more about the type of energy they were assigned.
   [SP2 – Developing and Using Models]

   Option 1: Drawing. Use large paper and coloring utensils to create a drawing that represents their assigned energy type.
   Option 2: Skit. Using all members of the group, act out a short skit that represents their assigned energy type.
   Option 3: Poem/Song. Create a poem or song that represents their assigned energy type.

4. Have each group share their assigned energy type with the whole class. Once all the groups have presented, have the students return to their seats.

****If time is restricted, this lesson can be divided into two parts** Note: If the lesson is to be divided into two parts the science fellow(s) and teacher should discuss if the lesson will continue with just the classroom teacher or wait until the science fellow(s) return the following week.**

5. **Mass Demonstration:** Now the science fellows will do a demonstration for the students. **Have the students make predictions *before* the demonstration.** Demonstration: Drop a metal marble and a bouncy ball (of the same size) from the same height, asking students for predictions about what will happen to each one when they hit the floor. *You will need to ask students to listen carefully during this demonstration as the metal ball should make a much larger noise and bounce only slightly, while the bouncy ball will make much less noise and will bounce much higher.*

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

(Science talk: Class discussion)

6. Discussion: Connect the ideas from previous lessons (especially the idea of kinetic energy and what happens to energy in collisions) to have students discuss (as a whole class, in small groups, or in pairs) these questions: *When do the balls have potential energy? What happens to the potential energy of the balls when we drop them? What happens to the kinetic energy of the balls when they hit the floor? Common student responses to the third question will likely include: it disappeared, it was lost, it went "into" the floor, or it changed. In all cases, ask students to provide evidence to support their idea.* **[SP6 – Constructing Explanations]**

7. **Energy Conversion Stations**

> **Teaching Tip**
> Remind students that energy is neither created or destroyed. It is just transferred or transformed. Have students recall previous marble lessons. Specifically, how the marble's potential energy became kinetic energy when it rolled down the ramp.

a. Ask the students to get back into their groups from earlier (you should have 5 groups). Assign each group a station. Make sure the stations are set up in advance (see "Setup" above).

b. Allow each group to stay at each station for 5-7 minutes and have the students bring their science journals to each station. At each station, make sure the students have recorded the different types of energy they observed, and how one has changed into another form of energy. [*The objective during these stations is to help students explore how different forms of energy can be converted, but to also familiarize them with physical examples of the different types of energy.]*

Classroom Extension: The classroom teacher should complete the following activity if there is enough time remaining during the lesson. The ideas of convection, conduction and radiation will be assessed on the 2016 end of year science assessment. Complete the online learning activity either as a whole class or individually: https://www.wisc-online.com/learn/abe-ell/science/sce304/heat-transfer-conduction-convection-radiation

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Assessment

In their science journals, ask students to record their observations and answers to the following questions:

- What happens when energy is changed from one form to another?
- Can energy be lost?
- Can you list different types of energy?

***Extension (if students do poorly on the assessment):

If students have difficulty answering the assessment questions in their science journals, the teacher should draw diagrams of the stations from the Energy Conversion Stations activity on the whiteboard. Then, as a class, the teacher should label the types of energy in each station. Possible questions the teacher can ask to guide students' thinking are: What type of energy is common to all objects? (Answer: potential energy.) What energy is associated with the motion of an object? (Answer: kinetic energy.) What type of energy sounds similar to electricity? (Answer: electric energy.) When humans move, what type of energy do they use? (Answer: kinetic energy.) After labeling each diagram, the students should refer back to the diagrams to revise and correct their answers to the questions.

Extension (optional)

Have students read two paired passages and answer questions. Students will read the "Solar Absorbers and the Future of Electricity" and "Houston Affects the Earth" (from the binder) and complete the Paired Text Questions worksheet.

Light

Light energy is a special type of wave (called electromagnetic radiation).

Sources of light energy

The Sun

Light Bulb

Heat

Heat energy comes from the motion of molecules; more motion means more heat. The transfer of thermal energy from one object to another is known as heat. In conduction, heat spreads through a substance when faster atoms and molecules collide with neighboring slower ones, transferring some of their kinetic energy to them.

Sources of heat energy

Oven

Fire

Electricity

Electric energy comes from the movement of charged particles called electrons.

Sources of electric energy

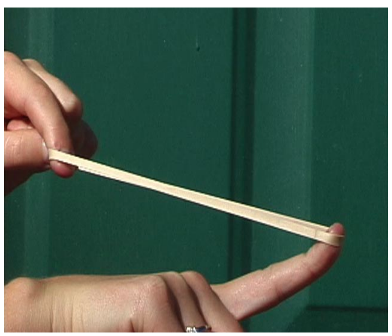
Batteries

Power Plants

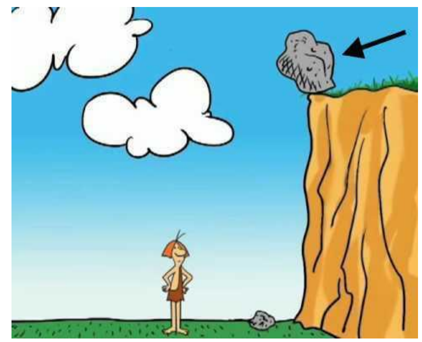
Potential

Potential energy is stored energy due to the position of an object.

Sources of potential energy



A stretched rubber band



A rock held high off the ground

Kinetic (Motion)

Kinetic energy comes from the motion of objects or materials.
Kinetic energy will increase when an object is either (a) moving faster or (b) larger.

Sources of kinetic energy

Bicycle

Waterfall

Sound

Sound energy comes from the vibration of air molecules.

Sources of sound energy

Bell

Speaker

Lesson 5: The Energy Dilemma

LESSON BACKGROUND:

This lesson will expand upon students' knowledge of energy sources because students will learn how energy sources can either be renewable or nonrenewable. Students will then learn how their energy use can impact the Earth. Specifically, students will learn about the harmful effects caused by nonrenewable energy. In this way, this lesson makes the unit relevant for students because currently, the majority of the world's energy relies on fossil fuels which harm the Earth. At the end of this lesson, students will build a solar water fountain, allowing them to utilize their knowledge of energy conversions to create technology powered by renewable energy. This solar water fountain activity will help students think about possible ways to incorporate renewable energy into their lives.

Science Content Background Knowledge (for instructors)

Unfortunately, there is not an endless amount of energy resources on Earth. One way of categorizing the energy that we use is: nonrenewable versus renewable energy resources. Nonrenewable energy sources are unsustainable, such as fossil fuels and oil. In other words, once we use all the nonrenewable resources, there will be none left. In contrast, renewable energy resources are sustainable; there is an effectively limitless supply. There are six general types of renewable energy: biomass, hydroelectric, wind, hydrogen, solar, and geothermal. Biomass comes from living organisms such as wood and charcoal from trees or corn ethanol from corn. Hydroelectric energy is electricity powered by the movement of tides and waves. Wind energy comes from wind turning wind turbines. Hydrogen energy is energy from fuel cells which are powered by hydrogen and oxygen molecules. Solar energy is energy taken from the Sun either actively through solar panels or passively through the windows of a house (or similar). Finally, geothermal energy is energy powered from the warm interior of the Earth. In America, nonrenewable resources create the majority of the energy used by people. The constant use of nonrenewable resources have negative effects on the Earth such as contributing to the greenhouse gases in the atmosphere, climate change, and oil spills. For this reason, scientists are trying to find ways to make renewable energy resources accessible for everyone.

Teach To Learn
A collaboration between MCLA, Williams College, and North Adams Public Schools
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Overview of the Lesson

In this lesson, students will explore renewable and nonrenewable energy resources through a variety of activities. Students will also learn about the lasting effects of nonrenewable energy and ways for humans to reduce pollution and waste.

Focus and Spiral Standard(s)

Focus Standard: 4-PS3-4. Apply scientific principles of energy and motion to test and refine a device that converts motion energy to electrical energy or uses stored energy to cause motion or produce light or sound.*

Clarification Statement:

- Sources of stored energy can include water in a bucket or a weight suspended at a height, and a battery.

Spiral Standard: 4.3-5-ETS1-3. Plan and carry out tests of one or more elements of a model or prototype in which variables are controlled and failure points are considered to identify which elements need to be improved. Apply the results of tests to redesign a model or prototype.*

Spiral Standard: 5-PS3-1. Use a model to describe that the food animals digest (a) contains energy that was once energy from the sun, and (b) provides energy and materials for body repair, growth, motion, body warmth, and reproduction.

Clarification Statement:

- Examples of models could include diagrams and flowcharts.

State Assessment Boundary:

- Details of photosynthesis or respiration are not expected in state assessment.

Spiral Standard: HS-PS3-3. Design and evaluate a device that works within given constraints to convert one form of energy into another form of energy.*

Clarification Statements:

- Emphasis is both on qualitative and quantitative evaluations of devices.
- Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators.
- Examples of constraints could include use of renewable energy forms and efficiency.

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State Assessment Boundary:

- Quantitative evaluations will be limited to total output for a given input in state assessment.

Focus Standard: 4-ESS3-1. Obtain information to describe that energy and fuels humans use are derived from natural resources and that some energy and fuel sources are renewable and some are not.

Clarification Statements:

- Examples of renewable energy resources could include wind energy, water behind dams, tides, and sunlight.
- Nonrenewable energy resources are fossil fuels and nuclear materials.

Spiral Standard: K-ESS3-3. Communicate solutions to reduce the amount of natural resources an individual uses.*

Clarification Statement:

- Examples of solutions could include reusing paper to reduce the number of trees cut down and recycling cans and bottles to reduce the amount of plastic or metal used.

Spiral Standard: 4-PS3-2. Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents.

State Assessment Boundary:

- Quantitative measurements of energy are not expected in state assessment.

Spiral Standard: 7.MS-ESS3-4. Construct an argument supported by evidence that human activities and technologies can be engineered to mitigate the negative impact of increases in human population and per-capita consumption of natural resources on the environment.

Clarification Statements:

- Arguments should be based on examining historical data such as population graphs, natural resource distribution maps, and water quality studies over time.
- Examples of negative impacts can include changes to the amount and quality of natural resources such as water, mineral, and energy supplies.

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Spiral Standard: 8.MS-ESS3-5. Examine and interpret data to describe the role that human activities have played in causing the rise in global temperatures over the past century.

Clarification Statements:

- Examples of human activities include fossil fuel combustion, deforestation, and agricultural activity.
- Examples of evidence can include tables, graphs, and maps of global and regional temperatures; atmospheric levels of gases such as carbon dioxide and methane; and the rates of human activities.

NGSS Alignment Table

Science/Engineering Practice (SP)	Disciplinary Core Idea (DCI)	Cross Cutting Concept (CCC)
Constructing Explanations and Designing Solutions Obtaining, Evaluating, and Communicating Information	**PS3.B Conservation of Energy and Energy Transfer:** -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) **ESS3.A: Natural Resources:** -Energy and fuels that humans use are	**Energy and Matter** -Energy can be transferred in various ways and between objects. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4) **Cause and Effect** -Cause and effect relationships are routinely identified and used to explain change. (4-ESS3-1) **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**

	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)	**and the Natural World** -Over time, people's needs and wants change, as do their demands for new and improved technologies. (4-ESS3-1) -Engineers improve existing technologies or develop new ones. (4-PS3-4) **Science is a Human Endeavor** -Most scientists and engineers work in teams. (4-PS3-4) -Science affects everyday life. (4-PS3-4)

Learning Targets

I can define nonrenewable and renewable energy.

I can name examples of nonrenewable and renewable energy resources.

I can explain the harmful effects caused by nonrenewable energy resources.

I can build a model powered by a renewable energy resource.

Assessment

Students will be assessed based on their science journal responses during the oil spill and pollution activities as well as their solar fountain models.

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

Targeted Academic Language

Tier 1:

Tier 2:

Tier 3: renewable, nonrenewable, sustainable, pollution, carbon dioxide, oil spill

RESOURCES AND MATERIALS

Quantity	Item	Source
4 (for teacher use only)	Index Cards	Bin
5 (1 per group)	**Plastic Tub**	**Bin**
2 bags	**Rocks**	**Bin**
Enough for each group	Leaves/Sticks	Classroom Teacher
1 bag	Fake Feathers	Bin
2 units	Fake Fur	Bin
1 bottle	**Dark Olive Oil**	**Bin**
1 spool	**String**	**Bin**
1 pack	**Sponges**	**Bin**
1 pack	**Cotton Balls**	**Bin**
1 box	**Spoons**	**Bin**
1 bottle	**Dish Detergent**	**Bin**
1 packet	**Plastic Cups**	**Bin**
1 per student	Paper Towels	Classroom Teacher
1 per group	**Solar Water Pump**	**Bin**
1 per group	**Solar Panel**	**Bin**
1 per group	**Plastic Tubing**	**Bin**
1 per group	**Plasticine**	**Bin**
1 per group	**Plastic Tub**	**Bin**
1 per group	**Ruler**	**Bin**

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1 per group (if there is no sunlight)	**Lamp and Light Bulb**	**Bin**

****Items in bold should be returned to the bin for use next year****

Lesson Details

Lesson Opener/Activator

Energy Concept Map: To begin this lesson, return to the energy concept map that the class created in the first lesson. Ask the students to add to the concept map based on what they learned about energy and types of energy. (Note: Students should be familiar with sound, mechanical, light, thermal, chemical, kinetic, and potential energy as well as the idea that the Sun is the largest energy source of all). If students have difficulty remembering the types of energy, guide them with examples from previous lessons. Refer back to the investigations students did with the marbles and ramps. What type of energy did the marbles have when they were on top of the ramps? What type of energy did the marbles have when they were rolling down the ramps? In the previous lesson, students learned hand movements to go along with each energy type. Ask students to recall these hand movements. The teacher could also ask students to name examples of where they can find energy in the world. Afterwards, to introduce students to renewable and nonrenewable energy, ask students if anyone is familiar with these words. Remind students that it is acceptable if they do not know the terms as they will be learning more about renewable and nonrenewable energy during the lesson. To guide students' thinking though, the teacher should tell the students that the types of energy they listed on the concept map (thermal, radiant, etc.) are either renewable or nonrenewable energy.

During the Lesson

1. Video Activity: Students will watch two short videos on different types of energy sources. As they watch the videos, they will fill out the fill in the blank worksheets provided in the binder. Pause frequently to ensure students understand all of the

material. When the videos are done, it may be helpful to quickly review the information to ensure that all students have the same answers for the questions on the worksheets.
https://www.youtube.com/watch?v=1sI_ot8qoXE (stop at 4:08)

- The renewable energy video talks about wind energy, hydro energy, geothermal energy, solar energy, and biomass.

https://www.youtube.com/watch?v=thdKsEA-llo (stop at 2:02)

This video:

- Explains the formation of fossils (specifically, how it takes millions of years to create fossil fuels)
- States how humans use fossils fuels for energy even though there is a limited supply
- Mentions how electricity and transportation such as cars are powered by fossil fuels

2. Revisit the Concept Map: After reviewing the information from the videos, redirect the students back to the energy concept map used at the beginning of the lesson. Ask students if there is any new information they would like to add (answers should include the definitions of renewable and nonrenewable energy). After adding new information to the map, tell students that the class will label the energy sources as either renewable or nonrenewable energy resources. Based on the students' answers, the teacher will label the types of energy by circling all renewable energy resources in one color such as green and circling all nonrenewable energy resources in a different color such as red.

3. **(Science Talk: Class Discussion): Air Pollution Activity**
(Note: The classroom teacher should prep this activity three days beforehand)
This activity was adapted from: https://www.education.com/science-fair/article/air-quality/

A. To prepare this activity, the teacher will need four index cards, string, a pen, petroleum jelly, cotton swabs, a resealable plastic bag, tape, scissors, and magnifying glasses. (There should be enough magnifying glasses for each student.) The teacher should prepare this activity three days in advance of the lesson. First, the teacher should cut out four 8-inch pieces of string and tape each piece of string to an index card. Next, the teacher should label each card as either house, yard, classroom, or control. Then, the teacher should spread petroleum jelly on each index card. After, the teacher should place the index cards according to their locations. The "house" card should be placed in the teacher's house. The "yard" card should be hung either in the school's playground, if possible, or in the teacher's yard. The "classroom card" should be hung in the classroom. The "control" card should be placed in the resealable plastic bag. On the day of the lesson, the teacher should bring all the index cards to the classroom.

B. This activity will begin with a class discussion. Ask students why nonrenewable energy harms the Earth. During the discussion, students should write down their ideas of why nonrenewable energy resources are harmful in their science journals. Other possible questions to ask students are: Why are nonrenewable energy resources harmful for humans? What do cars release? What do you think happens to the gases released from cars? Do these gases disappear? What type of energy source do cars use?

C. Explain to students that energy such as mechanical energy in cars and electricity release pollution into the air because they utilize fossil fuels. When humans burn fossil fuels, they release carbon dioxide and other gases which pollute the air. Tell students that when energy is released from fossil fuels, it creates waste which is called pollution.

D. Hand out magnifying glasses to each student and show the class the four index (house, yard, classroom, and control). Ask the class to identify similarities and differences between the index cards. Students should write down their observations in their science journals. Then, ask why some index cards are dirtier than the other index cards. Explain that air pollution varies depending on the environment. For instance, the classroom has less air pollution than outside because no one burns fossil fuels in the school. Then, tell students that because of this pollution, humans need to be aware of the consequences caused by their energy use, as it can sometimes harm the environment they live in. End the discussion by asking students if they have any ideas that can help reduce the pollution in the air.

4. **(Think-Pair-Share): Oil Spill Activity:**

This activity was adapted from: https://www.calacademy.org/educators/lesson-plans/slippery-shores-oil-spill-clean-up

This unit was developed with National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised as the unit is piloted and feedback received.

A. Ask students to define the term, oil spill, and brainstorm possible oil spill effects on the environment in their science journals. If students struggle to brainstorm oil spill consequences, then the teacher can ask the following questions: Can marine animals breathe in oil? What do you think will happen if you were a bird or seal and oil was caught in your feathers or fur? Is it easy to clean up oil? Have them think, pair, and share with each other.

B. Next, on the whiteboard or on poster paper, the teacher should draw a concept map with the word, oil spills, in the middle. The students should then create a class definition for oil spills which will also be written in the middle of the concept map. Next, each pair of students should share one consequence caused by an oil spill. This will be the spokes coming off the concept map. The teacher should keep the concept map visible during this activity, so students can refer back to it.

C. Tell the students that they will create a model of an oil spill and their job is to remove the oil from the environment.

D. Before beginning the next part of the activity, explain to the students that these materials are tools, not toys. Furthermore, tell the students that they should try to keep their area as clean as possible, otherwise they will have to clean up their own mess. Split the students into groups of four or five and give each group a tub with water, a small cup of dark olive oil, some rocks, some plants (sticks or leaves), and some feathers and fake fur (to represent marine life and animals). Have students build an island out of the rocks, rising out of the water. Then, tell them to place the plants, feathers, and fake fur around the island. Although some plants and animals can be on the island itself, this activity works best if they are in the water surrounding the island. Tell the students to pour the oil into the tub, so it spreads over the island, plants, feathers, and fake fur. Ask the students to discuss within their groups how each material reacts to or is affected by the oil and to take notes in their science journals.

E. The science fellows should then go to each station and hand out cleaning supplies (12" pieces of string, sponges, cotton balls, spoons, dish detergent, and paper towels) and a plastic cup to contain the removed oil. Ask the students to clean all the oil off of their island and the surrounding materials (the rock island, feathers, and fur). Students should place the removed oil into the plastic cups. As they clean, encourage students to take turns with different cleaning materials, so

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they can see how some cleaning tools may work better than others. When students are done cleaning, ask them to answer the following questions in their science journal:
Which tools worked best for cleanup? Why?

What was the hardest material in your habitat to get the oil off of? Why do you think this is?

What happens to animals who have fur and feathers during oil spills?

What does this tell us about real world oil spills? What are some other ways we could clean up oil spills?

What did you do with the removed oil afterwards? How do you think people dispose/get rid of removed oil in the real world?

Is there anything else we can do to minimize the impact of oil spills?

Oil Spill Extension: Ask the students to brainstorm ways they could prevent an oil spill from affecting their island. Have them do the investigation again, but this time, the students should implement one of their prevention methods.

5. Solar Water Fountain:

1. Split the class into groups of 2-3 students.
2. Each group should be given a solar water pump, a solar panel, plastic tubing, plasticine, a plastic tub, water, a ruler, and a protractor. Students should be given a lamp and light bulb if there is no sunlight. The teacher can decide whether or not to give the students additional building materials such as plastic bottles, cups, straws, rocks, etc.
3. The teacher should begin the activity by asking students to name the Earth's primary energy source. When the students say the answer is the Sun, the teacher should ask the students to name the main types of energy the Sun produces. (The answer is thermal and radiant energy.) Then, the teacher should ask students to name the most common method for humans to capture the Sun's energy and convert it into energy. (The answer is solar panels.)
4. The teacher should then explain to students how they will use a solar panel to power a water fountain. Since water fountains are located outside, they are exposed to sunlight on a daily basis, so they can be powered by solar energy.

5. The students will then be given time to explore their materials and build their water fountains.
6. The teacher should guide students if they have trouble by suggesting to students that they should place the solar panel at an angle to catch a large amount of sunlight.
7. To build the solar water fountain, the solar water pump should be placed in the plastic tub of water. The solar panel should be placed beside the plastic tub of water and be attached to the solar water pump. In order to make the water spout at a higher height or change the direction of the water flow, students may attach the plastic tubing to the water pump, using plasticine.
8. The fountains should look somewhat similar to the ones shown in the videos below:
   https://www.youtube.com/watch?v=Eab61Tl4eIk
   https://www.youtube.com/watch?v=3mlfTC4pUBc
9. Once students finish building their solar water fountains, they should test it outside. Students should measure how high their water fountain spouts water with their rulers. Then, they should record these measurements in their science journals. After, in their science journals, students should answer the following questions:
   What are the benefits for having a solar water fountain compared to a regular water fountain?

   What would happen to the fountain on a cloudy day? Would it still work? Why or why not?

   What are some drawbacks for having a solar water fountain compared to a regular water fountain?

Solar Water Fountain Extension: If there is extra time, the teacher may want to challenge each group of students to create a fountain with the highest water flow height. Students will use their rulers to measure the height and the teacher will record it on poster paper.

Lesson Closing:

Energy Song: Hand out copies of the energy song lyrics to each student. The science fellows have two options for this activity; they can either teach the students the entire song or just the chorus.
Song: https://www.teacherspayteachers.com/Product/Energy-1517385

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To access the song lyrics, the teacher will need to have an account for this website (teacherspayteachers.com). It is free to make an account and the song is free, so the teacher should not worry about any costs.

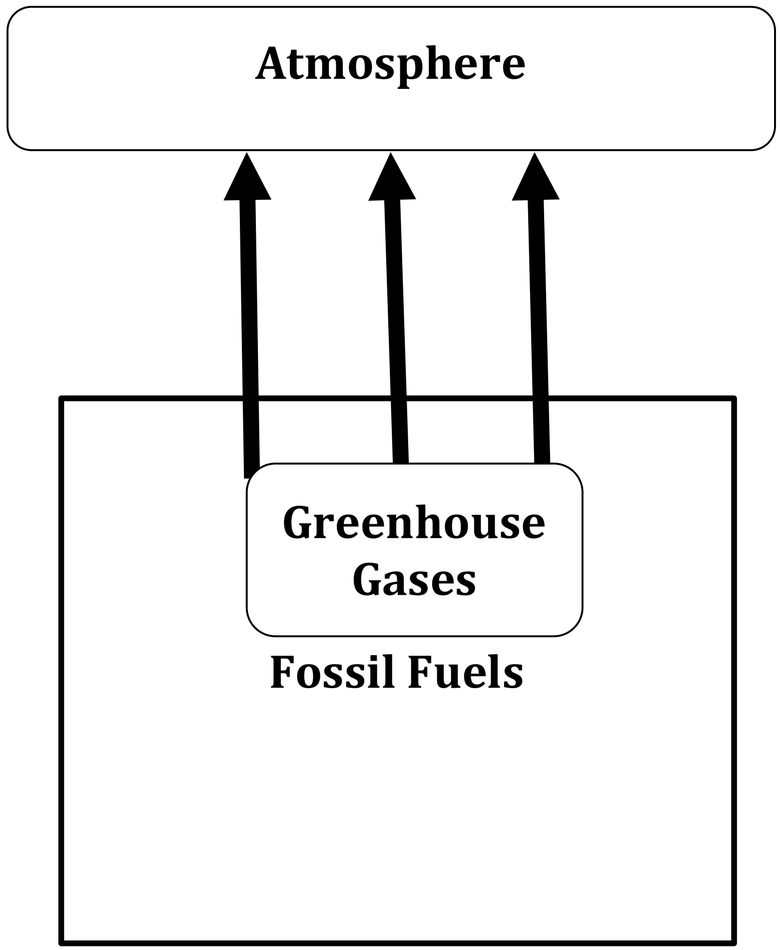
Assessment:

Students will be assessed based on their science journal responses during the oil spill and pollution activities as well as their solar fountain models.

*** Extension (if students do poorly on the assessment):
If students do not understand the connection between fossil fuels and air pollution, then the teacher should draw a simple diagram to depict the release of carbon dioxide into the atmosphere from fossil fuels. The diagram can be as simple as a square to represent a power plant with the word fossil fuels inside the square. To show that burning fossil fuels release gases into the air, the teacher should draw an arrow with the word gases underneath it. An example of a diagram can be found on the next page. Then, the teacher should project air pollution pictures on to the white board to show students real life examples. (To find these pictures, the teachers should google them.)

If students have difficulty answering the questions about oil spills in their science journals, the teacher should project images found on google of large oil spills such as the 2010 Gulf of Mexico oil spill. Then, to show the effects of the oil spill, the teacher should show images of birds and marine life caught in the oil spills. These images should help students understand how their oil spill models relate to real life oil spills, so they can answer the questions.
If students have difficulty answering the questions about the solar water fountain, the teacher should ask students some more guiding questions. Possible guiding questions the teacher can ask are: If the water fountain ran on nonrenewable energy sources, would it harm the Earth? What are the consequences for using nonrenewable energy sources? What powers the water fountain? Will this energy source harm the Earth? Why did you place your water fountain in a sunny area? What would happen if you placed it in a shady area?

Example of Climate Change Diagram



Lesson 6: How Can We Move Energy from One Place to Another?

LESSON BACKGROUND

For the end of the unit activity, students will conduct an energy scavenger hunt. In this scavenger hunt, students will draw upon their knowledge of energy and energy sources to locate examples of energy in their surrounding environment. Then, based on what they learned about energy conversions, students will draw a diagram or write about the energy conversions they observe in their school. In this way, this scavenger hunt allows students to draw upon the knowledge they acquired throughout the unit.

Science Content Background Knowledge (for the instructors)

Since energy is everywhere around us, people can find many examples of energy in their daily lives. For instance, to directly gain energy, humans consume food which contains chemical energy. In order to cook the food, electric energy was transformed into heat energy. These forms of energy can also be found in other places. In nature, the largest source of heat is the Sun which also provides light for plants to grow and for visibility. In addition, there is biomass such as burning wood which provides heat. Another major example of energy use in America is transportation. Cars utilize nonrenewable energy resources such as fossil fuels to create mechanical energy. Unfortunately, fossil fuels also provide most of the electricity in society. Thus, the majority of energy in people's lives come from nonrenewable energy resources which has an enormous impact on the planet.

Overview of Lesson

The goal of this lesson is for students to find examples of energy in their everyday surroundings and to articulate what forms of energy are being moved/changed.

Focus and Spiral Standard(s)

Focus Standard: 4-PS3-2: Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents.

Clarification Statement:

- Evidence of energy being transferred can include vibrations felt a small distance from a source, a solar-powered toy that moves when placed in direct light, warming a metal object on one end and observing the other end getting warm, and a wire carrying electric energy from a battery to light a bulb.

State Assessment Boundary:

- Quantitative measurements of energy are not expected in state assessment.

Spiral Standard: K-PS3-1. Make observations to determine that sunlight warms materials on Earth's surface.

Clarification Statements:

- Examples of materials on Earth's surface could include sand, soil, rocks, and water.
- Measures of temperature should be limited to relative measures such as warmer/cooler.

Spiral Standard: 1-PS4-1. Demonstrate that vibrating materials can make sound and that sound can make materials vibrate.

Clarification Statements:

- Examples of vibrating materials that make sound could include tuning forks, a stretched string or rubber band, and a drum head.
- Examples of how sound can make materials vibrate could include holding a piece of paper near a speaker making sound and holding an object near a tuning fork.

Spiral Standard: 1-PS4-3. Conduct an investigation to determine the effect of placing materials that allow light to pass through them, allow only some light through them, block all the light, or redirect when put in the path of a beam of light.

Clarification Statements:

- Effects can include some or all light passing through, creation of a shadow, and redirecting light.
- Qualitative measures are not expected.

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Spiral Standard: 4-ESS3-1. Obtain information to describe that energy and fuels humans use are derived from natural resources and that some energy and fuel sources are renewable and some are not.

Clarification Statements:

- Examples of renewable energy resources could include wind energy, water behind dams, tides, and sunlight.
- Non-renewable energy resources are fossil fuels and nuclear materials.

Spiral Standard: 5-LS1-1. Ask testable questions about the process by which plants use air, water, and energy from sunlight to produce sugars and plant materials needed for growth and reproduction.

State Assessment Boundary:

- The chemical formula or molecular details about the process of photosynthesis are not expected in state assessment.

Spiral Standard: 6.MS-PS1-6. Plan and conduct an experiment involving exothermic and endothermic chemical reactions to measure and describe the release of thermal energy.

Clarification Statements:

- Emphasis is on describing transfer of energy to and from the environment.
- Examples of chemical reactions could include dissolving ammonium chloride or calcium chloride.

Spiral Standard: 7.MS-PS3-6. Use a model to explain how thermal energy is transferred out of hotter regions or objects and into colder ones by convection, conduction, and radiation.

Spiral Standard: 7.MS-ESS2-4. Develop a model to explain how the energy of the Sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in Earth's hydrosphere.

Clarification Statement:

- Examples of models can be conceptual or physical.

State Assessment Boundary:

- A quantitative understanding of the latent heats of vaporization and fusion is not expected in state assessment.

NGSS Alignment Table

Science/Engineering Practices (SP)	Disciplinary Core Idea (DCI)	Cross Cutting Concepts (CCC)
Planning and Carrying Out Investigations	**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) **PS3.B:** Conservation of Energy and Energy Transfer -Energy is present wherever 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) -Light also transfers energy from place to place. (4-PS3-2) -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)	Energy and Matter -Energy can be transferred in various ways and between objects (4-PS3-2)

Learning Target

I can record observations that illustrate the movement of energy across space.

Assessments

- Students should write a paragraph to detail their findings and create a diagram with labels to accompany the text. (For classes in which iPads are available, students may work in groups to create a "video report"). Either option should answer the following questions:
    - Does energy move/change?
    - How does energy move/change?
    - Where did we see energy move/change during our scavenger hunt?
    - What are other places where energy is moved/changed from one place to another

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per student	Science journals	Classroom Teacher
1 per group	iPads (optional)	Classroom Teacher
4-6 per group	**Marbles**	**Bin**
A few for each group	**Materials to make ramps (rulers, tape, yardsticks, etc.)**	**Classroom Teacher/Bin**
1	**Flashlight**	**Bin**
1	**Solar cell**	**Bin**
1	**Set of wires**	**Bin**
1	**Fan**	**Bin**

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

Flashlight Demonstration: Shine a flashlight on a simple circuit composed of a solar cell and fan.

1. Ask students to describe the different forms of energy in the different locations of this demonstration. This demonstration will help them think about how energy can be moved from one location (the flashlight) to another (into the circuit and then the fan). **[SP7 – Engaging in Argument from Evidence]**

During the Lesson

1. **Energy Scavenger Hunt** *(Adapted from* https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_energy2/cub_energy2_lesson01_activity2.xml)

2. Explain to students that they will go on an energy scavenger hunt around school. Remind them that they need to be mindful of others students/classes while on the scavenger hunt. During the scavenger hunt, students need to find at least six examples of energy moving from one place to another. Optional: Create a worksheet to use in lieu of science journals.

3. Break the class into three groups; each group should have a science fellow or the classroom teacher. Students should bring their science journals (or worksheets on clipboards, if necessary) and a pencil. Students may also bring iPads (one per group) to take photographs or videos to illustrate their examples.

4. The students will need to find two examples in each of the places they visit on the scavenger hunt. The three places the students will visit are: the cafeteria, the playground, and the music room (it is okay to visit different locations, depending on weather, other classes, etc.). **[SP3 – Planning and Carrying Out Investigations]**

5. Send each group to a different location and spend 10 minutes in each location. Allow the students to walk around and explore; they may need some guidance on where to look for energy moving from one place to another. For each example that is found, students should record:
    - Location
    - Name of object
    - Type(s) of energy moving/changing
    - How we know (i.e., what is our evidence for that specific type of energy being present?) **[SP4, Analyzing and Interpreting Data.]**

Lesson Closing:

(Science talk: Class discussion)

After everyone is back in the classroom, allow students to share some of the observations. If there is any extra time, students can explore Rube Goldberg Machines online or use the iPads.

Assessments

- Students should write a paragraph to detail their findings and create a diagram with labels to accompany the text. (For classes in which iPads are available, students may work in groups to create a "video report"). Either option should answer the following questions:
    - Does energy move/change?
    - How does energy move/change?
    - Where did we see energy move/change during our scavenger hunt?
    - What are other places where energy is moved/changed from one place to another?

Unit Activity Planner

Activity	Learning Targets	Science Connection to Phenomena	MA Standards
Lesson 1 **Activity 1**: Recalling Scientists	I can define energy and identify its various forms including potential, kinetic, sound, light, heat, and electric energy. I can create a concept map to demonstrate the understanding of energy.	Energy can be found everywhere in the world. The Principle of Energy Conservation states that energy is neither created or destroyed; it is just transformed. There are two broad categories for energy: potential and kinetic. The types of energy people see on a daily basis (e.g. heat energy, light energy, etc.) are either potential or kinetic energy.	**4-PS3-2.** Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents. (**Clarification Statement:** Evidence of energy being transferred can include vibrations felt a small distance from a source, a solar-powered toy that moves when placed in direct light, warming a metal object on one end and observing the other end getting warm, and a wire carrying electric energy from a battery to light a bulb.) (**State Assessment Boundary:** Quantitative measurements of energy are not expected in state assessment.)
Lesson 1 **Activity 2**: 8 Scientific Practices			
Lesson 1 **Activity 3:** Moving Salt Investigation			
Lesson 1 **Activity 4**: Introducing Energy			
Lesson 1 **Activity 5**: Explaining Energy			
Lesson 1 **Activity 6**: Potential and Kinetic Energy			

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Lesson 1 **Activity 7**: Energy and Matter			
Lesson 1 **Activity 8**: Field Research			
Lesson 1 **Activity 9:** Concept Map			
Lesson 2 **Activity 1**: Energy Discussion **Lesson 2** **Activity 2:** Marbles Down a Ramp **Lesson 2** **Activity 3:** Marble Discussion	I can measure the time it takes for a marble to roll down a ramp. I can draw conclusions about the speed of an object based on the height from which the object was dropped. I can draw conclusions about energy based on observations of the speed of an object.	In order to transform potential energy into kinetic energy, a force needs to act upon an object or matter. The more potential energy an object contains, the less kinetic energy the object contains and vice versa. Potential energy is affected by height; the greater the height, the more potential energy in an object.	**Math 4.NF. 6.** Use decimal notation for fractions with denominators 10 or 100. For example, rewrite 0.62 as 62/100; describe a length as 0.62 meters; locate 0.62 on a number line diagram. **4-PS3-1** Use evidence to construct an explanation relating the speed of an object to the energy of that object.

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			(**State Assessment Boundaries:** State assessment will be limited to analysis of kinetic energy. Accounting for mass, quantitative measures of changes in the speed of an object, or any precise or quantitative definition of energy is not expected in state assessment.)
Lesson 3 **Activity 1:** Marble Investigation Discussion **Lesson 3** **Activity 2:** Marble Demonstrations **Lesson 3** **Activity 3:** Playing with Marbles **Lesson 3** **Activity 4:** The Great Marble Competition	I can explain the transfer of energy that occurs when objects collide. I can recognize the difference between potential and kinetic energy by observing a collision of two marbles.	Another factor that affects potential and kinetic energy is mass. The more mass in an object, the more kinetic energy and potential energy an object contains. Furthermore, collisions cause kinetic energy. When two marbles roll into each other, the force changes their kinetic energy, causing them to roll in opposite directions.	**4-PS3-3.** Ask questions and predict outcomes about the changes in energy that occur when objects collide. (**Clarification Statement:** Changes in energy can include a change in the object's motion, position, and the generation of heat and/or sound.) (**State Assessment Boundary:** Analysis of forces or quantitative measurements of energy are not expected in

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Lesson 3 **Activity 5:** Marble Video			state assessment.) **4-PS3-4.** Apply scientific principles of energy and motion to test and refine a device that converts motion energy to electrical energy or uses stored energy to cause motion or produce light or sound. * (**Clarification Statement:** Sources of stored energy can include water in a bucket or a weight suspended at a height, and a battery.)
Lesson 4 **Activity 1:** Marble Collision Discussion	I can name and give examples of the six types of energy (potential, kinetic, light, heat, electric, and sound). I can describe how energy changes from one form to another.	Energy transformations happen everywhere in life. For instance, the simple act of turning on a light bulb involves many energy transformations. First the energy is transformed from fossil fuels to electric energy and then finally to both thermal and radiant energy.	**4-PS3-2.** Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents. (**Clarification Statement:** Evidence of energy being transferred can include vibrations felt a small distance from a source, a solar-powered toy that moves when placed in direct
Lesson 4 **Activity 2:** Energy Powerpoint			
Lesson 4 **Activity 3:** Presenting Energy			

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Lesson 4 **Activity 4:** Mass Demonstration **Lesson 4** **Activity 5:** Energy Conversion Stations			light, warming a metal object on one end and observing the other end getting warm, and a wire carrying electric energy from a battery to light a bulb.) (**State Assessment Boundary:** Quantitative measurements of energy are not expected in state assessment.)
Lesson 5 **Activity 1:** Energy Concept Map **Lesson 5** **Activity 2:** Video Activity **Lesson 5** **Activity 3:** Revisit the Concept Map **Lesson 5** **Activity 4:** Air Pollution Activity	I can define nonrenewable and renewable energy. I can name examples of nonrenewable and renewable energy resources. I can explain the harmful effects caused by nonrenewable energy resources. I can build a model powered by a renewable energy resource.	All energy comes from either renewable or nonrenewable energy resources. Renewable energy resources are sustainable sources found in nature such as wind, water, and sunlight. In contrast, nonrenewable energy resources are limited resources such as fossil fuels. The use of fossil fuels negatively affects Earth as greenhouse gases from the fuels cause climate change.	**4-PS3-4.** Apply scientific principles of energy and motion to test and refine a device that converts motion energy to electrical energy or uses stored energy to cause motion or produce light or sound.* (**Clarification Statement:** Sources of stored energy can include water in a bucket or a weight suspended at a height, and a battery.)

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Lesson 5 **Activity 5:** Oil Spill Activity **Lesson 5** **Activity 6:** Solar Water Fountain **Lesson 5** **Activity 7:** Energy Song			**4-ESS3-1.** Obtain information to describe that energy and fuels humans use are derived from natural resources and that some energy and fuel sources are renewable and some are not. (**Clarification Statements:** Examples of renewable energy resources could include wind energy, water behind dams, tides, and sunlight. Nonrenewable energy resources are fossil fuels and nuclear materials.)
Lesson 6 **Activity 1:** Flashlight Demonstration **Lesson 6** **Activity 2:** Energy Scavenger Hunt	I can record observations that illustrate the movement of energy across space.	Energy is found everywhere in the world. The sun, wind, and water are a few examples of energy sources which can be found in nature. Even living organisms use energy. For instance, mammals produce	**4-PS3-2:** Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents. (**Clarification Statement:**

Lesson 6 **Activity 3:** Scavenger Hunt Discussion		thermal energy to maintain their body temperatures.	Evidence of energy being transferred can include vibrations felt a small distance from a source, a solar-powered toy that moves when placed in direct light, warming a metal object on one end and observing the other end getting warm, and a wire carrying electric energy from a battery to light a bulb. (**State Assessment Boundary:** Quantitative measurements of energy are not expected in state assessment.)

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Next Generation Science Standards (NGSS) Alignment

Performance Standard	Science/Engineering Practice (SP)	Disciplinary Core Idea (DCI)	Cross Cutting Concepts (CCC)
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.** **4-PS3-4. Apply scientific ideas to design, test, and**	**Asking Questions and Defining Problems** Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. -Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3) **Planning and Carrying Out Investigations**	**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	**<u>Energy and Matter</u>** -Energy can be transferred in various ways and between objects. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4) **Cause and Effect** -Cause and effect relationships are routinely identified and used to explain change. (4-ESS3-1) ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of**

refine a device that converts energy from one form to another. **4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.**	Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. -Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (4-PS3-2) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 3–5 builds on K–2 experiences	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) -Light also transfers energy from place to place. (4-PS3-2) -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	**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) Engineers improve existing technologies or develop new ones. (4-PS3-4) ***Connections to Nature of***

	and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. -Use evidence (e.g., measurements, observations, patterns) to construct an explanation. (4-PS3-1) -Apply scientific ideas to solve design problems. (4-PS3-4) **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	transforming the energy of motion into electrical energy. (4-PS3-2),(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) **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	***Science*** Science is a Human Endeavor -Most scientists and engineers work in teams. (4-PS3-4) -Science affects everyday life. (4-PS3-4)

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

Teach To Learn
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5E Instructional Model Background

This instructional model exists as a set of phases for science instruction that starts with students' prior knowledge in order to reconstruct a new knowledge with deeper understanding. The *Engagement* phase is first, in which teachers and students begin to mull over questions, prior knowledge and understanding, and potential frustrations they might have with a topic. This phase is meant to be informal – this is the start of the lesson. The second step involves *Exploring* phenomena, which acts as an introduction to the larger concepts that engages students in a hands-on approach. After exploration, *Explanation* of scientific concepts begins. To further student understanding, *Elaboration* is next, in which students are presented with even more challenging activities and problems. Following the learning process comes *Evaluation*, as deemed necessary by learning goals and defined achievements. The model is based on scientific research about how children learn and is meant to be followed chronologically, although some steps may be repeated.

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Science Talk and Oracy in T2L Units

Science talk is much more than talking about science. In line with the science and engineering practices, students are expected to make a claim that can be supported by scientific evidence. The MA STE Standards (and the NGSS) value the importance of engaging in an argument from evidence. NGSS defines how this practice takes form in the real world: *"In science, reasoning and argument are essential for identifying the strengths and weaknesses of a line of reasoning and for finding the best explanation for a natural phenomenon. Scientists must defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomenon being investigated."*

Students are asked to participate in articulate and sensible conversations in which they are able to communicate their ideas effectively, listen to others to understand, clarify and elaborate ideas, and reflect upon their understanding. These forms of talk can be developed using scaffolds such as the A/B Talk protocol (below) and strategies for class discussions (from the Talk Science Primer, link below).Oracy is developed in the physical, linguistic, cognitive, and social-emotional realms; each of these realms can be expanded upon over time in order to develop a thoughtful speaker. Being able to display appropriate body language, use proper tone and grammar, be thoughtful and considerate thinkers, and allow space for others thoughts and opinions are all important facets of oracy to work on and through with students. Incorporating the appropriate scaffolding is an important aspect of fostering these skills. Techniques for teaching effective science talk often include modeling, discussion guidelines, sentence-starters, and generating roles, while gradually putting more responsibility on students to own their thinking and learning.

Part of creating a safe school environment for students is allowing them a space that is comfortable enough for them to express ideas and ask questions, while being validated for their thoughts and questions; students should be feel comfortable and confident when speaking and listening for understanding. Effective talk is an important part of being an active, intelligent member of a community and society. Successful development in oracy is important for future employability and general well-being of adults.

The following resources should be helpful examples of how to employ effective use of progressive oracy and science talk in your classrooms.

- Oracy in the Classroom: https://www.edutopia.org/practice/oracy-classroom-strategies-effective-talk
- Science Talk Primer: https://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf

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A/B Talk Protocol

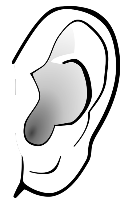
Adapted from https://ambitiousscienceteaching.org/ab-partner-talk-protocol/

1. Share your ideas

Partner A

- I think ______ happened because…
- Evidence that supports my idea is…
- The activity we did with ______ helps me know more about ______ because…
- One thing I'm wondering about is…

2. Listen to Understand



Partner B

- I heard you say ______. What makes you think that?
- I heard you say ______. What if ______?
- Can you explain the part about ______ again?
- What do you mean when you say ______?

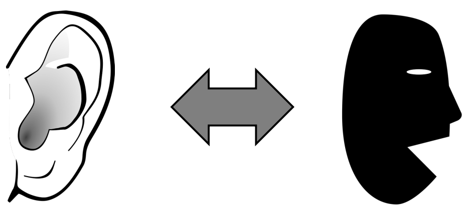
3. Clarify and elaborate

Partner A

Answer partner's questions or ask for clarification in order to understand a question.

4. Repeat steps 2 & 3 until all questions are answered

5. Switch roles and repeat steps 1-4



6. Reflect on your understanding in writing

- My idea about ______ changed when my partner said ______.
- I will add ______ to my idea about ______ because…
- I still have questions about…
- I may be able to answer my question(s) if I could investigate ______.

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List of Unit Resources

Lesson 1

Quantity	Item	Source
1 per student	Science journals	Classroom Teacher
1	Projector	Classroom Teacher
25	**Paper bowls (colored)**	**Bin**
25	Plastic straws	Bin
3 containers	**Salt**	**Bin**
1	Computer	Classroom Teacher
1 per group	iPads (optional)	Classroom Teacher
1	Potential and Kinetic energy video https://www.youtube.com/watch?v=AYRa8Ismplk&list=PLsAWD8mKKE97b_iwzdzXSijuYpVdxV4qO&index=1)	CMC website
1	Energy and Matter video (https://www.youtube.com/watch?v=a_JufiBuDzA&list=PLsAWD8mKKE97b_iwzdzXSijuYpVdxV4qO&index=2)	CMC website

Lesson 2

Quantity	Item	Source
1 per student	Science journals	Classroom Teacher
1 per group (should have at least 5 in bin)	**1 meter wooden ramp**	**Bin**
4-6 per group	**Marbles**	**Bin**

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A bunch for each group	Books, blocks, objects to raise one end of a ramp	Classroom Teacher
1 per group	Measuring tape or yardstick	Classroom Teacher
1 per group	**Stopwatch or timer**	**Bin**
1 per group	iPads (optional)	Classroom Teacher
1 per student	Marble speed worksheet	Binder (teacher needs to make copies
1 per group	Cardboard or plastic box!	Classroom Teacher
1 per group	Calculator (Only for challenge activity)	Classroom Teacher

Lesson 3

Quantity	Item	Source
1 per student	Science journals	Classroom Teacher
1 per group (should have at least 5)	**1 meter wooden ramp**	**Bin**
2 per group	**Marbles (make sure they are two different color)**	**Bin**
A bunch for each group	Books, blocks, objects to raise one end of a ramp	Classroom Teacher
1 per group	Measuring tape or yardstick	Classroom Teacher
1 per group	**Stopwatch or timer**	**Bin**
1	Marble Lab video (https://www.youtube.com/watch?v=z4e5hOMvmWQ)	CMC Website
1 per group	iPads (optional)	Classroom Teacher
1	Laptop (optional)	Classroom Teacher
1	Projector (optional)	Classroom Teacher

Lesson 4

Quantity	Item	Source
1 per student	Science journals	Classroom Teacher
1 per group	iPads (optional)	Classroom Teacher
1 per group	Measuring tape or yardstick	Classroom Teacher
1 per group (should have at least 5)	**Black plastic tube**	**Bin**
1	**Colored Slides**	**Bin**
1	**Bouncy ball**	**Bin**
4-6 per group	**Marbles**	**Bin**
2	**Battery holder**	**Bin**
4	**AA batteries**	**Bin**
1	**Multimeter**	**Bin**
4	**Wires with alligator clips**	**Bin**
1	**Motor with fan attached**	**Bin**
1	**Light bulb**	**Bin**
2	**Solar cell**	**Bin**
1-2 pages per student	Paper	Classroom Teacher
Enough for each student	Coloring Utensils (markers, crayons, pencils)	Classroom Teacher
1	Laptop	Classroom Teacher
1	Projector	Classroom Teacher
1	Electronic version of this lesson	Classroom Teacher
2	**Friction Blocks**	**Bin**
1	**Bell**	**Bin**
1 roll	Tape (clear is preferable)	Classroom teacher

1 per student	"Solar Absorbers and the Future of Electricity" Reading	Binder
1 per student	"Houston Affects the Earth" Reading	Binder
1 per student	Paired Text Questions	Binder
1	Multimeter Tutorial video (https://www.youtube.com/watch?v=2-px8YQR1_I)	Thumb drive

Lesson 5

Quantity	Item	Source
4 (for teacher use only)	Index Cards	Bin
5 (1 per group)	**Plastic Tub**	**Bin**
2 bags	**Rocks**	**Bin**
Enough for each group	Leaves/Sticks	Classroom Teacher
1 bag	Fake Feathers	Bin
2 units	Fake Fur	Bin
1 bottle	**Dark Olive Oil**	**Bin**
1 spool	**String**	**Bin**
1 pack	**Sponges**	**Bin**
1 pack	**Cotton Balls**	**Bin**
1 box	**Spoons**	**Bin**
1 bottle	**Dish Detergent**	**Bin**
1 packet	**Plastic Cups**	**Bin**
1 per student	Paper Towels	Classroom Teacher
1 per group	**Solar Water Pump**	**Bin**
1 per group	**Solar Panel**	**Bin**
1 per group	**Plastic Tubing**	**Bin**

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1 per group	**Plasticine**	**Bin**
1 per group	**Plastic Tub**	**Bin**
1 per group	**Ruler**	**Bin**
1 per group (if there is no sunlight)	**Lamp and Light Bulb**	**Bin**

Lesson 6

Quantity	Item	Source
1 per student	Science journals	Classroom Teacher
1 per group	iPads (optional)	Classroom Teacher
4-6 per group	**Marbles**	**Bin**
A few per group	**Materials to make ramps (rulers, tape, yardsticks, etc.)**	**Classroom teacher/Bin**
1	**Flashlight**	**Bin**
1	**Solar cell**	**Bin**
1	**Set of wires**	**Bin**
1	**Fan**	**Bin**