

**Unit 5: Transfer of Energy**

Instructional Days: 15

**Unit Summary*****Where do we get the energy we need for modern life?***

In this unit of study, fourth-grade students develop an understanding that energy can be transferred from place to place by sound, light, heat, and electrical currents. Students also obtain and combine information to describe that energy and fuels are derived from natural resources and that their uses affect the environment. The crosscutting *concepts of cause and effect, energy and matter, and the interdependence of science, engineering, and technology, and influence of science, engineering, and technology on society and the natural world* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in *planning and carrying out investigations and obtaining, evaluating, and communicating information*. Students are also expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on 4-PS3-2 and 4-ESS3-1.

**Student Learning Objectives**

**Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.** *[Assessment Boundary: Assessment does not include quantitative measurements of energy.]* **(4-PS3-2)**

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

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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-ESS3-1	Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment
ESS3.A	Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways
ESS3.B	A variety of hazards result from natural processes
ETS1.B	Testing a solution involves investigating how well it performs under a range of likely conditions
PS3.A	The faster a given object is moving, the more energy it possesses
PS3.B	Energy is present whenever there are moving objects, sound, light or heat
PS3.C	When objects collide, the contact forces transfer energy so as to change the objects' motions

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<b>Enduring Understandings</b>
<ul style="list-style-type: none"> <li>• The faster an object is moving, the more energy it possesses.</li> <li>• The slower an object is moving the less energy it possesses.</li> <li>• Moving objects, sound, light and heat all have energy.</li> <li>• Energy can be moved from place to place by moving objects through sound, light or electric currents.</li> </ul>
<b>Essential Questions</b>
<ul style="list-style-type: none"> <li>• What is the relationship between speed and energy?</li> <li>• How is energy transferable?</li> <li>• What happens to the energy when objects collide?</li> </ul>

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Unit Sequence	
<i>Part A: How does energy move?</i>	
Concepts	Formative Assessment
<ul style="list-style-type: none"> <li>• Energy can be transferred in various ways and between objects.</li> <li>• Energy can be moved from place to place through sound, light, or electric currents.</li> <li>• Energy is present whenever there are moving objects, sound, light, or heat.</li> <li>• Light also transfers energy from place to place.</li> <li>• Energy can also be transferred from place to place by electric currents; the currents may have been produced to begin with by transforming the energy of motion into electrical energy.</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>• Make observations to produce data that can serve as the basis for evidence for an explanation of a phenomenon or for a test of a design solution.</li> <li>• Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.</li> </ul>

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<b>Unit Sequence</b>	
<i>Part B: From what natural resources are energy and fuels derived? In what ways does the human use of natural resources affect the environment?</i>	
<b>Concepts</b>	<b>Formative Assessment</b>
<ul style="list-style-type: none"> <li>• Cause-and-effect relationships are routinely identified and used to explain change.</li> <li>• Knowledge of relevant scientific concepts and research findings is important in engineering.</li> <li>• Over time, people’s needs and wants change, as do their demands for new and improved technologies.</li> <li>• Energy and fuels that humans use are derived from natural sources.</li> <li>• The use of energy and fuels from natural sources affects the environment in multiple ways.</li> <li>• Some resources are renewable over time, and others are not.</li> </ul>	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> <li>• Identify cause-and-effect relationships in order to explain change.</li> <li>• Obtain and combine information from books and other reliable media to explain phenomena.</li> <li>• Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.                             <ul style="list-style-type: none"> <li>✓ Examples of renewable energy resources could include:                                     <ul style="list-style-type: none"> <li>○ Wind energy,</li> <li>○ Water behind dams, and</li> <li>○ Sunlight.</li> </ul> </li> <li>✓ Examples of nonrenewable energy resources are:                                     <ul style="list-style-type: none"> <li>○ Fossil fuels,</li> <li>○ Fissile materials</li> </ul> </li> <li>✓ Examples of environmental effects could include:                                     <ul style="list-style-type: none"> <li>○ Loss of habitat due to dams</li> <li>○ Loss of habitat due to surface mining</li> <li>○ Air pollution from burning of fossil fuels.</li> </ul> </li> </ul> </li> </ul>

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**What It Looks Like in the Classroom**

Students conduct investigations to observe that energy can be transferred from place to place by sound, light, heat, and electrical currents. They describe that energy and fuels are derived from natural resources and that their uses affect the environment. Throughout this unit, students obtain, evaluate, and communicate information as they examine cause-and-effect relationships between energy and matter.

To begin the unit of study's progression of learning, students need opportunities to observe the transfer of heat energy. They can conduct simple investigations, using thermometers to measure changes in temperature as heat energy is transferred from a warmer object to a colder one. For example, hot water can be poured into a large Styrofoam cup, and then a smaller plastic cup of cold water can be placed inside the larger cup of water. A thermometer can be placed in each cup, and students can observe and record changes in the temperature of the water in each cup every minute over the course of about 10–15 minutes, or until the temperatures are the same. Students can use their data as evidence to explain that some of the heat energy from the hot water transferred to the cold water. This transfer of heat caused the cold water to become gradually warmer and the hot water to cool. This process continued until the cups of water reached the same temperature.

Students can also place a thermometer in the palm of their hands, close their hands around it, and measure the temperature. They can then place a piece or two of ice into their palms and close their fists around the ice until it melts. When they again measure the temperature of their palms, they will observe a change. Students can use these data to describe how some of the heat from their hands transferred to the ice, causing it to melt, while the ice also decreased the temperature of their hand. It is important that students understand that heat is transferred from warmer to colder objects. When an object cools, it loses heat energy. When an object gets warmer, it gains heat energy.

To continue learning about energy transfer, students can build simple electric circuits. As students work in small groups to build circuits, they should add a bulb and/or a buzzer to the circuit in order to observe and describe the ways in which energy is transferred in the circuit. (The word "transfer" can refer to a change in the type of energy or a change in the location of energy.) For example, stored energy in a battery is transferred into electrical energy, which is then transferred into light energy if a bulb is added to the circuit. The energy transfers from the battery to the wire and then to the bulb. The same holds true if a buzzer is added to the circuit. The stored energy in the battery is transferred into electrical energy, which is then transferred into sound energy. (Keep in mind that energy is not actually produced. When we say that energy is "produced," this typically refers to the conversion of stored energy into a desired form for practical use. Students should be encouraged to use the term "transferred" rather than "produced").

After conducting these types of investigations, the class can create a list of events in which energy is transferred. For example, when a

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ball is thrown against a wall, some of the motion energy is transferred to sound energy; when water boils on the stove top, heat energy from the stove is transferred to the pot and to the water in the pot; and when a doorbell is rung, electrical energy is transferred into sound energy.

Next, students learn about fuels and energy, and conduct research using books and other reliable media to determine which natural resources are sources of energy. Light, heat, sound, and electricity are all forms of energy. Energy is not matter. Fuels, however, are matter. For example, fossil fuels, such as coal, oil, and natural gas, are matter. When fossil fuels are burned, energy stored in the fuel can be transferred from stored energy to heat, light, electrical, and/or motion energy. Therefore, fuels are considered to be a source of energy.

Energy can also be obtained from other sources, such as wind, water, and sunlight. Air and water are both matter, but when they are moving, they have motion energy. Energy from wind (moving air) and from moving water can be transferred into electrical energy. Light energy from the sun can also be transferred to heat energy or electrical energy. In addition, energy can be released through nuclear fission using materials known as fissile materials.

As students learn about fuels and other sources of energy, they should determine which sources are renewable and which are nonrenewable. Generally, a fuel or source of energy is considered nonrenewable if that source is limited in supply and cannot be replenished by natural means within a reasonable amount of time. Renewable sources of energy are those that are replenished constantly by natural means. Using this general description, all fossil fuels are considered nonrenewable, because these resources were naturally created over millions of years. Fissile materials are also nonrenewable. On the other hand, wind, moving water, and sunlight are renewable sources of energy.

As the population continues to grow, so does the demand for energy. Human use of natural resources for energy, however, has multiple effects on the environment. Students should conduct further research to determine how the use of renewable and nonrenewable resources affects the environment. Some examples include:

- ✓ Changes in and loss of natural habitat due to the building of dams and the change in the flow of water;
- ✓ Changes in and loss of natural habitat due to surface mining; and
- ✓ Air pollution caused by the burning of fossil fuels in factories, cars, and homes.

As students conduct research and gather information from a variety of reliable resources, they can take notes and use the information to describe and explain the impact that human use of natural resources has on the environment.

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**Connecting with English Language Arts/Literacy and Mathematics***English Language Arts*

Students will conduct research to build their understanding of energy, transfer of energy, and natural sources of energy. Students will recall relevant information from in-class investigations and experiences and gather relevant information from print and digital sources. They should take notes and categorize information and provide a list of sources. Students also draw evidence from literary and information texts in order to analyze and reflect on their findings. Students can also read, take notes, and construct responses using text and digital resources such as Scholastic News, Nat Geo Kids, Study Jams (Scholastic), Reading A–Z.com, NREL.com, switchenergyproject.com, and NOVA Labs by PBS.

*Mathematics*

Students reason abstractly and quantitatively as they gather and analyze data during investigations and while conducting research about transfer of energy and energy sources. Students model with mathematics as they represent and/or solve word problems. As students research the environmental effects of obtaining fossil fuels, they might be asked to represent a verbal statement of multiplicative comparison as a multiplication equation. For example, students might find information about a spill that was 5 million gallons of oil and was 40 times larger than a previous oil spill in the same location. They can be asked to represent this mathematically using an equation to determine the number of gallons of oil that were spilled in the previous event.

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**Modifications**

*(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: [All Standards, All Students/Case Studies](#) for vignettes and explanations of the modifications.)*

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals ([http://www.cast.org/our-work/about-udl.html#.VXmoXcfD\\_UA](http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)).

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**Research on Student Learning**

Students do not distinguish well between heat and temperature when they explain thermal phenomena. Their belief that temperature is the measure of heat is particularly resistant to change. Long-term teaching interventions are required for upper middle-school students to start differentiating between heat and temperature.

During instruction, upper elementary-school students use ideas that give heat an active drive or intent to explain observations of convection currents. They also draw parallels between evaporation and the water cycle and convection, sometimes explicitly explaining the upwards motion of convection currents as evaporation.

Students rarely think energy is measurable and quantifiable. Students' alternative conceptualizations of energy influence their interpretations of textbook representations of energy.

Students tend to think that energy transformations involve only one form of energy at a time. Although they develop some skill in identifying different forms of energy, in most cases their descriptions of energy-change focus only on forms which have perceivable effects. Finally, it may not be clear to students that some forms of energy, such as light and sound can be used to make things happen ([NSDL, 2015](#)).

**Prior Learning**

There are no disciplinary core ideas that are considered prior learning for the concepts in this unit of study.

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**Future Learning****Grade 5 Unit 5: Earth Systems**

- Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.

**Grade 7 Unit 7: Organization for Matter and Energy in Organisms**

- The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (*secondary*)
- Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (*secondary*)

**Grade 7 Unit 8: Earth Systems**

- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

**Grade 8 Unit 3: Stability and Change on Earth**

- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

**Grade 8 Unit 4: Human Impact**

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
- Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever

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climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.

**Grade 8 Unit 5: Relationships among Forms of Energy**

- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.
- A system of objects may also contain stored (potential) energy, depending on their relative positions.
- When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

**Grade 8 Unit 6: Thermal Energy**

- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.
- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

**Grade 8 Unit 7: Electromagnetic Radiation**

- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

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**Connections to Other Units**

The focus in this unit of study is energy transfer from place to place through sound, light, heat, or electric currents. In **Unit 6, Force and Motion**, and **Unit 7, Using Engineering Design with Force and Motion Systems**, students will work with concepts related to force, motion, energy, and energy transfer.

**Sample of Open Education Resources**

[Switch Energy Project](#): The Educator Portal provides free access to a documentary, energy labs, videos, and study guides.

[Wind Generator](#): Windmills have been used for hundreds of years to collect energy from the wind in order to pump water, grind grain, and more recently generate electricity. There are many possible designs for the blades of a wind generator and engineers are always trying new ones. Design and test your own wind generator, then try to improve it by running a small electric motor connected to a voltage sensor.

[Thermal Energy Transfer](#): Explore the three methods of thermal energy transfer: conduction, convection, and radiation, in this interactive from WGBH, through animations and real-life examples in Earth and space science, physical science, life science, and technology.

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**Teacher Professional Learning Resources****Assessment for the Next Generation Science Standards**

The presenters were Joan Herman, Co-Director Emeritus of the National Center for Research on Evaluation, Standards, and Student Testing (CRESST) at UCLA; and Nancy Butler Songer, Professor of Science Education and Learning Technologies, University of Michigan.

Dr. Herman began the presentation by summarizing a report by the National Research Council on assessment for the Next Generation Science Standards (NGSS). She talked about the development of the report and shared key findings. Next, Dr. Songer discussed challenges for classroom implementation and provided examples of tasks that can be used with students to assess their proficiency on the NGSS performance expectations.

View the [resource collection](#).

Continue discussing this topic in the [community forums](#).

**NGSS Crosscutting Concepts: Patterns**

The presenter was Kristin Gunckel from the University of Arizona. Dr. Gunckel began the presentation by discussing how patterns fit in with experiences and explanations to make up scientific inquiry. Then she talked about the role of patterns in NGSS and showed how the crosscutting concept of patterns progresses across grade bands. After participants shared their ideas about using patterns in their own classrooms, Dr. Gunckel shared instructional examples from the elementary, middle school, and high school levels.

**NGSS Crosscutting Concepts: Structure and Function**

The presenters were Cindy Hmelo-Silver and Rebecca Jordan from Rutgers University. Dr. Hmelo-Silver and Dr. Jordan began the presentation by discussing the role of the crosscutting concept of structure and function within NGSS. They then asked participants to think about the example of a sponge and discuss in the chat how a sponge's structure relates to its function. The presenters introduced the Structure-Behavior-Function (SBF) theory and talked about the importance of examining the relationships between mechanisms and structures. They also discussed the use of models to explore these concepts.

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**NGSS Core Ideas: Energy**

The presenter was Jeff Nordine of the San Antonio Children's Museum. Ramon Lopez from the University of Texas at Arlington provided supporting remarks. The program featured strategies for teaching about physical science concepts that answer questions such as "How is energy transferred between objects or systems?" and "What is meant by conservation of energy?"

Dr. Nordine began the presentation by talking about the role of disciplinary core ideas within *NGSS* and the importance of energy as a core idea as well as a crosscutting concept. He then shared physicist Richard Feynman's definition of energy and related it to strategies for teaching about energy. Dr. Nordine talked about the elements of the energy core idea and discussed common student preconceptions.

Visit the [resource collection](#).

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**Appendix A: NGSS and Foundations for the Unit**

**Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.** *[Assessment Boundary: Assessment does not include quantitative measurements of energy.]* [\(4-PS3-2\)](#)

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

The performance expectations above were developed using the following elements from the NRC document [A Framework for K-12 Science Education](#):

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p><b>Planning and Carrying Out Investigations</b></p> <ul style="list-style-type: none"> <li>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)</li> </ul> <p><b>Obtaining, Evaluating, and Communicating Information</b></p> <ul style="list-style-type: none"> <li>Obtain and combine information from books and other reliable media to explain phenomena. (4-ESS3-1)</li> </ul>	<p><b>PS3.A: Definitions of Energy</b></p> <ul style="list-style-type: none"> <li>Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2)</li> </ul> <p><b>PS3.B: Conservation of Energy and Energy Transfer</b></p> <ul style="list-style-type: none"> <li>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</li> </ul>	<p><b>Energy and Matter</b></p> <ul style="list-style-type: none"> <li>Energy can be transferred in various ways and between objects. (4-PS3-2)</li> </ul> <p><b>Cause and Effect</b></p> <ul style="list-style-type: none"> <li>Cause and effect relationships are routinely identified and used to explain change. (4-ESS3-1)</li> </ul> <p>-----</p> <p>-----</p> <p><b>Connections to Engineering, Technology, and Applications of Science</b></p>

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	<p>produced. (4-PS3-2)</p> <ul style="list-style-type: none"> <li>• Light also transfers energy from place to place. (4-PS3-2)</li> <li>• 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)</li> </ul> <p><b>ESS3.A: Natural Resources</b></p> <ul style="list-style-type: none"> <li>• 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)</li> </ul>	<p><b>Interdependence of Science, Engineering, and Technology</b></p> <ul style="list-style-type: none"> <li>• Knowledge of relevant scientific concepts and research findings is important in engineering. (4-ESS3-1)</li> </ul> <p><b>Influence of Engineering, Technology, and Science on Society and the Natural World</b></p> <ul style="list-style-type: none"> <li>• Over time, people’s needs and wants change, as do their demands for new and improved technologies. (4-ESS3-1)</li> </ul>
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English Language Arts	Mathematics
<p>Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2),(4-ESS3-1) <b>W.4.7</b></p> <p>Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-2),(4-ESS3-1) <b>W.4.8</b></p> <p>Draw evidence from literary or informational texts to support analysis, reflection, and research. (4-ESS3-1) <b>W.4.9</b></p>	<p>Reason abstractly and quantitatively. (4-ESS3-1) <b>MP.2</b></p> <p>Model with mathematics. (4-ESS3-1) <b>MP.4</b></p> <p>Interpret a multiplication equation as a comparison, e.g., interpret <math>35 = 5 \times 7</math> as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations. (4-ESS3-1) <b>4.OA.A.1</b></p>

Common Vocabulary	
<p>Flow</p> <p>Lever arm</p> <p>Magnet</p> <p>Pulley</p> <p>Force</p> <p>Exert</p> <p>Store</p> <p>Transfer</p> <p>Relative</p>	<p>Applied force</p> <p>Balanced force</p> <p>Collide</p> <p>Collision</p> <p>Controlled</p> <p>Force strength</p> <p>Friction</p> <p>Position over time</p>