Grade 4 Science, Unit 5

Transfer of Energy

Overview

Unit abstract

In this unit of study, fourth-grade students are expected to 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; 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. In the fourth grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in planning and carrying out investigations and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas.

Essential questions

- What is energy?
- How is energy transferred?

Bristol–Warren, Central Falls, Cranston, Tiverton, and Woonsocket, with process support from The Charles A. Dana Center at the University of Texas at Austin

Written Curriculum

Next Generation Science Standards

4. Energy

Students who demonstrate understanding can:

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

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
Planning and Carrying Out Investigations 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)	**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 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) ▪ 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)

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels: **MS.PS2.B** (4-PS3-2); **MS.PS3.A** (4-PS3-2); **MS.PS3.B** (4-PS3-2); **MS.PS4.B** (4-PS3-2)

Common Core State Standards Connections:

ELA/Literacy –

W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2)

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-2)

4. Energy

Students who demonstrate understanding can:

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

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
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluate the merit and accuracy of ideas and methods. ▪ Obtain and combine information from books and other reliable media to explain phenomena. (4-ESS3-1)	**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)	**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 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)

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels: **5.ESS3.C** (4-ESS3-1); **MS.PS3.D** (4-ESS3-1); **MS.ESS2.A** (4-ESS3-1); **MS.ESS3.A** (4-ESS3-1); **MS.ESS3.C** (4-ESS3-1); **MS.ESS3.D** (4-ESS3-1)

Common Core State Standards Connections:

ELA/Literacy –

W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. *(4-ESS3-1)*

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-ESS3-1)

W.4.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. *(4-ESS3-1)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(4-ESS3-1)*

MP.4 Model with mathematics. *(4-ESS3-1)*

4.OA.A.1 Interpret a multiplication equation as a comparison, e.g., interpret 35 = 5 × 7 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)

Clarifying the standards

Prior learning

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

Progression of current learning

Driving question 1
How can energy be transferred?

Concepts

- Energy can be transferred in various ways and between objects.
- Energy can be moved from place to place ~~by moving objects or~~ through sound, light, or electric currents.
- 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.~~ (Motion is addressed in Unit 6)
- Light also transfers energy from place to place.
- 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.

Practices

- 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.
- Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Driving question 2
From what natural resources are energy and fuels derived? In what ways does the human use of natural resources affect the environment?

Concepts

- Cause-and-effect relationships are routinely identified and used to explain change.
- Knowledge of relevant scientific concepts and research findings is important in engineering.
- Over time, people's needs and wants change, as do their demands for new and improved technologies.
- Energy and fuels that humans use are derived from natural sources.
- The use of energy and fuels from natural sources affects the environment in multiple ways.
- Some resources are renewable over time, and others are not.

Practices

- Identify cause-and-effect relationships in order to explain change.
- Obtain and combine information from books and other reliable media to explain phenomena.
- Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
  - Examples of renewable energy resources could include
    - Wind energy
    - Water behind dams
    - Sunlight.
  - Examples of nonrenewable energy resources are
    - Fossil fuels
    - Fissile materials.
  - Examples of environmental effects could include
    - Loss of habitat due to dams
    - Loss of habitat due to surface mining
    - Air pollution from burning of fossil fuels.

Integration of content, practices, and crosscutting concepts

In this unit of study, fourth-grade 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 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.

Integration of DCI from other units within this grade level

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.

Integration of English language arts and mathematics

English language arts

To support the integration of the CCSS for English language arts into this unit, 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

In this unit of study, students also need multiple opportunities to integrate the CCSS for 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 that 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 oils that were spilled in the previous event.

Future learning

The following disciplinary core ideas are future learning related to concepts in this unit of study.

In Grade 5, students will know that:

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

In middle school, students will know that:

- Electrical and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.
- Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass (e.g., Earth and the sun).
- Forces that act at a distance (electrical, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, a magnet, or a ball, respectively).

- 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 the objects' relative positions.
- 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 types, states, and amounts of matter present.
- When the kinetic energy of an object changes, there is inevitably some other change in energy at the same time.
- 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.
- 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.
- Cellular respiration in plants and animals involves 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.
- 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.
- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy derived from the sun and Earth's hot interior. The energy that flows and the 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.
- 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.
- 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 (positive and negative) 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 climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding human behavior and applying that knowledge wisely in decisions and activities.

Number of Instructional Days

Recommended number of instructional days: 12 (1 day = approximately 45–60 minutes)

Note—The recommended number of days is an estimate based on the information available at this time. Teachers are strongly encouraged to review the entire unit of study carefully and collaboratively to determine whether adjustments to this estimate need to be made.