4th Grade - Topical Model - Bundle 2
Energy Transfer and Information Transmission

This is the second bundle of the 4th Grade Topic Model. Each bundle has connections to the other bundles in the course, as shown in the Course Flowchart

Bundle 2 Question: This bundle is assembled to address the question "how do we move energy and information from place to place?"

Summary

The bundle organizes performance expectations around the theme of *energy transfer and information transmission.* Instruction developed from this bundle should always maintain the three-dimensional nature of the standards, but recognize that instruction is not limited to the practices and concepts directly linked with any of the bundle performance expectations.

Connections between bundle DCIs

The idea that energy can be moved from place to place by moving objects or through sound, light, or electric currents (PS3.A as in 4-PS3-2) connects to the idea that electric currents can 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 (PS3.B as in 4-PS3-4).

Just as energy can be transferred from place to place, digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa (PS4.C as in 4-PS4-3).

Bundle Science and Engineering Practices

Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the practices of planning and carrying out investigations (4-PS3-2) and constructing explanations and designing solutions (4-PS3-4 and 4-PS4-3). Many other practice elements can be used in instruction.

Bundle Crosscutting Concepts

Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the crosscutting concepts of Patterns (4-PS4-3) and Energy and Matter (4-PS3-2 and 4-PS3-4). Many other crosscutting concepts elements can be used in instruction.

All instruction should be three-dimensional.

Performance Expectations	4-PS3-2 **Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.** [*Assessment Boundary: Assessment does not include quantitative measurements of energy.*] 4-PS3-4 **Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*** [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [*Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.*] 4-PS4-3 **Generate and compare multiple solutions that use patterns to transfer information.*** [Clarification Statement: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, and using Morse code to send text.]
Example Phenomena	A radio uses electricity to produce sound. Hand crank flashlights produce light.

Additional Practices Building to the PEs	**Asking Questions and Defining Problems** • Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. Students could *define a simple design problem that can be solved through the development of a system* [that] ***transfers energy from place to place by electric currents,*** *including defining several criteria for success and constraints on materials, time, or cost*. 4-PS3-2 and 4-PS3-4 **Developing and Using Models** • Develop and/or use models to describe and/or predict phenomena. Students could *develop and/or use models to describe a phenomenon* [related to the idea that] ***energy can be moved from place to place by moving objects or through sound, light, or electric currents***. 4-PS3-2 **Planning and Carrying Out Investigations** • Make predictions about what would happen if a variable changes. Students could *make predictions about what would happen [to]* ***the energy present when objects collide***. 4-PS3-2 **Analyzing and Interpreting Data** • Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. Students could *analyze and interpret data, using logical reasoning, to make sense of a phenomenon* [related to] ***energy being moved from place to place through light***. 4-PS3-2 **Using Mathematical and Computational Thinking** • Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success. Students could *decide if qualitative or quantitative data are best to determine whether a proposed object or tool* [that] ***transfers energy from place to place*** *meets criteria for success.* 4-PS3-2 and 4-PS3-4 **Constructing Explanations and Designing Solutions** • Identify the evidence that supports particular points in an explanation. Students could *identify the evidence that supports particular points in an explanation* [that] ***electric currents can be used to produce motion, sound, heat, or light***. 4-PS3-4 **Engaging in Argument From Evidence** • Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. Students could *make a claim about the merit of a solution to a problem* [related to the movement of] ***energy from place to place through electric currents*** *by citing relevant evidence about how it meets the criteria and constraints of the problem*. 4-PS3-2

Additional Practices Building to the PEs (Continued)	**Obtaining, Evaluating and Communicating Information** • Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices. Students could *combine information from written text with information from diagrams and charts* [about] ***high-tech devices, such as computers or cell phones,*** [that] ***can convert information from digitized form to voice and vice versa*** *to define a simple design problem*. 4-PS4-3
Additional Crosscutting Concepts Building to the PEs	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change. Students could describe that *cause and effect relationships*—[such as] ***when objects collide, energy can be transferred from one object to another, thereby changing their motion***—*are routinely identified and used to explain change*. 4-PS3-2 **Systems and Systems Models** • A system can be described in terms of its components and their interactions. Students could describe ***objects colliding, the energy*** [that is] ***transferred from one object to another,*** [and] ***the surrounding air*** [as] *a system,* [and could describe that system] *in terms of* [its] *components and their interactions.* 4-PS3-2 **Stability and Change** • Change is measured in terms of differences over time and may occur at different rates. Students could describe how *change is measured in terms of differences over time and may occur at different rates*, [using the] ***transformation*** [of] ***the energy of motion into electrical energy*** as an example. 4-PS3-4
Additional Connections to Nature of Science	**Science Investigations Use a Variety of Methods** • Science investigations use a variety of methods, tools, and techniques. Students could describe that science investigations *use a variety of methods, tools, and techniques*, [using as an example the variety of methods that could be used to investigate that] ***energy can be moved from place to place by moving objects or through sound, light, or electric currents***. 4-PS3-2 **Science is a Human Endeavor** • Science affects everyday life. Students could use their understanding of ***the use of devices to transmit digitized information over long distances*** [to describe that] *science affects everyday life*. 4-PS4-3

4-PS3-2 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 expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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.

Disciplinary Core Ideas

PS3.A: Definitions of Energy

- Energy can be moved from place to place by moving objects or through sound, light, or electric currents.

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.
- Light also transfers energy from place to place.
- 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.

Crosscutting Concepts

Energy and Matter

- Energy can be transferred in various ways and between objects.

Observable features of the student performance by the end of the grade:		
1	Identifying the phenomenon under investigation	
	a	From the given investigation plan, students describe* the phenomenon under investigation, which includes the following ideas:
		i. The transfer of energy, including:
		1. Collisions between objects.
		2. Light traveling from one place to another.
		3. Electric currents producing motion, sound, heat, or light.
		4. Sound traveling from one place to another.
		5. Heat passing from one object to another.
		6. Motion, sound, heat, and light causing a different type of energy to be observed after an interaction (e.g., in a collision between two objects, one object may slow down or stop, the other object may speed up, and the objects and surrounding air may be heated; a specific sound may cause the movement of an object; the energy associated with the motion of an object, via an electrical current, may be used to turn on a light).
	b	Students describe* the purpose of the investigation, which includes providing evidence for an explanation of the phenomenon, including the idea that energy can be transferred from place to place by:
		i. Moving objects.

		ii. Sound.
		iii. Light.
		iv. Heat.
		v. Electric currents.
2	Identifying the evidence to address the purpose of the investigation	
	a	From the given investigation plan, students describe* the data to be collected that will serve as the basis for evidence, including:
		i. The motion and collision of objects before and after an interaction (e.g., when a given object is moving fast, it can move another object farther than when the same object is moving more slowly).
		ii. The relative presence of sound, light, or heat (including in the surrounding air) before and after an interaction (e.g. shining a light on an object can increase the temperature of the object; a sound can move an object).
		iii. The presence of electric currents flowing through wires causally linking one form of energy output (e.g., a moving object) to another form of energy output (e.g., another moving object; turning on a light bulb).
	b	Students describe* how their observations will address the purpose of the investigation, including how the observations will provide evidence that energy, in the form of light, sound, heat, and motion, can be transferred from place to place by sound, light, heat, or electric currents (e.g., in a system in which the motion of an object generates an observable electrical current to turn on a light, energy (from the motion of an object) must be transferred to another place (energy in the form of the light bulb) via the electrical current, because the motion doesn't cause the light bulb to light up if the wire is not completing a circuit between them; when a light is directed at an object, energy (in the form of light) must be transferred from the source of the light to its destination and can be observed in the form of heat, because if the light is blocked, the object isn't warmed.
3	Planning the investigation	
	a	From the given investigation plan, students identify and describe* how the data will be observed and recorded, including the tools and methods for collecting data on:
		i. The motion and collision of objects, including any sound or heat producing the motion/collision, or produced by the motion/collision.
		ii. The presence of energy in the form of sound, light, or heat in one place as a result of sound, light, or heat in a different place.
		iii. The presence of electric currents in wires and the presence of energy (in the form of sound, light, heat, or motion resulting from the flow of electric currents through a device).
	b	Students describe* the number of trials, controlled variables, and experimental set up.
4	Collecting the data	
	a	Students make and record observations according to the given investigation plan to provide evidence that:
		i. Energy is present whenever there are moving objects, sound, light, or heat.
		ii. That energy has been transferred from place to place (e.g., a bulb in a circuit is not lit until a switch is closed and it lights, indicating that energy is transferred through electric current in a wire to light the bulb; a stationary ball is struck by a moving ball, causing the stationary ball to move and the moving ball to slow down, indicating that energy has been transferred from the moving ball to the stationary one).

4-PS3-4 Energy

Students who demonstrate understanding can:

4-PS3-4. **Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*** [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [*Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 3–5 builds on K–2 experiences 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.

- Apply scientific ideas to solve design problems.

Disciplinary Core Ideas

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.

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.

ETS1.A: Defining Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.*(secondary)*

Crosscutting Concepts

Energy and Matter

- Energy can be transferred in various ways and between objects.

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Connections to Engineering, Technology, and Applications of Science

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

- Engineers improve existing technologies or develop new ones.

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Connections to Nature of Science

Science is a Human Endeavor

- Most scientists and engineers work in teams.
- Science affects everyday life.

Observable features of the student performance by the end of the grade:		
1	Using scientific knowledge to generate design solutions	
	a	Given a problem to solve, students collaboratively design a solution that converts energy from one form to another. In the design, students:
		i. Specify the initial and final forms of energy (e.g., electrical energy, motion, light).
		ii. Identify the device by which the energy will be transformed (e.g., a light bulb to convert electrical energy into light energy, a motor to convert electrical energy into energy of motion).
2	Describing* criteria and constraints, including quantification when appropriate	
	a	Students describe* the given criteria and constraints of the design, which include:
		i. Criteria:
		1. The initial and final forms of energy.
		2. Description* of how the solution functions to transfer energy from one form to another.

		ii. Constraints:
		1. The materials available for the construction of the device.
		2. Safety considerations.
3	Evaluating potential solutions	
	a	Students evaluate the proposed solution according to how well it meets the specified criteria and constraints of the problem.
4	Modifying the design solution	
	a	Students test the device and use the results of the test to address problems in the design or improve its functioning.

4-PS4-3 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

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

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 3–5 builds on K–2 experiences 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.

- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.

Disciplinary Core Ideas

PS4.C: Information Technologies and Instrumentation

- Digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa.

ETS1.C: Optimizing the Design Solution

- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. *(secondary)*

Crosscutting Concepts

Patterns

- Similarities and differences in patterns can be used to sort and classify designed products.

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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.

Observable features of the student performance by the end of the grade:		
1	Using scientific knowledge to generate design solutions	
	a	Students generate at least two design solutions, for a given problem, that use patterns to transmit a given piece of information (e.g., picture, message). Students describe* how the design solution is based on:
		i. Knowledge of digitized information transfer (e.g., information can be converted from a sound wave into a digital signal such as patterns of 1s and 0s and vice versa; visual or verbal messages can be encoded in patterns of flashes of light to be decoded by someone else across the room).
		ii. Ways that high-tech devices convert and transmit information (e.g., cell phones convert sound waves into digital signals, so they can be transmitted long distances, and then converted back into sound waves; a picture or message can be encoded using light signals to transmit the information over a long distance).
2	Describing* criteria and constraints, including quantification when appropriate	
	a	Students describe* the given criteria for the design solutions, including the accuracy of the final transmitted information and that digitized information (patterns) transfer is used.
	b	Students describe* the given constraints of the design solutions, including:
		i. The distance over which information is transmitted.
		ii. Safety considerations.
		iii. Materials available.
3	Evaluating potential solutions	
	a	Students compare the proposed solutions based on how well each meets the criteria and constraints.
	b	Students identify similarities and differences in the types of patterns used in the solutions to determine whether some ways of transmitting information are more effective than others at addressing the problem.