*Unless otherwise specified, "descriptions" referenced in the evidence statements could include but are not limited to written, oral, pictorial, and kinesthetic descriptions.

4-PS3-1 Energy

Students who demonstrate understanding can:

4-PS3-1. **Use evidence to construct an explanation relating the speed of an object to the energy of that object.** [*Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.*

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.

- Use evidence (e.g., measurements, observations, patterns) to construct an explanation.

Disciplinary Core Ideas

PS3.A: Definitions of Energy

- The faster a given object is moving, the more energy it possesses.

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	Articulating the explanation of phenomena		
	a	Students articulate a statement that relates the given phenomenon to a scientific idea, including that the speed of a given object is related to the energy of the object (e.g., the faster an object is moving, the more energy it possesses).	
	b	Students use the evidence and reasoning to construct an explanation for the phenomenon.	
2	Evidence		
	a	Students identify and describe* the relevant given evidence for the explanation, including:	
		i.	The relative speed of the object (e.g., faster vs. slower objects).
		ii.	Qualitative indicators of the amount of energy of the object, as determined by a transfer of energy from that object (e.g., more or less sound produced in a collision, more or less heat produced when objects rub together, relative speed of a ball that was stationary following a collision with a moving object, more or less distance a stationary object is moved).
3	Reasoning		
	a	Students use reasoning to connect the evidence to support an explanation for the phenomenon. In the explanation, students describe* a chain of reasoning that includes:	
		i.	Motion can indicate the energy of an object.
		ii.	The faster a given object is moving, the more observable impact it can have on another object (e.g., a fast-moving ball striking something (a gong, a wall) makes more noise than does the same ball moving slowly and striking the same thing).
		iii.	The observable impact of a moving object interacting with its surroundings reflects how much energy was able to be transferred between objects and therefore relates to the energy of the moving object.
		iv.	Because faster objects have a larger impact on their surroundings than objects moving more slowly, they have more energy due to motion (e.g., a fast-moving ball striking a gong makes more noise than a slow-moving ball doing the same thing because it has more energy that can be transferred to the gong, producing more sound). [Note: This refers only to relative bulk motion energy, not potential energy, to remain within the DCI.]
		v.	Therefore, the speed of an object is related to the energy of the object.

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-PS3-3 Energy

Students who demonstrate understanding can:

4-PS3-3. **Ask questions and predict outcomes about the changes in energy that occur when objects collide.** [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [*Assessment Boundary: Assessment does not include quantitative measurements of energy.*]

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

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.

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.

PS3.C: Relationship Between Energy and Forces

- When objects collide, the contact forces transfer energy so as to change the objects' motions.

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	Addressing phenomena of the natural world	
	a	Students ask questions about the changes in energy that occur when objects collide, the answers to which would clarify:
		i. A qualitative measure of energy (e.g., relative motion, relative speed, relative brightness) of the object before the collision.
		ii. The mechanism of energy transfer during the collision, including:
		1. The transfer of energy by contact forces between colliding objects that results in a change in the motion of the objects.
		2. The transfer of energy to the surrounding air when objects collide resulting in sound and heat.
	b	Students predict reasonable outcomes about the changes in energy that occur after objects collide, based on patterns linking object collision and energy transfer between objects and the surrounding air.
2	Identifying the scientific nature of the question	
	a	Students ask questions that can be investigated within the scope of the classroom or an outdoor environment.

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-PS4-1 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

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

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

Developing and Using Models
Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.

- Develop a model using an analogy, example, or abstract representation to describe a scientific principle.

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Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science findings are based on recognizing patterns.

Disciplinary Core Ideas

PS4.A: Wave Properties

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

Crosscutting Concepts

Patterns

- Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena.

Observable features of the student performance by the end of the grade:			
1	Components of the model		
	a	Students develop a model (e.g., diagrams, analogies, examples, abstract representations, physical models) to make sense of a phenomenon that involves wave behavior. In the model, students identify the relevant components, including:	
		i.	Waves.
		ii.	Wave amplitude.
		iii.	Wavelength.
		iv.	Motion of objects.
2	Relationships		
	a	Students identify and describe* the relevant relationships between components of the model, including:	
		i.	Waves can be described* in terms of patterns of repeating amplitude and wavelength (e.g., in a water wave there is a repeating pattern of water being higher and then lower than the baseline level of the water).
		ii.	Waves can cause an object to move.
		iii.	The motion of objects varies with the amplitude and wavelength of the wave carrying it.
3	Connections		
	a	Students use the model to describe*:	
		i.	The patterns in the relationships between a wave passing, the net motion of the wave, and the motion of an object caused by the wave as it passes.
		ii.	How waves may be initiated (e.g., by disturbing surface water or shaking a rope or spring).
		iii.	The repeating pattern produced as a wave is propagated.
	b	Students use the model to describe* that waves of the same type can vary in terms of amplitude and wavelength and describe* how this might affect the motion, caused by a wave, of an object.	

	c	Students identify similarities and differences in patterns underlying waves and use these patterns to describe* simple relationships involving wave amplitude, wavelength, and the motion of an object (e.g., when the amplitude increases, the object moves more).

4-PS4-2 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

4-PS4-2. **Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.** [*Assessment Boundary: Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works.*]

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	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop a model to describe phenomena.	**PS4.B: Electromagnetic Radiation** • An object can be seen when light reflected from its surface enters the eyes.	**Cause and Effect** • Cause and effect relationships are routinely identified.

Observable features of the student performance by the end of the grade:			
1	Components of the model		
	a	Students develop a model to make sense of a phenomenon involving the relationship between light reflection and visibility of objects. In the model, students identify the relevant components, including:	
		i.	Light (including the light source).
		ii.	Objects.
		iii.	The path that light follows.
		iv.	The eye.
2	Relationships		
	a	Students identify and describe* causal relationships between the components, including:	
		i.	Light enters the eye, allowing objects to be seen.
		ii.	Light reflects off of objects, and then can travel and enter the eye.
		iii.	Objects can be seen only if light follows a path between a light source, the object, and the eye.
3	Connections		
	a	Students use the model to describe* that in order to see objects that do not produce their own light, light must reflect off the object and into the eye.	
	b	Students use the model to describe* the effects of the following on seeing an object:	
		i.	Removing, blocking, or changing the light source (e.g., a dimmer light).
		ii.	Closing the eye.
		iii.	Changing the path of the light (e.g., using mirrors to direct the path of light to allow the visualization of a previously unseen object or to change the position in which the object can be seen, using an opaque or translucent barrier between 1) the light source and the object or 2) the object and the eye to change the path light follows and the visualization of the object).

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.