4th Grade - Topical Model - Bundle 3
Energy and Collisions

This is the third 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 3 Question: This bundle is assembled to address the question "what happens when objects collide?"

Summary

The bundle organizes performance expectations around the theme of *energy and collisions.* 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 concept that the faster a given object is moving, the more energy it possesses (PS3.A as in 4-PS3-1) connects to many other ideas about energy in this bundle, including the idea that energy is present whenever there are moving objects (PS3.B as in 4-PS3-3), and that When objects collide, the contact forces transfer energy so as to change the objects' motion (PS3.C as in 4-PS3-3).

The engineering design idea that different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints (ETS1.C as in 3-5-ETS1-3) can be applied to multiple science concepts in this bundle, such as that the faster a given object is moving, the more energy it possesses (PS3.A as in 4-PS3-1) and when objects collide, energy can be transferred from one object to another, thereby changing their motion (PS3.A as in 4-PS3-3). Connections could be made through engineering design challenges, such as one in which students attempt to reduce or increase the amount of energy a moving object has, or one in which students attempt to reduce or increase the amount of energy transferred from one object to another in a collision. In either case, different student solutions could be tested to determine which best meets the criteria within the identified constraints.

Bundle Science and Engineering Practices

Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the practices of asking questions and defining problems (4-PS3-3), developing and using models (4-PS4-1), planning and carrying out investigations (3-5-ETS1-3), and constructing explanations and designing solutions (4-PS3-1). 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-PS4-1) and Energy and Matter (4-PS3-1 and 4-PS3-3). Many other crosscutting concepts elements can be used in instruction.

All instruction should be three-dimensional

Performance Expectations	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.*] 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.*] 3-5-ETS1-3 **Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.***

Example Phenomena	A tennis ball that hits a wall bounces off. You hear a sound when a book is dropped.
Additional Practices Building to the PEs	**Asking Questions and Defining Problems** • Identify scientific (testable) and non-scientific (non-testable) questions. Students could *identify* [which] *questions* [about the speed of] ***a given object*** [are] *scientific (testable) and non-scientific (non-testable).* 4-PS3-1 **Developing and Using Models** • Develop and/or use models to describe and/or predict phenomena. Students could *use models to predict* [whether] ***objects' motions*** [will change] ***when objects collide***. 4-PS3-3 **Planning and Carrying Out Investigations** • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. Students could *make observations and/or measurements to produce data to serve as the basis for evidence* [about the relationship between the speed] ***a given object is moving*** [and] ***the energy it possesses***. 4-PS3-1 **Analyzing and Interpreting Data** • Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings. Students could *compare and contrast data collected by different groups* [about the relationship between the speed] ***a given object is moving*** [and] ***the energy it possesses*** *in order to discuss similarities and differences in their findings*. 4-PS3-1 **Using Mathematical and Computational Thinking** • Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems. Students could *measure and estimate quantities such as temperature to address engineering problems* [related to the] ***transfer of energy to the surrounding air when objects collide***. 4-PS3-3 **Constructing Explanations and Designing Solutions** • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. Students could *use evidence (e.g., measurements, observations, patterns) to support an explanation for a phenomenon* [related to the concept that] ***the faster an object is moving, the more energy it possesses***. 4-PS3-1

Additional Practices Building to the PEs (Continued)	**Engaging in Argument from Evidence** • Construct and/or support an argument with evidence, data, and/or a model. Students could *construct an argument with evidence* [that] ***identifying failure points or difficulties through tests*** [of design solutions meant to increase the] ***energy of an object*** [through its speed] ***suggests the elements of the design that need to be improved***. 3-5-ETS1-3 **Obtaining, Evaluating and Communicating Information** • Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence. Students could *read and comprehend grade-appropriate complex texts to summarize technical ideas about* [how] ***tests*** [of] ***collisions*** [between] ***objects are often designed to identify failure points or difficulties***. 4-PS3-3 and 3-5-ETS1-3
Additional Crosscutting Concepts Building to the PEs	**Patterns** • Patterns of change can be used to make predictions. Students could describe the *pattern of change* [between] ***collisions*** [between] ***objects*** [and] ***energy transfer to the surrounding air*** and use this *pattern to make predictions*. 4-PS3-1 **Cause and Effect** • Cause and effect relationships are routinely identified, tested, and used to explain change. Students could *identify cause and effect relationships* [such as between] ***sound*** [and] ***the movement of energy from place to place;*** students could *use* [these relationships] *to explain change*. 4-PS3-3 **Scale, Proportion, and Quantity** • Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. Students could describe why *standard units are used to measure and describe physical quantities such as time* [as they investigate the relationship between the speed] ***a given object is moving, the energy it possesses***. 4-PS3-1
Additional Connections to Nature of Science	**Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Science explanations describe the mechanisms for natural events. Students could *describe the mechanism*, [e.g.,] ***electric currents***, *for natural events*, [such as] ***energy moving from place to place***. 4-PS3-3 **Science is a Human Endeavor** • Most scientists and engineers work in teams. Students can describe that *most scientists and engineers work in teams*, [just as they did when investigating that] ***the faster a given object is moving, the more energy it possesses*.** 4-PS3-1

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-PS3-3 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.

3-5-ETS1-3 Engineering Design

Students who demonstrate understanding can:

3-5-ETS1-3. **Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.**

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.

- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.

Disciplinary Core Ideas

ETS1.B: Developing Possible Solutions

- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.

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.

Crosscutting Concepts

Observable features of the student performance by the end of the grade:			
1	Identifying the purpose of the investigation		
	a	Students describe* the purpose of the investigation, which includes finding possible failure points or difficulties to identify aspects of a model or prototype that can be improved.	
2	Identifying the evidence to be address the purpose of the investigation		
	a	Students describe* the evidence to be collected, including:	
		i.	How well the model/prototype performs against the given criteria and constraints.
		ii.	Specific aspects of the prototype or model that do not meet one or more of the criteria or constraints (i.e., failure points or difficulties).
		iii.	Aspects of the model/prototype that can be improved to better meet the criteria and constraints.
	b	Students describe* how the evidence is relevant to the purpose of the investigation.	
3	Planning the investigation		
	a	Students create a plan for the investigation that describes* different tests for each aspect of the criteria and constraints. For each aspect, students describe*:	
		i.	The specific criterion or constraint to be used.
		ii.	What is to be changed in each trial (the independent variable).
		iii.	The outcome (dependent variable) that will be measured to determine success.
		iv.	What tools and methods are to be used for collecting data.
		v.	What is to be kept the same from trial to trial to ensure a fair test.
4	Collecting the data		
	a	Students carry out the investigation, collecting and recording data according to the developed plan.	