

4th Grade - Thematic Model - Bundle 1

Energy, Motion, and Weathering

This is the first bundle of the 4th Grade Thematic Model. Each bundle has connections to the other bundles in the course, as shown in the [Course Flowchart](#).

Bundle 1 Question: This bundle is assembled to address the question “what evidence of patterns and systems do we see in motion, weathering, fossils, and rock formation?”

Summary

The bundle organizes performance expectations with a focus on helping students build understanding of systems and energy related to motion, weathering, fossils, and rock formation. 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 living things affect the physical characteristics of their regions (ESS2.E as in 4-ESS2-1) connects to the idea that water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around (ESS2.A as in 4-ESS2-1). These processes cause changes in Earth’s features, connecting to the idea that local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes (ESS1.C as in 4-ESS1-1). This concept also connects to the idea that when objects collide, energy can be transferred from one object to another, thereby changing their motion (PS3.B as in 4-PS3-3). This idea also connects to the concepts that the faster a given object is moving, the more energy it possesses (PS3.A as in 4-PS3-1), that energy can be moved from place to place by moving objects or through sound, light, or electric currents (PS3.A as in 4-PS3-3), and that when objects collide, the contact forces transfer energy so as to change the objects’ motions (PS3.C as in 4-PS3-3).

The engineering design idea that research on a problem should be carried out before beginning to design a solution (ETS1.B as in 3-5-ETS1-2) could be applied to multiple science concepts such as that water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around (ESS2.A as in 4-ESS2-1), and that when objects collide, energy can be transferred from one object to another, thereby changing their motion (PS3.A as in 4-PS3-3). These connections could be made through engineering design tasks, such as by having students design a solution to reduce effects of weathering or erosion by water, ice, wind, or living organisms, and by having students attempt to reduce or increase the amount of energy transferred from one object to another in a collision. In either case, students should learn about the importance of researching the given problem before beginning to design a solution.

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), planning and carrying out investigations (4-ESS2-1), and constructing explanations and designing solutions (4-PS3-1, 4-ESS1-1, and 3-5-ETS1-2). 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-ESS1-1), Cause and Effect (4-ESS2-1), 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.

<p>Performance Expectations</p> <p>4-ESS2-1 and 3-5-ETS1-2 are partially assessable.</p>	<p>4-PS3-1 Use evidence to construct an explanation relating the speed of an object to the energy of that object. <i>[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.]</i></p> <p>4-PS3-3 Ask questions and predict outcomes about the changes in energy that occur when objects collide. <i>[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.]</i></p> <p>4-ESS1-1 Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. <i>[Clarification Statement: Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time; and, a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.] [Assessment Boundary: Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.]</i></p> <p>4-ESS2-1 Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. <i>[Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [Assessment Boundary: Assessment is limited to a single form of weathering or erosion.]</i></p> <p>3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.</p>
<p>Example Phenomena</p>	<p>A tennis ball that hits the wall will make a louder sound when it is thrown faster.</p> <p>Hills without vegetation tend to have deep cuts, or gullies, in the soil, whereas hills with vegetation have fewer gullies.</p>
<p>Additional Practices Building to the PEs</p>	<p>Asking Questions and Defining Problems</p> <ul style="list-style-type: none"> Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. <p>Students could <i>ask questions</i> [about how] <i>living organisms break rocks, soils, and sediments into smaller particles and move them around that can be investigated, and predict reasonable outcomes based on patterns such as cause and effect relationships.</i> 4-ESS2-1</p> <p>Developing and Using Models</p> <ul style="list-style-type: none"> Identify limitations of models. <p>Students could <i>identify limitations of models</i> [that describe that] <i>when objects collide, some energy is typically also transferred to the surrounding air.</i> 4-PS3-3</p> <p>Planning and Carrying Out Investigations</p> <ul style="list-style-type: none"> 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. <p>Students could <i>make observations and measurements to serve as the basis for evidence for an explanation</i> [that] <i>the faster a given object is moving, the more energy it possesses.</i> 4-PS3-1</p>

<p>Additional Practices Building to the PEs (Continued)</p>	<p>Analyzing and Interpreting Data</p> <ul style="list-style-type: none"> • Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships. Students could <i>represent data in various graphical displays to reveal patterns that indicate relationships</i> [between] the location of certain fossil types [and] the order in which rock layers were formed. 4-ESS1-1 <p>Using Mathematical and Computational Thinking</p> <ul style="list-style-type: none"> • Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems. Students could <i>measure and graph quantities, such as time, to address engineering problems</i> [related to the idea that] the faster a given object is moving, the more energy it possesses. 4-PS3-1 <p>Constructing Explanations and Designing Solutions</p> <ul style="list-style-type: none"> • Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). Students could <i>construct an explanation of observed</i> [cause and effect] <i>relationships</i> [between] living things [and] the physical characteristics of their regions, [such as the relationship between vegetation and erosion]. 4-ESS2-1 <p>Engaging in Argument from Evidence</p> <ul style="list-style-type: none"> • Construct and/or support an argument with evidence, data, and/or a model. Students could <i>construct and/or support an argument with evidence</i> [that] local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. 4-ESS1-1 <p>Obtaining, Evaluating, and Communicating Information</p> <ul style="list-style-type: none"> • 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 <i>read and comprehend grade-appropriate complex texts and/or other reliable media to obtain scientific ideas</i> [about] energy moving from place to place by moving objects or through sound, light, or electric currents and to describe [how these ideas are] <i>supported by evidence</i>. 4-PS3-3
<p>Additional Crosscutting Concepts Building to the PEs</p>	<p>Patterns</p> <ul style="list-style-type: none"> • Patterns of change can be used to make predictions. Students could use the <i>pattern of change</i> [between] the energy [of a] moving object [and] the [speed the] object is moving to make predictions. 4-PS3-1 <p>Scale, Proportion, and Quantity</p> <ul style="list-style-type: none"> • Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. Students could identify <i>observable phenomena</i> [such as the results of] water, ice, wind, living organisms, and gravity breaking rocks, soils, and sediments into smaller particles and moving them around [that] <i>exist from the very small to the immensely large or from very short to very long time periods</i>. 4-ESS2-1

<p>Additional Crosscutting Concepts Building to the PEs (Continued)</p>	<p>Stability and Change</p> <ul style="list-style-type: none"> • Change is measured in terms of differences over time and may occur at different rates. <p>Students could use examples of <i>the presence and location of certain fossil types</i> [that] <i>indicate the order in which rock layers were formed</i> [and] <i>patterns of rock formations due to earth forces</i> [to provide evidence] <i>that change is measured in terms of differences over time and may occur at different rates.</i> 4-ESS2-1</p>
<p>Additional Connections to Nature of Science</p>	<p>Science Investigations Use a Variety of Methods</p> <ul style="list-style-type: none"> • Science methods are determined by questions. <p>Students could describe how the <i>science methods</i> [they used to investigate that] <i>energy can be moved from place to place by moving objects or through sound, light, or electric currents</i> [were] <i>determined by</i> [their] <i>questions.</i> 4-PS3-3</p> <p>Scientific Knowledge is Based on Empirical Evidence</p> <ul style="list-style-type: none"> • Science findings are based on recognizing patterns. <p>Students could use [patterns of] <i>living things affecting the physical characteristics of their regions</i> [to describe that] <i>science findings are based on recognizing patterns.</i> 4-ESS2-1</p>

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	Disciplinary Core Ideas	Crosscutting Concepts
<p>Constructing Explanations and Designing Solutions</p> <p>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.</p> <ul style="list-style-type: none"> Use evidence (e.g., measurements, observations, patterns) to construct an explanation. 	<p>PS3.A: Definitions of Energy</p> <ul style="list-style-type: none"> The faster a given object is moving, the more energy it possesses. 	<p>Energy and Matter</p> <ul style="list-style-type: none"> 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: <ol style="list-style-type: none"> 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: <ol style="list-style-type: none"> 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.

4-ESS1-1 Earth's Place in the Universe

Students who demonstrate understanding can:

- 4-ESS1-1. Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.** [Clarification Statement: Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time; and, a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.] [Assessment Boundary: Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.]

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.

- Identify the evidence that supports particular points in an explanation.

Disciplinary Core Ideas

ESS1.C: The History of Planet Earth

- Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed.

Crosscutting Concepts

Patterns

- Patterns can be used as evidence to support an explanation.

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes consistent patterns in natural systems.

Observable features of the student performance by the end of the grade:

1	Articulating the explanation of phenomena
a	Students identify the given explanation for a phenomenon, which includes a statement about the idea that landscapes change over time.
b	From the given explanation, students identify the specific aspects of the explanation they are supporting with evidence.
2	Evidence
a	Students identify the evidence relevant to supporting the explanation, including local and regional patterns in the following: <ol style="list-style-type: none"> Different rock layers found in an area (e.g., rock layers taken from the same location show marine fossils in some layers and land fossils in other layers). Ordering of rock layers (e.g., layer with marine fossils is found below layer with land fossils). Presence of particular fossils (e.g., shells, land plants) in specific rock layers. The occurrence of events (e.g., earthquakes) due to Earth forces.
3	Reasoning
a	Students use reasoning to connect the evidence to support particular points of the explanation, including the identification of a specific pattern of rock layers and fossils (e.g., a rock layer containing shells and fish below a rock layer containing fossils of land animals and plants is a pattern indicating that, at one point, the landscape had been covered by water and later it was dry land). Students describe* reasoning for how the evidence supports particular points of the explanation, including: <ol style="list-style-type: none"> Specific rock layers in the same location show specific fossil patterns (e.g., some lower rock layers have marine fossils, while some higher rock layers have fossils of land plants). Since lower layers were formed first then covered by upper layers, this pattern indicates that the landscape of the area was transformed into the landscape indicated by the upper layer (e.g., lower marine fossils indicate that, at one point, the landscape was covered by water, and upper land fossils indicate that later the landscape was dry land).

		iii. Irregularities in the patterns of rock layers indicate disruptions due to Earth forces (e.g., a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock).
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4-ESS2-1 Earth's Systems

Students who demonstrate understanding can:

- 4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.** [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [Assessment Boundary: Assessment is limited to a single form of weathering or erosion.]

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 and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.

Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems

- Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.

ESS2.E: Biogeology

- Living things affect the physical characteristics of their regions.

Crosscutting Concepts

Cause and Effect

- Cause and effect relationships are routinely identified, tested, and used to explain change.

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 identify the phenomenon under investigation, which includes the following idea: the effects of weathering or the rate of erosion of Earth's materials.	
	b	From the given investigation plan, students identify the purpose of the investigation, which includes providing evidence for an explanation of the phenomenon.	
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.	
	b	From the given investigation plan, students describe* the evidence needed, based on observations and/or measurements made during the investigation, including:	
		i.	The change in the relative steepness of slope of the area (e.g., no slope, slight slope, steep slope).
		ii.	The kind of weathering or erosion to which the Earth material is exposed.
iii.		The change in the shape of Earth materials as the result of weathering or the rate of erosion by one of the following:	
1.	Motion of water.		
2.	Ice (including melting and freezing processes).		
3.	Wind (speed and direction).		
4.	Vegetation.		
c	Students describe* how the data to be collected will serve as evidence to address the purpose of the investigation, including to help identify cause and effect relationships between weathering or erosion, and Earth materials.		
3	Planning the investigation		
	a	From the given investigation plan, students describe* how the data will be collected, including:	
		i.	The relative speed of the flow of air or water.
		ii.	The number of cycles of freezing and thawing.
iii.	The number and types of plants growing in the Earth material.		

		iv. The relative amount of soil or sediment transported by erosion.
		v. The number or size of rocks transported by erosion.
		vi. The breakdown of materials by weathering (e.g., ease of breaking before or after weathering, size/number of rocks broken down).
	b	Students describe* the controlled variables, including:
		i. Those variables that affect the movement of water (e.g., flow speed, volume, slope).
		ii. Those variables that affect the movement of air.
		iii. The water temperature and forms of matter (e.g., freezing, melting, room temperature).
		iv. The presence or absence of plants growing in or on the Earth material.
4	Collecting the data	
	a	Students make and record observations according to the given investigation plan to provide evidence for the effects of weathering or the rate of erosion on Earth materials (e.g., rocks, soils, and sediment).

3-5-ETS1-2 Engineering Design

Students who demonstrate understanding can:

- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.**

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 problem.

Disciplinary Core Ideas

ETS1.B: Developing Possible Solutions

- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions.
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.

Crosscutting Concepts

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

- Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

Observable features of the student performance by the end of the grade:

1	Using scientific knowledge to generate design solutions	
	a	Students use grade-appropriate information from research about a given problem, including the causes and effects of the problem and relevant scientific information.
	b	Students generate at least two possible solutions to the problem based on scientific information and understanding of the problem.
	c	Students specify how each design solution solves the problem.
	d	Students share ideas and findings with others about design solutions to generate a variety of possible solutions.
2	Describing* criteria and constraints, including quantification when appropriate	
	a	Students describe*: <ol style="list-style-type: none"> The given criteria (required features) and constraints (limits) for the solutions, including increasing benefits, decreasing risks/costs, and meeting societal demands as appropriate. How the criteria and constraints will be used to generate and test the design solutions.
	e	Students describe* the necessary steps for designing a solution to a problem, including conducting research and communicating with others throughout the design process to improve the design [note: emphasis is on what is necessary for designing solutions, not on a step-wise process].
3	Evaluating potential solutions	
	a	Students test each solution under a range of likely conditions and gather data to determine how well the solutions meet the criteria and constraints of the problem.
	b	Students use the collected data to compare solutions based on how well each solution meets the criteria and constraints of the problem.