4th Grade - Topical Model - Bundle 4
Waves and Erosion

This is the fifth 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 4 Question: This bundle is assembled to address the question "what effect can water have on land?"

Summary

The bundle organizes performance expectations around the theme of *waves and erosion.* 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 rainfall, water, ice, wind, and living organisms help to shape the land (ESS2.A as in 4-ESS2-1) connects to the idea waves, which are regular patterns of motion, can be made in water by disturbing the surface, and can cause objects to move (PS4.A as in 4-PS4-1).

Another concept related to affecting the land is that living things affect the physical characteristics of their regions (ESS2.E as in 4-ESS2-1). And the relationship between living things and the land connects to the ideas that the presence and location of certain fossil types indicate the order in which rock layers were formed (ESS1.C as in 4-ESS1-1), and that rainfall affects the types of living things found in a region (ESS2.A as in 4-ESS2-1).

The engineering design idea that testing a solution involves investigating how well it performs under a range of likely conditions (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 waves can cause objects to move (PS4.A as in 4-PS4-1). Connections could be made through tasks such as by having students design a solution to reduce effects of erosion by wind, or by having students design a solution to ocean waves moving beach sand. Either kind of design should be tested within a range of likely conditions since rates of erosion can vary, as can the size of waves.

Bundle Science and Engineering Practices

Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the practices of developing and using models (4-PS4-1), planning and carrying out investigations (4-ESS2-1), and constructing explanations and designing solutions (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-PS4-1 and 4-ESS1-1) and Cause and Effect (4-ESS2-1). Many other crosscutting concepts elements can be used in instruction.

All instruction should be three-dimensional.

Performance Expectations 4-PS4-1 and 3-5-ETS1-2 are partially assessable.	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.*]

Performance Expectations (Continued)	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.*] 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.*] 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.***
Example Phenomena	In bends in rivers, the outside of a bend has a steeper bank than the inside of a bend. Waves can be produced using a slinky.
Additional Practices Building to the PEs	**Asking Questions and Defining Problems** • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. Students could *ask questions* [about] ***gravity breaking rocks, soils, and sediments into smaller particles and moving them around*** *that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.* 4-ESS2-1 **Developing and Using Models** • Develop and/or use models to describe and/or predict phenomena. Students could *develop a model to describe* [that] ***local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes,*** [and that] ***the presence and location of certain fossil types indicate the order in which rock layers were formed***. 4-ESS1-1 **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 for an explanation of a phenomenon* [related to] ***waves moving across the surface of deep water,*** [including that] ***the water goes up and down in place*** [and that] ***there is no net motion in the direction of the wave.*** 4-PS4-1

Additional Practices Building to the PEs (Continued)	**Analyzing and Interpreting Data** • Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships. Students could *represent data in various graphical displays to reveal patterns that indicate relationships* [between] ***ice*** [and the] ***breaking*** [of] ***rocks, soils, and sediments into smaller particles***. 4-ESS2-1 **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 *describe and measure quantities*, [such as length], *to address questions* [about the] ***amplitude and wavelength*** [of] ***waves***. 4-PS4-1 **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] ***waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks)***. 4-PS4-1 **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**] *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***. 4-PS4-1 **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 in written text with information in charts to support an argument* [about how] ***rainfall affects the types of living things found in a region***. 4-ESS2-1
Additional Crosscutting Concepts Building to the PEs	**Cause and Effect** • Cause and effect relationships are routinely identified, tested, and used to explain change. Students could use *cause and effect relationships* [between] ***the presence of certain fossil types*** [and] ***the order in which rock layers were formed*** *to* [construct explanations]. 4-ESS1-1 **Scale, Proportion and Quantity** • 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 *observable phenomena* [related to] ***local, regional, and global patterns of rock formations*** [that occurred over] *very short* [versus] *very long time periods*. 4-ESS1-1

Additional Crosscutting Concepts Building to the PEs (Continued)	**Stability and Change** • Change is measured in terms of differences over time and may occur at different rates. Students could use examples of ***local, regional, and global patterns of rock formations*** [to explain] *that change is measured in terms of differences over time and may occur at different rates.* 4-ESS1-1
Additional Connections to Nature of Science	**Science Investigations Use a Variety of Methods** • Science methods are determined by questions. Students could describe how the *science methods* [they used to investigate] ***the presence and location of certain fossils*** [were] *determined by* [their] *questions*. 4-ESS1-1 **Scientific Knowledge is Based on Empirical Evidence** • Science findings are based on recognizing patterns. Students could use *patterns* [of] ***rainfall helping to shape the land*** [to describe that] *science findings are based on recognizing patterns*. 4-ESS2-1

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-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.

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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:
		i. 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).
		ii. Ordering of rock layers (e.g., layer with marine fossils is found below layer with land fossils).
		iii. Presence of particular fossils (e.g., shells, land plants) in specific rock layers.
		iv. 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:
		i. 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).
		ii. 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).

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.
	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].
2	Describing* criteria and constraints, including quantification when appropriate	
	a	Students describe*:
		i. The given criteria (required features) and constraints (limits) for the solutions, including increasing benefits, decreasing risks/costs, and meeting societal demands as appropriate.
		ii. How the criteria and constraints will be used to generate and test the design solutions.
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.