# TOWNSHIP OF UNION PUBLIC SCHOOLS

## Science Grade 4

# Curriculum Guide

# Updated December 18, 2018

# Mission Statement

The mission of the Township of Union Public Schools is to build on the foundations of honesty, excellence, integrity, strong family, and community partnerships. We promote a supportive learning environment where every student is challenged, inspired, empowered, and respected as diverse learners. Through cultivation of students' intellectual curiosity, skills and knowledge, our students can achieve academically and socially, and contribute as responsible and productive citizens of our global community.

# Philosophy Statement

The Township of Union Public School District, as a societal agency, reflects democratic ideals and concepts through its educational practices. It is the belief of the Board of Education that a primary function of the Township of Union Public School System is the formulation of a learning climate conducive to the needs of all students in general, providing therein for individual differences. The school operates as a partner with the home and community.

# Statement of District Goals

- Develop reading, writing, speaking, listening, and mathematical skills.
- Develop a pride in work and a feeling of self-worth, self-reliance, and self-discipline.
- Acquire and use the skills and habits involved in critical and constructive thinking.
- Develop a code of behavior based on moral and ethical principles.
- Work with others cooperatively.
- Acquire a knowledge and appreciation of the historical record of human achievement and failures and current societal issues.
- Acquire a knowledge and understanding of the physical and biological sciences.
- Participate effectively and efficiently in economic life and the development of skills to enter a specific field of work.
- Appreciate and understand literature, art, music, and other cultural activities.
- Develop an understanding of the historical and cultural heritage.
- Develop a concern for the proper use and/or preservation of natural resources.
- Develop basic skills in sports and other forms of recreation.

# Pacing Guide

**Unit 1: Weathering and Erosion** **Instructional Days: 10**

In this unit of study, students develop understandings of the effects of weathering and the rate of erosion by water, ice, wind, or vegetation. The crosscutting concepts of *patterns* and *cause and effect* are called out as organizing concepts. Students demonstrate grade-appropriate proficiency in *planning and carrying out investigations* and *constructing explanations*. Students are also expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on 4-ESS2-1 and 4-ESS1-1.

**Unit 2: Earth Processes** **Instructional Days: 10**

In this unit of study, students apply their knowledge of natural Earth processes to generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans. In order to describe patterns of Earth's features, students analyze and interpret data from maps. The crosscutting concepts of *patterns, cause and effect,* and the influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in planning and carrying out investigations, analyzing and interpreting data, and constructing explanations and designing solutions. Students are also expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on 4-ESS2-2, 4-ESS3-2, 3-5-ETS1-2, and 3-5-ETS1-3.

**Unit 3: Structures and Functions** **Instructional Days: 10**

In this unit of study, students develop an understanding that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. The crosscutting concepts of *systems and system models* are called out as organizing concepts for this disciplinary core idea. Students are expected to demonstrate grade-appropriate proficiency *in engaging in argument from evidence*. Students are also expected to use this practice to demonstrate understanding of the core idea.

This unit is based on 4-LS1-1.

**Unit 4: How Organisms Process Information** **Instructional Days: 10**

In this unit of study, students are expected to develop an understanding that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. By developing a model, they describe that an object can be seen when light reflected from its surface enters the eye. The crosscutting concepts of *cause and effect, systems and system models,* and *structure and function* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in *developing and using models*. Students are expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on 4-LS1-2 and 4-PS4-2.

**Unit 5: Transfer of Energy** **Instructional Days: 15**

In this unit of study, fourth-grade students develop an understanding that energy can be transferred from place to place by sound, light, heat, and electrical currents. Students also obtain and combine information to describe that energy and fuels are derived from natural resources and that their uses affect the environment. The crosscutting *concepts of cause and effect, energy and matter,* and the *interdependence of science, engineering, and technology, and influence of science, engineering, and technology on society and the natural world* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in *planning and carrying out investigations* and *obtaining, evaluating, and communicating information*. Students are also expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on 4-PS3-2 and 4-ESS3-1.

**Unit 6: Force and Motion** **Instructional Days: 15**

In this unit of study, students are able to use evidence to construct an explanation of the relationship between the speed of an object and the energy of that object, and are expected to develop an understanding that energy can be transferred from object to object through collisions. The crosscutting concept of *energy and matter* is called out as an organizing concept. Students are expected to demonstrate grade-appropriate proficiency in *asking questions, defining problems,* and *constructing explanations, and designing solutions*. Students are also expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on 4-PS3-1 and 4-PS3-3.

**Unit 7: Using Engineering Design with Force and Motion Systems** **Instructional Days: 15**

In this unit of study, students use evidence to construct an explanation of the relationship between the speed of an object and the energy of that object. Students develop an understanding that energy can be transferred from place to place by sound, light, heat, and electrical currents or from objects through collisions. They apply their understanding of energy to design, test, and refine a device that converts energy from one form to another. The crosscutting concepts of *energy and matter* and the *influence of engineering, technology, and science on society and the natural world* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in *asking questions and defining problems*, *planning and carrying out investigations*, *constructing explanations*, and *designing solutions*. Students are also expected to use these practices to demonstrate their understanding of the core ideas.

This unit is based on 4-PS3-4, 3-5-ETS1-1, 3-5-ETS1-2, and 3-5-ETS1-3.

**Unit 8: Waves and Information** **Instructional Days: 15**

In this unit of study, students use a model of waves to describe patterns of waves in terms of amplitude and wavelength and to show that waves can cause objects to move. The crosscutting concepts of *patterns; interdependence of science, engineering, and technology; and influence of engineering, technology, and science on society and the natural world* are called out as organizing concepts for these disciplinary core ideas. Students demonstrate grade-appropriate proficiency in developing and *using models*, *planning and carrying out investigations*, and *constructing explanations, and designing solutions*. Students are also expected to use these practices to demonstrate their understanding of the core ideas.

This unit is based on 4-PS4-1, 4-PS4-3, 3-5-ETS1-2, and 3-5-ETS1-3.

***Note:*** *The number of instructional days is an estimate based on the information available at this time. 1 day equals approximately 42 minutes of seat time. Teachers are strongly encouraged to review the entire unit of study carefully and collaboratively to determine whether adjustments to this estimate need to be made.*

## Unit 1 - Weathering and Erosion

***What do the shapes of landforms and rock formations tell us about the past?***

In this unit of study, students develop understandings of the effects of weathering and the rate of erosion by water, ice, wind, or vegetation. The crosscutting concepts of patterns and cause and effect are called out as organizing concepts. Students demonstrate grade-appropriate proficiency in planning and carrying out investigations and constructing explanations. Students are also expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on 4-ESS2-1 and 4-ESS1-1.

### Student Learning Objectives

**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.*]* **(4-ESS2-1**

**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-ESS1-1)**

**Part A:** ***Part A:*** *How can evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation be observed or measured?*

| Concepts | Formative Assessment |
|---|---|
| • Cause-and-effect relationships are routinely identified, tested, and used to explain change.<br>• Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.<br>• Rainfall helps to shape the land and affects the types of living things found in a region.<br>• Living things affect the physical characteristics of their regions. | *Students who understand the concepts can:*<br>• Identify, test, and use cause-and-effect relationships in order to explain change.<br>• Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.<br>• Make observations and/or measurements to produce evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. *(Note: Assessment is limited to a single form of weathering or erosion.)* Examples of variables to test could include: |

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| | • Examples of variables to test could include:<br>✓ Angle of slope in the downhill movement of water<br>✓ Amount of vegetation<br>✓ Speed of the wind<br>✓ Relative rate of deposition<br>✓ Cycles of freezing and thawing of water<br>✓ Cycles of heating and cooling<br>✓ Volume of water flow |
| **Part B:** *What can rock formations tell us about the past?* | |
| **Concepts** | **Formative Assessment** |
| • Science assumes consistent patterns in natural systems.<br>• Patterns can be used as evidence to support an explanation.<br>• Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes.<br>• The presence and location of certain fossil types indicate the order in which rock layers were formed. | *Students who understand the concepts can:*<br>• Support explanations using patterns as evidence.<br>• Identify the evidence that supports particular points in an explanation.<br>• Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. *(Note: 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.)* Examples of evidence from patterns could include<br>✓ Rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time.<br>✓ 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. |

| **Connecting with English Language Arts/Literacy and Mathematics** |
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| *English Language Arts/Literacy*<br>*To support integration of the language arts standards in this unit, students can read content-specific texts to deepen their understanding of the cause-and-effect relationships within earth systems. As they read, students should take notes, which can be used to help them understand and explain how earth processes affect the world around them. They should ask questions, such as,* |

- ✓ *What types of soil erode faster?*
- ✓ *Why do some rocks weather more easily or more quickly than others?*
- ✓ *What patterns of change can be observed using models?*

*As they attempt to answer these questions, students can cite evidence from observations and from texts to support their thinking. In addition, students can conduct short research projects that will help them gather additional evidence to support explanations. Throughout this unit, students should collect and record data in science journals and analyze the data to identify patterns of change.*

*Mathematics*

To support integration of the Mathematics standards into this unit, students are expected to use mathematics when analyzing quantitative data to identify patterns, explain cause-and-effect relationships, and make predictions. Students need opportunities to measure earth materials using tools, such as balances and graduated cylinders, and to measure distances and heights using rulers or tape measures. Students should also be required to solve problems involving measurement and data

**Future Learning**

**Grade 5 Unit 4: Water on Earth**

- Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.

**Grade 5 Unit 5: Earth Systems**

- Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.

**Modifications**

*(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)*

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).

- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

| NGSS and Foundations for the Unit |
|---|
| **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.*]* **(4-ESS2-1** |
| **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-ESS1-1** |
| |

The performance expectations above were 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 |
|---|---|---|
| **Planning and Carrying Out Investigations**<br>• Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1)<br>**Constructing Explanations and Designing Solutions** | **ESS2.A: Earth Materials and Systems**<br>• 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. (4-ESS2-1)<br>**ESS2.E: Biogeology** | **Cause and Effect**<br>• Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS2-1)<br>**Patterns**<br>• Patterns can be used as evidence to support an explanation. (4-ESS1-1) |

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|---|---|---|
| • Identify the evidence that supports particular points in an explanation. (4-ESS1-1) | • Living things affect the physical characteristics of their regions. (4-ESS2-1)<br><br>**ESS1.C: The History of Planet Earth**<br><br>• 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. (4-ESS1-1) | ---<br><br>***Connections to Nature of Science***<br><br>**Scientific Knowledge Assumes an Order and Consistency in Natural Systems**<br><br>• Science assumes consistent patterns in natural systems. (4-ESS1-1) |

**Unit Resources and Suggested Activities**

**Suggested Mentor Texts:**

- Weathering and Erosion Books: Cracking Up: A story about erosion by Jacquai Bailey
- Weathering and Erosion: Wearing Down Rocks by Steven Hoffman
- Shaping the Earth: Erosion by Sandra Downs
- Sand on the Move by Roy Gallant
- The Mystery of the Round Rocks by Mark Meierhenry and David Volk

**Suggested Websites/Videos:**

- http://www.readworks.org/
- www.engineeringiselementary.com
- http://pbskids.org/plumlanding/
- www.NationalGeographic.com National Geographic photo examples of weathering, erosion and deposition gallery
- www.engineeringiselementary.com
- http://www.thenaturalhomeschools.com/erosion-vs-weathering-awesome-science-stem-activities.html
- http://sciencing.com/fourthgrade-weathering-erosion-activities-8368482.html

**Suggested Activities**

- Sedimentary Rock and Fossil Fuel- students can create their own Fossil Fuel Formation Model
- Weathering, Erosion and Desposition- students will sort the differences between the three concepts into categories
- Earth's Surface- Students will be able to explain how the Earth's surface changes due to weathering, erosion, and deposition after viewing multiple pictures and videos and participating in a virtual simulation as well as hands on experiments. Students will design, construct, and evaluate a model of erosion prevention. http://www.ccsoh.us/Downloads/4ESS2and3_ErosionWeathering2.pdf
- Erosion Tray Experiment: Dirtmeister's site: Students will investigate erosion and its effects. http://teacher.scholastic.com/dirt/erosion/lab.htm
- Shape it up interactive online activity where students match time and weathering agent of two images wind, volcanoes, water and glaciers http://sciencenetlinks.com/interactives/shapeitup.html
- S.T.E.M. Activities- Erosion Engineering STEM Activity: Students will be able to design a method of protection for the Earth's land that would withstand water or wind erosion. They will gain an understanding of why engineers must be aware of the different types of erosion and what preventive measures they can take against erosion. This lesson will address the misconceptions that erosion is not a very serious environmental problem, we as humans have no control over the increasing rate of erosion on the earth, and that engineers work is not concerned with erosion. http://rochelleshall.weebly.com/uploads/1/9/3/7/19375069/stem_lesson.pdf

***Is it possible to engineer ways to protect humans from natural Earth?***

In this unit of study, students apply their knowledge of natural Earth processes to generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans. In order to describe patterns of Earth's features, students analyze and interpret data from maps. The crosscutting concepts of *patterns, cause and effect*, and the influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in planning and carrying out investigations, analyzing and interpreting data, and constructing explanations and designing solutions. Students are also expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on 4-ESS2-2, 4-ESS3-2, 3-5-ETS1-2, and 3-5-ETS1-3.

**Student Learning Objectives**

**Analyze and interpret data from maps to describe patterns of Earth's features.** *[Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]* **(4-ESS2-2)**

**Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.*** *[Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.]* [Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.*]* **(4-ESS3-2**

**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. (3-5-ETS1-2**

**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. (3-5-ETS1-3**

**Part A:** *What can maps tell us about the features of the world?*

| Concepts | Formative Assessment |
|---|---|
| • Patterns can be used as evidence to support an explanation.<br>• Maps can help locate the different land and water features of Earth.<br>• The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns.<br>• Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans.<br>• Major mountain chains form inside continents or near their edges. | *Students who understand the concepts are able to:*<br>• Support an explanation using patterns as evidence.<br>• Analyze and interpret data to make sense of phenomena using logical reasoning.<br>• Analyze and interpret data from maps to describe patterns of Earth's features. Maps can include:<br>✓ Topographic maps of Earth's land |

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|---|---|
| | ✓ Topographic maps of Earth's ocean floor<br>✓ Locations of mountains<br>✓ Locations of continental boundaries<br>✓ Locations of volcanoes and earthquakes |

**Part B:** *: In what ways can the impacts of natural Earth processes on humans be reduced?*

| Concepts | Formative Assessment |
|---|---|
| • Cause-and-effect relationships are routinely identified, tested, and used to explain change.<br>• Engineers improve existing technologies or develop new ones to increase benefits, decrease known risks, and meet societal demands.<br>• A variety of hazards result from natural processes (e.g., earthquakes, floods, tsunamis, volcanic eruptions).<br>• Humans cannot eliminate the hazards, but they can take steps to reduce their impacts.<br>• Research on a problem should be carried out before beginning to design a solution.<br>• Testing a solution involves investigating how well it performs under a range of likely conditions.<br>• At whatever stage, communicating with peers about proposed solutions to a problem is an important part of the design process, and shared ideas can lead to improved designs.<br>• Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.<br>Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. | *Students who understand the concepts are able to:*<br>• Identify and test cause-and-effect relationships in order to explain change.<br>• Generate multiple solutions to a problem and compare them based on how well they meet the criteria and constraints of the design solution.<br>• Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans *(Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.)* Examples of solutions could include:<br>✓ Designing an earthquake-resistant building<br>✓ Improving monitoring of volcanic activity.<br>• Generate multiple possible solutions to a problem and compare them based on how well each is likely to meet the criteria and constraints of the problem.<br>• 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.<br>• 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. |

**Connecting with English Language Arts/Literacy and Mathematics**

*English Language Arts*

To support integration of the CCSS for English Language Arts in this unit, students should have access to multiple sources of information about Earth's features and earth processes. Students should have opportunities to read, analyze, and interpret information from nonfiction text, charts, graphs, diagrams, timelines, and interactive elements on the Internet. Students use this information, along with data they collect during investigations, to help explain, both orally and in writing, the patterns they observe in the features of the Earth and in the natural hazards that occur on the Earth.

As students engage in the engineering design process, they need opportunities to conduct research to build their understanding of how earth processes affect humans and to find examples of ways in which engineers reduce the effect of volcanic eruptions, earthquakes, floods, and tsunamis. Students should take notes as they read and summarize or paraphrase their notes to support their work throughout the engineering design process.

In addition, students should provide a list of sources when using this type of information.

*Mathematics*

- Use measurements to determine how far earthquakes and volcanoes tend to occur from continental boundaries.
- Analyze data to determine patterns of change that occur in areas where volcanoes erupt, earthquakes occur, and in flood zones.
- Reason abstractly and quantitatively to draw diagrams to build scale models.
- Analyze timelines, charts, and graphs to determine patterns in Earth's features and patterns of change caused by earth processes.
- Reason abstractly and quantitatively when discussing the effects of an earth process on humans. For example, on average, 3,000 lives are lost every year due to tsunamis. When early warning systems are in place, fewer than 1,000 lives are lost annually.

  Analyze constraints on materials, time, or cost to in order to determine criteria for design solutions.

**Future Learning**

**Grade 5 Unit 4: Water on the Earth**

- Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.

**Modifications**

*(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)*

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

| **NGSS and Foundations for the Unit** |
|---|
| **Analyze and interpret data from maps to describe patterns of Earth's features.** *[Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]* **(4-ESS2-2** |
| **Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.*** *[Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.]* [Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.*]* **(4-ESS3-2)** |
| **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. (3-5-ETS1-2)** |
| **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. (3-5-ETS1-3** |

The performance expectations above were 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 |
|---|---|---|
| **Analyzing and Interpreting Data**<br>• Analyze and interpret data to make sense of phenomena using logical reasoning. (4-ESS2-2)<br>**Constructing Explanations and Designing Solutions**<br>• Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-ESS3-2),(3-5-ETS1-2)<br>**Planning and Carrying Out Investigations**<br>• 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. (3-5-ETS1-3) | **ESS2.B: Plate Tectonics and Large-Scale System Interactions**<br>• The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth. (4-ESS2-2)<br>**ESS3.B: Natural Hazards**<br>• A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. (4-ESS3-2) *(Note: This Disciplinary Core Idea can also be found in 3.WC.)*<br>**ETS1.B: Designing Solutions to Engineering Problems**<br>• Testing a solution involves investigating how well it performs under a range of likely conditions. *(secondary to 4-ESS3-2)*<br>**ETS1.B: Developing Possible Solutions**<br>• 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. (3-5-ETS1-2) | **Patterns**<br>• Patterns can be used as evidence to support an explanation. (4-ESS2-2)<br>**Cause and Effect**<br>• Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS3-2)<br>---<br>***Connections to Engineering, Technology, and Applications of Science***<br>**Influence of Engineering, Technology, and Science on Society and the Natural World**<br>• Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. (4-ESS3-2)<br>• Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2) |

| | | |
|---|---|---|
| | • 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. (3-5-ETS1-2)<br>• Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)<br>**ETS1.C: Optimizing the Design Solution**<br>• Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3) | |

**Unit Resources and Suggested Activities**

**Suggested Websites:**

- www.teachengineering.org
- www.pbs.org
- https://nj.pbslearningmedia.org/resource/ess05.sci.ess.earthsys.lp_platetectonics/plate-tectonics/#.WX9ilq2ZNEI- Tectonic Plates
- https://www.teachengineering.org/lessons/view/cub_rock_lesson04 - How mountains are formed
- http://www.explorit.org/scienceonline/teacher-resources/TERP_Earths_Features.pdf

**Suggested Activities:**

- Gelatin Volcanoes - An activity that teaches students how and why magma moves inside volcanoes. Colored water is injected into a clear gelatin cast. http://www.spacegrant.hawaii.edu/class_acts/GelVolTe.html
- Volcanic Panic! Students learn about the causes, composition and types of volcanoes. They begin with an overview of the Earth's interior and how volcanoes form. Once students know how volcanoes function, they learn how engineers predict eruptions. In a class demonstration, students watch and measure a mock volcanic eruption and observe the eruption phases, seeing how a volcano gets its shape and provides us with clues to predict a blast. https://www.teachengineering.org/lessons/view/cub_natdis_lesson04
- Explosive or Effusive? Why do some volcanoes erupt violently and others do not? In this activity, students will learn how lava chemistry affects the type of eruption. http://static.ehe.osu.edu/sites/beyond/penguins/downloads/misc/explosive-or-effusive.pdf
- Volcano Types Students learn about the three main types of volcanoes: cinder cone, composite, and shield.
- The Origin of Calderas and Craters Model the formation of calderas and craters.

- S.T.E.M. Activity- Students will design an earthquake resistant building https://engineering.jhu.edu/sabes/wp-content/uploads/sites/28/2015/07/Shake-Things-Up-Educators-Guide-2014.pdf
- S.T.E.M. Activity- Engineering for Three Little Pigs Activity – This activity helps to demonstrate the importance of rocks, soils, and minerals in engineering and how using the right material for the right job is important. The students build 3 different sand castles composed of varying amounts of sand, water and glue. The "buildings" in this lesson are made of sand and glue, sand being a soil and glue being composed of different minerals. They then test them for strength (load bearing), and resistance to weathering. The students will then compare possible solutions and discuss how well each is likely to work while meeting the criteria and constraints of the problem. The students will be the engineers who figure out which materials are best for the buildings they are making, taking into consideration all the properties of materials that are discussed in the lesson. http://ngss.nsta.org/Resource.aspx?ResourceID=26

## Unit 3 - Structure and Function

***How do the internal and external parts of plants and animals support their survival, growth, behavior, and reproduction.***

In this unit of study, students develop an understanding that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. The crosscutting concepts of *systems and system models* are called out as organizing concepts for this disciplinary core idea. Students are expected to demonstrate grade-appropriate proficiency *in engaging in argument from evidence*. Students are also expected to use this practice to demonstrate understanding of the core idea.

This unit is based on 4-LS1-1.

## Student Learning Objectives

**Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.** *[Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin.]* [Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.*]* **(4-LS1-1**

**Part A:** ***Part A:*** *How do internal and external parts of plants and animals help them to survive, grow, behave, and reproduce?*

| Concepts | Formative Assessment |
|---|---|
| • A system can be described in terms of its components and their interactions.<br>• Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. | *Students who understand the concepts are able to:*<br>• Describe a system in terms of its components and their interactions.<br>• Construct an argument with evidence, data, and/or a model.<br>• Construct an argument to support the claim that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. *(Assessment is limited to macroscopic structures within plant and animal systems.)* Examples of structures could include:<br>✓ Thorns<br>✓ Stems<br>✓ Roots<br>✓ Colored petals<br>✓ Heart<br>✓ Stomach<br>✓ Lung<br>✓ Brain<br>✓ Skin |

| | |
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| Connecting with English Language Arts/Literacy and Mathematics |
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| *English Language Arts*<br><br>Students use the evidence from their observations of plants and animals to support the claim that all organisms are systems with structures that function in growth, survival, behavior, and/or reproduction. Students need opportunities to observe plants and animals closely, taking notes and drawing pictures, so that they can describe various structures and their functions.<br><br>*Mathematics*<br><br>Students describe the symmetry that can be observed in an organism's structures. For example, the leaves of many plants and the bodies of many animals display bilateral symmetry. Students should be encouraged to draw each organism that they observe, pointing out any structures that are symmetrical. Students should also trace lines of symmetry in their drawings to support their thinking. In addition, students can conduct research to determine whether the symmetry serves a function in the growth, reproduction, or survival of the organism. |

| Future Learning |
|---|
| **Grade 3 Unit 4: Traits**<br><br>• Different organisms vary in how they look and function because they have different inherited information.<br><br>• The environment also affects the traits that an organism develops.<br><br>**Grade 7 Unit 4: Structure and Function**<br><br>• All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).<br><br>• Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.<br><br>• In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. |

| Modifications |
|---|
| *(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)* |

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

| NGSS and Foundations for the Unit |
|---|
| **Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.** *[Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin.]* [Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.*]* **(4-LS1-1** |

The performance expectations above were 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 |
|---|---|---|
| **Engaging in Argument from Evidence**<br>• Construct an argument with evidence, data, and/or a model. (4-LS1-1) | **LS1.A: Structure and Function**<br>• Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (4-LS1-1) | **Systems and System Models**<br>• A system can be described in terms of its components and their interactions. (4-LS1-1) |

**Unit Resources and Suggested Activities**

**Suggested Websites:**

- https://www.youtube.com/watch?v=BuwY38ABMF0 - You Tube Video about amazing animal and plant adaptations

https://nj.pbslearningmedia.org/resource/1050daca-32b7-4b5b-b4df-9d0825e0ffd6/life-science-for-grade-4-with-wild-kratts/#.WX9j662ZNEI

This website outlines video, interactive, and document resources to teach Life Science for Grade 4, targeted to address concepts outlined in the Next Generation Science Standards. Using multiple resources from the hit KIDS series Wild Kratts, as well as content drawn from SciGirls and *IdahoPTV*, this catered unit is perfect for bringing exciting, engaging media into fourth grade science classrooms.

- https://www.brainpop.com/science/ecologyandbehavior/foodchains/- Food Chains

**Suggested Activities:**

- Adaptation project- students use the information they have learned about adaptations to cold and hot, to create their own adaptations to a chosen biome https://betterlesson.com/lesson/636167/adaptation-project
- Busy Bees Project- students will be able to understand specialized body parts of bees and their role in agricultural science https://betterlesson.com/lesson/640362/busy-bees
- The Daffodil Project- students study how a daffodil bulb is specifically designed to weather a long cold winter because of specific adaptive parts https://betterlesson.com/lesson/629769/the-daffodil-project-part-1
- Plant or Animal Cell Model- students can create their own 3D model of a plant or animal cell

## Unit 4 - How Organisms Process Information

***How do animals use their perceptions and memories to make decisions?***

In this unit of study, students are expected to develop an understanding that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. By developing a model, they describe that an object can be seen when light reflected from its surface enters the eye. The crosscutting concepts of *cause and effect, systems and system models,* and *structure and function* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in *developing and using models*. Students are expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on 4-LS1-2 and 4-PS4-2.

### Student Learning Objectives

**Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.** *[Clarification Statement: Emphasis is on systems of information transfer.]* [Assessment Boundary: Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.*]* **(4-LS1-2**

**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.*]* **(4-LS4-2)**

**Part A:** *How do animals receive and process different types of information from their environment in order to respond appropriately?*

| Concepts | Formative Assessment |
|---|---|
| • A system can be described in terms of its components and its interactions.<br>• Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain.<br>• Animals are able to use their perceptions and memories to guide their actions. | *Students who understand the concepts are able to:*<br>• Describe a system in terms of its components and their interactions.<br>• Use a model to test interactions concerning the functioning of a natural system.<br>• Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.<br>✓ Emphasis is on systems of information transfer.<br>*Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.* |

**Part B:** *What happens when light from an object enters the eye?*

| Concepts | Formative Assessment |
|---|---|
| • Cause-and-effect relationships are routinely identified.<br>• An object can be seen when light reflected from its surface enters the eyes. | *Students who understand the concepts are able to:*<br>• Identify cause-and-effect relationships.<br>• Develop a model to describe phenomena.<br>Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. *(Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works).* |

**Connecting with English Language Arts/Literacy and Mathematics**

*English Language Arts*

Students should use text and online media resources when appropriate to help them understand how animals receive and process information they receive from the environment, and to develop a conceptual understanding of what happens when light reflects off objects and enters the eye. They should also use visual displays to enhance their observations and explanations of the concepts in this unit of study.

*Mathematics*

Students should model with mathematics as they draw points, lines, line segments, and angles to describe how light behaves when coming into contact with lenses, mirrors, and other objects. Students will also use points, lines, and angles when drawing pictures and diagrams that show how light reflects off objects and into the pinhole viewer or into the human eye.

**Future Learning**

**Grade 7 Unit 4: Structure and Function**

- All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).
- Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.

**Grade 7 Unit 5: Body Systems**

- In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.
- Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.

**Grade 8 Unit 7: Electromagnetic Radiation**

- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

**Modifications**

*(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)*

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

**NGSS and Foundations for the Unit**

**Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.** *[Clarification Statement: Emphasis is on systems of information transfer.]* [Assessment Boundary: Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.] **(4-LS1-2**

**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.] **(4-LS4-2**

The performance expectations above were 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**<br>• Use a model to test interactions concerning the functioning of a natural system. (4-LS1-2)<br>• Develop a model to describe phenomena. (4-PS4-2) | **LS1.D: Information Processing**<br>• Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions. (4-LS1-2)<br>**PS4.B: Electromagnetic Radiation**<br>• An object can be seen when light reflected from its surface enters the eyes. (4-PS4-2) | **Systems and System Models**<br>• A system can be described in terms of its components and their interactions. (4-LS1-1),(4-LS1-2)<br>**Cause and Effect**<br>• Cause and effect relationships are routinely identified. (4-PS4-2) |

**Unit Resources and Suggested Activities**

**Suggested Websites/Videos:**

- http://ngss.nsta.org/DisplayStandard.aspx?view=pe&id=71
- https://betterlesson.com/common_core/browse/2148/ngss-4-ls1-2-use-a-model-to-describe-that-animals-receive-different-types-of-information-through-their-senses-process-the-inform
- https://faculty.washington.edu/chudler/amaze.html- Animals Senses

**Suggested Activities:**

- Pinhole Camera and Eye Activity In this activity, students make a pinhole camera and see images formed on an internal screen. They then use a lens to see how this affects the images. Students investigate variables in its construction, and explore how it models the human eye's ability to receive and process information. http://ngss.nsta.org/Resource.aspx?ResourceID=88
- Animal Mouth Structures- In these activity students examines how the structure of various animal mouthparts affects their function. They will have an

opportunity to predict what foods are likely to be eaten by birds with different beak types, watch a video comparing and analyzing snake and human mouth structures, and construct explanations about how other animals' mouths are related to their feeding strategies.
http://ngss.nsta.org/Resource.aspx?ResourceID=397

***Where do we get the energy we need for modern life?***

In this unit of study, fourth-grade students develop an understanding that energy can be transferred from place to place by sound, light, heat, and electrical currents. Students also obtain and combine information to describe that energy and fuels are derived from natural resources and that their uses affect the environment. The crosscutting *concepts of cause and effect, energy and matter,* and the *interdependence of science, engineering, and technology, and influence of science, engineering, and technology on society and the natural world* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in *planning and carrying out investigations* and *obtaining, evaluating, and communicating information*. Students are also expected to use these practices to demonstrate understanding of the core ideas. This unit is based on 4-PS3-2 and 4-ESS3-1.

**Student Learning Objectives**

**Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.** *[*Assessment Boundary: Assessment does not include quantitative measurements of energy.*]* **(4-PS3-2)**

**Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.** *[Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]* **(4-ESS3-1)**

**Part A:** *How does energy move?*

| Concepts | Formative Assessment |
|---|---|
| • Energy can be transferred in various ways and between objects.<br>• Energy can be moved from place to place through sound, light, or electric currents.<br>• Energy is present whenever there are ~~moving objects~~, sound, light, or heat.<br>• Light also transfers energy from place to place.<br>• Energy can also be transferred from place to place by electric currents; the currents may have been produced to begin with by transforming the energy of motion into electrical energy. | *Students who understand the concepts are able to:*<br>• Make observations to produce data that can serve as the basis for evidence for an explanation of a phenomenon or for a test of a design solution.<br>• Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. |

**Part B:** *From what natural resources are energy and fuels derived? In what ways does the human use of natural resources affect the environment?*

| Concepts | Formative Assessment |
|---|---|

| | |
|---|---|
| • Cause-and-effect relationships are routinely identified and used to explain change.<br>• Knowledge of relevant scientific concepts and research findings is important in engineering.<br>• Over time, people's needs and wants change, as do their demands for new and improved technologies.<br>• Energy and fuels that humans use are derived from natural sources.<br>• The use of energy and fuels from natural sources affects the environment in multiple ways.<br>• Some resources are renewable over time, and others are not. | *Students who understand the concepts are able to:*<br>• Identify cause-and-effect relationships in order to explain change.<br>• Obtain and combine information from books and other reliable media to explain phenomena.<br>• Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.<br>✓ Examples of renewable energy resources could include:<br>○ Wind energy,<br>○ Water behind dams, and<br>○ Sunlight.<br>✓ Examples of nonrenewable energy resources are:<br>○ Fossil fuels,<br>○ Fissile materials<br>✓ Examples of environmental effects could include:<br>○ Loss of habitat due to dams<br>○ Loss of habitat due to surface mining<br>○ Air pollution from burning of fossil fuels. |

**Connecting with English Language Arts/Literacy and Mathematics**

*English Language Arts*

Students will conduct research to build their understanding of energy, transfer of energy, and natural sources of energy. Students will recall relevant information from in-class investigations and experiences and gather relevant information from print and digital sources. They should take notes and categorize information and provide a list of sources. Students also draw evidence from literary and information texts in order to analyze and reflect on their findings. Students can also read, take notes, and construct responses using text and digital resources such as Scholastic News, Nat Geo Kids, Study Jams (Scholastic), Reading A–Z.com, NREL.com, switchenergyproject.com, and NOVA Labs by PBS.

*Mathematics*

Students reason abstractly and quantitatively as they gather and analyze data during investigations and while conducting research about transfer of energy and energy sources. Students model with mathematics as they represent and/or solve word problems. As students research the environmental effects of obtaining fossil fuels, they might be asked to represent a verbal statement of multiplicative comparison as a multiplication equation. For example, students might find information

about a spill that was 5 million gallons of oil and was 40 times larger that a previous oil spill in the same location. They can be asked to represent this mathematically using an equation to determine the number of gallons of oils that were spilled in the previous event.

**Future Learning**

**Grade 5 Unit 5: Earth Systems**

- Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.

**Grade 7 Unit 7: Organization for Matter and Energy in Organisms**

- The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.*(secondary)*
- Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. *(secondary)*

**Grade 7 Unit 8: Earth Systems**

- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

**Grade 8 Unit 3: Stability and Change on Earth**

- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

**Grade 8 Unit 4: Human Impact**

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
- Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.

**Grade 8 Unit 5: Relationships among Forms of Energy**

- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.
- A system of objects may also contain stored (potential) energy, depending on their relative positions.
- When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

**Grade 8 Unit 6: Thermal Energy**

- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.
- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

**Grade 8 Unit 7: Electromagnetic Radiation**

- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

**Modifications**

*(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)*

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their

understandings.

- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

**Unit 6-Force and Motion**

***What is the relationship between the speed of an object and the energy of that object?***

In this unit of study, students are able to use evidence to construct an explanation of the relationship between the speed of an object and the energy of that object, and are expected to develop an understanding that energy can be transferred from object to object through collisions. The crosscutting concept of *energy and matter* is called out as an organizing concept. Students are expected to demonstrate grade-appropriate proficiency in *asking questions, defining problems,* and *constructing explanations, and designing solutions*. Students are also expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on 4-PS3-1 and 4-PS3-3.

**Student Learning Objectives**

**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-PS3-1)**

**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.*]* **(4-PS3-3)**

**Part A:** *What is the relationship between the speed of an object and its energy?*

| Concepts | Formative Assessment |
|---|---|
| • Energy can be transferred in various ways and between objects.<br>• The faster a given object is moving, the more energy it possesses. | *Students who understand the concepts are able to:*<br>• Describe various ways that energy can be transferred between objects.<br>• Use evidence (e.g., measurements, observations, patterns) to construct an explanation.<br>• Use evidence to construct an explanation relating the speed of an object to the energy of that object. *(Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.)* |

**Part B:** *In what ways does energy change when objects collide?*

| Concepts | Formative Assessment |
|---|---|
| • Energy can be transferred in various ways and between objects.<br>• Energy can be moved from place to place by moving objects or through sound, light, or electric currents.<br>• Energy is present whenever there are moving objects, sound, light, or heat.<br>• 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.<br>• When objects collide, the contact forces transfer energy so as to change the objects' motions. | *Students who understand the concepts are able to:*<br>• Describe the various ways that energy can be transferred between objects.<br>• Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.<br>• Ask questions and predict outcomes about the changes in energy that occur when objects collide. Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact. *(Assessment does not include quantitative measurements of energy.)* |

**Connecting with English Language Arts/Literacy and Mathematics**

*English Language Arts*

Students will conduct a short research project to build their understanding of the transfer of energy (motion, heat, and sound) in force and motion systems. They will need access to a variety of texts and should use information from their class experiences and from print and digital sources to write informative/explanatory texts. As students gather information, they should take notes and categorize information. In their writing, students should detail what they observed as they investigated simple force and motion systems, describe procedures they followed as they conducted investigations, and use information from their observations and research to explain the patterns of change that occur when objects move and collide. As students participate in discussions and write explanations, they should refer specifically to text, when appropriate.

*Mathematics*

N/A

**Future Learning**

**Grade 6 Unit 4: Forces and Motion**

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size.

In order to share information with other people, these choices must also be shared.

- When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.

**Grade 6 Unit 5: Types of Interactions**

- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.
- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

**Grade 8 Unit 5: Relationships among Forms of Energy**

- When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

**Modifications**

*(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)*

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

**NGSS and Foundations for the Unit**

| |
|---|
| **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-PS3-1** |
| **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.*]* **(4-PS3-3)** |

| The performance expectations above were 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** |
| **Planning and Carrying Out Investigations**<br>• Make observations to produce data to serve as | **PS3.A: Definitions of Energy**<br>• The faster a given object is moving, the more | **Energy and Matter**<br>• Energy can be transferred in various ways and |

| | | |
|---|---|---|
| the basis for evidence for an explanation of a phenomenon or test a design solution. (4-PS3-2)<br><br>**Asking Questions and Defining Problems**<br><br>• Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3)<br><br>**Constructing Explanations and Designing Solutions**<br><br>Use evidence (e.g., measurements, observations, patterns) to construct an explanation. (4-PS3-1) | energy it possesses. (4-PS3-1)<br><br>• Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-3)<br><br>**PS3.B: Conservation of Energy and Energy Transfer**<br><br>• 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. (4-PS3-3)<br><br>**PS3.C: Relationship Between Energy and Forces**<br><br>• When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3) | between objects. (4-PS3-1) (4-PS3-3) |

**Unit Resources and Suggested Activities**

**Suggested Websites:**

- https://nj.pbslearningmedia.org/resource/idptv11.sci.phys.maf.d4kfom/force-and-motion/#.WX9v662ZPuQ The world is full of motion, and all motion in the world happens because of force. So how do forces and motion move our world? What is inertia? What are Newton's laws of motion? Find out more about Sir Isaac Newton's laws of force and motion. This episode of IdahoPTV's Science Trek defines gravity, force, friction and inertia through examples from amusement park rides. Examples and explanations of Sir Isaac Newton's *Three Laws of Motion* are also included.
- https://www.turtlediary.com/video/force-and-motion.html
- www.pbs.org
- http: sciencetrek.com
- https://sciencenetlinks.com/afterschool-resources/fun-forces/
- www.teachengineering.org
- https://www.scholastic.com/teachers/activities/teaching-content/force-and-motion-6-studyjams-interactive-science-activities/
- https://nj.pbslearningmedia.org/resource/kqed07.sci.phys.invisfo/invisible-forces/#.WX9wgq2ZPuQ- Videos About Forces of Nature

**Suggested Activities:**

- The Art of Forces and Motion- Students learn about Forces and Motion by creating art that helps them to visualize, identify and explain these phenomena. https://nj.pbslearningmedia.org/resource/kqed07.sci.phys.lpforces/the-art-of-forces-and-motion/#.WX9x462ZPuR
- Gravity- Students investigate the force of gravity and how all objects, regardless of their mass, fall to the ground at the same rate. https://nj.pbslearningmedia.org/resource/phy03.sci.phys.mfe.lp_gravity/gravity-and-falling-objects/#.WX9y5K2ZPuQ
- Raceway To Science- Movement depends on the amount of force applied http://www.cape.k12.mo.us/blanchard/hicks/news%20pages/Force%20pdf%20files/Raceway%20to%20Science.pdf
- The Marble Challenge- What effect will force have on an object's motion? http://www.cape.k12.mo.us/blanchard/hicks/news%20pages/Force%20pdf%20files/Marbles%20Challenge.pdf
- Fun with Forces- http://sciencenetlinks.com/media/filer/2011/09/27/tf-snl-fun-with-forces.pdf

**Unit 7 -Using Engineering Design with Force and Motion Systems**

***How can scientific ideas be applied to design, test, and refine a device that converts energy from one form to another?***

In this unit of study, students use evidence to construct an explanation of the relationship between the speed of an object and the energy of that object. Students develop an understanding that energy can be transferred from place to place by sound, light, heat, and electrical currents or from objects through collisions. They apply their understanding of energy to design, test, and refine a device that converts energy from one form to another. The crosscutting concepts of *energy and matter* and the *influence of engineering, technology, and science on society and the natural world* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in *asking questions and defining problems*, *planning and carrying out investigations*, *constructing explanations*, and *designing solutions*. Students are also expected to use these practices to demonstrate their understanding of the core ideas.

This unit is based on 4-PS3-4, 3-5-ETS1-1, 3-5-ETS1-2, and 3-5-ETS1-3.

**Student Learning Objectives**

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

**Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)**

**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. (3-5-ETS1-2)**

**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. (3-5-ETS1-3**

**Part A:** *How can scientific ideas be applied to design, test, and refine a device that converts energy from one form to another?*

| Concepts | Formative Assessment |
|---|---|
| • Science affects everyday life.<br>• Most scientists and engineers work in teams.<br>• Engineers improve existing technologies or develop new ones.<br>• People's needs and wants change over time, as do their demands for new and improved technologies. | *Students who understand the concepts are able to:*<br>• Describe the various ways that energy can be transferred between objects.<br>• Apply scientific ideas to solve design problems.<br>• Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. (Devices should be limited to those |

| | |
|---|---|
| • Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.<br>• Energy can be transferred in various ways and between objects.<br>• 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.<br>• The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use.<br>• Possible solutions to a problem are limited by available materials and resources (constraints).<br>• The success of a designed solution is determined by considering the desired features of a solution (criteria).<br>• 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.<br>• Research on a problem should be carried out before beginning to design a solution.<br>• Testing a solution involves investigating how well it performs under a range of likely conditions.<br>• 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.<br>• Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.<br>• Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. | that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.)<br>• Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound or passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.<br>• Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.<br>• Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.<br>• Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.<br>• 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.<br>• 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.<br>• 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. |

## Connecting with English Language Arts/Literacy and Mathematics

*English Language Arts*

Students conduct research that builds their understanding of energy transfers. They will gather relevant information from their investigations and from multiple print or digital sources, take notes, and categorize their findings. They should use this information to construct explanations and support their thinking.

*Mathematics*

Students can:

- ✓ Solve multistep word problems, using the four operations.
- ✓ Represent these problems using equations with a letter standing for the unknown quantity.
- ✓ Assess the reasonableness of answers using mental computation and estimating strategies, including rounding.

For example, "The class has 144 rubber bands with which to make rubber band cars. If each car uses 6 rubber bands, how many cars can be made? If there are 28 students in the class, how many rubber bands can each car have (if every car has the same number of rubber bands)?"

Students can also analyze constraints on materials, time, or cost to determine what implications the constraints have for design solutions. For example, if a design calls for 20 screws and screws are sold in boxes of 150, how many copies of the design can be made?

## Future Learning

**Grade 5 Unit 3: Energy and Matter in Ecosystems**

- The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water).
- Plants acquire their material for growth chiefly from air and water.

**Grade 8 Unit 5: Relationships among Forms of Energy**

- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.
- A system of objects may also contain stored (potential) energy, depending on their relative positions.
- When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

**Grade 8 Unit 6: Thermal Energy**

- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.
- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

**Modifications**

*(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)*

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

**NGSS and Foundations for the Unit**

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

**Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)**

**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. (3-5-ETS1-2)**

**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. (3-5-ETS1-3**

The performance expectations above were 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 |
|---|---|---|
| **Constructing Explanations and Designing Solutions**<br>• Apply scientific ideas to solve design problems. (4-PS3-4)<br>• Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2)<br>**Asking Questions and Defining Problems**<br>• Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)<br>**Planning and Carrying Out Investigations**<br>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. (3-5-ETS1-3) | **PS3.B: Conservation of Energy and Energy Transfer**<br>• 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. (4-PS3-4)<br>**PS3.C: Relationship Between Energy and Forces**<br>• When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3)<br>**PS3.D: Energy in Chemical Processes and Everyday Life**<br>• The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)<br>**ETS1.A: Defining and Delimiting Engineering Problems**<br>• 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. (3-5-ETS1-1) | **Energy and Matter**<br>• Energy can be transferred in various ways and between objects. (4-PS3-4)<br>---<br>***Connections to Engineering, Technology, and Applications of Science***<br>**Influence of Engineering, Technology, and Science on Society and the Natural World**<br>• Engineers improve existing technologies or develop new ones. (4-PS3-4)<br>---<br>***Connections to Nature of Science***<br>**Science is a Human Endeavor**<br>• Most scientists and engineers work in teams. (4-PS3-4)<br>• Science affects everyday life. (4-PS3-4)<br>**Influence of Science, Engineering, and Technology on Society and the Natural World**<br>• People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1)<br>• Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal |

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|---|---|---|
| | **ETS1.B: Developing Possible Solutions**<br>• 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. (3-5-ETS1-2)<br>• 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. (3-5-ETS1-2)<br>• Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)<br>**ETS1.C: Optimizing the Design Solution**<br>• Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3) | demands. (3-5-ETS1-2) |

**Unit Resources and Suggested Activities**

**Suggested Mentor Texts:**

- Forces and Motion at Work by Shirley Duke
- Energy All Around Us by Buffy Silverman
- Energy Alternatives by Karen Povey
- Harnessing Power from the Sun by Niki Walker
- Turn on the Light; How Electricity Works by Ella Newell
-

**Suggested Websites:**

- www.eia.doe.gov/kids/energyfacts/sources/electricity.html (activities/puzzles)
- www.stemworks.com
- www.teachengineering.org
- www.engineeringiselementary.com
- www.pbs.org
- http://powerhousekids.com
- www.neok12.com/Laws-of-Motion.htm

**Suggested Activities:**

- Post It Note Towers- students will work in teams to create their tower. It needs to be as tall as they can make it with only 15 post-it notes. They need to be flexible in their thinking, create a plan, re-vise their plans as necessary, look for patterns and structure and persevere. This activity allows you to have Class discussion about the importance of mistakes and how they would do things differently if given the opportunity to do this activity again. https://betterlesson.com/lesson/resource/3101640/build-a-post-it-tower

- Engineering Project: Balloon Car- SWBAT work through the engineering design process to plan, build and test a car powered by a balloon. The engineering design process is a process used by scientists in the real world. This process encourages scientific thinking and promotes teamwork. https://betterlesson.com/lesson/628155/engineering-project-ballooncar

- Engineering: Touchdown- students will use what they know and can investigate about gravity, motion, and forces to design and build a shock-absorbing system that will protect two "astronauts" when they land. Just as engineers had to develop solutions for landing different vehicle types on the moon and Mars, students will follow the engineering design process to design and build a shock –absorbing system out of paper, straws, and mini-marshmallows; attach their shock absorber to a cardboard platform; and improve their design based on testing results. https://www.jpl.nasa.gov/edu/teach/activity/touchdown

- Soda Straw Rockets: this is an excellent opportunity for students to practice the engineering design process. This activity provides students with a template that creates a rocket that can be launched from a soda straw. They are challenged to modify the design to see how the changes impact the rocket performance. Length, fin shape or angle can be changed-one variable at a time-to see how the rocket launch performs, and compares the control design. https://www.jpl.nasa.gov/edu/teach/activity/straw-rocket/
- You can create flash cards using engineering design with force and motion systems on https://quizlet.com/148713827/

**Unit 8 - Waves and Information Summary**

***How can we use waves to gather and transmit information?***

In this unit of study, students use a model of waves to describe patterns of waves in terms of amplitude and wavelength and to show that waves can cause objects to move. The crosscutting concepts of *patterns; interdependence of science, engineering, and technology; and influence of engineering, technology, and science on society and the natural world* are called out as organizing concepts for these disciplinary core ideas. Students demonstrate grade-appropriate proficiency in developing and *using models*, *planning and carrying out investigations*, and *constructing explanations, and designing solutions*. Students are also expected to use these practices to demonstrate their understanding of the core ideas.

**Student Learning Objectives**

**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.]* **(4-PS4-1)**

**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.]* **(4-PS4-3)**

**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. (3-5-EST-1-2)**

**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. (3-5-ETS1-3)**

**Part A:** *If a beach ball lands in the surf, beyond the breakers, what will happen to it?*

| Concepts | Formative Assessment |
|---|---|
| • Science findings are based on recognizing patterns.<br>• Similarities and differences in patterns can be used to sort and classify natural phenomena.<br>• Waves, which are regular patterns of motion, can be made in water by disturbing the surface.<br>• 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.<br>• Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks) | *Students who understand the concepts can:*<br>• Sort and classify natural phenomena using similarities and differences in patterns.<br>• Develop a model using an analogy, example, or abstract representation to describe a scientific principle.<br>• Develop a model (e.g., diagram, analogy, or physical model) of waves to describe patterns in terms of amplitude and wavelength, and that waves can cause objects to move. *(Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength).* |

**Part B:** *Which team can design a way to use patterns to communicate with someone across the room?*

| Concepts | Formative Assessment |
|---|---|
| • Similarities and differences in patterns can be used to sort and classify designed products.<br>• Knowledge of relevant scientific concepts and research findings is important in engineering.<br>• Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.<br>• 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—that is, convert it from digitized form to voice and vice versa.<br>• Different solutions need to be tested in order to determine which of them best solve the problem, given the criteria and the constraints.<br>• 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.<br>• 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.<br>• Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. | *Students who understand the concepts can:*<br>• Sort and classify designed products using similarities and differences in patterns.<br>• Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.<br>• 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.<br>• Generate and compare multiple solutions that use patterns to transfer information. Examples of solutions could include:<br>✓ Drums sending coded information through sound waves;<br>✓ Using a grid of ones and zeroes representing black and white to send<br>✓ information about a picture;<br>✓ Using Morse code to send text.<br>• Plan and conduct an investigation collaboratively to produce data that can serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.<br>• 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. |

**Connecting with English Language Arts/Literacy and Mathematics**

*English Language Arts/Literacy*

To support integration of English language arts into this unit, students conduct short research projects, using both print and digital sources, to build their understanding of wave properties and of the use of waves to communicate over a distance. Students should take notes, categorize information collected, and

document a list of the sources used. Using the information they collect during research, as well as information from their experiences with waves, sound, and light, students integrate the information and use it to design a device or process that can be used to communicate over a distance using patterns. As students create presentations that detail how their design solutions can be used to communicate, they should use details and examples from both their research and experiences to explain how patterns are used in their design to communicate over a distance. They can include audio or video recordings and visual displays to enhance their presentations.

*Mathematics*

To support the integration of the CCSS for mathematics into this unit of study, students should have opportunities to draw points, lines, line segments, rays, angles, and perpendicular and parallel lines, and identify these in two-dimensional drawings as they identify rays and angles in drawings of the ways in which waves move. Students should also have opportunities to use the four operations to solve problems. Students can analyze constraints on materials, time, or cost to draw implications for design solutions. For example, if a design calls for 20 screws and screws are sold in boxes of 150, how many copies of the design could be made?

As students represent and solve word problems, such as these, they reason abstractly and quantitatively and model with mathematics. As students create models of waves and engage in engineering design, they have opportunities to use tools strategically while measuring, drawing, and building.

**Future Learning**

In middle school, students will know that:

- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.
- A sound wave needs a medium through which it is transmitted.
- Digitized signals (sent as wave impulses) are a more reliable way to encode and transmit information.
- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.
- Models of all kinds are important for testing solutions.
- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process— that is, some of those characteristics may be incorporated into the new design.
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.

**Modifications**

*(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)*

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

| NGSS and Foundations for the Unit |
|---|
| **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.]* **(4-PS4-1)** |
| **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.]* **(4-PS4-3)** |
| **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. (3-5-EST-1-2)** |
| **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. (3-5-ETS-1-3)** |

| The performance expectations above were 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** | **PS4.A: Wave Properties** | **Patterns** |

- Develop a model using an analogy, example, or abstract representation to describe a scientific principle. (4-PS4-1)

**Constructing Explanations and Designing Solutions**

- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-PS4-3)
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2)

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***Connections to Nature of Science***

**Scientific Knowledge is Based on Empirical Evidence**

- Science findings are based on recognizing patterns. (4-PS4-1)

**Planning and Carrying Out Investigations**

- 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. (3-ETS1-3)

- 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.)* (4-PS4-1)
- Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). (4-PS4-1)

**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. (4-PS4-3)

**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 to 4-PS4-3)*

**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. (3-5-ETS1-2)
- 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. (3-5-ETS1-2)
- Tests are often designed to identify failure

- Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena. (4-PS4-1)
- Similarities and differences in patterns can be used to sort and classify designed products. (4-PS4-3)

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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. (4-PS4-3)

**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. (3-5-ETS1-2)

| | | |
|---|---|---|
| | points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)<br><br>**ETS1.C: Optimizing the Design Solution**<br><br>• Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3) | |

**Unit Resources and Suggested Activities**

**Suggested Mentor Texts:**

- The Amazing Facts About Sounds by Buffy Silverman
- Phone Book: The Ultimate Guide to Cell Phone Phenomenon by Thames and Hudson
- How Do Waves Form? By Wil Mara
- Investigating Sound by Sally M. Walker
- Light Fundamentals by Robert W. Wood
- Life in the Oceans, Animals, People, Plants by Lucy Baker

**Suggested Websites:**

- www.yoto98.noaa.gov
- www.oceanconservancy.org
- www.fec.gov/cgb/kidszone/fags_cellphones.html
- http://www.grc.nasa.gov/WWW/k-12/airplane/sndwave.html

**Suggested Activities:**

- Waves and information Activity
  https://www.fcusd.org/site/handlers/filedownload.ashx?moduleinstanceid=33731&dataid=60718&FileName=4th%20Grade%20STEM%20Unit.pdf
- Free virtual STEM competition designed to prepare students for STEM competition using standards-aligned activities in a contest format.
  www.stemplayground.org
- Alternative Energy- students will build an understanding of the idea that energy can be converted from one form into another. Students also build an initial understanding of forces, motion, and air that can be built on in later grade levels. Students engage in the engineering design process, they develop a deep

conceptual understanding of the work of scientists and engineers.

- https://www.teachingchannel.org/wing-energy-engineering-unit-boeing

- Jam with a Rubber Band- Students explore and create a stringed instrument that demonstrates their understanding of sound waves and how energy is transferred. What do pianos and rubber bands have in common? Students get to really explore and play with sound!
- www.betterlessons.com/lesson/6372401/jam-jam-jam

- Waves Science Unit: https://tinyurl.com/wavesunit

## Best Practices and Exemplars

**Students with Disabilities, English Language Learners, and Gifted & Talented Students:**
Differentiating instruction is a flexible process that includes the planning and design of instruction, how that instruction is delivered, and how student progress is measured. Teachers recognize that students can learn in multiple ways. By providing appropriately challenging learning, teachers can maximize success for all students.

**Examples of Strategies and Practices that Support Students with Disabilities:**
***Refer to students' IEP for specific modifications and accommodations**

- Use of visual and multisensory formats
- Use of assisted technology
- Use of prompts
- Modification of content and student products
- Testing accommodations
- Authentic assessments

**Examples of Strategies and Practices that Support Gifted & Talented Students:**

- Adjusting the pace of lessons
- Curriculum compacting
- Inquiry-based instruction
- Independent study
- Higher-order thinking skills
- Interest-based content
- Student-driven instruction
- Real-world problems and scenarios

**Examples of Strategies and Practices that Support English Language Learners:**
***All WIDA Can Do Descriptors can be found at:** https://wida.wisc.edu/teach/can-do/descriptors

- Pre-teaching of vocabulary and concepts
- Visual learning, including graphic organizers
- Use of cognates to increase comprehension
- Teacher modeling
- Pairing students with beginning English language skills

with students who have more advanced English language skills

- Scaffolding

•Word walls
•Sentence frames
•Think-pair-share
•Cooperative learning groups
•Teacher think-aloud

**Interdisciplinary connections are made across grades and content areas to model the integration of knowledge and skills in the real world.**

**21st Century Themes**

- Global Awareness
- Environmental Literacy
- Health Literacy
- Civic Literacy
- Financial, Economic, Business, and Entrepreneurial Literacy

**21st Century Skills**

- Creativity and Innovation (E)
- Critical Thinking and Problem Solving (T) (A)
- Communication (E)
- Collaboration (E) (T)

**Career Ready Practices:**

- CRP1: Act as a responsible and contributing citizen and employee.
- CRP2: Apply appropriate academic and technical skills.
- CRP3: Attend to personal health and financial well-being.
- CRP4: Communicate clearly and effectively and with reason.
- CRP5: Consider the environmental, social and economic impacts of decisions.
- CRP6: Demonstrate creativity and innovation.
- CRP7: Employ valid and reliable research strategies.
- CRP8: Utilize critical thinking to make sense of problems and persevere in solving them.
- CRP9: Model integrity, ethical leadership and effective management.
- CRP10: Plan education and career paths aligned to personal goals.
- CRP11: Use technology to enhance productivity.
- CRP12: Work productively in teams while using global competence.

**9.1 Personal Financial Literacy**

This standard outlines the important fiscal knowledge, habits, and skills that must be mastered in order for students to make informed decisions about personal finance. Financial literacy is an integral component of a student's college and career readiness, enabling students to achieve fulfilling, financially-secure, and successful careers.

**9.2 Career Awareness, Exploration, and Preparation**

This standard outlines the importance of being knowledgeable about one's interests and talents, and being well informed about postsecondary and career options, career planning, and career requirements.

**9.3 Career and Technical Education**

This standard outlines what students should know and be able to do upon completion of a CTE Program of Study

**Technology Standards: Technology standards are embedded throughout all curricular units.**

**8.1 Educational Technology** All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and create and communicate knowledge.

**8.2 Technology Education, Engineering, Design and Computational Thinking - Programming**
All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.