Unit Overview	
Content Area: Physical Science	
Unit Title: Energy & Waves	**Unit:** 5, 6, 7, & 8
Target Course/Grade Level: 4	**Timeline:** 30 Days

Unit Summary:

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.

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.

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

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.
Learning Targets
NJSLS-Science

4-PS3-2	Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
4-ESS3-1	Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
4-PS3-1	Use evidence to construct an explanation relating the speed of an object to the energy of that object.
4-PS3-4	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.* *[Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.]* [Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.
3-5-ETS1-1	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-ETS1-2	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-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
4-PS4-1	Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. *[Clarification Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.] [Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.]*
4-PS4-3	Generate and compare multiple solutions that use patterns to transfer information. *[Clarification Statement: Examples of solutions could include drums sending coded*

	information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, and using Morse code to send text.]
3-5-EST-1-2	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-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Disciplinary Core Ideas

PS3.A: Definitions of Energy

- Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2)

PS3.B: Conservation of Energy and Energy Transfer

- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2)
- Light also transfers energy from place to place. (4-PS3-2)
- 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-PS3-2)

ESS3.A: Natural Resources

- Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. (4-ESS3-1)

PS3.A: Definitions of Energy

- The faster a given object is moving, the more energy it possesses. (4-PS3-1)
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-3)

PS3.B: Conservation of Energy and Energy Transfer

- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-3)

PS3.C: Relationship Between Energy and Forces

- When objects collide, the contact forces transfer energy so as to change the object's' motions. (4-PS3-3)

PS3.B: Conservation of Energy and Energy Transfer

- Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-4)

PS3.C: Relationship Between Energy and Forces

- When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3)

PS3.D: Energy in Chemical Processes and Everyday Life

- The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)

ETS1.A: Defining and Delimiting Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)

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 points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)

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. (3-5-ETS1-3)

PS4.A: Wave Properties

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

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 points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)

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. (3-5-ETS1-3)

PS4.A: Wave Properties

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

Science and Engineering Practices

Planning and Carrying Out Investigations

- Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (4-PS3-2)

Obtaining, Evaluating, and Communicating Information

- Obtain and combine information from books and other reliable media to explain phenomena. (4-ESS3-1)

Asking Questions and Defining Problems

- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3)

Constructing Explanations and Designing Solutions

- Use evidence (e.g., measurements, observations, patterns) to construct an explanation. (4-PS3-1)

Constructing Explanations and Designing Solutions

- Apply scientific ideas to solve design problems. (4-PS3-4)
- 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)

Asking Questions and Defining Problems

- 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)

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. (3-5-ETS1-3)

Developing and Using Models

- 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)

NJSLS Connections

Primary Interdisciplinary Connections:

English Language Arts/Literacy:

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.

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.

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.

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:

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.

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?

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.

Unit Essential Questions	**Unit Understandings**
1. From what natural resources are energy and fuels derived? In what ways does the human use of natural resources affect the environment?	Cause-and-effect relationships are routinely identified and used to explain change. ● Knowledge of relevant scientific concepts and research findings is important in engineering. ● Over time, people's needs and wants change, as do their demands for new and improved technologies. ● Energy and fuels that humans use are derived from natural sources. ● The use of energy and fuels from natural sources affects the environment in multiple ways.

2. What is the relationship between the speed of an object and its energy? 3. In what ways does energy change when objects collide? 4. How can scientific ideas be applied to design, test, and refine a device that converts energy from one form to another? 5. If a beach ball lands in the surf, beyond the breakers, what will happen to it? 6. Which team can design a way to use patterns to communicate with someone across the room?	• Some resources are renewable over time, and others are not. • Energy can be transferred in various ways and between objects. • The faster a given object is moving, the more energy it possesses. • Energy can be transferred in various ways and between objects. • Energy can be moved from place to place by moving objects or through sound, light, or electric currents. • 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. • When objects collide, the contact forces transfer energy so as to change the object's' motions. • Science affects everyday life. • Most scientists and engineers work in teams. • Engineers improve existing technologies or develop new ones. • People's needs and wants change over time, as do their demands for new and improved technologies. • Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. • Energy can be transferred in various ways and between objects. • 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. • The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. • 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. • Research on a problem should be carried out before beginning to design a solution. • Testing a solution involves investigating how well it performs under a range of likely conditions.

	• At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. • Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. • Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. • Science findings are based on recognizing patterns. • Similarities and differences in patterns can be used to sort and classify natural phenomena. • 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. • Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks. • Similarities and differences in patterns can be used to sort and classify designed products. • Knowledge of relevant scientific concepts and research findings is important in engineering. • Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. • 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. • Different solutions need to be tested in order to determine which of them best solve the problem, given the criteria and the constraints. • Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. • At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. • Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.

Unit Learning Targets (Outcomes) – Formative Assessment *Students who understand the concepts are able to …*
• 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.

• Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
• Identify cause-and-effect relationships in order to explain change. • Obtain and combine information from books and other reliable media to explain phenomena. • Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. ✓ Examples of renewable energy resources could include: o Wind energy, o Water behind dams, and o Sunlight. ✓ Examples of nonrenewable energy resources are: o Fossil fuels, o Fissile materials ✓ Examples of environmental effects could include: o Loss of habitat due to dams o Loss of habitat due to surface mining o Air pollution from burning of fossil fuels.
• Describe various ways that energy can be transferred between objects. • Use evidence (e.g., measurements, observations, patterns) to construct an explanation. • Use evidence to construct an explanation relating the speed of an object to the energy of that object. • Describe the various ways that energy can be transferred between objects. • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. • 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.
• Describe the various ways that energy can be transferred between objects. • Apply scientific ideas to solve design problems. • Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. (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.) • 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.

- 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.
- Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.
- 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.
- 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.
- 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.
- Sort and classify natural phenomena using similarities and differences in patterns.
- Develop a model using an analogy, example, or abstract representation to describe a scientific principle.
- 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.
- Sort and classify designed products using similarities and differences in patterns.
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.
- 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.
- Generate and compare multiple solutions that use patterns to transfer information. Examples of solutions could include:

✓ Drums sending coded information through sound waves;
✓ Using a grid of ones and zeroes representing black and white to send
✓ information about a picture;
✓ Using Morse code to send text.

- 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.
- 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.

Cross Cutting Concepts:

Energy and Matter

- Energy can be transferred in various ways and between objects. (4-PS3-2)

Cause and Effect

- Cause and effect relationships are routinely identified and used to explain change. (4-ESS3-1)

- -

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-ESS3-1)

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

- Over time, people's needs and wants change, as do their demands for new and improved technologies. (4-ESS3-1)

Energy and Matter

- Energy can be transferred in various ways and between objects. (4-PS3-1) (4-PS3-3)

Energy and Matter

- Energy can be transferred in various ways and between objects. (4-PS3-4)

- -

Connections to Engineering, Technology, and Applications of Science

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

- Engineers improve existing technologies or develop new ones. (4-PS3-4)

- -

Connections to Nature of Science

Science is a Human Endeavor

- Most scientists and engineers work in teams. (4-PS3-4)
- Science affects everyday life. (4-PS3-4)

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

- People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1)
- Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)

Patterns

- 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)

- -

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)

Integration of Technology:: Web-based textbook, interactive whiteboard, interactive texts, videos, digital board builder

Technology Resources:

http://knowingscience.com/TeacherResources

www.nsa.gov

www.eia.gov/kids/index.cfm

Opportunities for Differentiation: Differentiation and support tips, which includes suggestions for ELL, struggling students, and accelerated students, are available below the instructional practice section of each model lesson.

Teacher Notes:

Career Ready Practices: *In this unit the following career ready practices are addressed*
CRP1: Act as a reasonable 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 cultural global competence

Prior Learning- by the end of Grade K, 1, 2, & 3 , students understand that:

Kindergarten Unit 1: Pushes and Pulls

- When objects touch or collide, they push on one another and can change motion.

Grade 3 Unit 2: Forces and Motion

- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. *(Boundary: Qualitative and conceptual used at this level.)*
- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.)

Kindergarten Unit 1: Pushes and Pulls

- Pushes and pulls can have different strengths and directions.
- Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.

- A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. *(secondary)*

Grade 3 Unit 2: Force and Motion

- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual understandings used at this level.)
- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it.

By the end of Grade 1, students know that:

- People also use a variety of devices to communicate (send and receive information) over long distances.

By the end of Grade 2, students know that:

- A situation that people want to change or create can be approached as a problem to be solved through engineering.
- Asking questions, making observations, and gathering information are helpful in thinking about problems.
- Before beginning to design a solution it is important to clearly understand the problem.
- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.
- Because there is always more than one possible solution to a problem, it is useful to compare and test designs.

By the end of Grade 3, students know that:

- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. *(Boundary: Qualitative and conceptual, but not quantitative, addition of forces is used at this level)*.
- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. *(Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.)*

Evidence of Learning
Summative Assessment
Communication, p. 15, Knowing Science, Divide the students into groups of 3-4. Teach at least one member of the group to use a stopwatch, and then assign the group to design an activity where they can measure how long something takes and chart the results. Each group then explains to the rest of the class how they set up the activity and the results they achieved. Rubric, p. 15 & 16, Knowing Science. Motion Machine, p. 27, Knowing Science

Rubric, p. 27, Knowing Science
Communication, p. 101, Knowing Science
Rubric, p. 101

Equipment needed: Whiteboard, laptops, headphones, and hands-on materials for lessons

Teacher Instructional Resources (Hyperlinks):

Switch Energy Project: The Educator Portal provides free access to a documentary, energy labs, videos, and study guides.

Wind Generator: Windmills have been used for hundreds of years to collect energy from the wind in order to pump water, grind grain, and more recently generate electricity. There are many possible designs for the blades of a wind generator and engineers are always trying new ones. Design and test your own wind generator, then try to improve it by running a small electric motor connected to a voltage sensor.

Thermal Energy Transfer: Explore the three methods of thermal energy transfer: conduction, convection, and radiation, in this interactive from WGBH, through animations and real-life examples in Earth and space science, physical science, life science, and technology.

Spool Racers: This resource includes three parts: a video clip from the TV show, Zoom, to introduce the activity, an essay with background information about energy, and a set of printable instructions. Students use a spool, a toothpick, a washer, a rubber band, and a pencil to build a racer. They conduct tests with the racer by varying the number of twists in the rubber band or changing other design features. These websites provide additional ideas for modifying the basic rubber band racer design: http://www.scienceworld.ca/resources/activities/popcan-porsche and http://pbskids.org/designsquad/build/rubber-band-car/.

Advanced High-Powered Rockets: Students select a flight mission (what they want the rocket to do) and design and construct a high-power paper rocket that will achieve the mission. They construct their rocket, predict its performance, fly the rocket, and file a post-flight mission report. Missions include achieving high altitude records, landing on a "planetary" target, carrying payloads, testing a rocket recovery system, and more.

Forces and Motion: This video segment from IdahoPTV's D4K defines gravity, force, friction and inertia through examples from amusement park rides. Examples and explanation of Sir Isaac Newton's Three Laws of Motion are also included.

The Sound of Science: Students are given a scenario/problem that needs to be solved: Their school is on a field trip to the city to listen to a rock band concert. After arriving at the concert, the students find out that the band's instruments were damaged during travel. The band needs help to design and build a stringed instrument with the available materials, satisfying the following criteria and constraints: 1) Produce three different pitched sounds. 2) Include at least one string. 3) Use only available materials. 4) Be no longer than 30 cm / 1 foot. The challenge is divided into 4 activities. Each activity is designed to build on students' understanding of the characteristics and properties of sound. By using what they learn about sound from these activities, students are then encouraged to apply what they know about sound to complete the engineering design challenge.

Energy Makes Things Happen: The Boy Who Harnessed the Wind: This article from Science and Children provides ideas for using the trade book, The Boy Who Harnessed the Wind, as a foundation for a lesson on generators. This beautiful book is the inspiring true story of a teenager in Malawi who built a generator from found materials to create much-needed electricity. The lesson allows students to explore the concept of energy transfer using crank generators. Students then design improvements to the crank mechanism on the generator. The lesson may be extended by having students build their own generators.

Light Your Way: Using the engineering design process, students will be designing and building a lantern that they will hypothetically be taking with them as they explore a newly discovered cave. The criteria of the completed lantern will include: hands need to be free for climbing, the lantern must have an on/off switch, it must point ahead when they are walking so they can see in the dark, and the lantern must be able to stay lit for at least 15 minutes. The constraints of the activity will be limited materials with which to build. At the completion of the activity, the students will present their final lantern to the class explaining how they revised and adapted the lantern to meet the criteria of the project. Students will include in the presentation the sketch of the model they created prior to building showing the labeled circuit they designed. This activity was one of numerous engineering lessons from the Virginia Children's Engineering Council geared towards Grades 1-5. http://www.childrensengineering.org/technology/designbriefs.php.

The "What it Looks Like in the Classroom" section of this document describes several student sense-making and engineering tasks.

The Utah Education Network has created several resources for fourth grade science teachers.

Michigan NGSS Moodle: The purpose of this website to provide K-5 Science teachers with resources, lessons, and activities based on the NGSS which were created by teachers in our region.

Modifications for ELL's, Special Education, 504, and Gifted and Talented Students:

(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 principles (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

ACTIVITIES	**MATERIALS**
Unit 1 - Energy **(19-24 Days)** **1.1 Review of Distance and Motion** Session 1 Explain that distance is the separation between two objects Measure the distance between two objects	
1.1 Review of Distance and Motion Session 2 Identify an object's initial and final positions Measure the distance an object travels in two dimensions Measure in seconds how long it takes an object to travel a specified distance Explain that the faster an object moves over a specified distance, the less time it takes.	Take the students outside to a playing field that has straight lines (yard lines for football, lines between the bases on a baseball field) and mark starting and finish lines. Then measure the time it takes individual students to run from the initial position to the final position.
1.2 Energy and Motion Session 1 Explain that energy can be transferred from one object to another	
1.2 Energy and Motion Session 2 *****2 Days** Argue from evidence that the more massive an object, the more the energy required to move it	
Challenge students to drop the lidded cans from three significantly different heights onto a hard surface. Ask them to measure each height, describe the noise that results from each drop, and chart the data.	
1.2 Energy and Motion Session 3 **** **2 Days** **Day 1 - Read Energy Sources (activity sheet) & Assign Jobs** **Day 2 - Activity & Conclusions** **Assessment**	**Pre-teach:** Calculating averages (during math review??) and definition of **density.** **Copy:** Activity Sheet 1 -"Who's Faster?"

1.3 Energy and Forces Session 1 Construct an argument, using evidence, to show that when forces are balanced, energy is stored Construct an argument, using evidence, to show that when forces are unbalanced, energy is transformed into motion	**Pre-teach:** Definition of perpendicular. Balanced/Unbalanced using a scale??
1.3 Energy and Forces Session 2 Construct an argument, using evidence, to show that when forces are balanced, energy is stored Construct an argument, using evidence, to show that when forces are unbalanced, energy is transformed into motion	**Copy:** Activity Sheet - "Energy Work"
1.4 Producing Electrical Energy Session 1 ****__2 Days__** **__Day 1 -__** Steps # 1-5 **__Day 2 -__** Steps # 6-10 Explain how mechanical energy is converted into electrical energy Explain that electricity is our most prominent form of energy because it can be stored and transferred easily and over long distances Introduce students to food chains. In a food chain the primary source of energy is the Sun. Producers (plants) use the Sun to produce their own food, transforming light energy into chemical energy.	**Pre-teach:** Note taking or paraphrasing lesson **Copy:** Activity Sheet 1 "Making Electricity" - Part 1, Part 2, and Part 3
1.4 Producing Electrical Energy Session 2 ****3-5 Days - Research and/or creating Snap Circuit projects in groups** Construct projects related to the production or use of electrical energy Collect information on one of six types of energy sources Collaborate to create an oral presentation on one of six types of energy sources Multiple sessions may be required for researching and for preparing the presentation.	**Tip:** Charge solar cell in Snap Circuit Kit

1.4 Producing Electrical Energy Session 3 ******1-2 Days -** **Groups are practicing and preparing for presentations** Construct projects related to the production or use of electrical energy Collect information on one of six types of energy sources Collaborate to create an oral presentation on one of six types of energy sources Multiple sessions may be required for researching and for preparing the presentation.	
1.4 Producing Electrical Energy Session 4 *****3-5 Days - Oral Presentations** Construct projects related to the production or use of electrical energy Collect information on one of six types of energy sources Collaborate to create an oral presentation on one of six types of energy sources Multiple sessions may be required for researching and for preparing the presentation.	
Construct projects related to the production or use of electrical energy Collect information on one of six types of energy sources Collaborate to create an oral presentation on one of six types of energy sources Multiple sessions may be required for researching and for preparing the presentation.	
Construct projects related to the production or use of electrical energy Collect information on one of six types of energy sources	

Collaborate to create an oral presentation on one of six types of energy sources Multiple sessions may be required for researching and for preparing the presentation.	
1.4 Producing Electrical Energy Session 5 Construct projects related to the production or use of electrical energy Collect information on one of six types of energy sources Collaborate to create an oral presentation on one of six types of energy sources	Visit Power plant. Explore more Snap Circuit projects.
Unit 2 - Waves **(7-8 Days)** **2.1 Amplitude and Wavelength** Session 1 Describe waves using scientific vocabulary Model waves graphically Explain that waves are caused by repetitive motion	**Tips:** Sit on ground to demonstrate movement with slinky and move it rapidly. Do demo outside or in cafeteria if possible due to space.
2.1 Amplitude and Wavelength Session 2 Describe waves using scientific vocabulary Model waves graphically Explain that waves are caused by repetitive motion Construct a wave generator	**Tip:** Save sketch for making oscillator to be used in Session 3 **Copy**: Activity Sheet 1 -"Making Waves"

2.1 Amplitude and Wavelength Session 3 **** **1-2 Days** Construct a wave generator	**Tip:** Cut strings and make pinhole in cups before session. **Pre-teach**: Measuring with a ruler. (Math Review Time??) **Copy:** Activity Sheet 2- "Making an Oscillator"
2.2 How We See Session 1 Explain that light travels in a straight line Explain that light bends Explain that light reflects off objects Place mirrors to form a maze to reflect the laser beam along a path.	**Tip:** Darken room completely
2.2 How We See Session 2 Construct a simple model of the human eye	**Tip:** Cut circles in foldable boxes prior to lesson. **Copy**: Activity Sheet 1 -"How to Make an Eye"
2.3 Using Waves to Transfer Information Session 1 Explain what a code is Create a code to send information to a recipient	**Tip:** Show Youtube on Morse Code prior to lesson? **Copy:** Activity Sheet 1 -"What is a Code?'
2.3 Using Waves to Transfer Information Session 2 Create a code to send information to a recipient Decode a coded message from a sender Observe the role of waves in transmitting information	Distribute Activity Sheet 3: Digital and Analog Information to the students. **Copy:** Activity Sheet 2 - "Spy Work"