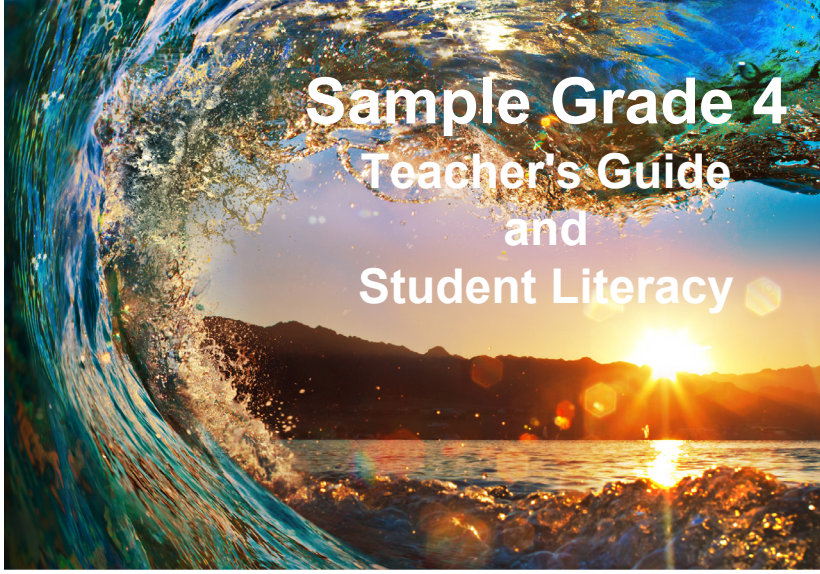


Sample Grade 4
Teacher's Guide
and
Student Literacy

Energy Works

A New Generation

Building Blocks of Science®

Materials List

Needed from the kit

1 bag of soil
8 basins
35 batteries, D-cell
35 battery holders
20 bulb holders
5 buzzers
8 foam cups
20 lightbulbs
1 Literacy Series Reader: *Energy Works!*
40 marbles
48 medicine cups
5 motors
1 pair of wire strippers
15 ping-pong balls
8 pipettes
30 plastic cups
8 plastic cup lids
48 plastic spoons
158 plastic straws (60 of smaller diameter, 98 of larger diameter)
8 rolls of clear tape
1 roll of insulated electrical wire
1 roll of string
16 rulers (with center groove), 12 in
30 sheets of construction paper
5 solar panels
30 thermometers
8 wooden dowels

Provided by the teacher

1 battery-operated toy
1 musical instrument
1 rock, book, or ball
8 clean soda bottles, 8 or 16 oz
8 pairs of scissors
8 paper clips
2 pieces of cardboard or aluminum foil (about 8.5 x 11 inches)
8 staplers
32 textbooks
Art supplies
Chart paper
Examples of different types of energy (e.g., batteries, a radio or TV, a wooden match, a fan, food, a musical instrument, a wind-up or battery-operated toy, a rock, a pencil, etc.)
Glue
Masking tape
Markers
Sponges or rags
Water

Provided by the student

1 science notebook

Energy Works!

A New Generation

Teacher's Guide

Building Blocks of Science®

Unit and Lesson Summaries

Unit Overview

Energy is one of the most important topics in science; however, because it is a complex and somewhat abstract topic, students need lots of concrete experiences and need to recognize many ways of applying the ideas to themselves and their daily lives. Thus, students begin *Energy Works!* by tracing the flow of energy that comes into their bodies and giving examples of how they use that energy to grow, live, and function. As a pre-unit assessment activity, students hunt for different types of energy in the classroom. Students then classify energy into two broad categories: kinetic (moving) energy and potential (stored) energy. They participate in interactive demonstrations that help them better understand the difference between the two.

In a series of five hands-on lessons, students gain experiences with different kinds of energy and see how energy is converted to different forms within a system. Students are encouraged to record new questions they have and ideas they form in their science notebooks, a process which helps prepare them to conduct their own experiments.

Students take a closer look at the transfer of energy by observing models. Students explore water waves and how energy passes through a row of marbles. They have the opportunity to apply the concepts of energy transfer from Lesson 3 and also to explore the factors that change the characteristics of waves.

Through research and discussion, students become aware of the relative advantages and disadvantages of alternative energy versus fossil fuels. They have practical experiences constructing wind- and water-operated apparatus and testing them. Again, students record new questions and ideas in their science notebooks.

Finally, students return to the questions they have been generating and recording throughout their investigations and select a question to investigate in more depth. They plan projects to design and construct apparatus that demonstrate the main ideas of the unit: that there are different forms of energy, that energy can be converted from one form to another, and that energy is the ability to do work or create change. As a culmination, students revisit their pre-unit assessment activity to evaluate how much they have learned about energy.

Assessment

This unit offers several ways to assess students, including a pre- and a post-unit assessment opportunity. Teachers can also use class discussions and charts to assess each lesson. Student activity sheets and science notebook entries—including drawings, writings, and dictated statements—can be used to gauge individual understanding of objectives and key vocabulary throughout the unit. Finally, a general rubric is provided to help teachers evaluate individual students at any point in the unit. The rubric provides a progression of skills and understanding that covers exploration, vocabulary, concept building, and notebook entries.

Lesson 1: Where Do You Get Your Energy?

Students focus on themselves to begin their study of energy: they are both receivers and users of energy. They discuss and map out their ideas about where their energy comes from and how their bodies transform it so they are able to engage in different types of activities.

Students take a survey of the different types of energy they observe in the classroom. They record their findings on Student Activity Sheet 1 as a pre-unit assessment.

Lesson 2: What Are Potential Energy and Kinetic Energy?

Students continue to explore the idea that energy has many forms. The teacher introduces the concept that energy may be classified into two broad categories: kinetic (moving) energy and potential (stored) energy. The class participates in several interactive demonstrations that show the differences between potential and kinetic energy.

Lesson 3: How Can We Show Energy Is Transferred and Converted?

Students grapple with the concept of how energy is converted into other forms by identifying examples of conversion. Students investigate energy firsthand, which enables them to explore various forms of energy and how they are converted and transferred to other forms within a system.

Lesson Summaries, continued

Lesson 4: How Does Energy Move in Water Waves?

Students take a closer look at waves as one of the ways energy moves. They apply what they learned about energy transfer in Lesson 3 by setting up a model to investigate how waves of energy move through water in an up-and-down motion, and explore the factors that can change the way a waves move. Students also use patterns to transfer information via signals and relate that to practical applications of waves.

Lesson 5: What Are Alternative Forms of Energy?

In an opening discussion, students learn about alternative forms of energy: solar energy, geothermal energy, wind energy, water energy, and biomass. They weigh the relative advantages and disadvantages of alternative energy sources versus fossil fuels.

Then students assemble two constructions: one that uses wind, and another that uses water. They discuss how wind energy or water energy can be transferred to their apparatus, and then how that energy is transformed into mechanical energy. Throughout the activities, students are encouraged to record new ideas and questions they might investigate in Lesson 6.

Lesson 6: What Have We Learned About Energy?

Working in teams, students plan a demonstration or an experiment and then design and construct their own apparatus to show different types of energy and the transfer of energy. Teams present their projects and explain their inventions to the rest of the class.

As a post-unit assessment, students complete Student Activity Sheet 1: *Energy Hunt* again. They compare their post-unit sheet with the one they completed in Lesson 1 to measure their own progress from the beginning to the end of the unit.

Lesson 4: How Does Energy Move in Water Waves?

Lesson Essentials	Next Generation Science Standards*	Language Arts and Math Standards**
Objectives: • Identify and define waves as regular patterns of motion. • Identify the parts of a wave. • Determine that waves are made in water by disturbing the surface. • Determine that waves have different sizes and frequencies. • Understand that waves move up and down in place. **Time Requirements:** **Teacher Preparation** **Part A:** 5 minutes **Part B:** 10 minutes **Part C:** 10 minutes **Part D:** 5 minutes **Lesson** **Part A:** 0.5 class session **Part B:** 1 class session **Part C:** 1 class session **Part D:** 1 class session **Essential Questions:** • What are the characteristics of waves? • How do waves move? • How can waves be used to transmit information? **Vocabulary:** • Amplitude • Frequency • Wave • Wavelength	**Performance Expectations** • **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. • **4-PS4-3:** Generate and compare multiple solutions that use patterns to transfer information. **Disciplinary Core Ideas** • **PS4.A:** Wave Properties • **PS4.C:** Information Technologies and Instrumentation **Engineering Practices** • Developing and Using Models • Constructing Explanations and Designing Solutions **Crosscutting Concepts** • Patterns	**Language Arts** • **L.4.6:** Vocabulary Acquisition and Use • **RI.4.7:** Integration of Knowledge and Ideas • **RI.4.9:** Integration of Knowledge and Ideas • **SL.4.1:** Comprehension and Collaboration • **W.4.1:** Text Type and Purposes • **W.4.2**: Text Type and Purposes **Math** • **4.MD.A.2:** Solve problems involving measurement and conversion of measurements.

Cross-Curricular Connections	Literacy	Assessment Strategies
Science Notebooks Language Arts Math Science Technology Art Music Social Studies Engineering and Design Take-Home Science	**Literacy** ***Energy Works!* Literacy Reader***: • "Energy Sources—Renewable Energy," pg. 12–13 **See Appendix E for Literacy Connections for before, during, and after reading.*	**Student Activity Sheets:** • Student Activity Sheet 4A: *Test the Waters* • Student Activity Sheet 4B: *Parts of a Wave* • Student Activity Sheet 4C: *The Way the Wind Blows* • Student Activity Sheet 4D: *Keep It Rolling* • Student Activity Sheet 4E: *Patterns and Signals* **Science Notebook Opportunity:** • Students explain what factors changed the frequency, wavelength, and amplitude of the waves when they dropped the marbles from different heights. (TG pg. 66) • Students explain what happens to the amplitude, frequency, and wavelength when a strong force is used to disturb the surface of the water. (TG pg. 67) • Students explain how energy moved when one marble rolled into other marbles. (TG pg. 69) **Formative Assessment:** **1.** In the opening discussion, take note of students' prior knowledge about the way water waves move to pre-assess their current knowledge and misconceptions. **2.** As students work in groups and test wave movement in water, notice if they recognize that energy is moving through the water, and are applying appropriate vocabulary. Check completed copies of Student Activity Sheets 4A, 4B (if used), and 4C as well. **3.** Review completed copies of Student Activity Sheets 4D and 4E to evaluate students' understanding of how energy moves in waves through solid objects and how waves can be used to send and receive messages. **General Rubric:** • Use the General Rubric included in Appendix D to assess individual progress as needed. **Science Notebooks**

Lesson 4

HOW DOES ENERGY MOVE IN WATER WAVES?

MATERIALS

Student

1 science notebook*
1 copy of Student Activity Sheet 4A: *Test the Waters*
1 copy of Student Activity Sheet 4B: *Parts of a Wave*
1 copy of Student Activity Sheet 4C: *The Way the Wind Blows*
1 copy of Student Activity Sheet 4D: *Keep It Rolling*
1 Student Activity Sheet 4E: *Patterns and Signals*
1 straw (large diameter)
Scissors* (optional)
Glue or tape* (optional)

Team of four students

1 basin
1 pipette
5 marbles
1 ruler
Water*

Teacher

Chart paper or white board*
Markers*
General Rubric (Appendix D)

*These materials are needed but not supplied.

LESSON OVERVIEW

This lesson begins with a brainstorming session to assess what students know about water waves and to get them thinking about how water waves look and move. Students are introduced to the parts of a wave, and draw and label a wave accordingly. Then students build on what they learned about the movement of energy in Lesson 3 by simulating waves using a model. Using a basin of water, students observe how the water in a wave moves in an up-and-down motion as energy passes through, and identify the factors that can change the way a wave moves.

OBJECTIVES

- Identify and define waves as regular patterns of motion.
- Identify the parts of a wave.
- Determine that waves are made in water by disturbing the surface.
- Determine that waves have different sizes and frequencies.
- Understand that waves move up and down in place

VOCABULARY

Science Words

- Amplitude
- Frequency
- Wave
- Wavelength

TIME CONSIDERATIONS

Teacher Preparation

Part A ..... 5 minutes
Part B ..... 10 minutes
Part C ..... 10 minutes
Part D ..... 5 minutes

Lesson

Part A ..... 0.5 class session
Part B ..... 1 class session
Part C .....1 class session
Part D .....1 class session

TEACHER PREPARATION

Part A

1. Prepare a class chart for the opening discussion titled "Let's Find Out About Water Waves." Use a marker and chart paper or a white board.

2. For each team of four students, fill a water basin with 2–3 inches of water. (As an option, you can assign this job to a responsible student.)

3. Have the eight pipettes from the kit available. Each group will need one.

4. Each group will need a ruler. Have these available to distribute.

5. Make a copy of Student Activity Sheet 4A: *Test the Waters* for each student.

6. Student Activity Sheet 4B: *Parts of a Wave* is an optional notebook opportunity to develop vocabulary (see Part A, Science Notebook Opportunity 2). If you wish to have students complete this, make a copy for each student. Additionally, each student will need glue or tape and a pair of scissors. Have these materials available as needed.

Part B

1. For each team of four students, fill a water basin with 2–3 inches of water. (As an option, you can assign this job to a responsible student.)

2. Have the straws from the kit available. Each student will need one straw.

3. Make a copy of Student Activity Sheet 4C: *The Way the Wind Blows* for each student.

Part C

1. Have the marbles from the kit ready to distribute. Each group will need five marbles.

2. Make a copy of Student Activity Sheet 4D: *Keep It Rolling* for each student.

Part D

1. Make a copy of Student Activity Sheet 4E: *Patterns and Signals* for each student.

2. This activity requires student pairs to send and receive signals they can hear. Consider conducting this activity in a large space where pairs can spread out to ensure that they can hear their partner clearly and aren't bothered by the sounds of other pairs.

BACKGROUND INFORMATION

Waves are one of the ways in which energy is transferred. A **wave** can be described as a disturbance that transfers energy without transporting matter from one place to another. As energy moves, the space through which the energy is being transported is temporarily disturbed. Once the energy has passed, the space returns to its original state.

Energy is also transferred from place to place in waves. There are many different kinds of waves (sound waves, earthquake waves, light waves, etc.). Basic properties of waves include **amplitude** (height of the wave), **wavelength** (spacing between the wave), and **frequency** (the time it takes waves to travel). This lesson will use models to address waves on the surface of the water. It is important to note that there are different types of water waves. For example, although tsunami waves also occur in water, tsunami waves are caused by tectonic plate movement on the ocean floor, which causes the water to move from beneath the surface. A surface wave is formed when energy moves through the surface of deep water by a force such as wind. At the end of this lesson, students should understand water waves as regular patterns of motion that can be made by disturbing the water's surface.

A common misconception about water waves is that the water moves forward in the direction that the wave is traveling. However, water moves up and down at the surface as the wave of energy passes through; the water does not move forward with the wave. Water only moves in the direction of the wave when it "breaks," or topples forward as the shore slopes upward and makes the water more shallow.

Because waves occur in consistent, predictable ways, sound, light, and other electromagnetic waves can be transmitted in ordered patterns to transfer information. For example, telephone signals sent through fiber-optic cable are transmitted as patterns of light that make up a code.

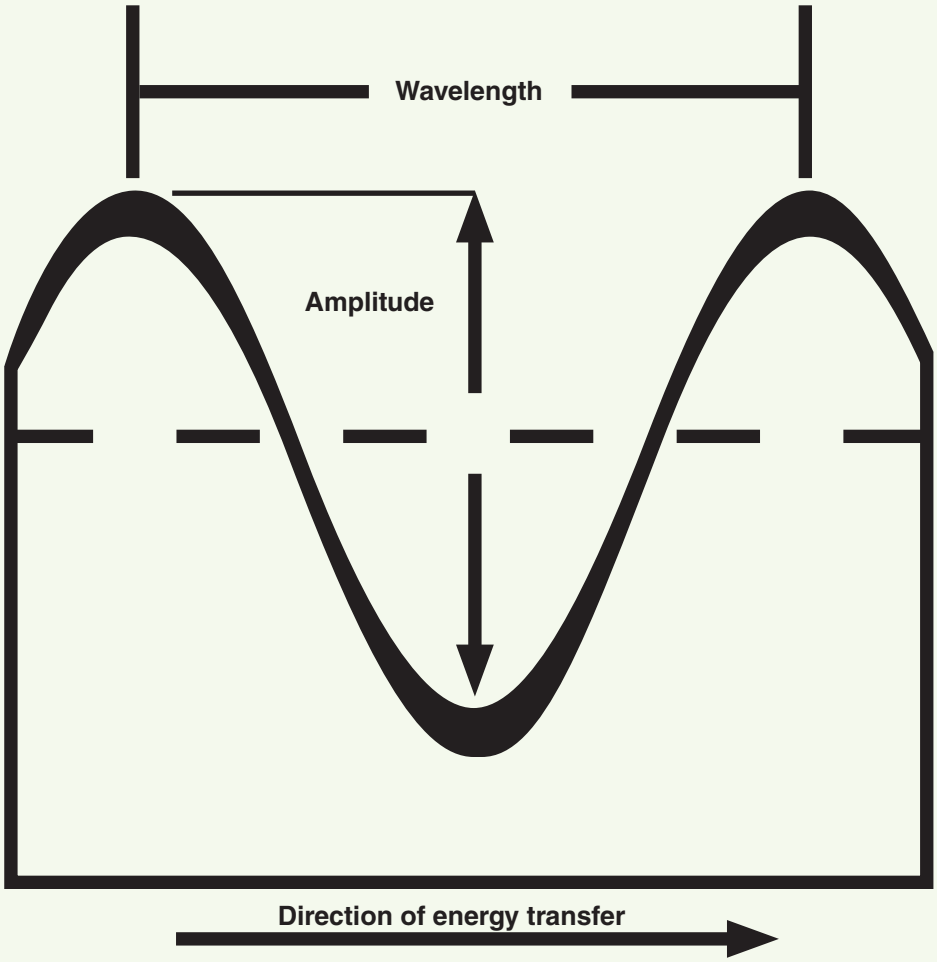


Figure 4.1
A wave

ACTIVITY INSTRUCTIONS

Part A

What Is a Wave?

Teacher Tip

A common misconception about water waves is that they move from side to side. Water actually moves in an up-and-down motion, except when the waves crash into the shore.

1. **Begin with a brainstorming session, and invite students to share what they already know about water waves. Use some or all of the following questions to guide the discussion, and record students' responses on the chart titled "Let's Find Out About Water Waves."**

   Teacher-guided questions, an example:

   - Where do we see waves?
   - How do waves move?
   - What makes waves move?
   - What happens to the water?
   - Where does the water come from?

2. **Have students draw a picture of a wave in their science notebooks. Allow them to share their pictures and identify the characteristics the waves have in common (i.e., crests and valleys).**

3. **Review students' drawings of waves. Have students hold up their pictures and sort the waves from smallest to greatest in height.**

4. **Explain that today they will make waves in a basin of water and observe the different heights of the waves, the spaces between them, and how fast the waves move.**

5. **Divide students into teams of four and distribute one pipette, one ruler, and one basin of water to each group. Distribute one copy of Student Activity Sheet 4A: *Test the Waters* to each student.**

6. **Ask students to predict what will happen to the water when a single drop of water is released from the pipette into the basin from 1 inch above the water's surface. Students should record their predictions under Step A on Student Activity Sheet 4A.**

7 **Guide student teams to test their predictions by using the pipette to create waves. Groups should place the basin of water on the floor, and wait to begin until the water is completely still. When the water has stopped moving, one student in each group should hold the pipette 1 inch above the surface of the water (using the ruler as a guide), then release one drop of water into the basin.**

8 **All group members should observe how the water moves. Ask students to share what they notice, and to draw a picture under Step B on the student activity sheet.**

9 **Challenge students to predict what will happen to the water if another drop of water is released from 6 inches above the surface of the water. Have students record their predictions, test them, and draw what they observe under Steps C and D on Student Activity Sheet 4A.**

10 **Allow students ample time to conduct additional trials and to observe the waves as needed. As they are conducting these additional trials, move from group to group and discuss their observations. Use some or all of the following questions to guide exploration.**

Teacher-guided questions, an example:

- What caused the water to move? *(Students may give a wide variety of responses, but they should understand that the surface of the water was disturbed by the falling drop of water.)*
- What happened to the surface of the water in the basin when you released a single drop of water from the pipette? *(Students should observe waves in the water.)*
- What did the waves look like? *(The water is moving up and down.)*
- What happened to the waves when you released a drop of water from 12 inches? *(Students should observe a large splash and the water moving up and down at a fast rate.)*
- How did that compare to dropping it from 1 inch? *(Students will have a variety of answers, but should see a bigger splash and higher, faster waves when the drop of water is released from the higher height.)*
- What was the difference in the height of the waves? *(The waves were taller when the drop of water was released from 12 inches.)*
- What was the difference in the spaces between the waves? *(The waves had shorter spaces between them when the drop of water was released from 12 inches.)*
- Why did the speeds of the waves differ? *(The waves moved faster when the water drop was released from a greater height because the surface of the water was disturbed with greater force.)*

Teacher Tip

To help students build vocabulary, explain the meanings of the terms "amplitude," "wavelength," and "frequency." Have students add the terms and their definitions to their science notebooks or to the class chart from Part A.

9 **Allow time for students to complete Step E of Student Activity Sheet 4A.**

Science Notebook Opportunity

1. Notebook Prompt:
Have students write to explain in their science notebooks what factors changed the frequency, wavelength, and amplitude of the waves when they dropped the marbles from different heights.

2. Student Activity Sheet 4B: *Parts of a Wave*
If students need additional practice with the vocabulary from this activity, distribute Student Activity Sheet 4B: *Parts of a Wave* and allow time for students to complete the sheet and connect vocabulary to their observations.

Part B

Blowing Waves

Teacher Tip

Be sure students understand that they are not to share straws with other members of their group. Each student should blow only into his or her own straw.

1 **Explain that students will work in groups to explore another way water waves are formed. Divide students into groups of four. Distribute one basin of water to each group, and a straw and a copy of Student Activity Sheet 4C: *The Way the Wind Blows* to each student.**

2 **Ask students to predict what will happen when one student blows air on the water through a straw. Direct them to record their predictions in Step A of Student Activity Sheet 4C.**

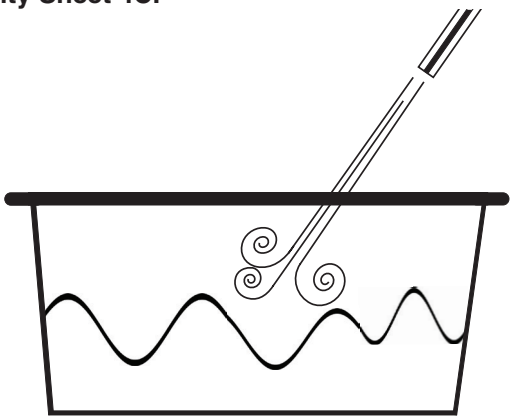


Figure 4.2
Using the straw to make waves

3 **After students have made predictions, one student in each group should blow air on the water through a straw onto the water. Suggest that students position the end of the straw about 1 foot from the side of the basin to reduce splashing.**

4 **Have students record their observations in Step B on Student Activity Sheet 4C.**

5 **Have students predict what would happen if two students blew air on the water through a straw. They should record their predictions under Step C on Student Activity Sheet 4C, then test their predictions and record what they observe under Step D.**

6 **Discuss with the class the connection between the wind and the waves. If they don't reach the conclusion on their own, explain that the stronger the wind, the larger the waves that result. Allow student teams to come up with ideas about how they could make a stronger wind (e.g., have more than two students blow air onto the water). Groups should test their predictions and record their findings on Student Activity Sheet 4C.**

7 **After ample time, bring students together to discuss observations as a class. Ask them what causes waves. Discuss their answers, relating them to students' experiences with the water wave experiments they conducted.**

8 **As a class, discuss what students have learned about how wind causes waves. Use the questions in Step E of the activity sheet to guide the discussion, and have students complete the sheet.**

Science Notebook Opportunity

Notebook Prompt:
Write to explain what happens to the amplitude, frequency, and wavelength when a strong force is used to disturb the surface of the water.

Teacher Tip

The distance at which students position the straw is an estimate. Students who are blowing gently may need to be closer. Those students who blow very hard may need to be farther away. The goal is for students to create a noticeable disturbance on the surface of the water by blowing through the straw.

Teacher Tip

When more than one student blows on the water, more force is being applied, causing more energy to move through the water. As a result, the wave's frequency is faster, the amplitude is higher, and the wavelength is shorter.

Part C

Rolling Waves

Teacher Tip

Although the water moves up and down, students may have the misconception that water waves move from side to side. Students may find this analogy helpful: Have them picture a crowd doing "the wave" at a baseball game. The wave moves in a direction (around the stadium), but the people who make up the wave only stand up and sit down while remaining in a fixed position (their seats). This is how energy (the wave) moves through the water (the crowd). Students will next use marbles to model this phenomenon.

1 **Distribute Student Activity Sheet 4D: *Keep It Rolling*. Review the observations made during Part B. Ask students to explain the direction in which the water moved when they blew on it through their straws. Have them record their answers on Student Activity Sheet 4D, Step A.**

2 **Give each group a set of five marbles. Direct students to place four marbles on the desktop, lined up in a row with each marble touching its neighbors. Ask students to predict what will happen if the fifth marble is gently rolled toward the marble at one end of the row, and hits it. They should record their predictions on Student Activity Sheet 4D, Step B.**

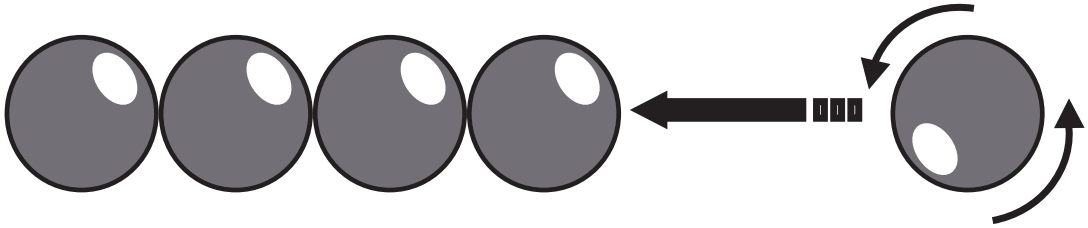


Figure 4.3
How to set up the marbles

Teacher Tip

If after observing the marbles, students still think water in a wave moves side to side, ask them to consider the movement of the middle marbles (they should have remained stationary). It may be helpful to revisit the idea of "the wave" at a baseball game, but this time to seat the class in a circle and have them do "the wave." Students should recognize that they are not moving from side to side; just like water as energy passes through it, they are moving up and down in place as the wave moves around the circle.

3 **Have one student in each group roll the fifth marble as directed on Student Activity Sheet 4D, Step C, to test the group's predictions. Students should observe the marble at the far end of the row rolling away while the others remain in a line. Have students repeat the experiment several times. As they complete these additional trials, all members of the group should complete the flow chart in Step D.**

4 **As a class, discuss the idea that the energy in the rolling marble was transferred into the marble it hit, and then from that marble to the next, until the energy reached the last marble. Since there was no other marble into which to transfer the energy, the energy made that marble roll away. Point out that energy moved through the marbles in waves, the same way that it moved through the water in their earlier experiments.**

5 **Ask students what causes water waves. At this point, students should be able to explain that the disturbance of the water by energy (as seen in the water basin experiments) is what causes water waves. Discuss their ideas, relating them to the experiments they conducted in this lesson.**

6 **Ask whether water moves sideways inside a wave, or if the water stays in one place while the energy moves through it. Again, students should be able to relate their answers to their experiences with the waves and with the row of marbles. (Students may say that water moves side to side. If they do, take the opportunity to reinforce the understanding that the water moves up and down as the energy moves through the water, as seen in the marble experiment.)**

7 **Allow time for students to complete Step E of the activity sheet.**

Science Notebook Opportunity

Notebook Prompt:
How did the energy move when the marble rolled into the other marbles?

I think the energy moved _____ because_____.

Part D

Using Patterns and Waves as Signals

1. Ask students a series of simple yes or no questions about any topic. Instruct them to answer only by nodding or shaking their heads. Explain that when they respond this way, they are using patterns of motion to communicate coded messages. The pattern of up-and-down movement that we call nodding is code for the answer "yes." The pattern of side-to-side motion that we make when we shake our heads is a code for the answer "no." Point out that any time we communicate over a distance, we use codes carried by waves to do it. Explain that all digital electronic devices use codes made of patterns to transfer information.

2. Distribute a copy of Student Activity Sheet 4E: *Patterns and Signals* to each student. Explain that before telephones were invented, Morse code was used to send coded messages as a series of simple clicking sounds. These clicks could be transmitted with electricity through wires across long distances (though those distances were nowhere near as far as we can send messages through cables [and wirelessly] today!). Referring to Student Activity Sheet 4E, write the Morse code patterns for a few letters to write on the board. Ask students to refer to the activity sheet to decode the letters you chose.

3. Separate students into pairs and have them complete the activity sheet as they perform the following investigation. Tell students that they will work with a partner to brainstorm one way to send a Morse code message using a pattern they can hear and one way to send a Morse code message using a pattern they can see. They will then use their codes to send and receive simple messages.

4. Instruct pairs to work together to develop a plan to send messages using a code that can be seen and a code that can be heard. They should answer the questions and complete the table in Part A of Student Activity Sheet 4E at this time. Circulate around from group to group and offer coaching as needed.

5. Once each pair has developed both audible and visible representations it will use to produce patterns, instruct them to complete Part B of the activity sheet, and try to send messages using their codes. Allow time for each student in the pair to send a message to his or her partner. Be sure that within each pair, students have a chance to act as both sender and receiver.

6. Gather the class together after each student has sent, received, and decoded a message. Ask pairs to share their codes and their experiences. Compare the different solutions that groups came up with, and the differences between the patterns that were seen and the patterns that were heard.

Teacher Tip

Provide coaching to students about possible ways to differentiate sound to make patterns. For example, the duration between the "clicks" of Morse code is what distinguishes dots and dashes. Students can also produce *different* sounds to develop patterns—for example, tapping a pencil on a desk produces a different sound from tapping the pencil on a book. One of those sounds could be associated with dots and the other with dashes.

Teacher Tip

Remind students that, because they are using patterns of sounds to transfer their messages, the class space will need to be quiet during the activity so students can hear their partners' signals. Conduct the activity in a space that permits pairs to spread out to minimize distractions from other teams.

EXTENSIONS

Make Waves in a Bottle

1. Fill a clear 16-oz bottle two-thirds full with water. Add a few drops of food coloring to the water, secure the cap, and shake to mix.
2. Remove the cap and fill the bottle the rest of the way with mineral oil or vegetable oil, so there's no room for air. Secure the cap.
3. Lay the bottle on its side. The oil will float to the top.
4. Roll the bottle back and forth. The waves move up and down as energy moves through the water.
5. Roll the bottle back and forth. The waves move up and down as energy moves through the water.

Earthquakes Make Waves

Earthquakes are catastrophic events that make waves on the earth's surface. The United States Geological Survey website offers several resources students can explore to learn about the science of earthquakes:

Read facts about earthquakes and how scientists study them:

- http://earthquake.usgs.gov/learn/kids/eqscience.php

Explore the different ways the earth can shift in an earthquake:

- http://earthquake.usgs.gov/learn/animations
- How is geothermal energy used in Iceland?

Tsunami Waves

Watch how a wave can form by movement of the ocean floor:

- http://www2.gov.bc.ca/gov/content/safety/emergency-preparedness-response-recovery

Wave Simulator

In a station/center or whole class demonstration, students can use a wave simulator to test and observe what happens when the wavelength, frequency, and amplitude of a wave are changed. The National Geographic website provides a simulator:

- http://education.nationalgeographic.org/media/interactive/wavesimulator/

How Fast Is a Tsunami Wave?

Have students visit the NOAA website to read about tsunamis, and then answer the following word problem.

- http://www.srh.noaa.gov/jetstream/tsunami/tsunami_faq.htm

An undersea earthquake unleashes a tremendous amount of energy and powerful waves. Tsunami waves move at speeds of up to 800 kilometers per hour, or as fast as a jet plane. If there are 1.5 kilometers in 1 mile, how many miles can a tsunami wave travel per hour? (Answer: 500 miles)

Concrete Poems

A concrete poem is written in a special shape related to the theme of the poem. Invite students to write and share a concrete poem about waves.

Literacy Series Reader: *Energy Works!*

As a class, in small groups, or in pairs, have students explore the informational text in the literacy reader for this unit. Refer to Appendix E for strategies for before, during, and after reading the lesson-specific chapters or for exploring the literacy reader as a whole after the unit.

EXTENSIONS

Making Sound Waves

1. Students can make drums using jars, balloons, rubber bands, and rice. Provide the materials to individuals, small groups, or the whole class, and follow these steps to lead students through assembling and using drum.

a. Cut a balloon vertically through the middle.

b. Stretch one-half of the cut balloon over the mouth of the jar.

c. Place the rubber band around the mouth of the jar to secure the balloon skin.

d. Place a few grains of rice on the skin so that when they tap on the drum (apply force) to produce sound, students can observe the effects of the vibration.

2. After everyone has had a chance to experience the model and create sounds, discuss the following questions:

- Is your drum different from other students' drums?
- What do you think would happen if you filled the jar with something? Would the sound produced be the same?

The Great Japan Earthquake

Read about the Great Japan Earthquake of 1923 on the Smithsonian's website:

- http://www.smithsonianmag.com/history-archaeology/The-Great-Japan-Earthquake-of-1923.html

EVALUATION/ASSESSMENT

1. In the opening discussion, take note of students' prior knowledge about the way water waves move to pre-assess their current knowledge and misconceptions.

2. As students work in groups and test wave movement in water, notice if they recognize that energy is moving through the water, and are applying appropriate vocabulary. Check completed copies of Student Activity Sheets 4A, 4B (if used), and 4C as well.

3. Review completed copies of Student Activity Sheets 4D and 4E to evaluate students' understanding of how energy moves in waves through solid objects and how waves can be used to send and receive messages.

4. Use the General Rubric included in Appendix D to assess individual progress as needed.

PLANNING AHEAD

Preparing for Lesson 5

In Part C, each group will need a small plastic bottle of water, either 8 oz or 16 oz in size, to use with their waterwheels. Ask students to bring these in, or collect them yourself.

Student Activity Sheet 4A

Name _____

Test the Waters

Date:

Team of Scientists:

A) _____ **B)** _____

C) _____ **D)** _____

Equipment: 1 pipette 1 basin of water 1 ruler

A. Predict

What will happen to the surface of the water in the basin when a single drop of water is released from 1 inch above the surface?

I think _____

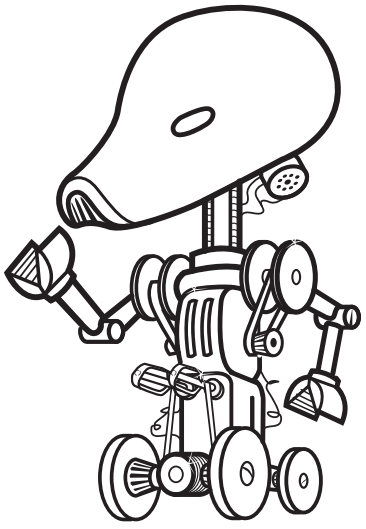
_____

_____

because _____

_____

_____.



B. Observe and Record

Hold the pipette 1 inch above the water and release a single drop of water into the basin. Draw what you see.

C. Predict

What will happen to the water in the basin when a single drop of water is released from 6 inches above the surface?

I think _____

_____

_____

because _____

_____

_____.

D. Observe and Record

Hold the pipette 12 inches above the water and release a single drop of water into the basin. Draw what you see.

E. Conclude

1. What happened to the surface of the water in the basin when you released a single drop of water from 1 inch above?

2. What happened to the surface of the water in the basin when you released a single drop of water from 12 inches above?

3. How were the waves the same?

4. How were the waves different?

5. What caused the waves?

6. Where did the energy come from?

7. Where did the energy go?

Student Activity Sheet 4A: Teacher's Version

Test the Waters

E. Conclude

1. What happened to the surface of the water in the basin when you released a single drop of water from 1 inch above the surface? *(The falling water drop disturbed the still surface of the water in the basin. Small ripples of energy moved outward from the impact.)*

2. What happened to the surface of the water in the basin when you released a single drop of water from 12 inches above the surface? *(The impact produced a greater disturbance. There was a small splash, and a ring of larger waves moved out from the center.)*

3. How were the waves the same? *(They appeared as rings of crests and troughs moving out from the center of the impact.)*

4. How were the waves different? *(They differed in size and the space between them.)*

5. What caused the waves? *(The waves were caused by the transfer of energy from the falling drop of water.)*

6. Where did the energy come from? *(The energy came from the kinetic energy of the falling drop of water.)*

7. Where did the energy go? *(The energy moved into the water in the basin.)*

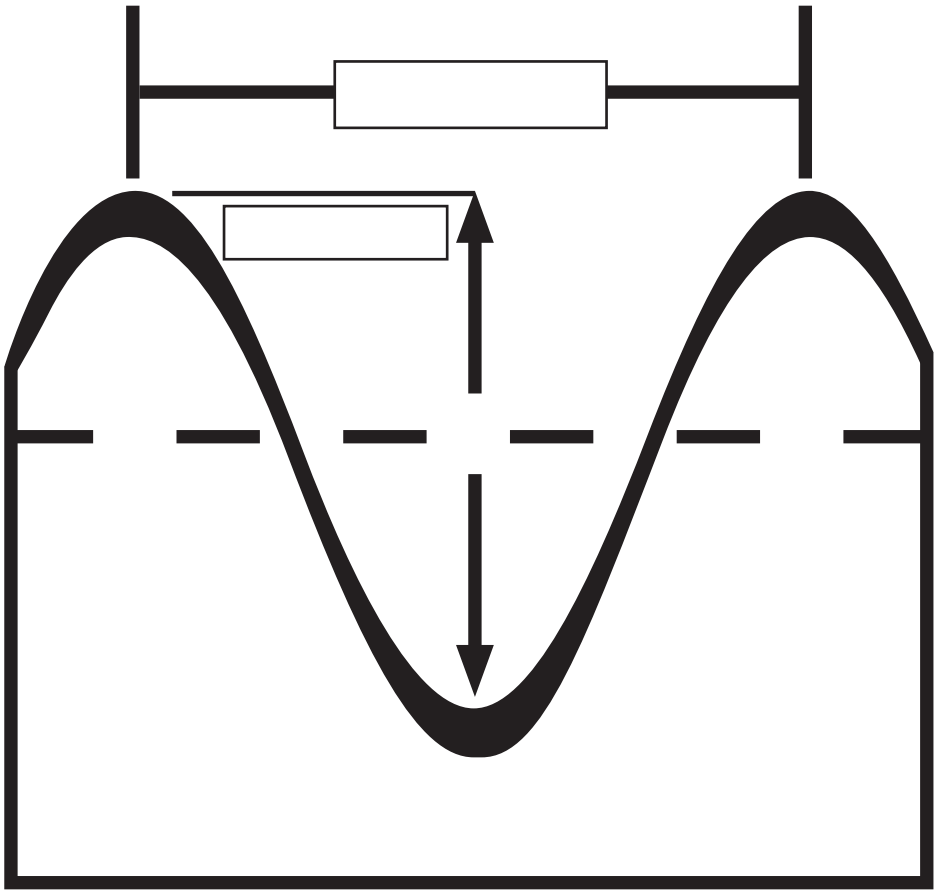
Student Activity Sheet 4B

Name _____

Parts of a Wave

Water waves are created by disturbing the surface of the water. The height, speed and distance between waves can vary depending on the amount of energy being transferred.

After testing and observing the waves created by disturbing the surface of the water with a marble, cut and paste the labels to identify the parts of the wave on the picture below.



Amplitude: the height of a wave

Wavelength: the space between wave peaks

Frequency: the speed of the wave

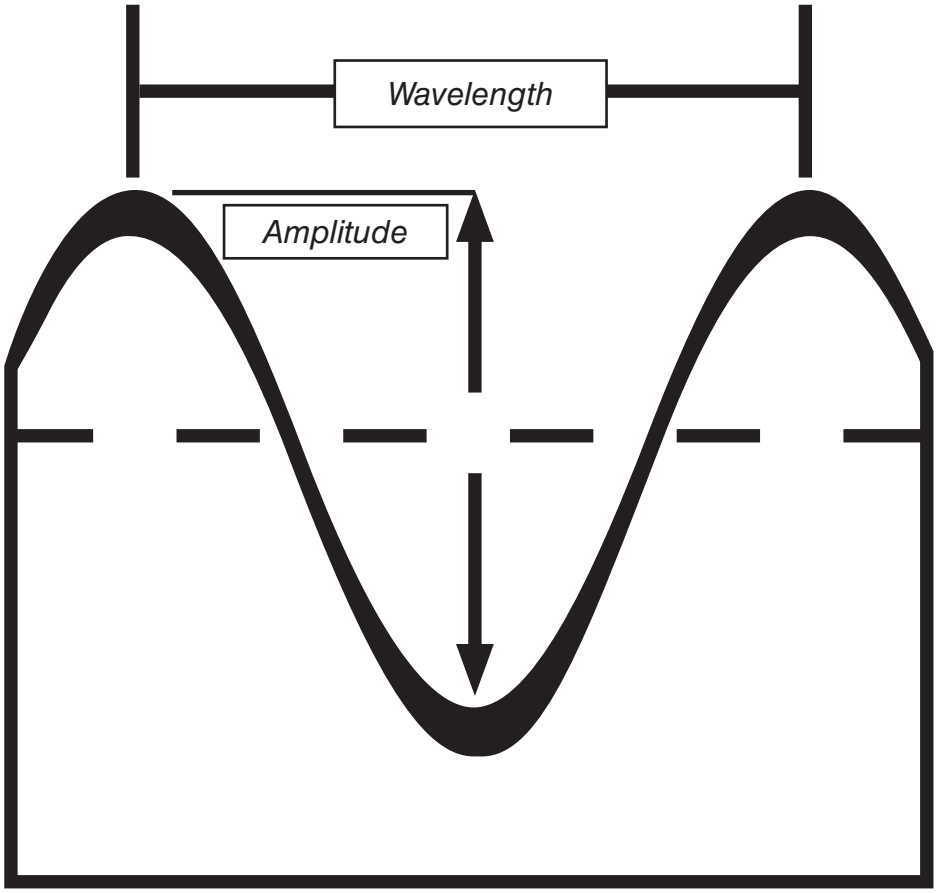
Amplitude

Wavelength

Frequency

Student Activity Sheet 4B: Teacher's Version

Parts of a Wave



Student Activity Sheet 4C

Name _____

The Way the Wind Blows

Date:

Team of Scientists:

A) _____ **B)** _____

C) _____ **D)** _____

Equipment: 1 straw 1 basin of water

A. Predict

What will happen to the surface of the water when one person blows air on the water through a straw?

I think _____

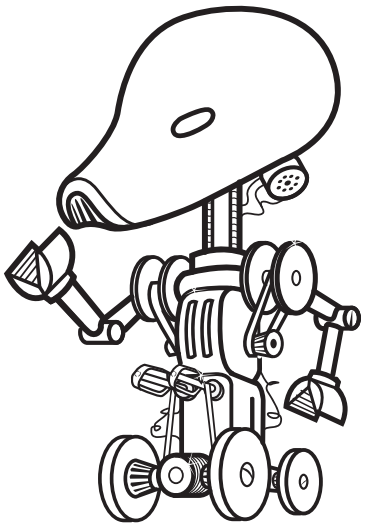
_____

_____

because _____

_____

_____.



B. Observe and Record

Pick one student in your group to blow air on the surface of the water with a straw. Draw what you see.

C. Predict

What will happen to the surface of the water when two people blow air on the water through straws at the same time?

I think _____

_____

_____

because _____

_____

_____.

D. Observe and Record

Pick two students in your group to blow air on the water through straws at the same time. Draw what you see.

E. Conclude

1. What happened to the water when one person blew air through a straw? _____

2. What caused the water to move? _____

3. What happened to the amplitude of the waves when more than one person was blowing on the water?

4. What happened to the wavelength of the waves when more than one person was blowing on the water?

5. What happened to the frequency of the waves when more than one person was blowing on the water?

6. Where did the energy come from? _____

Student Activity Sheet 4C: Teacher's Version

The Way the Wind Blows

E. Conclude

1. What happened to the water when one person blew air through a straw? *(Waves appeared on the surface of the water.)*

2. What caused the water to move? *(Energy transferring from the moving air to the water and moving through it.)*

3. What happened to the amplitude of the waves when more than one person was blowing on the water? *(The amplitude was higher.)*

4. What happened to the wavelength of the waves when more than one person was blowing on the water? *(The wavelengths were shorter.)*

5. What happened to the frequency of the waves when more than one person was blowing on the water? *(It became faster [higher].)*

6. Where did the energy come from? *(It transferred from the kinetic energy of the moving air.)*

Student Activity Sheet 4D

Name _____

Keep It Rolling

Date:

Team of Scientists:

A) _____ **B)** _____

C) _____ **D)** _____

Equipment: 5 marbles

A. Review

In which direction does a water wave move?

_____

_____

_____

B. Predict

What will happen when one marble is rolled into the end of the row of marbles?

I think _____

_____

_____

because _____

_____

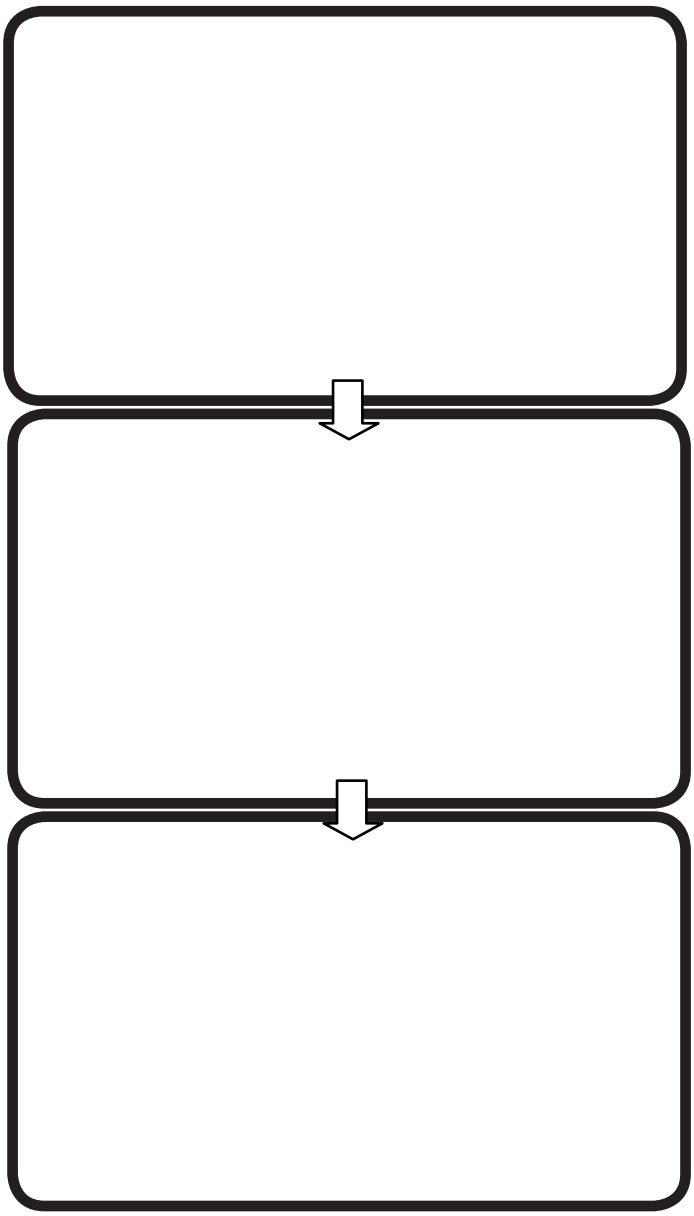
_____.

C. Observe

Line up four marbles. Choose one team member to roll one marble gently into the first marble in the row.

D. Record

Draw and write to complete the flow chart below to show what happened to the marbles.



What happened to the rolled marble?

What happened to the three marbles in the middle?

What happened to the last marble in the row?

E. Conclude

Energy moved through the marbles in a wave just as it moved through water. Compare what happened to the three marbles in the middle of the row and what happened to the water in the basin when energy moved through it. In which direction do the marbles and the water move?

Student Activity Sheet 4D: Teacher's Version

Keep It Rolling

A. Review

In which direction does a water wave move? *(A water wave moves out in all directions from the energy source.)*

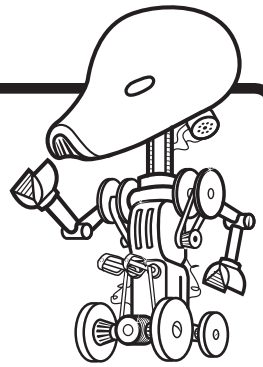
E. Conclude

Energy moved through the marbles in a wave just as it moved through water. Compare what happened to the three marbles in the middle of the row and what happened to the water in the basin when energy moved through it. In which direction do the marbles and the water move? *(The marbles in the middle of the row transferred the energy, from one to the next, without changing location themselves. This is similar to the way waves move through water without relocating the water. The energy moves outward, away from the energy source.)*

Student Activity Sheet 4E

Name _____

Patterns and Signals



Date:

Team of Scientists:

A) _____ **B)** _____

Morse Code Key

A •–	K –•–	U ••–	1 •————
B –•••	L •–••	V •••–	2 ••–––
C –•–•	M ––	W •––	3 •••––
D –••	N –•	X –••–	4 ••••–
E •	O –––	Y –•––	5 •••••
F ••–•	P •––•	Z ––••	6 –••••
G ––•	Q ––•–		7 ––•••
H ••••	R •–•		8 –––••
I ••	S •••		9 ––––•
J •–––	T –		10 –––––

A. Plan

With your partner, look at the patterns of dots and dashes that stand for the letters and numbers in Morse code.

1. To make a similar set of patterns using signals that you can hear, how many different sounds do you need to be able to hear and tell apart? _____

_____

2. To make a similar set of patterns using signals that you can see, how many different sights do you need to be able to see and tell apart? _____

_____

3. Think of ideas with your partner. Decide what signals you will use to make patterns to transfer your information from one place to another. In the table below, describe what you will use to make the patterns.

	See	Hear
To represent dots		
To represent dashes		

4. You and your partner will each send and receive information. Decide which of you will be the sender for the signals you can see. The other will be the receiver during that message. During the next turn, switch roles. If you were the sender, you will be the receiver of the signals you can hear. Circle the signals for which you will be the sender:

signals we can see signals we can hear

5. Choose a question to answer when you are the sender. Check it off below, but do not share you choice with your partner.

- ☐ 1. In which month is my birthday?
- ☐ 2. What is my favorite snack?
- ☐ 3. What is my mom's name?

B. Try Your Solution

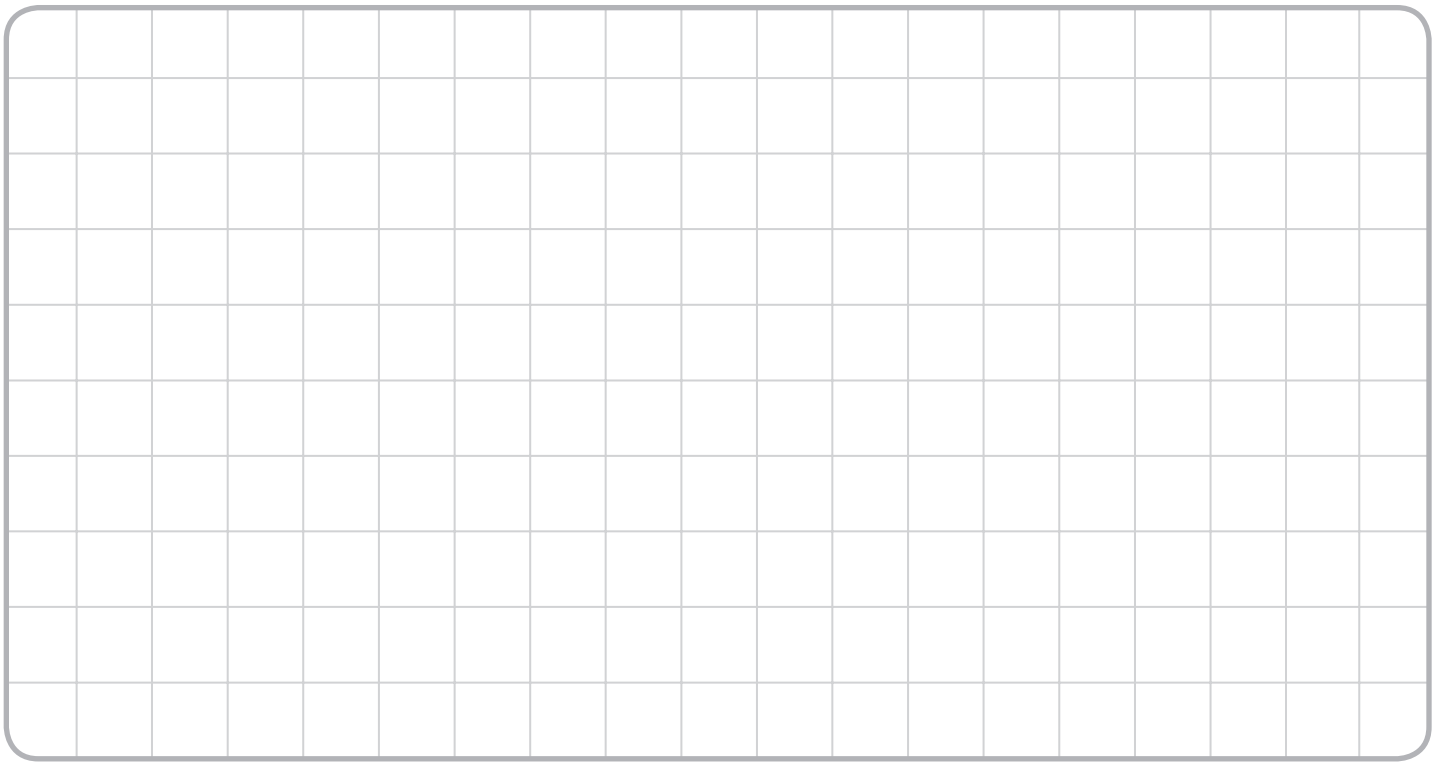
1. Sending a Message

a. Transmit the signal to let the receiver know the number of the question you will answer.

b. Use your code to send the pattern of signals to tell the receiver your answer to the question.

2. Receiving a Message

a. Record the pattern of signals you receive from the sender below.



b. Decode the information using the Morse Code key on the first page of this activity sheet. Check your results with your partner to see if you received the information accurately.

C. Compare Solutions

1. Which of your pattern methods worked best to transfer information? _____

2. What made one solution better or less effective than the other? _____

Student Activity Sheet 4E: Teacher's Version

Patterns and Signals

A. Plan

1. To make a similar set of patterns using signals that you can hear, how many different sounds do you need to be able to hear and tell apart? *(Two)*

2. To make a similar set of patterns using signals that you can see, how many different sights do you need to be able to see and tell apart? *(Two)*

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Energy Works!

by Janette Schuster

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