FOCUS ON SCIENCE

Energy Waves

Basic Level

Physical Science
Interactions Between Matter and Energy

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Scientific Inquiry

The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.

Represent, present, and defend their proposed explanations of everyday observations so that they can be understood and assessed by others.

Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

Use conventional techniques and those of their own design to make further observations and refine their explanations, guided by a need for more information.

Physical Science

Energy exists in many forms, and when these forms change energy is conserved.

Different forms of electromagnetic energy have different wavelengths. Some examples of electromagnetic energy are microwaves, infrared light, visible light, ultraviolet light, X-rays, and gamma rays.

Light passes through some materials, sometimes refracting in the process. Materials absorb and reflect light, and may transmit light. To see an object, light from that object, emitted by or reflected from it, must enter the eye.

Vibrations in materials set up wave-like disturbances that spread away from the source. Sound waves are an example. Vibrational waves move at different speeds in different materials. Sound cannot travel in a vacuum.

Electrical energy can be produced from a variety of energy sources and can be transformed into almost any other form of energy.

English Language Arts

The following is a selective listing of the competencies and indicators addressed in this book.

Word Recognition

- Use word recognition skills and strategies quickly,accurately, and automatically when decodingunfamiliar words

Background Knowledge and Vocabulary Development

- Use self-monitoring strategies to identify specific vocabulary difficulties that disrupt comprehension,and employ an efficient course of action, such asusing a known word base or a resource such as aglossary to resolve the difficulty

Comprehension Strategies

- Use a variety of strategies (e.g., summarizing,forming questions, visualizing, and making connections) to support understanding of texts read

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How to Help Your Students Make the Best Use of This Book

Encourage students to develop nonfiction literacy skills by completing the Active Reader activities. Also encourage them to . . .

- Underline main ideas in paragraphs.
- Circle details that support the main ideas.
- Write down questions as they read.
- Circle key words as well as unfamiliar words.

Printing Instructions

Student Book: print pages 5–24

Assessments: print pages 25–28

Answer Key: print pages 29–30

FOCUS ON SCIENCE

Energy Waves

How do the properties and interactions of matter and energy explain physical and chemical change?

Energy cannot be created or destroyed. It just changes form. For example, a ball has potential energy when it is sitting at the top of a hill. It changes to kinetic energy when it rolls down the hill.

Energy can travel from one place to another. For example, sound waves travel with the help of air. Particles of air vibrate and hit other particles, causing them to vibrate. This passes the wave along. Earthquakes create waves. They travel through the ground and cause it to vibrate.

Air and ground are made of matter. But in outer space, there is no matter. In outer space, energy waves can travel without the help of matter.

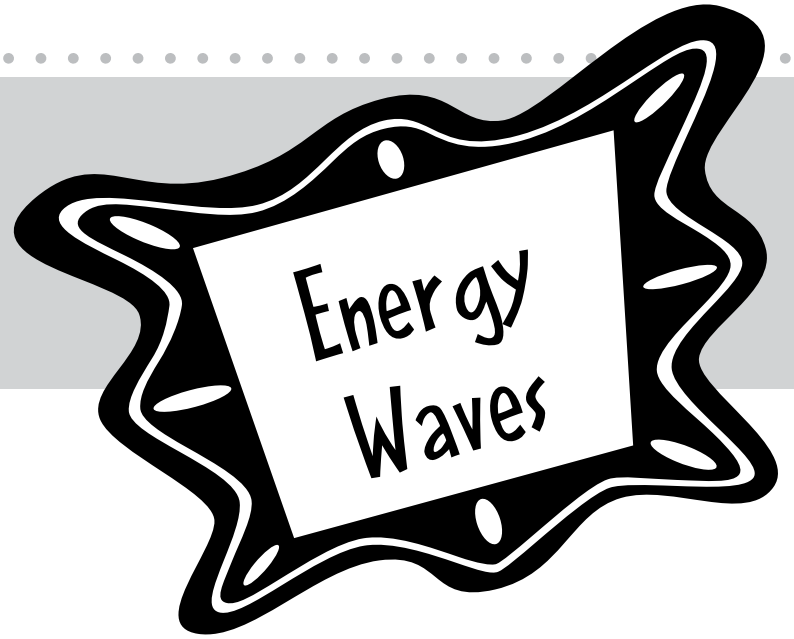


Table of Contents

Build Background

Brainstorm

How many different kinds of waves are you familiar with? List as many kinds of waves as you can on the lines below. Then, look for these words as you read this book. If you find the name of a wave you listed below, come back here and circle it. After you have completed this book, come back and add to the list.

_____

_____

_____

Define

What do you already know about kinetic and potential energy? Write your own definitions for the terms *kinetic energy* **and** *potential energy.*

1. **Kinetic energy is**

_____

2. **Potential energy is**

_____

Explain

Write a few words explaining the differences between kinetic and potential energy.

_____

_____

Starting Points

Key Vocabulary

Rate Your Knowledge

The words listed below have to do with energy. Each word is important, but some of them may be new. Read each word. Rate your knowledge of each by putting a check or a few words in the appropriate column. After completing this book, come back to this page and write the definitions of words you did not know.

	I don't know it.	I've seen it, but I'm not sure what it means.	I know it well. It means . . .
decibels			
electromagnetic spectrum			
energy			
fault			
focus			
medium			
oscilloscope			
pitch			
wavelengths			

Starting Points

Key Concepts

Energy Waves

Energy travels from place to place by waves. Energy waves can move up and down or back and forth.

When waves pass through matter, they cause the small particles in matter to vibrate. The particles themselves do not move along with the wave. Once the wave passes, they stop vibrating.

Think of a boat bobbing up and down in the sea as a wave passes by. The boat will move up and down. But it won't move toward the beach along with the wave.

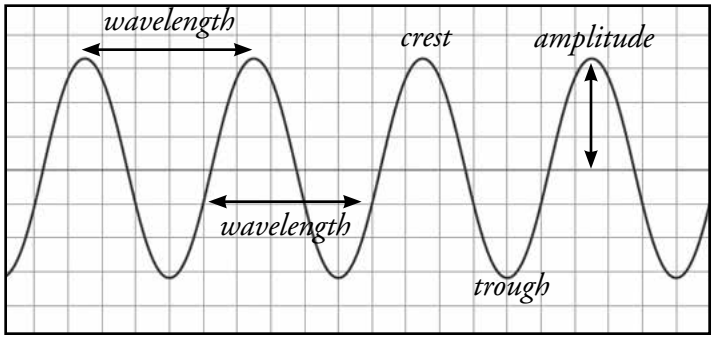
Parts of a Wave

We use these terms in bold type to describe waves:

The highest point of a wave is called its **crest**.
The lowest point in a wave is called the **trough**.
The distance between two waves is called the **wavelength**.
The distance between the crest and the trough of a wave is twice the **amplitude**.

A wave with high amplitude has more energy than a wave with lower amplitude. A large wave at the beach could knock you over, but a smaller wave will only get you wet.

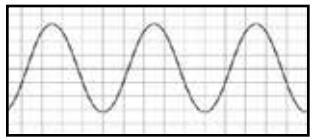
Scientists also measure the number of waves that pass a certain point during a certain span of time. This number is called **frequency**.

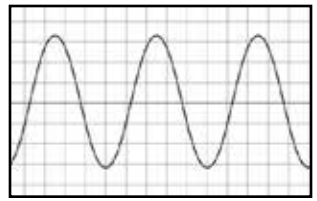


Scientists measure the wavelength, amplitude, and frequency of a wave.

ACTIVE READER

1 Identify *The higher the amplitude of a wave the more energy it has. Number the waves below in order of how much energy they have: 1 being the least energy and 3 being the most.*





Hands On Science

Watch Waves

Using a jump rope, demonstrate how waves can be measured.

1. **Tie one end of the jump rope to a chair and hold onto the other end. Shake the rope vigorously up and down. Record the properties of the wave. Draw a picture of it at the right.**

   Type of Energy Wave: _____

   High or Low Amplitude: _____

   High or Low Frequency: _____

2. **Keeping the jump rope tied to a chair, now move the rope back and forth slowly parallel to the ground, like a snake. Record the properties of the wave. Draw a picture of it at the right.**

   Type of Energy Wave: _____

   High or Low Amplitude: _____

   High or Low Frequency: _____

3. **With the jump rope still tied to the chair, move the rope slowly up and down. Record the properties of the wave. Draw a picture of it at the right.**

   Type of Energy Wave: _____

   High or Low Amplitude: _____

   High or Low Frequency: _____

Chapter 1 What Are Energy Waves?

FOCUS The underlined sentence states an important idea about energy waves. As you read, discover how waves behave.

Energy Waves

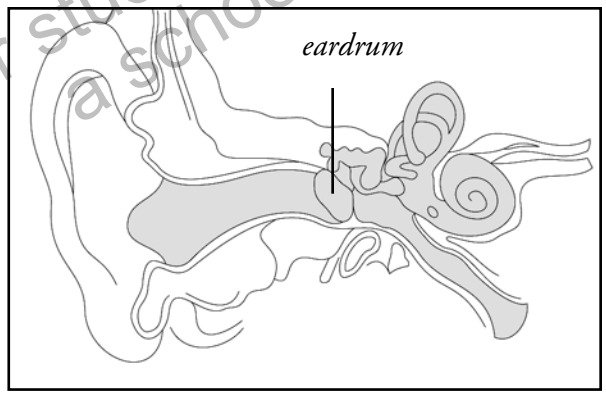
Energy uses waves to get from one place to another. When people think of waves, they think of ocean waves. Ocean waves carry a lot of energy. But they are not the only kind of wave. We cannot see most waves.

Sound Waves

Sound waves are made by vibrations. For example, when a musician bangs on a drum, the skin of the drum moves back and forth. This creates sound waves. They travel through the air. The sound waves cause your eardrums to vibrate. Your brain reads these vibrations as sound.

Sound waves need a medium, such as air or water in order to travel. Waves carry energy along, but the medium itself does not move along. The more dense a medium is, the slower waves will travel.

Without a medium, there would be no sound. When astronauts are in space, there is no air. Sound waves cannot travel. Astronauts must use radios in their helmets to talk to each other.



Just like a drum vibrates when struck with drumsticks, your eardrum vibrates when sound waves hit it.

ACTIVE READER

1 Infer *The more dense a medium is, the slower sound waves will travel when passing through it. In which medium would the sound made by banging on a drum travel faster: water or air? Why?*

_____

_____

_____

_____

2 Connect *Tell about a time you experienced a really loud sound. How did it make your ears or head feel?*

_____

_____

_____

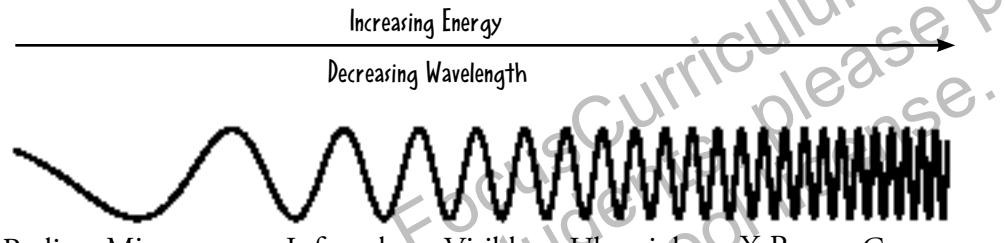
_____

Electromagnetic Waves

When you turn on a burner of an electric stove, the coil heats up. Soon it turns red. Then it turns orange as it gets hotter. The matter in the coil is giving off electromagnetic waves. We see these waves as light. Many things in your home create electromagnetic waves. Light bulbs and microwave ovens are examples.

Seven types of electromagnetic waves make up the **electromagnetic spectrum**: gamma, x-ray, ultraviolet, visible light, infrared, microwave, and radio. Each has a different wavelength. Electromagnetic waves are different from sound waves. They don't need a medium to travel through.

Electromagnetic Spectrum



Wave Type	Radio	Microwave	Infrared	Visible	Ultraviolet	X Ray	Gamma
Approximate Size	buildings	people	insects	amoebas	molecules	atoms	atomic nuclei

Here are some facts about the electromagnetic waves:

Gamma waves produce the most energy.
X-rays can pass through skin, but not bone.
Ultraviolet waves are given off by the sun and can cause sunburn.
Visible light waves are the only ones that we can see.
Infrared waves can be felt as heat.
Microwave are also called radar waves. They are used for locating airplanes and submarines.
Without radio waves, your cell phone wouldn't work.

ACTIVE READER

1 Investigate *Which of your appliances at home uses waves from the electromagnetic spectrum? List two or three.*

_____

_____

_____

_____

_____

_____

_____

Good to Know

Electromagnetic waves vary by wavelength. Radio waves are very long; some are as long as a building is tall. Visible light has a wavelength that is about the size of an amoeba. On the other end of the spectrum, gamma rays have a wavelength that is smaller than the nucleus of an atom.

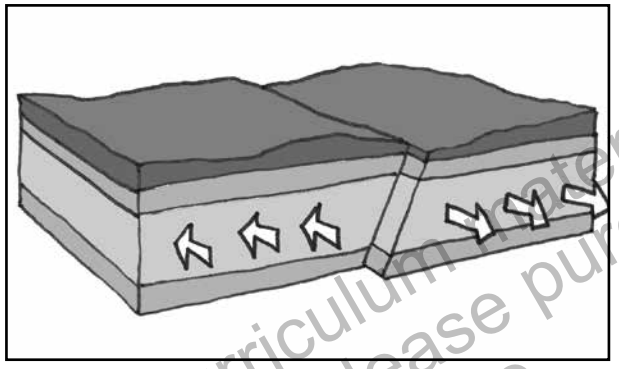
Seismic Waves

Earthquakes create seismic waves. They cause the ground to shake. Seismic waves cannot be seen, but they can be felt.

Earthquakes happen when tectonic plates slip or move past each other. The pressure released creates violent seismic waves. These waves pass through Earth's crust. The waves spread out in all directions from the **focus**, or center, of the earthquake.

There are three kinds of seismic waves:

- P waves can travel through Earth's molten core.
- S waves can only go through solid parts of Earth's crust and mantle.
- Ground waves travel along the surface of the Earth. They cause the most damage.



Earthquakes happen when two plates move against each other. This movement creates a release of energy that forms seismic waves.

FOCUS QUESTIONS

1. What do waves carry along from one place to another?

_____

_____

2. Complete the diagram below.

gamma → _____ → ultraviolet → visible light → _____ → microwave → radio

Most earthquakes in the United States occur on the West Coast along the San Andreas Fault. This is where the Pacific Plate and the North American Plate move against each other. However, there have been earthquakes in New York, too. Search the Internet using the term New York Earthquake. List the date and place where two earthquakes have occurred. Find out what caused them.

Good to Know

It is important to know what to do when an earthquake occurs. If you are inside, you should drop to the floor and take cover under a sturdy desk or table. If you are outside, try to get to an open space, away from buildings, streetlights, or power lines.

Stop and Think

This page will help you summarize what you have read so far.

Tip:
An effect is the result of a cause. Reread to recall the effect of rocks pushing against each other.

1. Complete this chart to show the effect of plates on either side of a fault pushing against each other. Then describe the kind of energy that is involved.

Cause	Effect
Plates on either side of a fault press against each other.	

-

2. Which type of seismic wave causes the most damage at the Earth's surface?

(1) P waves
(2) Gamma rays
(3) S waves
(4) Ground waves

3. What are two examples of media that sound waves can travel through?

Dear Ms. Understanding,

Does the ground really open up when there is an earthquake? Is that what causes all the damage?

Confused in Canarsie

Dear Confused,

No, the ground does not actually open up when there is an earthquake. In fact, if it did, there would not be any earthquakes because there would not be any friction to cause the build up of energy that causes earthquakes. Sometimes a highway or other paved surface may crack, causing crevasses, but the ground will not open up and swallow people and buildings.

Ms. Understanding

Chapter 2 Measuring Energy Waves

FOCUS The underlined sentence states important information about how sound waves are measured. Read on to learn about loudness and pitch.

Measuring Sound Waves

A sound can be measured in two ways: its intensity or loudness and its frequency, or **pitch**.

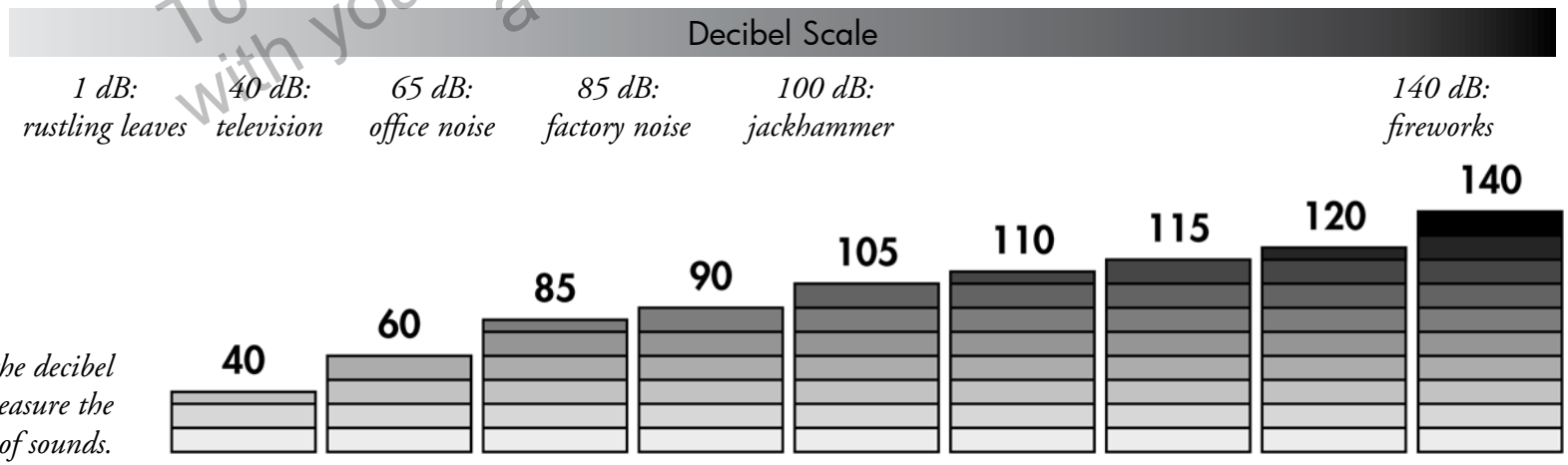
The loudness of a sound is measured in **decibels** (dB). The louder the sound, the higher it is on the decibel scale. The sound of someone whispering is on the low end of the decibel scale. The sound of a jet engine is at the high end. Anything above 130 dB can harm our ears.

Sound waves with a short wave pattern make soft sounds. Sound waves with a tall wave pattern make loud sounds. Sound wave patterns are measured using a machine called an **oscilloscope**.

A sound can be low-pitched or high-pitched. A low-pitched sound is made by waves that vibrate slowly. A big truck makes a low-pitched sound as it rumbles down the highway. A high-pitched sound is made by waves that vibrate more quickly. A bird makes a high-pitched sound when it sings.

ACTIVE READER

1 Report *How loud is a dog's bark? Where do you think the sound of a dog barking falls on the decibel scale? Is a dog's bark high-pitched or low-pitched?*



Scientists use the decibel scale to measure the loudness of sounds.

Measuring Earthquake Waves

The **magnitude**, or size, of an earthquake is measured using a **seismograph**. This machine makes a squiggly line when an earthquake happens. A big squiggle means a big earthquake has happened

Scientists use the **Richter Scale** to measure the energy released by an earthquake. The scale goes from 1 to 10. Each number stands for 10 times more energy than the number below it.

For example, an earthquake that registers a 6 on the Richter Scale is ten times more powerful than an earthquake that registers a 5. Earthquakes that register at 2 or below are not always felt. The highest ever recorded was 9.5 when a massive earthquake struck Chile on May 22, 1960.

More than a million earthquakes occur each year. Most of them are minor. They register below 2 on the Richter Scale. Scientists closely watch seismographs so they can try to predict when a big earthquake might happen.

Scientists measure the strength of an earthquake using a seismograph.

FOCUS QUESTIONS

1. **What is the decibel scale?**

2. **Describe how a seismograph works.**

ACTIVE READER

1 Infer *How many times more powerful was the 8.8 earthquake that struck Chile in February 2010 than the 7.0 quake that struck Haiti earlier that same year?*

___ *between 1 and 10 times*

___ *between 10 and 20 times*

___ *between 10 and 100 times*

Good to Know

Charles F. Richter was born in 1900 on Sunnyside Farm in Overpeck, Ohio. Overpeck is near Cincinnati in Butler County. He developed a way to measure the magnitude of earthquakes, which became known as the Richter Scale.

Stop and Think

This page will help you summarize what you have read so far.

Tip:
Look back through the chapter to find the words in the answer. Reread the sentences that contain those words.

1. What is one way in which the sounds created by a fire alarm and a drum are alike?

_____

_____

_____

2. What is one way in which the sounds created by a fire alarm and a drum are different?

_____

_____

_____

3. Which of these is used to display sound wave patterns?

(1) decibel scale
(2) Richter scale
(3) seismograph
(4) oscilloscope

Dear Ms. Understanding,

The other day on the news, a reporter briefly mentioned a magnitude 5.9 earthquake that occurred in an unpopulated area. Yet, I have heard a great deal about smaller magnitude earthquakes that occurred near large cities. Why is the smaller earthquake a bigger news story?

Mystified in Monroe County

Dear Mystified,

A major factor in determining how devastating an earthquake is where it occurs. A large magnitude earthquake that occurs in an unpopulated or sparsely populated area is most likely going to cause less damage than a smaller earthquake that happens in a large city, where there are more buildings and roads.

Ms. Understanding

Chapter 3 Visible Light

FOCUS

This section explain important ideas about light. As you read, discover how light waves behave.

What Is Light?

You open your eyes in the morning and look around. You see a fly sleeping upside down on the ceiling. You look at your clothing for the day. What colors go together?

Did you ever wonder how you can see these things? Light is the reason. When we see objects, our eyes sense the light bouncing off the objects.

The type of light energy our eyes can see is visible light energy. Visible light is made up of many colors. We see red when red light bounces off an object. When our eyes sense light with all the colors, we see white light.

What causes light? Light is created by the release of energy from tiny particles in matter.

For example, when particles in metal are heated, they start to move around. They bump into each other creating heat. This makes the metal turn red. In a red-hot object, the particles have enough energy to begin making light that we can see. As the metal heats up, it becomes very hot and turns white. The particles are giving off lots of energy.

glowing hot molten metal
Image: Kittikun Atsawintarangkul / FreeDigitalPhotos.net

ACTIVE READER

1 Recall *Where does visible light fall on the electromagnetic spectrum?*

_____

_____

_____

_____

2 Infer *As metal heats up, it begins to glow red. As it get hotter, it turns white. This suggests that which of the following statements is true?*

(1) As metal heats up, energy waves are released in shorter and shorter wavelengths.

(2) As metal heats up, energy waves are released in longer and longer wavelengths

How Light Behaves

Light travels in a straight line until it hits an object. It may pass through the object, or it may bounce off it.

Light that bounces off an object is reflected light. Smooth surfaces reflect light in one direction. This is wh we can see ourselves in a mirror.

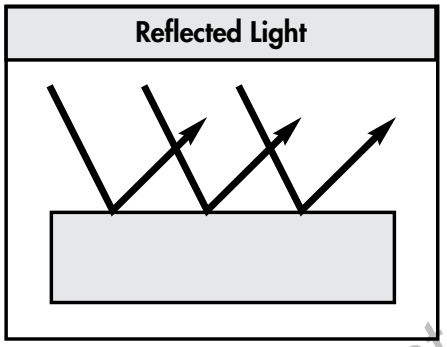
Some objects let light pass through it, but bend it. The light is refracted. Water, for example, slows down light and refracts it. This causes a pencil to look bent when placed in a glass of water. Try it and see.

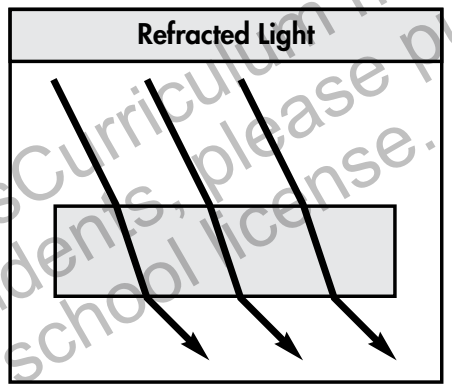
Light that is absorbed enters an object without reflecting or refracting. Tiny particles in objects absorb certain colors. The remaining color or colors bounce off. The colors that bounce off are the ones that we see.

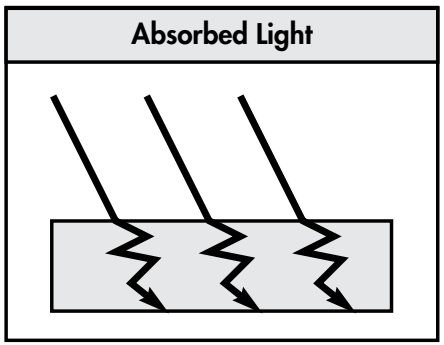
The Visible Light Spectrum

Isaac Newton was a leader in the study of light in the 1600s and 1700s. He experimented with the white light to discover how it was related to color.

To find the answer, Newton shaded a window. The shade had a hole in it. One beam of sunlight fell into the room through the hole. Newton placed a prism in front of the beam of light. A prism is a wedge-shaped piece of polished glass.







ACTIVE READER

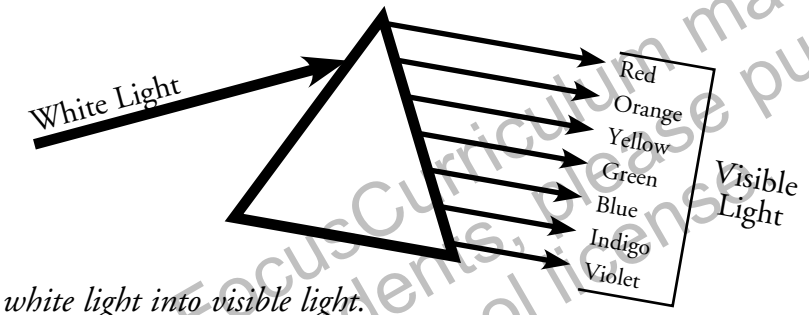
1 Analyze *The diagram of refracted light on this page shows that the light is bent twice. Use the diagram to explain in your own words what causes light to be refracted.*

Good to Know

A rainbow is produced when the Sun shines through tiny rain droplets that fill the air. The droplets act like a prism and refract white light into the visible color spectrum. You can only see a rainbow if the sun is behind you. The rainbow then appears in front of you.

The prism bent, or refracted the light. The light hit the wall. It looked like a beautiful rainbow. Newton repeated the experiment many times to be sure of the same result. Newton discovered that white light passing through a prism bends. The prism split the invisible white light into visible colored light. Newton decided that white light is not the absence of colors. It is, instead, the presence of all visible colors.

The colors of light that make up the visible spectrum are the colors in a rainbow. You can remember them by using the acronym, ROY G. BIV, which stands for Red, Orange, Yellow, Green, Blue, Indigo, and Violet. These are the colors of the visible spectrum in the order of their wavelength.



A prism splits white light into visible light.

Web Quest

Sir Isaac Newton was one of the most important scientists who ever lived. Find out more about his life and discoveries and share information about him with others in the form of an oral report, video, or slide presentation.

FOCUS QUESTIONS

1. Sometimes when light hits an object, some of the light is absorbed and some is reflected. How do we sense the reflected light?

Stop and Think

This page will help you summarize what you have read so far.

1. Which explains why a yellow sweater appears yellow?

(1) The sweater reflects all colors including yellow.

(2) The sweater absorbs all colors except yellow, which it reflects.

(3) The sweater refracts all colors except yellow, which it absorbs.

(4) The sweater absorbs only the color yellow, and reflects all others.

2. Light is refracted when it passes through an object that

(1) causes it to bounce off

(2) traps it and won't let it escape

(3) bends it as it passes in and out

(4) allow it to pass through without changing speed

3. Which color of visible light has the longest wavelength? Which has the shortest?

_____

_____

Dear Ms. Understanding,

I thought that light was reflected only from shiny surfaces such as mirrors or polished metal. How can something soft and dull reflect light?

Lit Up in Levittown

Dear Lit,

There are two ways that you can see things. The Sun and stars, for example, produce light and send it to your eye where you receive it.

You can only see other objects because light reflects off them and travels directly to you eye. So, the ability to reflect light is not a property of shiny things alone. Everything you see reflects light.

Ms. Understanding

Glossary

amplitude – half distance between the crest and trough of a wave

crest – the highest point of a wave

decibel – measurement used to assess the loudness of a sound

electromagnetic waves – waves that carry energy as electricity and magnetism at the speed of light

electromagnetic spectrum – seven types of waves (gamma rays, X-rays, ultraviolet waves, visible light waves, infrared waves, microwaves, and radio waves) that carry energy as electricity and magnetism

fault – cracks in the earth along which bodies of rock move

focus – exact point where the earth moves causing an earthquake

frequency – the number of times a wave passes a certain point

kinetic energy – energy of objects in motion

longitudinal waves – waves that move back and forth

magnitude – the size of an earthquake

medium – substance, such as air or water, that energy uses to move back and forth

oscilloscope – a machine that translates sound into a pattern; it measures sound waves

pitch – property of sound which makes it high or low

potential energy – stored energy

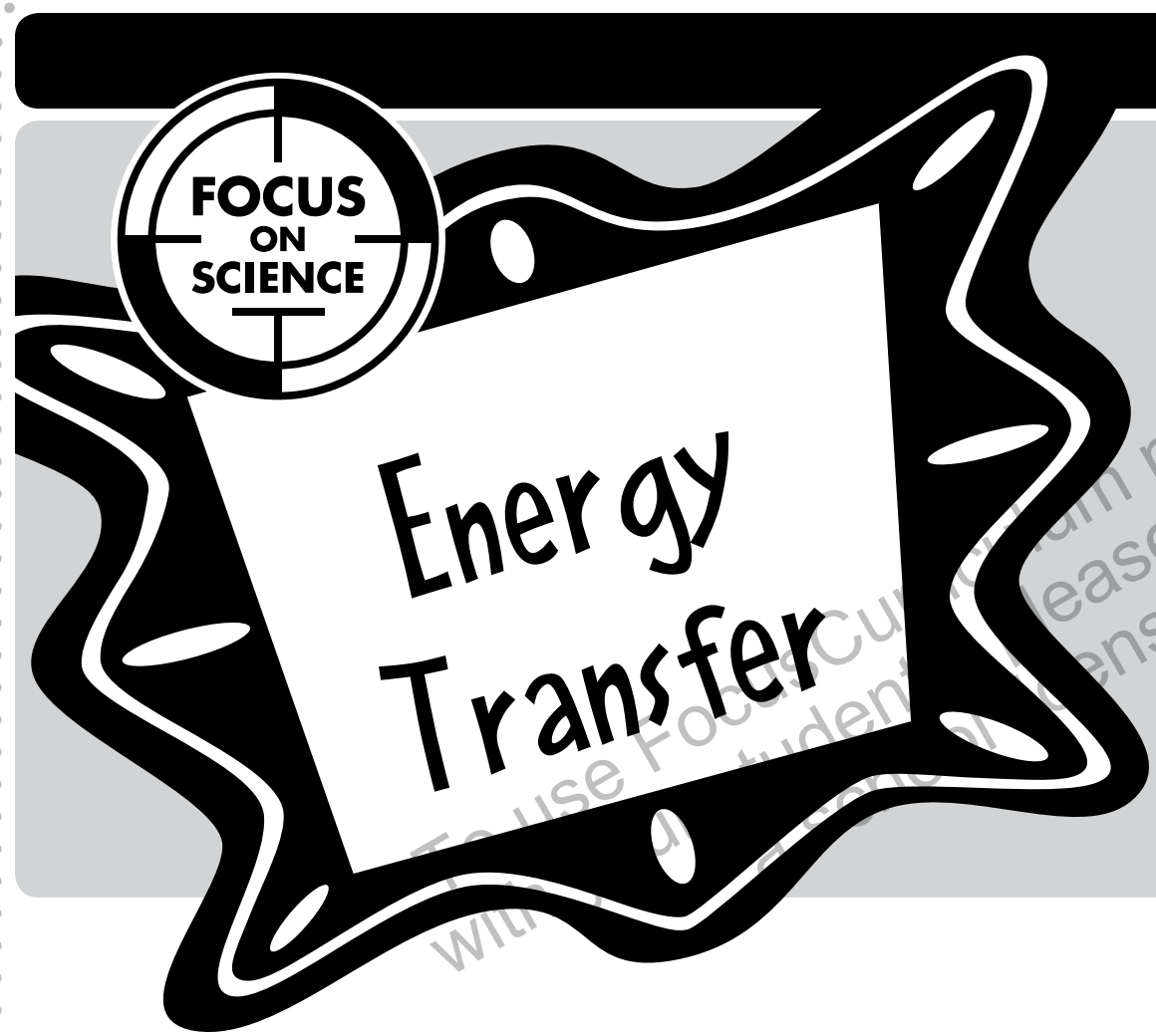
Richter scale – a scale used to measure the amount of energy released by an earthquake

seismograph – an instrument that measures the vibrations of a seismic wave

transverse waves – waves that move up and down

trough – the lowest point of a wave

wavelength – the distance between two waves



Assessments

Check Understanding

In the Answer Document on this page, mark your answer in the row of circles for each question by filling in the circle that has the same number as the answer you have chosen.

1. Which term refers to the highest point of a wave?

   (1) crest

   (2) trough

   (3) amplitude

   (4) wavelength

2. Sound will not travel in space. What is space lacking that stops sound from traveling?

   (1) air

   (2) gravity

   (3) vibrations

   (4) gamma rays

3. Light that enters an object but does not leave is

   (1) reflected then absorbed

   (2) refracted then absorbed

   (3) absorbed then reflected

   (4) refracted then reflected

4. Why are earthquakes less common in New York than they are in California?

   (1) New York is above sea level.

   (2) New York does not have a coastline.

   (3) New York does not have active volcanoes.

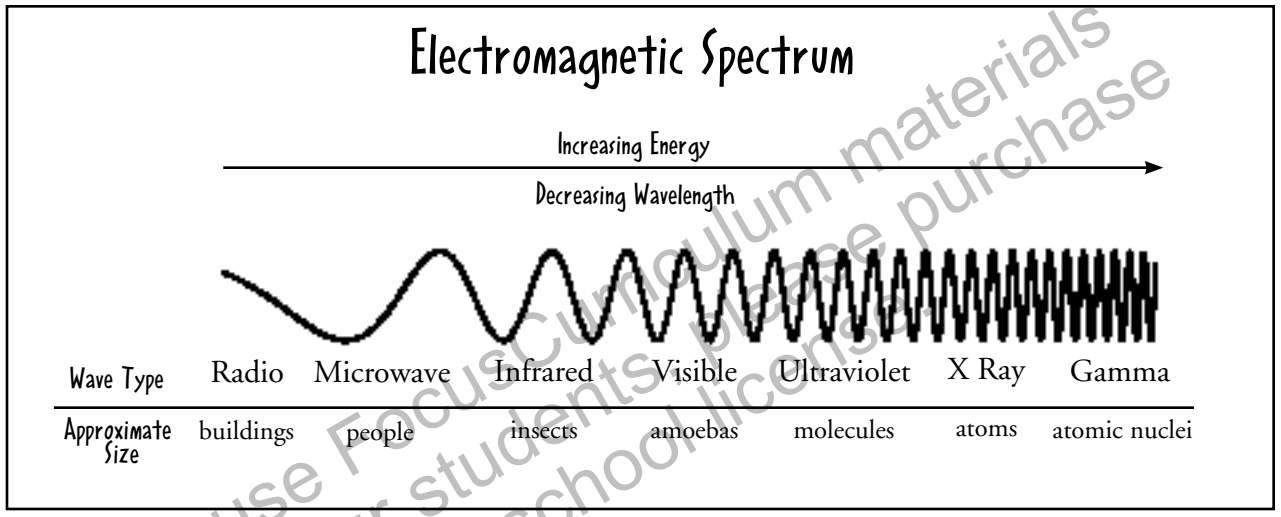
   (4) New York does not sit along a major fault line.

Answer Document

1.	①	②	③	④		3.	①	②	③	④
2.	①	②	③	④		4.	①	②	③	④

Check Understanding

Base your answers to questions 5 and 6 on the diagram of the electromagnetic spectrum and on your knowledge of science.



5. . Choose one type of wave from the diagram. Describe this type of wave in your own words.

_____

_____

_____

6. Explain where such a wave might come from or how it might be created.

_____

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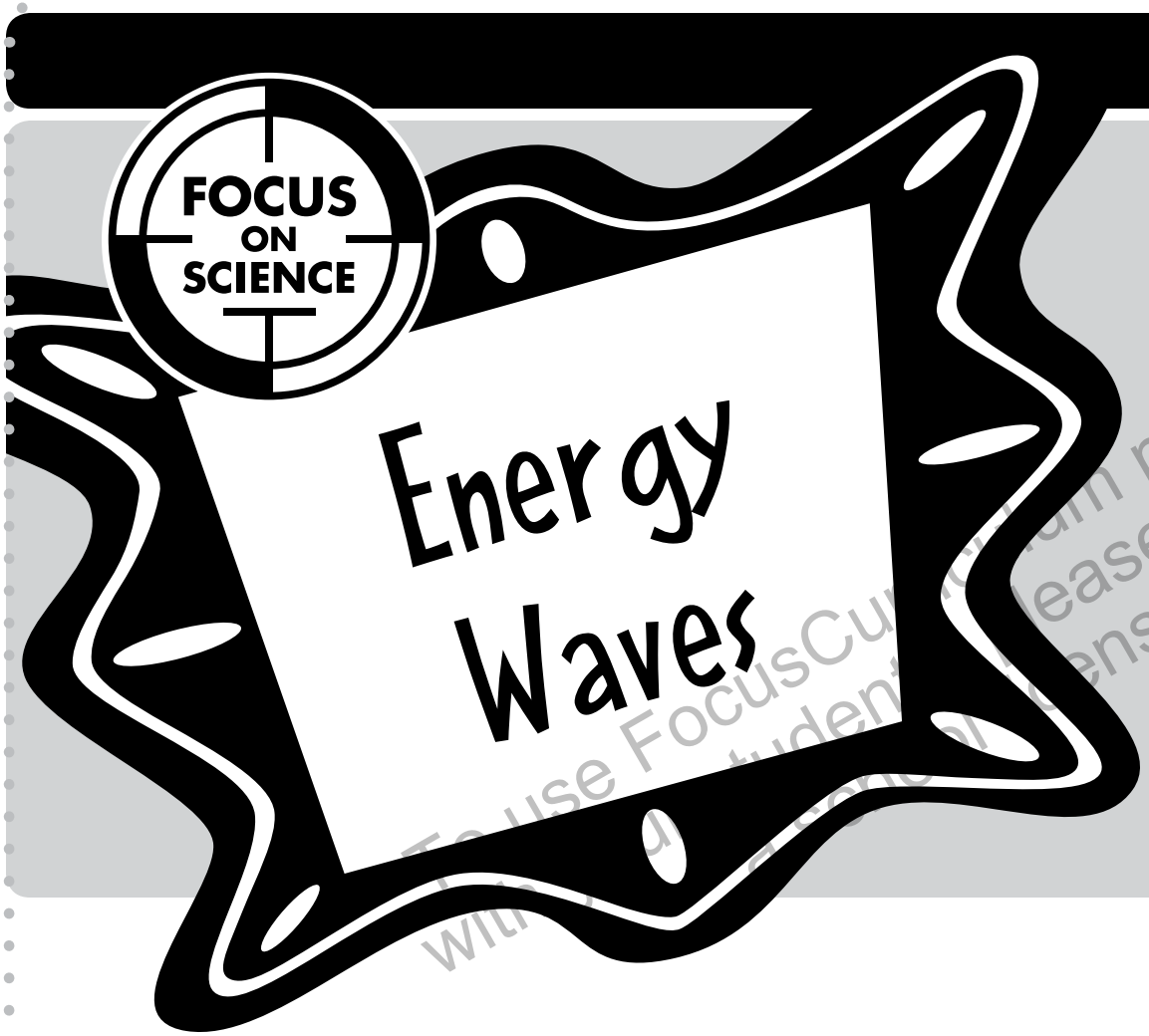

Answer Key

Answer Key

Page 8: Starting Points:
Build Background
Explain: Answers will vary according to the student's prior knowledge.
Brainstorm: Answers will vary.
Define: Potential energy is energy that is stored and kinetic energy is motion energy.

Page 9: Starting Points:
Key Vocabulary
Rate Your Knowledge: Answers will vary.

Page 10: Starting Points:
Key Concepts
Active Reader: Identify: 2, 1, 3

Page 11: Starting Points:
Key Concepts
Hands on Science: Watch Waves:
1. high, high; 2. low, low; 3. low, low

Page 12: Chapter 1
Active Reader: 1. Infer: Air would transmit the sound of banging on a drum faster than water.; 2. Connect: Answers will vary.

Page 13: Chapter 1
Active Reader: 1. Investigate: Answers will vary, but students should list appliances that use waves from the electromagnetic spectrum, such as microwave oven, television, radio, or computer.

Page 14: Chapter 1
Focus Questions: 1. To move energy from one place to another.; 2. gamma rays, X-rays, ultraviolet rays, visible light, infrared rays, microwaves, radio waves

Page 15: Chapter 1
Stop and Think: 1. Cause: Plates on either side of a fault line press against each other. Effect: The plates build up potential energy. When they finally slip, the stored up energy is released and causes an earthquake.; 2. (4); 3. Sound waves travel through air and water.

Page 16: Chapter 2
Active Reader: 1. Report: A dog barking would be in the middle of the decibel scale and it could be either high- or low-pitched.

Page 17: Chapter 2
Active Reader: 1. Infer: The 8.8 Chile earthquake was between 10 and 100 times stronger than the 7.0 Haiti earthquake.
Focus Questions: 1. The decibel scale is used to measure the loudness of a sound.;
2. A seismograph measures tremors in the earth. A pen hangs over a roll of paper. As the tremors occur, the pen makes wiggles on the paper. The more intense the tremor, the bigger the wiggle.

Page 18: Chapter 2
Stop and Think: 1. They are both caused by vibrations; they both can be loud; 2. They are different in that one is high-pitched, one is low-pitched. 3. (4)

Page 19: Chapter 3
Active Reader: 1. It falls in the middle between infrared and ultraviolet light.

Page 20: Chapter 3
Active Reader: 1. Light is refracted when it goes from one type of material to another. So, when it passes through glass, it is bent when it goes from air to glass and is bent again when it goes from glass to air.

Page 21: Chapter 3
Focus Questions: 1. Reflected lights enters our eye and we see the object off of which it has been reflected.

Page 22: Chapter 3
Stop and Think: 1. (2); 2. (3); 4. Of the visible light, red has the longest wavelength and indigo has the shortest.

Page 27: Assessments
Check Understanding: 1.(1); 2. (1); 3. (2); 4. (4)

Page 28: Assessments
Check Understanding: 5. Sample answer: X-rays are rays that can pass through skin, but not bone. 6. You might find machines that create x-rays in a dentist's office or hospital.