Lesson 1 Waves

Scan *Lesson 1. Read the lesson titles and bold words. Look at the pictures. Identify three facts you discovered about waves. Record your facts in your Science Journal.*

Main Idea / Details

What are waves?

I found this on page ________.

Organize *information about waves.*

Waves		
begin with	transfer	do not transfer

I found this on page ________.

Differentiate *two main types of waves.*

Mechanical Waves	Electromagnetic Waves

Classify *wave motion. Circle the type of motion that occurs in* electromagnetic waves.

I found this on page ________.

I found this on page ________.

Type of Wave Motion	Description of Disturbance	Examples
		flag waving in a breeze; light waves
		sound waves
		water waves

Waves, Light, and Sound

Waves

Before You Read

What do you think? Read the two statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.

Before	Statement	After
	1. Waves carry matter from place to place.	
	2. All waves move with an up-and-down motion.	

Key Concepts
- What are waves, and how are waves produced?
- How can you describe waves by their properties?
- What are some ways in which waves interact with matter?

Read to Learn

What are waves?

A flag waves in the breeze. Ocean waves break onto a beach. You wave your hand at a friend. All of these actions have something in common. Waves always begin with a source of energy that causes a back-and-forth or up-and-down disturbance. For example, wind causes a disturbance in the flag. This disturbance moves along the length of the flag as a wave. A wave is a disturbance that transfers energy from one place to another without transferring matter.

Study Coach

Building Vocabulary Write each vocabulary term in this lesson on an index card. Shuffle the cards. After you have studied the lesson, take turns picking cards with a partner. Each of you should define the term using your own words.

Key Concept Check

1. Define What are waves?

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Energy Transfer

Wind transfers energy to the fabric of the flag. The flag ripples back and forth as the energy travels along the fabric. Each point on the flag moves back and forth, but the fabric doesn't move along with the wave. Waves transfer energy, not matter, from place to place.

When you lift a pebble, you transfer energy to it. Suppose you drop the pebble into a pond. The pebble's energy transfers to the water.

Waves carry the energy away from the point where the pebble hit the water. The water itself moves up and down as the wave passes, but the water does not move along with the wave.

Two Main Types of Waves

The ways in which waves transport energy differ. Some waves carry energy only through matter. Others can carry energy through matter or through empty space.

Mechanical Waves *A wave that travels only through matter is a* **mechanical wave.** A medium is the matter through which a mechanical wave travels. A mechanical wave forms when a source of energy causes particles that make up a medium to vibrate. A pebble falling into water transfers its kinetic energy to particles of the water. The water particles vibrate and push against nearby particles, transferring the energy outward. After each particle pushes the next particle, it returns to its original rest position. Energy is transferred, but the water particles are not.

Electromagnetic Waves *A wave that can travel through empty space or through matter is an* **electromagnetic wave.** This type of wave forms when a charged particle, such as an electron, vibrates. For example, electromagnetic waves transfer the Sun's energy to Earth through empty space. Once the waves reach Earth, they travel through matter, such as the atmosphere or a glass window in a house.

Key Concept Check

2. Explain How are waves produced?

Describing Wave Motion

Some waves move particles of a medium up and down or side to side, perpendicular to the direction the wave travels. For example, the waves in a flag move side to side, perpendicular to the direction of the wind. Other wave disturbances move particles of the medium forward, then backward in the same direction, or parallel, to the motion of the wave. And some waves are a combination of both types of motion. The table below summarizes these three types of wave motion—transverse, longitudinal, and a combination of both.

Review Vocabulary

perpendicular
at right angles

Interpreting Tables

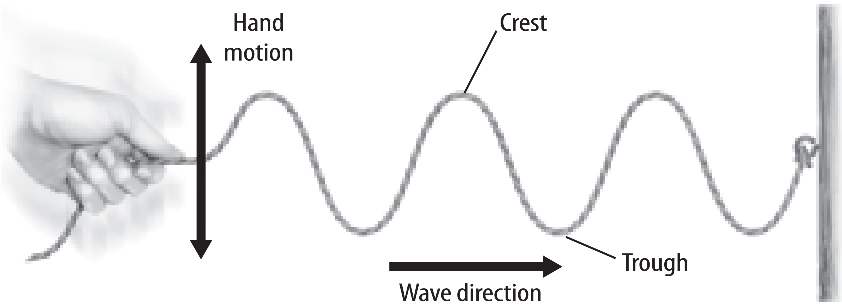
3. Contrast How is the motion of electromagnetic waves different from the motion of mechanical waves?

Types of Wave Motion

Type of Wave Motion	Mechanical Waves	Electromagnetic Waves
Transverse— perpendicular to the direction the wave travels	example: flag waving in a breeze	example: light waves
Longitudinal— parallel to the direction the wave travels	example: sound waves	
Combination— both transverse and longitudinal	example: water waves	

Transverse Waves *A wave in which the disturbance is perpendicular to the direction the wave travels is a* **transverse wave.** You can make a transverse mechanical wave by attaching one end of a rope to a hook and holding the other end, as shown in the figure below. When you move your hand up and down, transverse waves travel along the rope. High points on a wave are called crests, and low points are called troughs.

Transverse Wave



A vibrating charge, such as an electron, produces an electromagnetic wave. Electromagnetic waves are transverse waves. The electric and magnetic wave disturbances are perpendicular to the motion of the vibrating charge. Light is a form of energy transferred by transverse electromagnetic waves. X-rays and radio waves are electromagnetic waves.

Longitudinal Waves *A wave that makes the particles of a medium move back and forth parallel to the direction the wave travels is a* **longitudinal wave.** Longitudinal waves are mechanical waves. Like a transverse wave, a longitudinal wave disturbance passes energy from particle to particle of a medium. For example, when you knock on a door, energy of your hand transfers to the particles that make up the door. The energy of the vibrating particles of the door is transferred to the air in the next room.

You can also make a longitudinal wave by pushing or pulling on a coiled spring toy. Pushing moves the coils closer together. Pulling spreads the coils apart. The back-and-forth motion of your hand causes a back-and-forth motion in the spring. The longitudinal waves move parallel to your hand's motion.

Waves in Nature

Waves are common in nature because so many different energy sources produce waves. Two common waves in nature are water waves and seismic, or earthquake, waves.

Reading Check

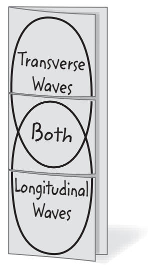
4. Identify What is the direction of the disturbance in a transverse wave?

Visual Check

5. Apply If the hand moved side to side instead of up and down, what direction would the wave travel?

FOLDABLES®

Make a vertical three-tab Venn book to compare and contrast transverse and longitudinal waves.



Water Waves Although water waves look like transverse waves, water particles move in circles. Water waves are a combination of transverse and longitudinal waves. Water particles move forward and backward. They also move up and down. The result is a circular path that gets smaller as the waves approach land.

Water waves form because there is friction between the wind at sea and the water. Energy from the wind transfers to the water as the water moves toward land. Like all waves, water waves only transport energy. Because the waves move only through matter, water waves are mechanical waves.

Reading Check

6. Recognize How does a water wave get its energy?

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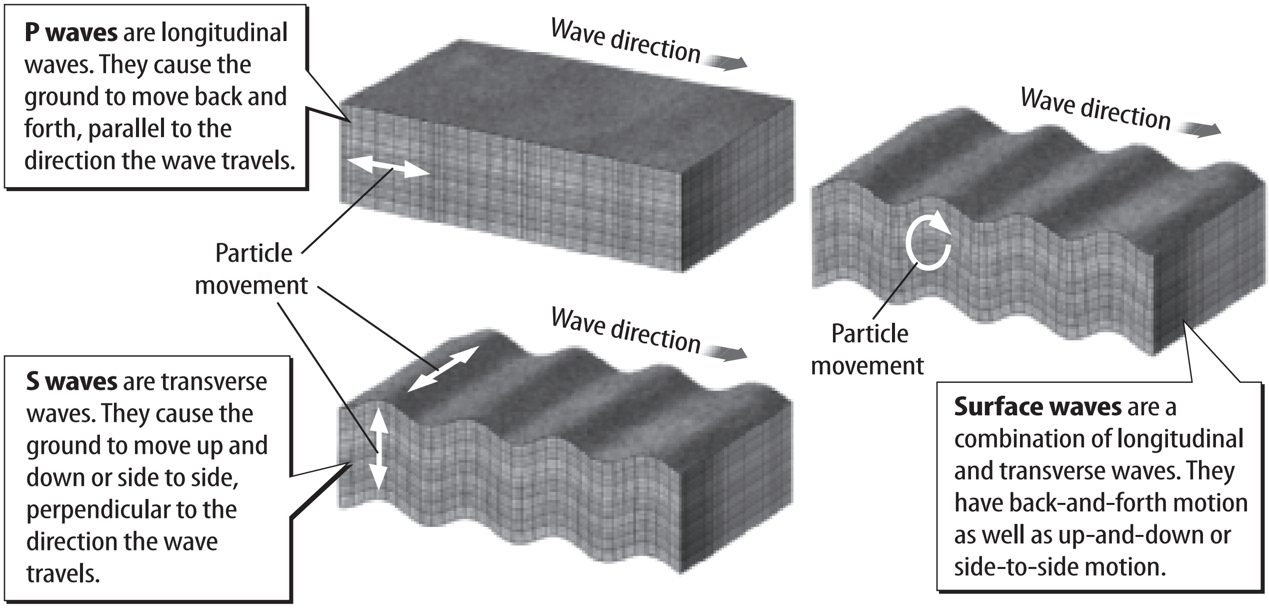
Seismic Waves An earthquake occurs when layers of rock of Earth's crust suddenly shift. This movement of rock sends out waves that travel to Earth's surface. An earthquake wave is called a seismic wave.

As shown in the figure below, there are different types of seismic waves. Seismic waves can be longitudinal, transverse, or a combination of the two. Seismic waves are mechanical waves because they move through matter.

Seismic Waves



Visual Check

7. Compare Which seismic wave is similar to a water wave?

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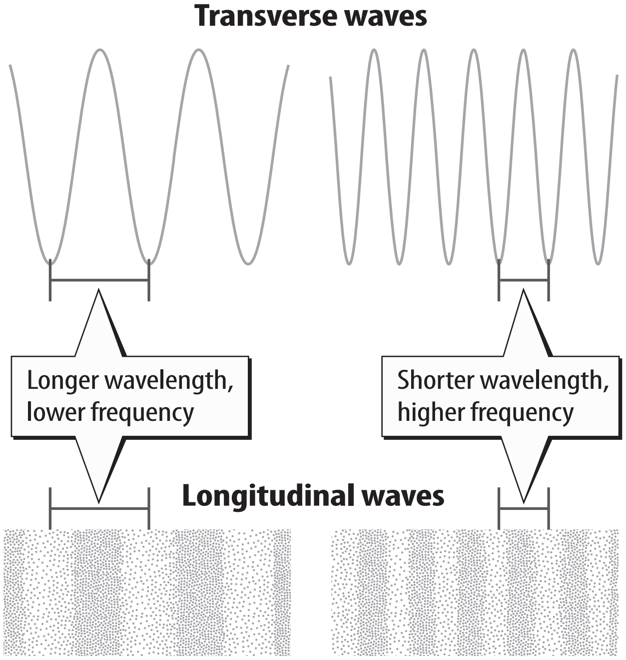
Properties of Waves

How could you describe water waves at a beach? You might describe how tall the waves are or how fast the waves move toward shore. When scientists describe waves, they describe the properties of wavelength and frequency.

Wavelength

Waves have high points called crests and low points called troughs. As shown in the figure below, the distance between a point on one wave and the same point on the next wave is called the wavelength. Different types of waves can have wavelengths that range from thousands of kilometers to less than the size of an atom!

Wavelength and Frequency



Frequency

The number of wavelengths that pass a point each second is a wave's **frequency.** Frequency is measured in hertz (Hz). One hertz equals one wave per second. As shown in the figure above, the longer the wavelength, the lower the frequency. As the distance between the crests decreases, the number of waves passing a point each second increases.

Wave Speed

The speed of a wave depends on the medium, or type of material, through which it travels. Electromagnetic waves always travel through empty space at a speed of 3×10^8 m/s. That's 300 million meters each second! They travel slower through a medium, or matter, because they must interact with particles. Mechanical waves travel only through matter. They travel slower than electromagnetic waves travel through space. Sound waves travel about one-millionth the speed of light waves. The speed of water waves depends on the strength of the wind that produces them. The table to the right compares the speeds of different types of waves.

Visual Check

8. Examine Based on their appearance, how can you tell that the waves on the right have a shorter wavelength than those on the left?

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Reading Check

9. Recognize What is frequency?

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Interpreting Tables

10. Identify Circle the wave speed for a sound wave in air.

Wave Speeds

Type of Wave	Typical wave speed (m/s)
Ocean wave	25
Sound wave in air	340
Transverse seismic wave (S wave)	1,000 to 8,000
Longitudinal seismic wave (P wave)	1,000 to 14,000
Electromagnetic wave through empty space	300,000,000

Amplitude and Energy

Different waves carry different amounts of energy. Some earthquakes, for example, can be catastrophic because they carry so much energy. A shift in Earth's crust can cause particles in the crust to vibrate back and forth very far from their rest position, producing seismic waves. In January 2010, seismic waves in Haiti transferred enough energy to destroy entire cities.

A wave's **amplitude** *is the maximum distance a wave varies from its rest position.* For mechanical waves, amplitude is the maximum distance the particles of the medium move from their rest positions as a wave passes. The more energy a mechanical wave has, the larger its amplitude.

The figure below shows the amplitude of a transverse mechanical wave. As more energy is used to produce a mechanical wave, particles of the medium vibrate farther from their rest positions.

Key Concept Check
11. Identify How can you describe waves?

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Visual Check
12. Recognize How are amplitude and energy of a mechanical wave related?

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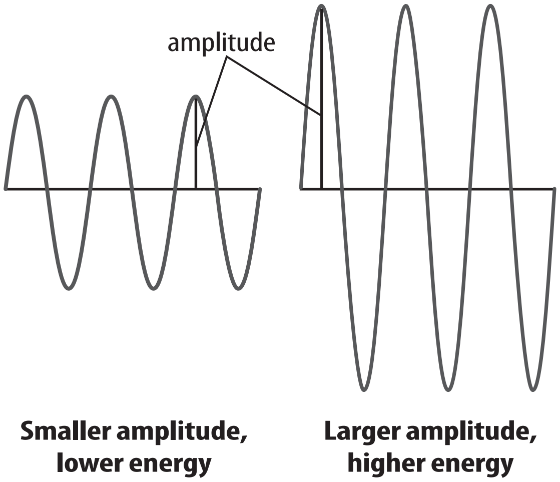
Amplitude and Energy
Transverse mechanical wave



Wave Interaction with Matter

You have read that when you knock on a door, longitudinal sound waves transfer the energy of the knock through the door. However, when a person in the next room hears the knock, it is not as loud as the sound on your side of the door. The sound is weaker after it passes through the door because the waves interact with the matter that makes up the door.

Transmission

Some of the sound from your knock passes through the door. The waves transmit, or carry, the energy all the way through the door. The energy then passes into air particles, and the person on the other side hears the knock.

Absorption

Some of the sound is absorbed by the particles that make up the door. Instead of passing through the door, the energy increases the motion of the particles of the wood. The sound energy changes to thermal energy within the door. So, less sound energy passes into the air in the next room. ✓

Reflection

Some of the energy you used to knock on the door reflects, or bounces back, into the room you are in. Sound waves in the air transfer sound back to your ears. The energy of electromagnetic waves also can be transmitted, absorbed, or reflected. ✓

Law of Reflection

You can predict how waves will reflect from a smooth surface. A light wave approaching a surface at an angle is called the incident wave. The wave that leaves the surface is the reflected wave. Picture a dotted line drawn perpendicular to the surface at the point where the wave hits the surface. This dotted line is called the normal.

The law of reflection states that the angle between the incident wave and the normal always equals the angle between the reflected wave and the normal. If the incident angle increases, the reflected angle also increases.

Refraction

The change in direction of a wave as it changes speed, moving from one medium into another, is called **refraction.** Refraction causes an object to appear to be in a place different from its real location. The image of the fish in the figure at right is an example. Light reflects off the fish in all directions. The reflected light waves move faster after they leave the water and move into the air. Recall that the normal is an imaginary line perpendicular to the surface at the point where a wave hits a surface. As light rays pass from the water into the air, they refract away from the normal, changing direction. In the figure, the boy's brain assumes the light traveled in a straight line. The light rays seem to come from the position of the image he sees.

Reading Check

13. Describe How does the absorbed energy affect the wood?

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Reading Check

14. Define What are transmission, absorption, and reflection?

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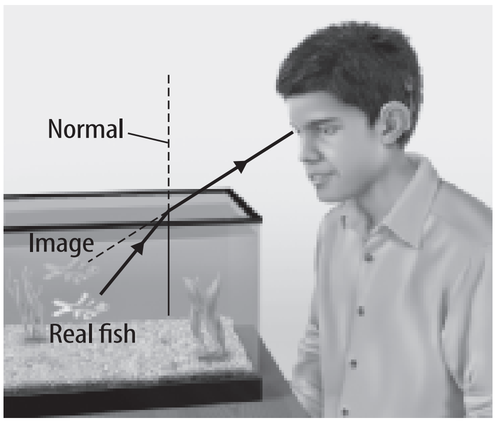
Visual Check

15. Identify Circle the place where the light refracts away from the normal.

Refraction



When Waves Refract Note that waves refract only if they move at an angle into another medium. They do not refract if they move straight into a medium. Waves refract toward the normal if they move slower after entering a medium and away from the normal if they move faster.

Diffraction

Diffraction is the change in direction of a wave when it travels past the edge of an object or through an opening. If you are walking in a school hallway and hear sound coming from an open classroom door, the sound waves have diffracted around the corner to your ears. Diffraction causes waves to spread around barriers and through openings.

Key Concept Check

16. Summarize What are some ways in which waves interact with matter?

Mini Glossary

amplitude: the maximum distance a wave varies from its rest position

electromagnetic wave: a wave that can travel through empty space or through matter

frequency: the number of wavelengths that pass a point each second

longitudinal wave: a wave that makes the particles of a medium move back and forth parallel to the direction the wave travels

mechanical wave: a wave that travels only through matter

refraction: the change in direction of a wave as it changes speed, moving from one medium into another

transverse wave: a wave in which the disturbance is perpendicular to the direction the wave travels

1. Review the terms and their definitions in the Mini Glossary. Write a sentence that compares electromagnetic waves and mechanical waves.

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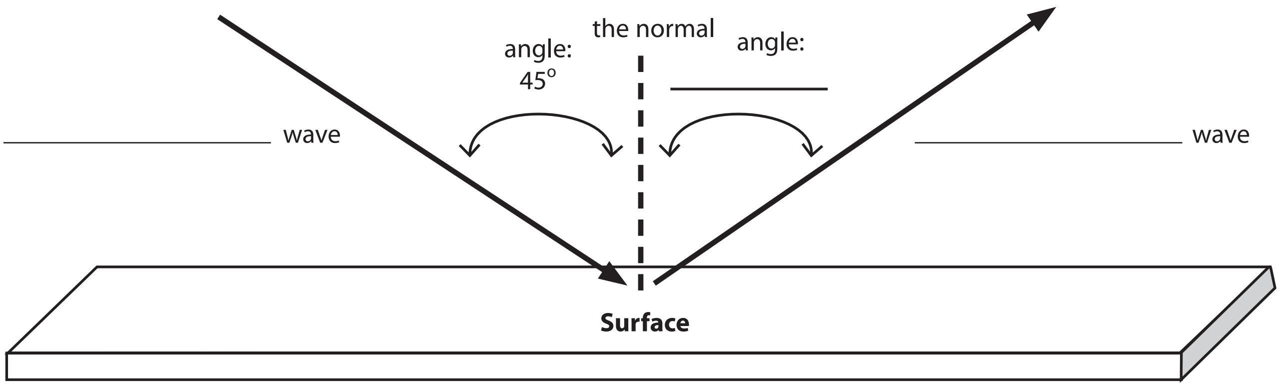
2. The straight arrows in the diagram below illustrate a light wave hitting and bouncing off a surface. Name the waves that each arrow represents. Then predict the degree of the angle at which the wave will reflect from the surface.



3. What is the difference between P waves, S waves, and surface waves in an earthquake?

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What do you think NOW?

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?

ConnectED

Log on to ConnectED.mcgraw-hill.com and access your textbook to find this lesson's resources.

END OF LESSON

Main Idea	Details

I found this on page ______ .

Contrast *the motion of water waves and seismic waves.*

Water Waves	Seismic Waves
	• • •

Properties of Waves

I found this on page ______ .

Interpret *wavelength in the two* transverse wave *diagrams. Mark and label with descriptions one wavelength in each wave.*

I found this on page ______ .

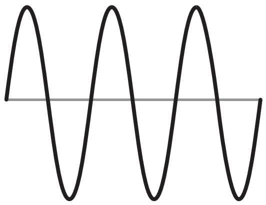
Relate *wavelength to* frequency.

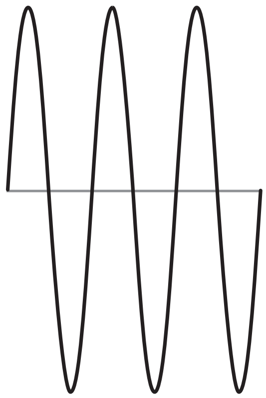
Wavelength	Frequency

Main Idea | **Details**

I found this on page ______ .

Interpret amplitude *and energy in the two* transverse wave *diagrams. Mark and label the* amplitude *in each wave, and identify it as having higher or lower energy than the other.*





Wave Interaction with Matter

I found this on page ______ .

I found this on page ______ .

Describe *ways that waves interact with matter.*

Interaction	Description
Transmission	
Absorption	
Reflection	
Refraction	
Diffraction	

Analyze It Explain why you see rings form and grow outward when you drop a pebble through the surface of still water.

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