# Waves

## Wave Interactions

### 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 |
|---|---|---|
| | **5.** When light waves strike a mirror, they change direction. | |
| | **6.** Light waves travel at the same speed in all materials. | |

### Read to Learn

#### Interaction of Waves with Matter

Waves interact with matter in many ways. Waves can be reflected by matter. Waves can change direction when they travel from one material to another. Also, as waves move through matter, some of the energy they carry can be transferred to the matter.

Waves also interact with each other, or work together. Two different waves can overlap, or cross over each other. When this occurs, a new wave forms. The new wave has different properties from those of either original wave.

#### Absorption

When you shout, you create sound waves. As the waves travel in air, some of their energy transfers to particles in the air. The energy the waves carry decreases as they travel through matter. **Absorption** *is the transfer of energy by a wave to the medium through which it travels*. The amount of energy absorbed depends on the type of wave and the material in which it moves.

Absorption also occurs for electromagnetic waves. All materials absorb electromagnetic waves. Darker materials absorb more visible light waves than lighter materials.

**Key Concepts**

- How do waves interact with matter?
- What are reflection, refraction, and diffraction?
- What is interference?

**Study Coach**

**Use an Outline** As you read, make an outline to summarize the information in the lesson. Use the main headings in the lesson as the main headings in the outline. Complete the outline with the information under each heading to help you study.

**Reading Check**

**1. Explain** Why does the energy carried by sound waves decrease as sound waves travel through air?

## Transmission

Light waves are absorbed by some materials but can pass through other materials. For example, you can see through glass, but you cannot see through metal. Metal absorbs almost all the energy of the visible light rays. However, light waves pass through glass because it absorbs only a small amount of the waves' energy. **Transmission** *is the passage of light through an object.*

## Reflection

When waves reach the surface of a material, they can also be reflected. **Reflection** *is the bouncing of a wave off a surface.* An object that reflects all visible light appears white. An object that reflects no visible light appears black.

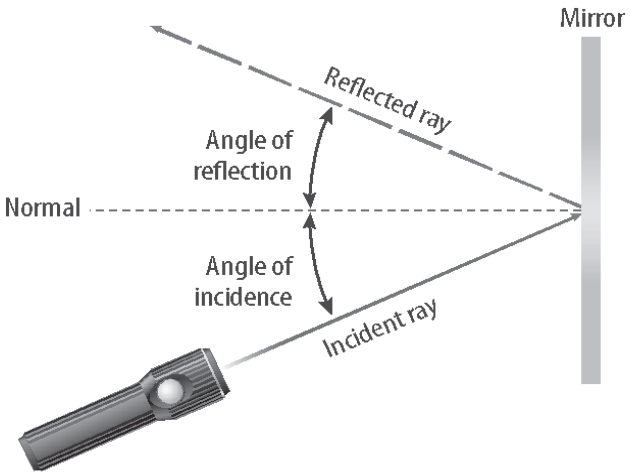
All types of waves can reflect when they hit a surface. Reflection causes waves to change direction. When you drop a basketball at an angle, it bounces up at the same angle but in the opposite direction. When waves reflect from a surface, they change direction like a basketball bouncing off a surface.

**Key Concept Check**

**2. Identify** What are three ways that waves interact with matter?

**Visual Check**

**3. Describe** How do the angle of incidence and the angle of reflection of the light rays shown in the figure compare?




# The Law of Reflection

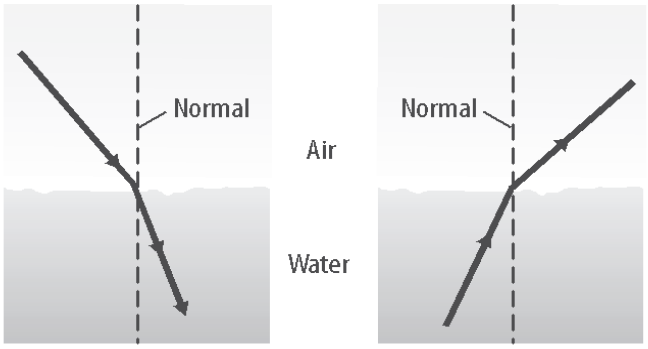
The direction of an incoming wave that hits a surface and the reflected wave are related. A line that is perpendicular, at a 90° angle, to a surface is called the normal. The angle between the direction of the incoming wave and the normal is the angle of incidence. The angle between the direction of the reflected wave and the normal is the angle of reflection. *The* **law of reflection** *states that when a wave is reflected from a surface, the angle of reflection is equal to the angle of incidence.* The figure above shows the law of reflection in action.

**Reading Check**

**4. Explain** the law of reflection to a classmate.

## Refraction

Waves also change direction when they travel from one material to another material. Light waves travel at different speeds in different materials. So, when light waves travel from one material into another, they change speed. A change in speed causes a change in direction. As shown in the figure below, **refraction** *occurs when a wave changes direction because its speed changes*. The greater the change in speed, the more the wave changes direction.




## Diffraction

Waves can also change direction as they travel by objects. Have you ever heard people talking in a room before you got to the open doorway? You heard some of the sound waves because they changed direction and spread out as they traveled through the doorway.

### What is diffraction?

**Diffraction** *is the change in direction of a wave when it travels by the edge of an object or through an opening*. Diffraction causes waves to travel around the edges of an object. Diffraction also causes waves to spread out after they travel through an opening. More diffraction occurs as the size of the object or opening becomes similar in size to the wavelength of the wave.

### Think it Over

**5. Explain** What causes a light wave to change direction when it moves from one material into another material?

_____

_____

### Visual Check

**6. Identify** What materials are the light rays moving through in the figure on the left?

_____

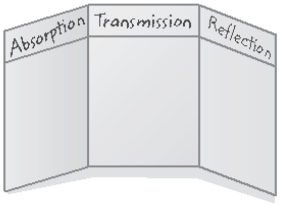
_____

_____

_____

FOLDABLES®

Make a tri-fold book about the interactions of waves with matter: absorption, transmission, and reflection.



### Diffraction of Sound Waves and Light Waves

The wavelengths of sound waves are similar in size to many common objects. Because of this size similarity, you often hear sound from sources that you can't see. For example, the wavelengths of sound waves are about the same size as the width of a doorway. Therefore, sound waves spread out as they travel through a doorway. The wavelengths of light waves are more than a million times smaller than the width of a doorway. Light waves do not spread out as they travel through a doorway. Because the wavelengths of light waves are so much smaller than sound waves, you can't see into a room until you reach the doorway. You can hear sounds much sooner.

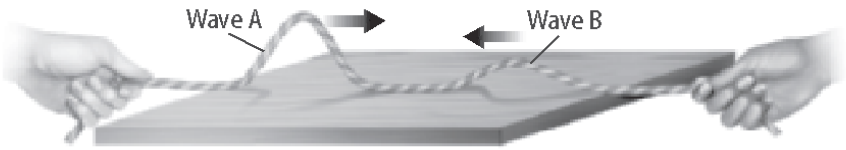
**Key Concept Check**

**7. Compare and Contrast** reflection, refraction, and diffraction.

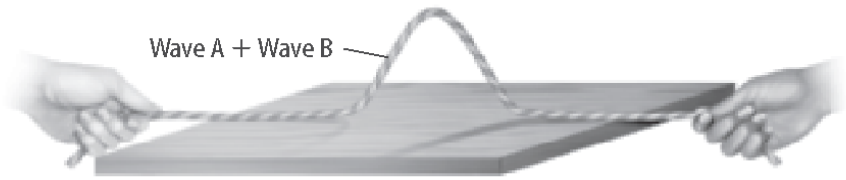
## Interference

Waves not only interact with matter, but they also interact with each other. As shown in the figure below, when two waves meet, they overlap for a while as they travel through each other. **Interference** *occurs when waves that overlap combine and form a new wave*. After the waves travel through each other, they continue moving in the same direction.

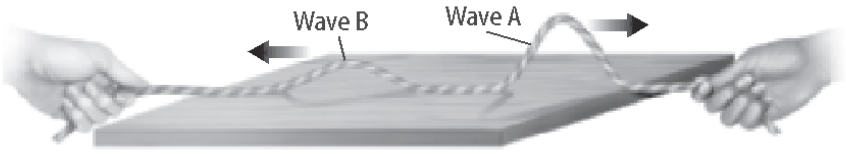
Two waves approach each other from opposite directions.




The waves interfere with each other and form a large amplitude wave.

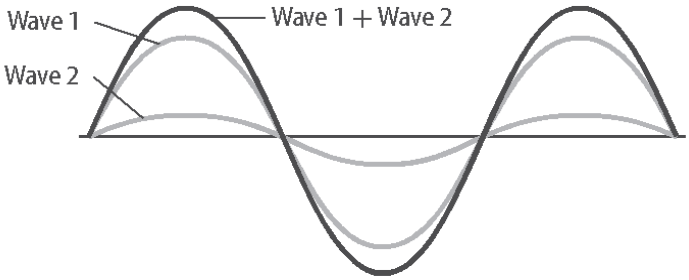



The waves keep moving in opposite directions after they pass through each other.

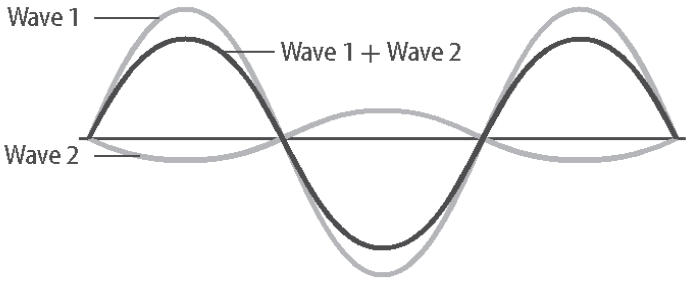



**Visual Check**

**8. Choose** Which wave in the figure on the right has the larger amplitude?




Constructive Interference




Destructive Interference

## Constructive and Destructive Interference

When two waves meet, their crests might overlap. If this happens, a new wave forms. This new wave has an amplitude that is greater than either of the two original waves. This type of interference is called constructive interference. It occurs when crests overlap with crests and troughs overlap with troughs.

Destructive interference occurs when a crest of one wave overlaps the trough of another wave. The new wave that forms has a smaller amplitude than that of the original waves added together. If the two waves have the same amplitude, they cancel each other when their crests and troughs overlap. Both constructive and destructive interference are shown in the figure above.

## Standing Waves

Imagine shaking one end of a rope that has the other end attached to a wall. You will create a wave in the rope that travels away from you. When the wave reaches the wall, it reflects off the wall. As the wave you create and the reflected wave interact, interference occurs. If this happens in just the right way, the two waves interfere with each other. When they do, the wave that forms from the combined waves seems to stand still. This is called a standing wave. If you pluck the string of a musical instrument and look closely, you will see what looks like a single wave on the whole length of the string.

**Visual Check**

**9. Describe** What happens to the amplitudes of waves as a result of constructive interference?

**ACADEMIC VOCABULARY**

**constructive**
***(adjective)*** pertaining to building or putting parts together to make a whole

**Key Concept Check**

**10. Describe** two types of wave interference.

# After You Read

## Mini Glossary

**absorption (ub SORP shun):** the transfer of energy by a wave to the medium through which it travels

**diffraction (dih FRAK shun):** change in direction of a wave when it travels by the edge of an object or through an opening

**interference (ihn tur FIR unts):** occurs when waves that overlap combine to form a new wave

**law of reflection:** states that when a wave is reflected from a surface, the angle of reflection is equal to the angle of incidence

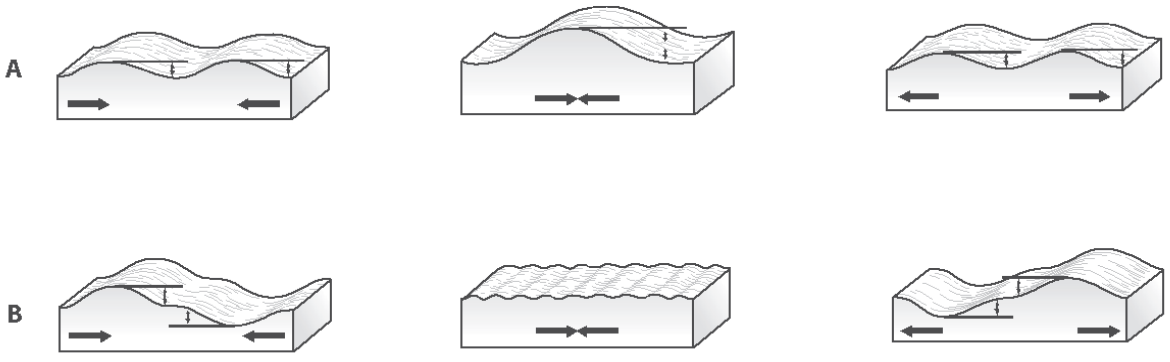
**reflection (rih FLEK shun):** the bouncing of a wave off a surface

**refraction (rih FRAK shun):** the change in direction of a wave as it changes speed

**transmission (trans MI shun):** the passage of light through an object

1. Review the terms and their definitions in the Mini Glossary. Write a sentence that explains three possibilities for what might happen when a wave reaches a surface.

2. The diagram below shows an example of constructive interference between ocean waves and an example of destructive interference between ocean waves. Which is which? How can you tell?




## 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?

Connect ED

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

END OF LESSON