chapter 9

Introduction to Waves

section 1 The Nature of Waves

What You'll Learn
- how waves transfer energy but not matter
- about mechanical, transverse, and longitudinal waves

Before You Read

Write what you think a wave is and list two types of waves you have seen or heard about.

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Study Coach

Communicate Work with another student. When you read a paragraph that is hard to understand, share with your partner what you think it means. Continue to discuss the information until you understand it better.

Read to Learn

What's in a wave?

Imagine that you are watching a surfing championship on television. As you look at the surfers riding the giant waves, you heat up some leftover pizza in the microwave. You call a friend to tell her about the surfing. Your friend tells you to turn on your radio to listen to a song you both like. You have just experienced three different types of waves. You saw the waves in the ocean. You cooked using microwaves. Sound waves were produced by the television, your friend's voice, and the radio.

A **wave** is a repeating disturbance or movement that transfers energy through matter or space. For example, ocean waves disturb the water and transfer energy through it. In an earthquake, powerful waves transfer energy through Earth. Light is a type of wave that can travel through empty space to transfer energy from one place to another, such as from the Sun to Earth.

Waves and Energy

Have you ever watched a pebble fall into a pool of water and seen ripples form? The pebble causes a disturbance in the water. Some of the kinetic energy from the falling pebble transfers to the water molecules that are close by. The water molecules pass the energy along to other water molecules that are next to them. In this way, the energy passes from molecule to molecule until it is far from where the pebble first fell. A wave is formed. It carries the energy through the water.

Reading Check

1. **Identify** What do waves transfer with them?

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Do waves carry matter?

Suppose you are in a boat on a lake. The waves in the water bump against your boat. You notice that the boat moves up and down and maybe even back and forth a little. After the waves have moved past, your boat has not moved to a different place. The waves don't carry the water along with them. They only carry energy as they move. This is true for all waves. They carry energy without moving matter from place to place.

How can you make a wave?

A wave will travel as long as there is both energy and a medium to carry it. Think of the pebble and the pool of water. The ripples eventually stop and the water is smooth again. There is no more energy to carry.

The figure shows a hand making a wave with a rope. As the hand moves up and down, a wave begins to travel along the rope. The wave moves along the rope until it reaches the end. Once the wave reaches the end, the rope is still because there is no more energy to transfer.

Producing a Wave

The hand in the figure is moving up and down. Anything that moves up and down or back and forth repeatedly is vibrating. The hand moving up and down is a vibrating movement. Vibrations cause all waves.

Mechanical Waves

Sound waves travel through the air to reach your ears. Ocean waves travel through water to reach the shore. Both kinds of waves move their energy through a medium. A **medium** is the matter through which a wave travels. A medium can be a solid, a liquid, or a gas. It can also be a combination of these forms of matter. The medium for sound waves is air. The medium for ocean waves is water. Not all waves need a medium in order to travel. Light waves and radio waves are examples of waves that do not need a medium. They can travel through space. Waves that can travel only through matter are called mechanical waves. The two types of mechanical waves are transverse waves and longitudinal waves.

Picture This

2. Mark the Figure Use a pen or a pencil to circle the parts of the rope that show the location of the wave.

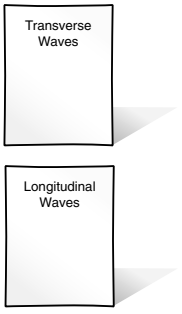
Reading Check

3. Identify What must a mechanical wave travel through?

FOLDABLES™

A Compare and Contrast

Use two quarter-sheets of notebook paper to make a Foldable that compares and contrasts transverse waves and longitudinal waves.



Picture This

4. **Explain** Why are the coils closer together at the middle of the spring in the figure?

Think it Over

5. **Analyze** When a wave travles through a spring, why does it look like the whole spring is moving?

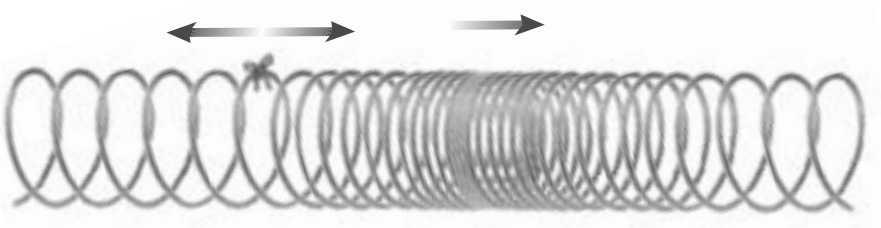
How does matter move in a transverse wave?

In a **transverse wave**, the matter in the medium moves at a right angle to the direction the wave travels. An ocean wave moves across, horizontally, while the water it passes through moves up and down, vertically. The wave and the matter in the medium move at right angles to each other.

How does matter move in a longitudinal wave?

In a **longitudinal wave**, matter in the medium moves back and forth in the same direction that the wave travels. The figure below shows how a longitudinal wave moves along a coiled spring. Suppose you hold onto both ends of a spring. You squeeze some coils together at one end of the spring, then let go of them. A wave travels along the spring.

If you tie a piece of yarn to one of the coils of the spring, you can see the back-and-forth movement in the spring. As the wave passes through the coil with the yarn, the yarn moves in the direction of the wave. After the wave passes the yarn, it moves back to its original position. However, the wave continues to move to the end of the spring. The yarn moves back and forth as the wave passes. The wave carries energy with it, but it doesn't carry matter. Another name for longitudinal waves is compressional waves.



Loungitudinal wave

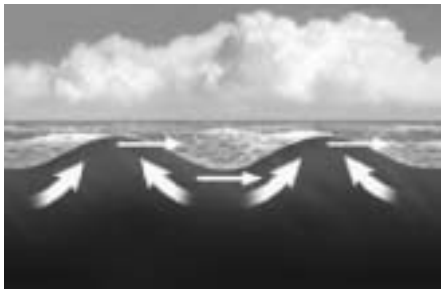
How do sound waves move?

Sound waves are longitudinal waves. Some sound waves travel through air. If you pick a string on a guitar, the string vibrates. The vibration pushes nearby air molecules close together. The air molecules squeeze together like the coils in the spring. Then the compressions travel through the air to make a wave. Sound waves also can travel through mediums such as water and wood. The particles in those mediums also squeeze together and move apart when sound waves travel through them.

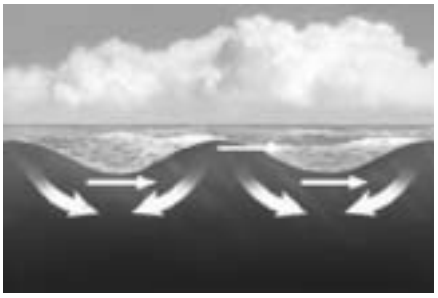
When a sound wave reaches your ear, it causes your eardrum to vibrate. Your inner ear sends signals to your brain. Your brain understands these signals as sound.

How do water waves move?

Water waves look like transverse waves. They are actually a combination of transverse and longitudinal waves. The figures below show the movement of water in a wave. The small arrows show the direction of the wave and the large arrows show the movement of the water. As a wave goes by, the water moves up and down. The water also moves back and forth for a short distance in the same direction that the wave moves. Waves have both high and low points. Water pushes forward or backward toward the high part of the wave. This causes the low part of the wave to form as the first figure shows. Then as the wave passes, the water that was pushed forward or backward moves back to where it was.



Water is pushed aside.



Water returns to where it was.

The up-and-down and back-and-forth motion causes the water to move in circles. An object that floats on the surface of the water takes in some of the energy from the waves. This causes it to bob in a circular motion.

How are ocean waves formed?

Wind blowing across the ocean surface causes most ocean waves to form. The changing speed of the wind acts like a vibration on the water. The size of the waves depends on the speed of the wind, the length of time the wind blows, and how far it travels over the water.

What are seismic waves?

Forces in Earth's crust can cause parts of the crust to shift, bend, or even break. When this happens, Earth's crust vibrates and releases energy. This creates seismic (SIZE mihk) waves that carry energy outward and cause an earthquake.

Seismic waves are a combination of transverse and longitudinal waves. They travel through Earth and along Earth's surface. Objects on Earth's surface move and shake when they take in some of the energy from the seismic waves. The more Earth's crust moves during an earthquake, the more energy is released.

Picture This

6. Observe Use your highlighter to trace the arrows that show the movement of water when it is pushed forward or backward toward the high part of the wave.

Reading Check

7. Identify What usually starts the movement of a wave in an ocean?

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After You Read

Mini Glossary

longitudinal wave: a wave in which the matter in the medium moves back and forth in the same direction that the wave travels

medium: the matter through which a wave travels

mechanical wave: waves that travel only through matter

transverse wave: a wave in which matter in the medium moves back and forth at a right angle to the direction the wave travels

wave: a repeating disturbance or movement that transfers energy through matter or space

1. Review, the terms and their definitions in the Mini Glossary above. What is the difference between a transverse wave and a compressional wave?

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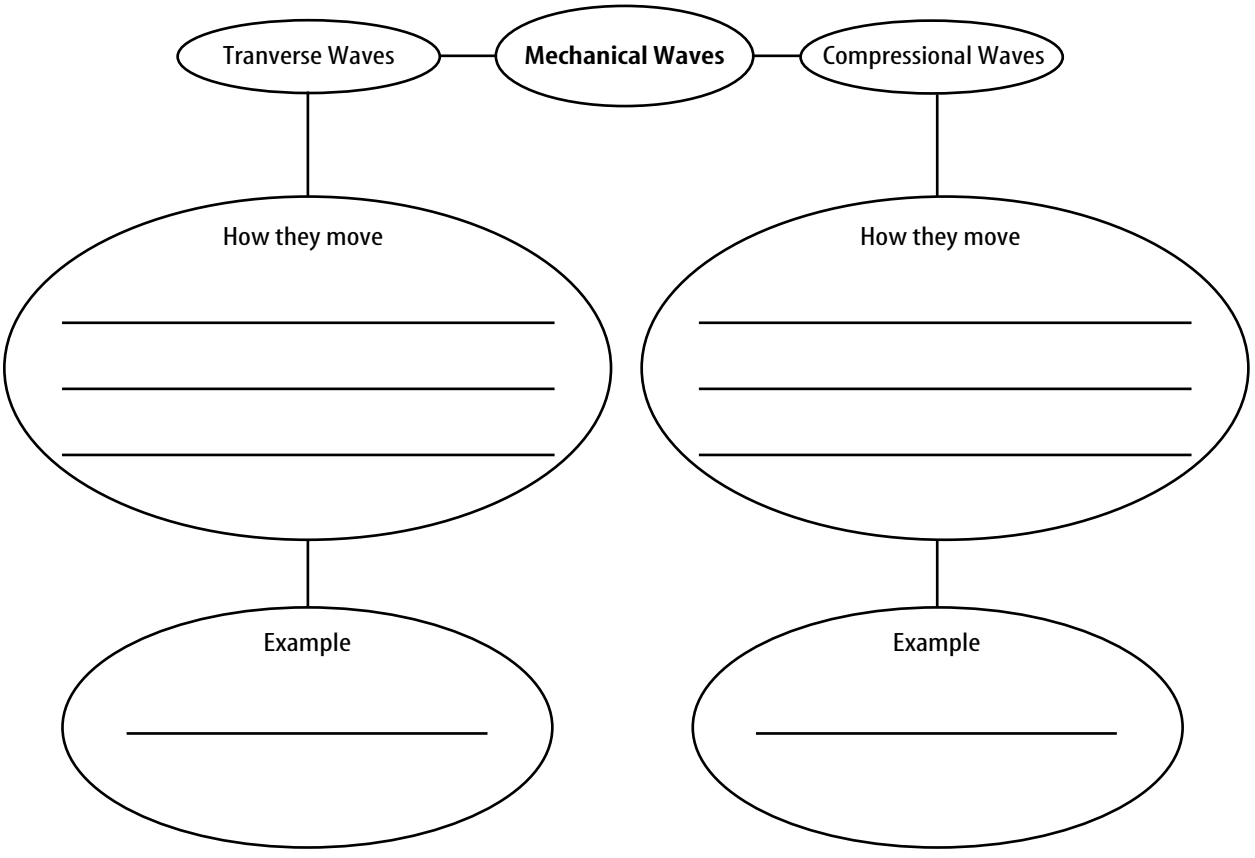
2. Complete the diagram below to list what you learned about mechanical waves.



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