chapter 1

Waves

section 2 Wave Properties

What You'll Learn

- about the frequency and the wavelength of a wave
- why waves travel at different speeds

Before You Read

Think about waves in an ocean and waves in a pond. How would you describe each kind of wave?

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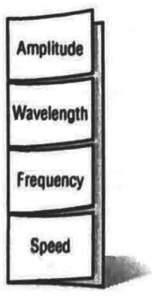
Mark the Text

Underline Terms As you read this section, underline each property of a wave. Then, highlight information about each property in a different color.

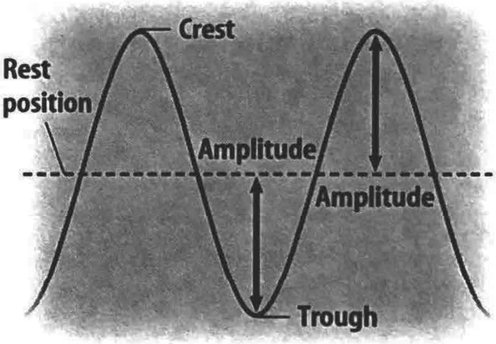
FOLDABLES™

C Organize Information Make the following Foldable to help you organize information about the different properties of waves.



Read to Learn

Amplitude

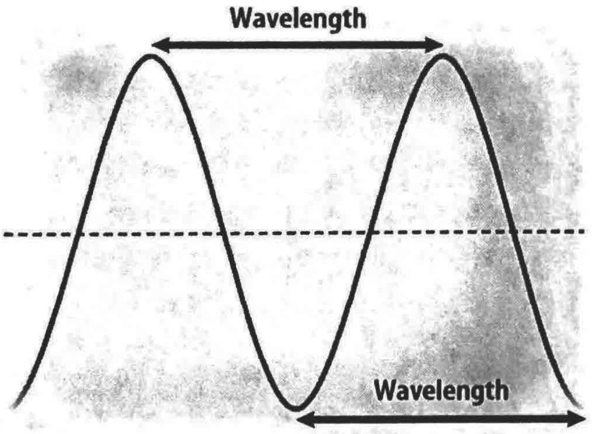


To describe a water wave, you might say how high the wave rises above, or falls below, a certain level. This distance is called the wave's amplitude. The **amplitude** of a transverse wave is one-half the distance between a crest and a trough, as shown in the figure.

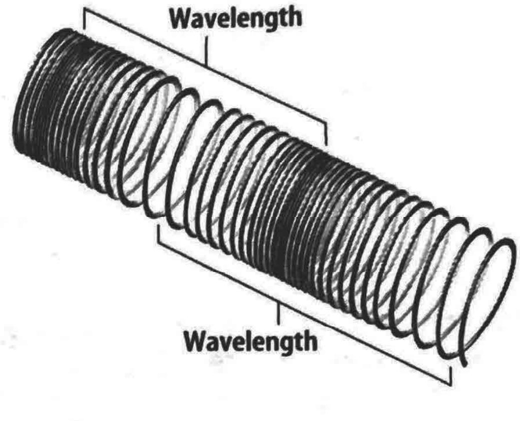
In a compressional wave, the amplitude depends on how close together the particles of the medium are. The amplitude is greater when the particles of the medium are squeezed closer together in each compression and spread farther apart in each rarefaction.

How are amplitude and energy related?

A wave's amplitude is related to the energy that the wave carries. For example, electromagnetic waves of bright light carry more energy and have greater amplitudes than electromagnetic waves of dim light. Loud sound waves carry more energy and have greater amplitudes than soft sound waves. A very loud sound can carry enough energy to damage your hearing.



Transverse Wave



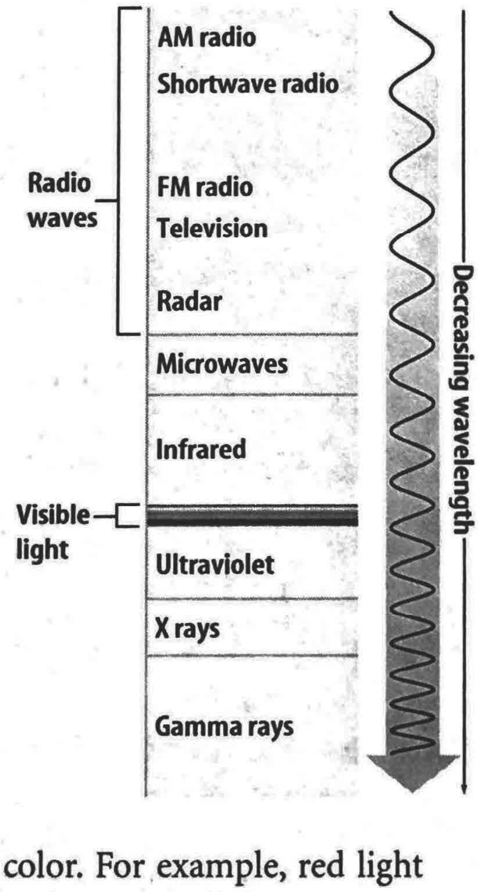
Compressional Wave

Wavelength

You also can describe a wave by its wavelength. Look at the figure above. For a transverse wave, **wavelength** is the distance from the top of one crest to the top of the next crest, or from the bottom of one trough to the bottom of the next trough. For a compressional wave, the wavelength is the distance between the center of one compression and the center of the next compression, or from the center of one rarefaction to the center of the next rarefaction.

The wavelengths of electromagnetic waves can vary from extremely short to longer than a kilometer. X rays and gamma rays have wavelengths that are smaller than the diameter of an atom.

This range of wavelengths is called the electromagnetic spectrum. The figure at the right shows the names given to different parts of the electromagnetic spectrum. Visible light, or light you can see, is only a small part of the electromagnetic spectrum. The wavelength of visible light gives light its color. For example, red light waves have longer wavelengths than green light waves.



Picture This

1. Describe Look at the figure of the transverse wave. Compare the wavelengths between two crests to the wavelength between two troughs. Describe what you find.

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Picture This

2. Use Graphs Which of the following has the greatest wavelength?

a. microwaves
b. X rays
c. AM radio waves
d. FM radio waves

Frequency

The **frequency** of a wave is the number of wavelengths that pass a given point in 1 s. Frequency is measured in hertz (Hz). Hertz are the number of wavelengths per second. So, 1 Hz means one wavelength per second. Remember that waves are made by something that vibrates. The faster the vibration is, the higher the frequency is of the wave. ☑

✔ Reading Check

3. **Summarize** Write the correct words to complete the sentence on the lines below.

Waves that vibrate fast have ____a.____ frequencies. Waves that vibrate slowly have ____b.____ frequencies.

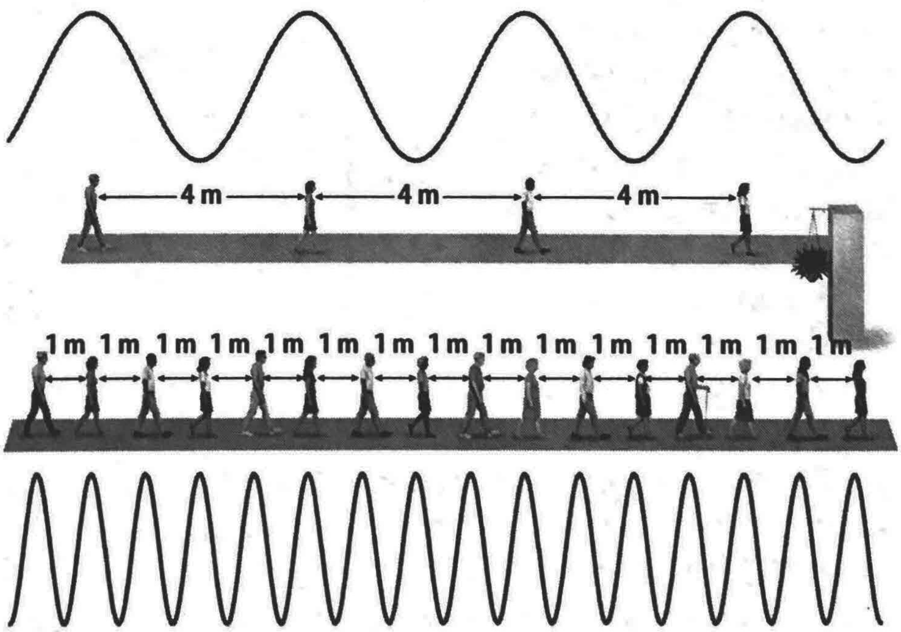
a. ______________________

b. ______________________

How can you model frequency?

You can use a model to help you understand frequency. If two waves travel with the same speed, their frequency and wavelength are related. Look at the figure below. Imagine people on two moving sidewalks next to each other. One sidewalk has four people on it. They are spaced 4 m apart. The other sidewalk has 16 people on it. They are spaced 1 m apart.

Imagine both sidewalks are moving at the same speed. The sidewalks move toward a pillar. On which sidewalk will more people go past the pillar? The sidewalk with 16 people on it has a shorter distance between people. Four people on this sidewalk will pass the pillar for every one person on the other sidewalk.



Picture This

4. **Use Models** On the bottom sidewalk, circle groups of four people each. Then draw a line from each group of four people to one person on the top sidewalk.

How are frequency and wavelength related?

Suppose that each person on the sidewalks represents the crest of a transverse wave. The movement of the people on the first sidewalk is like a wave with a 4 m wavelength. For the second sidewalk, the wavelength would be 1 m.

Applying Math

5. **Calculate** If three people on the top sidewalk pass the pillar, how many people on the bottom sidewalk will have passed the pillar?

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The sidewalk with the longer, 4 m, wavelength carries a person past the pillar less frequently. Longer wavelengths have lower frequencies. On the second sidewalk, people pass the pillar more frequently. There, the wavelength is shorter—only 1 m. Shorter wavelengths have higher frequencies. This is true for all waves that travel at the same speed. As the frequency of a wave increases, its wavelength decreases.

What makes different colors and pitches?

The color of a light wave depends on the wavelength or the frequency of the light wave. For example, blue light has a higher frequency and shorter wavelength than red light.

Pitch is how high or how low a sound seems to be. Either the wavelength or the frequency determines the pitch of a sound wave. The pitch and frequency increase from note to note when you sing a musical scale. High-sounding pitches have higher frequencies. As the frequency of sound waves increases, their wavelengths decrease. Lower pitches have lower frequencies. As the frequency of a sound wave decreases, their wavelengths increase. ☑

Wave Speed

You have probably watched a thunderstorm on a hot summer day. You see lightning flash between a dark cloud and the ground. If the thunderstorm is far away, it takes many seconds before you will hear the sound of the thunder that goes with the lightning. This happens because light travels much faster in air than sound does. Light travels through air at about 300 million m/s. Sound travels through air at about 340 m/s. You can calculate the speed of any wave using this equation. The Greek letter lambda, λ, represents wavelength.

Wave Speed Equation

wave speed (m/s) = **frequency** (Hz) × **wavelength** (m)

$$v = f\lambda$$

Mechanical waves, such as sound, and electromagnetic waves, such as light, change speed when they travel in different mediums. Mechanical waves usually travel fastest in solids and slowest in gases. Electromagnetic waves travel fastest in gases and slowest in solids. For example, the speed of light is about 30 percent faster in air than in water.

Reading Check

6. **Summarize** What determines color and pitch? Circle your answer.
   a. wavelength
   b. frequency
   c. wavelength and frequency
   d. wavelength or frequency

Applying Math

7. **Use an Equation** What is the speed in m/s of a wave with a frequency of 50 Hz and wavelength of 2 m? Show your work.

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After You Read

Mini Glossary

amplitude: transverse wave—one-half the distance between a crest and a trough; compressional wave—how close together the particles of the medium are

frequency: the number of wavelengths that pass a given point in 1 s

wavelength: transverse wave—the distance from the top of one crest to the top of the next crest, or from the bottom of one trough to the bottom of the next trough; compressional wave—the distance between the center of one compression and the center of the next compression, or from the center of one rarefaction to the center of the next rarefaction

1. Review the terms and their definitions in the Mini Glossary. Explain in your own words how wavelength and frequency are related.

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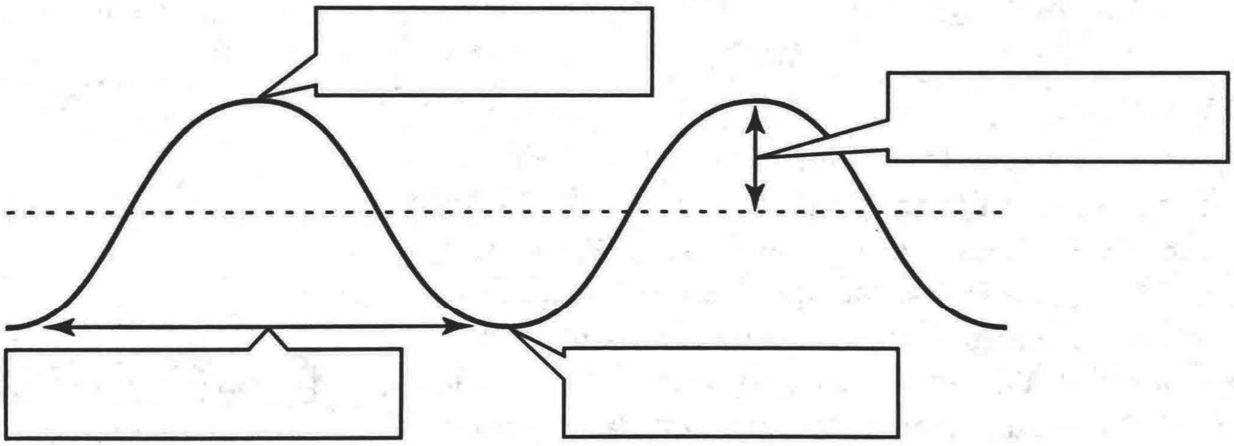
2. Label the parts of the transverse wave in the diagram below.



3. You were asked to underline properties of waves and highlight information about them. How did this help you understand and learn about properties of waves?

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End of Section

Science Online Visit **booko.msscience.com** to access your textbook, interactive games, and projects to help you learn more about properties of waves.