chapter 2 Sound

section 1 What is sound?

Before You Read

Write down two sounds that you like to hear and two sounds that you do not like to hear. Why are some sounds pleasant and others not?

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What You'll Learn

- what the characteristics of sound waves are
- how sound travels
- what the Doppler effect is

Read to Learn

Sound and Vibration

Think of all the sounds you have heard today. You may have heard the sound of your alarm clock, people talking, or locker doors slamming. All sounds have one thing in common. Every sound is made by something that vibrates.

Mark the Text

Identify Characteristics As you read this section, highlight the sentences that describe characteristics of sound waves.

What are sound waves?

How does an object that is vibrating make sound? When you speak, vocal cords in your throat vibrate. The vibrations make sound waves that travel through the air to other people's ears. Their brain understands the sound waves and they hear your voice.

A wave carries energy from one place to another. A wave does not move matter from one place to another. An object that is vibrating in air makes a sound wave. The vibrating object causes air molecules to move back and forth. These air molecules bump into other air molecules nearby and make them move back and forth, too. This happens again and again. In this way, energy is transferred from one place to another as a sound wave.

What type of wave is a sound wave?

A sound wave is a compressional wave. Have you ever played with a coiled spring toy? When you hold both ends of the spring and someone squeezes together the coils at one end, a wave moves along the spring. You can see the coils of the spring move together and then apart as the compressional wave moves along the spring. The coils move back and forth as the compressional wave moves past them but the toy stays in the same place. ☑

In a compressional wave, the material the wave passes through moves back and forth along the same direction that the wave moves. In the toy, the coils of the spring move back and forth along the same direction the wave is moving as energy is transferred. In a sound wave, air molecules move back and forth along the same direction the sound wave is moving.

☑ Reading Check

1. Describe What type of wave is a sound wave?

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How are sound waves made?

Look at the tuning fork on the left in the figure below. When the end moves outward into the air, it pushes the air molecules together. This makes an area where the air molecules are closer together, or more dense. This area of higher density is called a compression.

When the end of the tuning fork moves inward, the air molecules next to it spread farther apart. This area of lower density is called a rarefaction. You can see a rarefaction on the right in the figure below.

As the tuning fork vibrates, it forms a series of compressions and rarefactions. The compressions and rarefactions move away from the tuning fork as the molecules bump into other molecules. Energy is transferred from one molecule to the next as the compressions and rarefactions move away from the tuning fork.

Picture This

2. Compare and Contrast In the figures, how do the molecules in the rarefaction differ from the molecules in the compression?

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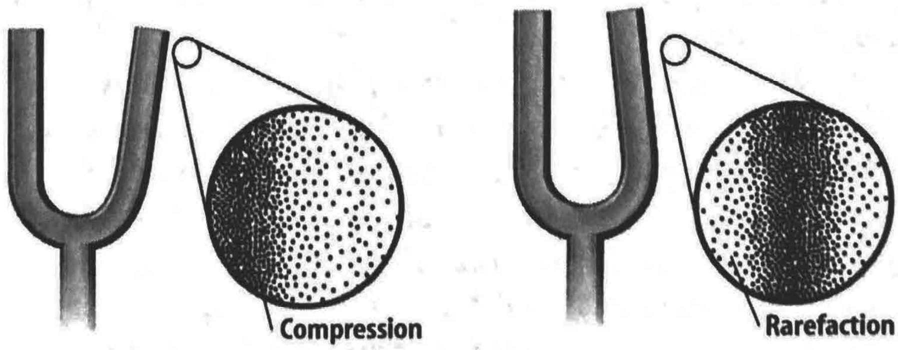
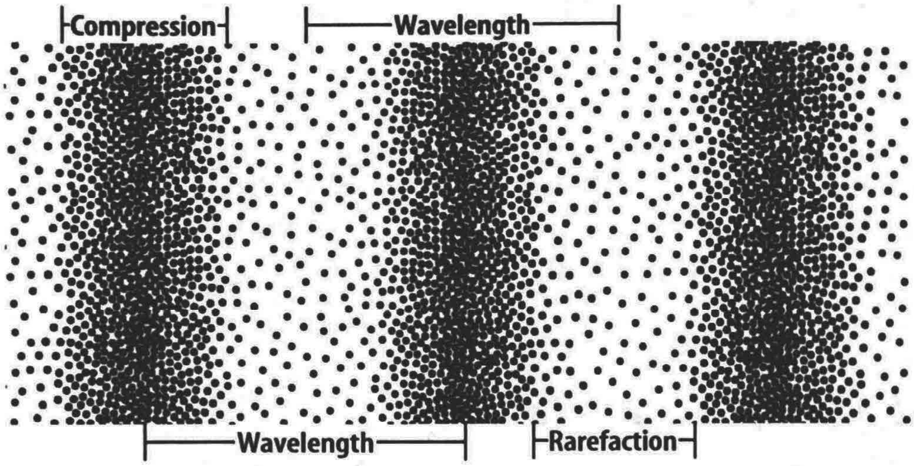


Sound Wave



What is a wavelength?

Like other waves, a sound wave can be described by its wavelength and frequency. Look at the figure above. It shows the wavelength of a compressional wave. The wavelength is the distance from one compression to the next or from one rarefaction to the next.

What is frequency?

The frequency of a sound wave is the number of compressions or rarefactions that pass by a certain point in one second. The faster an object vibrates, the higher the frequency of the sound wave it forms.

The Speed of Sound

Sound waves can travel through other materials in the same way they travel through air. But, sound waves travel at different speeds through different materials.

As a sound wave travels through a material, molecules in that material bump into each other. Molecules in a solid are closer together than they are in a liquid or a gas. That means they do not have to travel far before they bump into nearby molecules. Sound travels fastest in solids because the molecules are closest together. Sound usually travels slowest through gases because the molecules are farthest apart. For example, sound travels through air at 343 m/s. Sound travels through water at 1,483 m/s, and through glass at 5,640 m/s.

Picture This

3. **Determine** How many compressions can be seen in the wave in the figure?

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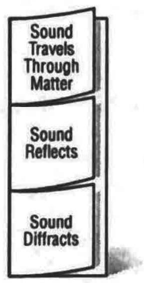
FOLDABLES™

A Organize Information Make the following Foldable to help you organize information about sound. Give examples under each tab.



Applying Math

4. Calculate How much faster does sound travel through air at 20°C than through air at 0°C?

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Does temperature change the speed of sound?

Sound travels faster through a material when that material is at a higher temperature. The molecules of a material move faster as the material heats up. The faster the molecules move, the more often they bump into each other. The more times the molecules hit each other, the faster sound travels through the material. For example, the speed of sound in air at 0°C is 331 m/s. When the air warms to 20°C, sound travels through it at 343 m/s.

Amplitude and Loudness

What's the difference between loud sounds and quiet sounds? Play a radio loudly, then play it quietly. You will hear the same instruments and voices, but something is different. The difference is that loud sound waves usually carry more energy than soft sound waves do. **Loudness** is a person's understanding of how much energy a sound wave carries.

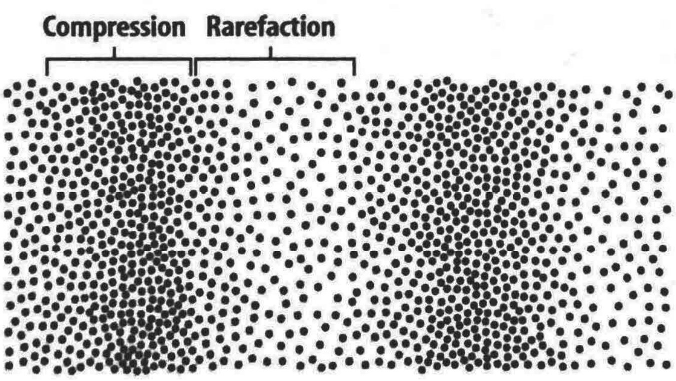
How are amplitude and energy related?

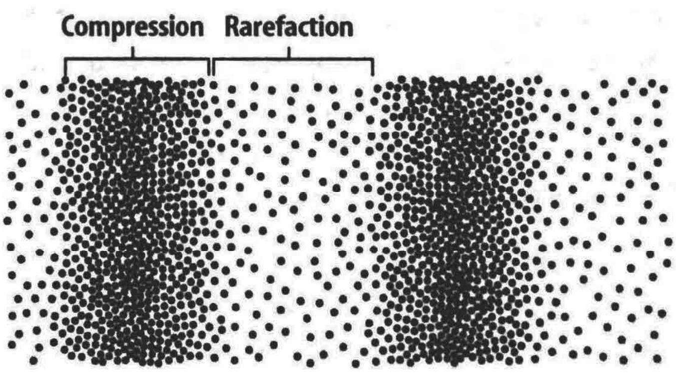
The amount of energy a wave carries depends on its amplitude. The amplitude of a sound wave shows how spread out the molecules are in the compressions and rarefactions of the wave.

Compare the two sound waves in the figure below. In the sound wave on the right, the molecules are closer together in the compressions and farther apart in the rarefactions than in the wave on the left. This wave has a higher amplitude. The vibrating object that made the wave on the right transferred more energy to move the particles closer together or spread them farther apart. Sound waves with greater amplitude carry more energy and sound louder. Sound waves with smaller amplitude carry less energy and sound quieter.

Picture This

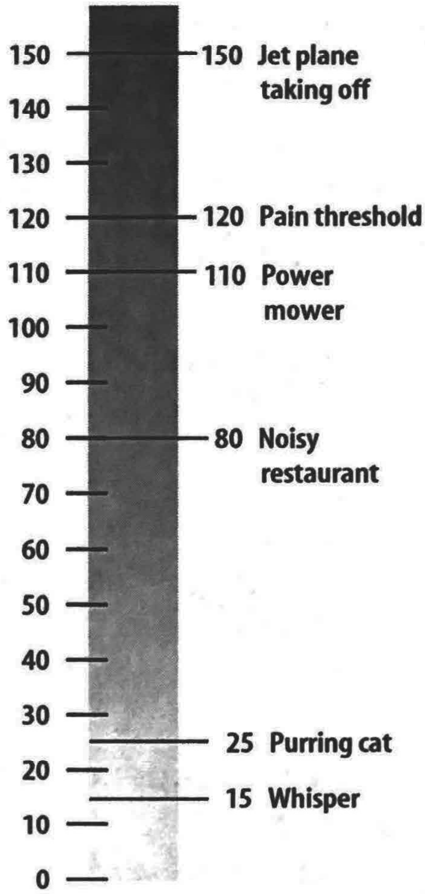
5. Infer Circle the sound wave that will sound louder.





How is the energy of a sound wave measured?

How loud a sound seems is different for each person. But, the energy carried by sound waves can be measured by a scale called the decibel (dB) scale. The figure to the right shows the decibel scale. An increase of 10 dB means the energy carried by a sound has increased ten times. But, an increase of 20 dB means that the sound carries 100 times more energy.



Decibel Scale

Hearing Damage Hearing damage begins to happen at sound levels of about 85 dB. The amount of damage depends on the frequencies of the sound and how long a person is exposed to the sound. Some music concerts produce sound levels as high as 120 dB. The energy carried by these sound waves is about 30 billion times greater than the energy carried by sound waves made by whispering.

Frequency and Pitch

The <u>pitch</u> of a sound is how high or how low it sounds. A flute makes a high-pitched sound. A tuba makes a low-pitched sound. The pitch of a sound depends on the frequency of the sound. The higher the pitch is, the higher the frequency is. For example, a sound wave with a frequency of 440 hertz (Hz) has a higher pitch than a sound wave with a frequency of 220 Hz.

What frequencies can be heard?

You can hear sound waves with frequencies between about 20 Hz and 20,000 Hz. Some animals can hear sounds with even higher or lower frequencies. Dogs can hear frequencies up to almost 50,000 Hz. Dolphins and bats can hear frequencies as high as 150,000 Hz.

Picture This

6. **Use Diagrams** How many decibels is the sound level of a purring cat?

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Think it Over

7. **Think Critically** Explain why going to some music concerts could damage your hearing.

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Think it Over

8. **Infer** Which sound wave has a higher pitch, a wave with a frequency of 100 Hz or a wave with a frequency of 500 Hz?

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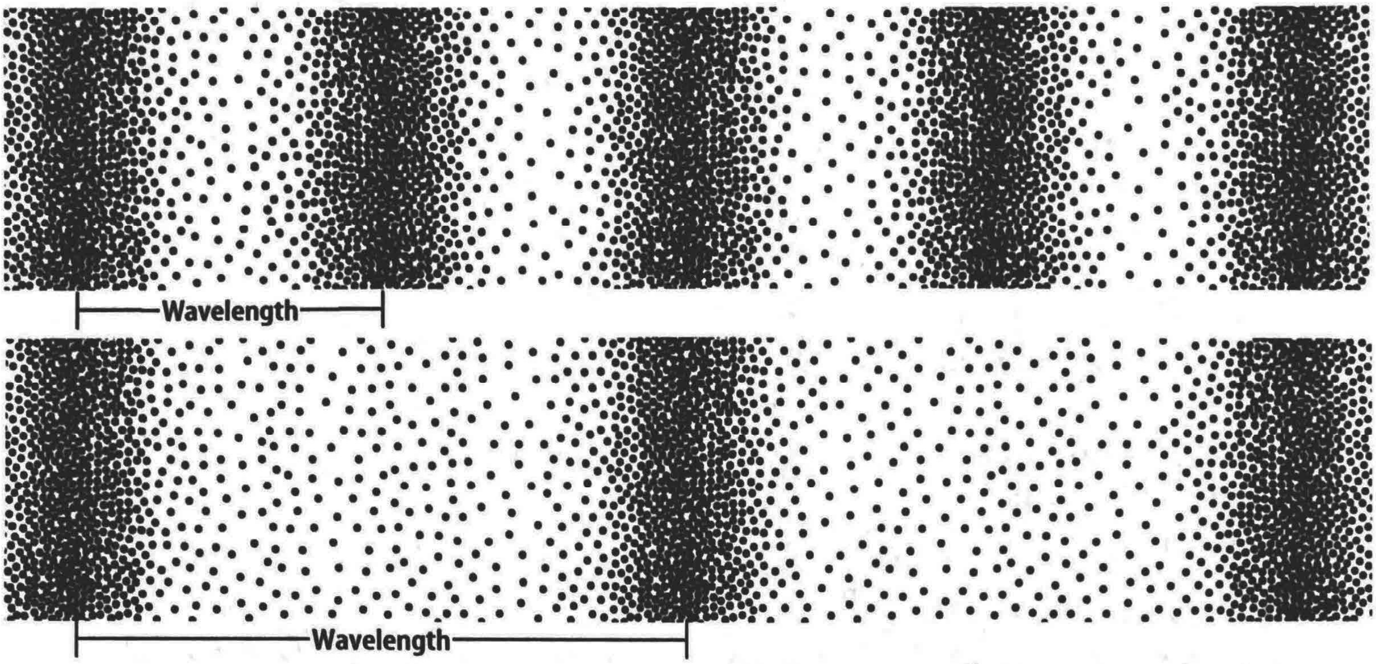
Frequency and Wavelength



Picture This

9. Interpret Scientific Diagrams Circle the sound wave that has the higher pitch.

Reading Check

10. Identify Who has shorter vocal cords, a child or an adult?

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How are frequency and wavelength related to pitch?

Recall that frequency and wavelength are related. If two sound waves travel at the same speed, the wave with the shorter wavelength has the higher frequency. Look at the sound waves in the figure. The wavelength of the upper wave is shorter. So, more compressions and rarefactions will go past a certain point every second than for the wave at the bottom of the figure. This means the upper sound wave has a higher frequency than the lower sound wave. It also means that the upper wave is higher in pitch. Sound waves with a higher pitch have shorter wavelengths than those with a lower pitch.

Why do some human voices sound higher than others?

When you make a sound, you breathe out past your vocal cords and your vocal cords vibrate. Not everyone's vocal cords are the same length and thickness. Shorter, thinner vocal cords vibrate at higher frequencies than longer or thicker ones. Children have shorter, thinner vocal cords because their vocal cords are still growing. So, most children's voices sound higher than adults' voices. Muscles in the throat can stretch the vocal cords tighter. People can change the pitch of their voices by controlling these muscles. ☑

Echoes

Sound waves reflect off hard surfaces just like a water wave bounces off rocks at the beach. An **echo** is a reflected sound wave. The amount of time it takes an echo to return to where the sound wave was first made depends on how far away the reflecting surface is.

Sonar systems use reflected sound waves to find the location and shape of objects under water. A pulse of sound is sent toward the ocean floor. The wave reflects off the ocean floor and back to a receiver. By measuring the length of time it took the echo to return, the distance to the ocean floor can be measured. Sonar can be used to map the ocean floor, locate submarines, schools of fish, and other objects under water. ☑

What is echolocation?

Some animals use echoes to tell their location and to hunt. This is called echolocation. Bats give off high-pitched squeaks, then listen for the echoes. The type of echo a bat hears tells it exactly where an insect is. Dolphins also use echolocation to help navigate or find their way and to locate objects in the ocean. People who have vision problems might use echolocation to estimate the size and shape of a room.

The Doppler Effect

Have you listened to an ambulance siren as the ambulance sped toward you, then passed you? The pitch gets higher as the ambulance moves toward you. It gets lower as the ambulance moves away from you. The **Doppler effect** is the change in frequency of a sound wave when the source of a sound moves compared to the listener.

The Doppler effect occurs if the source of the sound is moving or if the listener is moving. Suppose you drive past a factory as its whistle blows. As you move toward the factory, the whistle will sound higher pitched. As you move closer, you meet each sound wave a little earlier than you would if you were not moving. You hear more wavelengths per second, so the whistle sounds higher in pitch. As you move away from the factory, each sound wave takes a little longer to reach you. You hear fewer wavelengths per second. So, the whistle sounds lower in pitch.

Reading Check

11. Explain What does sonar measure to find the depth of the ocean floor?

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Think it Over

12. Determine Which sound would have a higher pitch, a sound moving toward you or a sound moving away from you?

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Radio Waves Radar guns can measure the speed of cars and baseball pitches by using the Doppler effect. A radar gun sends out a radio wave instead of a sound wave. The radio wave reflects off a moving object. The frequency of the radio wave changes depending on the speed of the moving object and whether the object is moving toward the radar gun or away from it. The radar gun uses the change in the frequency of the reflected wave to find the speed of the object. ☑

Reading Check

13. **Describe** What does a radar gun use to find the speed of an object?

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Diffraction of Sound Waves

A sound wave diffracts when it bends around an object in its path or when it spreads out after passing through a small opening. The amount a wave diffracts depends on whether the wavelength is bigger or smaller than the object or opening. A wave barely diffracts if its wavelength is much smaller than the object or opening. As the size of the wavelength becomes closer to the size of the object or opening, the amount of diffraction increases.

You can hear the diffraction of sound waves if you go to the band room while the band is practicing. If you stand in the open doorway, you will hear the band normally. If you stand around the corner from the band room, you will hear the tubas and other low-pitched instruments better than the high-pitched instruments.

The low-pitched instruments make sound waves with longer wavelengths than the high-pitched instruments. The long wavelengths are closer to the size of the door opening than the shorter wavelengths made by the high-pitched instruments. The longer wavelengths diffract more. So, you hear them even when you are not standing in the doorway. In the same way, the lower frequencies in the human voice allows you to hear someone talking even when the person is around the corner.

Think it Over

14. **Evaluate** Which instrument are you more likely to hear if you are standing around the corner from the band room, a trombone or a flute?

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Using Sound Waves

Sound waves can be used to treat some health problems. A process called ultrasound uses sound waves with high frequencies. Ultrasound can be used to make an image of the inside of the body. Ultrasound can be used to see how a fetus is developing and to study the heart. Ultrasound along with the Doppler effect can be used to determine if a heart is working properly.

After You Read

Mini Glossary

Doppler effect: the change in frequency of a sound wave when the source of a sound moves compared to the listener

echo: a reflected sound wave

loudness: a person's understanding of how much energy a sound wave carries

pitch: how high or how low a sound is

1. Review the terms and their definitions in the Mini Glossary. Write one or two sentences that describe how animals use echoes.

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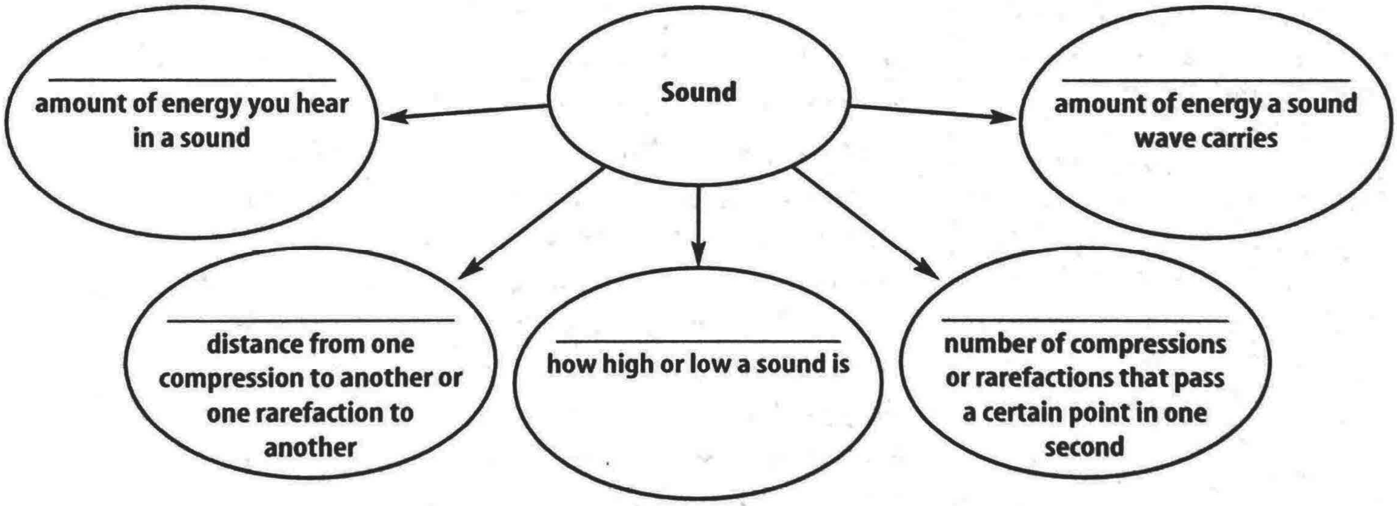
2. Place each characteristic of sound in the correct space on the concept map below.

wavelength **frequency** **loudness** **amplitude** **pitch**



3. You were asked to highlight the sentences that describe characteristics of sound waves. How did this help you learn the content of the section?

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

End of Section