chapter 10

Sound

section 2 Properties of Sound

Before You Read

Do your parents ever ask you to turn down the volume on the television? Why do you think some sounds might seem too loud to one person and just right to another?

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_____

What You'll Learn

- how amplitude, intensity, and loudness are related
- how sound is measured
- the relationship between frequency and pitch
- the Doppler effect

Read to Learn

Mark the Text

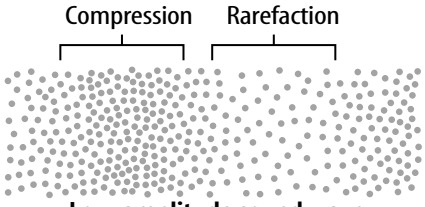
Identify Definitions As you read the section, highlight the headings that are questions. Highlight the answers in a different color.

Intensity and Loudness

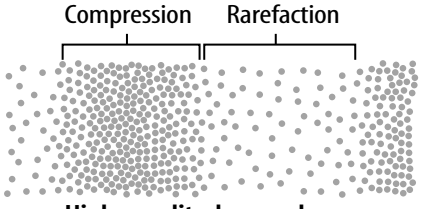
Suppose you turn down the volume on your radio. The notes sound the same, but the sound is not as loud. What happens to the sound waves? The quieter sound waves do not carry as much energy as louder sound waves do.

The amount of energy a wave carries depends on its amplitude. For a longitudinal wave, amplitude is related to the density of the molecules. Density means how close together molecules are.

Compare the figures. Molecules vibrate with a lot of energy. Sound waves with dense compressions vibrate with a lot of energy. The second sound wave shown has a high-amplitude. The compressions are much denser in a high-amplitude sound wave. Molecules act in the opposite way in the rarefactions. The rarefactions are less dense in the high-amplitude sound wave.



Low-amplitude sound wave



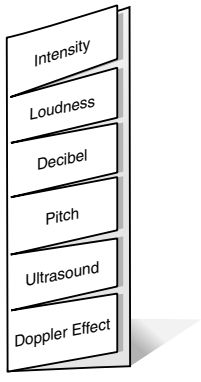
High-amplitude sound wave

Remember that sound waves are longitudinal waves. The wave carries energy, but it doesn't carry matter. Matter compresses and expands as a sound wave passes through the matter.

FOLDABLES™

B Build Vocabulary

Make the following vocabulary book Foldable to define the vocabulary terms of this section.



Think it Over

1. **Apply** How can you increase the intensity of the sound coming from a radio?

What is intensity?

Imagine sound waves moving from a radio, through a small window, and then to your ear. The amount of energy that passes through the window in 1 s is a measure of intensity. **Intensity** is the amount of energy that flows through a certain area in a specific amount of time. When you turn down the volume of your radio, you reduce the energy carried by the sound waves. So you are also reducing their intensity.

Intensity affects how far away a sound can be heard. Think about whispering with a friend. The sound waves you make have low intensity. They do not travel far. You have to sit close together to hear each other. Now think about shouting to someone. You can be much farther apart. When you shout, the sound waves have high intensity. They can travel farther.

How are intensity and distance related?

Some of a wave's energy is converted into other forms of energy when it is passed from particle to particle. So intensity affects how far a wave will travel.

What happens when you drop a basketball? The ball held above the ground has potential energy. When the ball falls, the potential energy is changed into energy of motion. When it hits the ground and bounces up, some of the ball's energy is transferred to the ground. The ball doesn't have enough energy to bounce back as high as it was. The ball transfers a small amount of energy with each bounce. Finally, the ball has no more energy and it stops bouncing. If you held the ball higher above the ground, it would have more energy and would bounce for a longer time before it stopped.

In a similar way, a sound wave with low intensity loses its energy more quickly than one with high intensity. It travels a shorter distance than a sound wave of higher intensity.

What is loudness?

Reading Check

2. **Define** the terms *loudness*.

Your ears and brain can tell the difference between low-intensity sounds and high-intensity sounds. You do not need special equipment to know which sounds have greater intensity. **Loudness** is the way humans understand sound intensity.

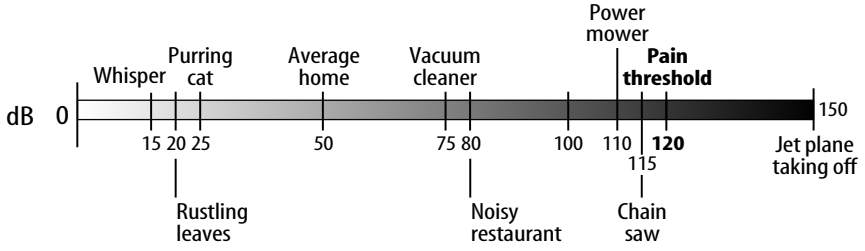
Sound waves with high intensity carry more energy. They make your eardrums move back and forth a greater distance than sound waves of low intensity do. The bones of the middle ear change the increased movement of the eardrum into increased movement of the hair cells in the inner ear. This makes you hear a loud sound instead of a quiet one. As the intensity of a sound waves increases, the loudness of the sound you hear increases.

How is loudness measured?

It is hard to say how loud too loud is. Two people might not agree on whether a noise is too loud. A sound that seems fine to you may seem much too loud to your teacher. However, the intensity of sound can be measured. Each unit on the scale for sound intensity is called a **decibel** (DE suh bel). The abbreviation for decibels is dB.

The quietest sound that most people can hear is 0 dB. The intensity of the noises in an average home is 50 dB. Sounds that are louder than 120 dB can cause pain and even permanent hearing loss. During some rock concerts, sound intensity reaches this damaging level. Factories, construction sites, and other workplaces also can have noise levels that might damage hearing. Wearing ear protection, such as earplugs, around loud sounds can help protect against hearing loss. The figure below shows the intensity levels of some sounds in decibels.

Loudness in Decibels



Pitch

Have you ever sung the musical scale do, re, mi, fa, so, la, ti, do? When you sing this scale, your voice starts low and becomes higher with each note. What you hear is a change in pitch. **Pitch** is how high or low a sound seems to be. The pitch of a sound is related to the frequency of the sound waves.

How are frequency and pitch related?

Frequency, being the number of wavelengths that pass a fixed point in one second, is measured in hertz (Hz). One hertz means one wavelength passes by in 1 second. The frequency of a compressional wave is the number of compressions or the number of rarefactions passing by a fixed point each second.

When a sound wave with high frequency hits your ear, many compressions hit your eardrum each second. The vibrations are transmitted to your brain. You understand them as a sound with a high pitch. As the frequency of a sound wave decreases, the pitch becomes lower. A whistle with a frequency of 1,000 Hz has a high pitch. Low-pitched thunder has a frequency of less than 50 Hz.

Picture This

3. Interpret a Graph How many decibels louder is a jet plane taking off than a vacuum cleaner?

_____

Think it Over

4. Explain Why can the frequency of a compressional wave be counted as either the number of compressions or the number of rarefactions that passes by in one second?

_____

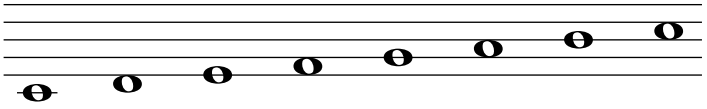
_____

_____

The figure shows different notes and their frequencies. A healthy human ear can hear sound waves with frequencies from about 20 Hz to about 20,000 Hz. Humans can best hear sounds that are between 440 Hz and 7,000 Hz. Most people can hear much softer sounds at this range than at higher or lower frequencies.

Applying Math

5. Apply Notice that the musical note C is both the first and the last note of the scale. What do you notice about the frequencies of these two notes?



Note:	C	D	E	F	G	A	B	C
Sound:	do	re	mi	fa	so	la	ti	do
Frequency:	262 Hz	294 Hz	330 Hz	349 Hz	393 Hz	440 Hz	494 Hz	524 Hz

Are there sounds humans can't hear?

There are some sounds with frequencies that are too high or too low for people to hear. Ultrasonic waves have sound frequencies above 20,000 Hz. People cannot hear sound frequencies that are this high. Dogs can hear sounds with frequencies up to about 35,000 Hz. Bats can hear sounds with frequencies of more than 100,000 Hz. Even though humans can't hear ultrasonic waves, they use them for many things. Doctors use ultrasonic waves to diagnose and treat illnesses. Ultrasonic waves also are used to estimate the size, shape, and depth of underwater objects.

Reading Check

6. Identify What are two ways that people use ultrasonic waves?

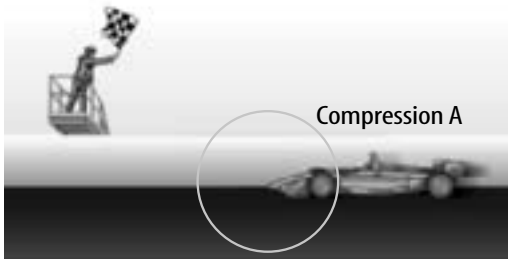
Sound waves with frequencies below 20 Hz are called infrasonic waves. They are also called subsonic waves. These frequencies are too low for most people to hear. Infrasonic waves are produced by sources that vibrate very slowly. Wind, heavy machinery, and earthquakes are some things that produce infrasonic waves. You probably can't hear infrasonic waves. But sometimes you can feel them as a rumble inside your body.

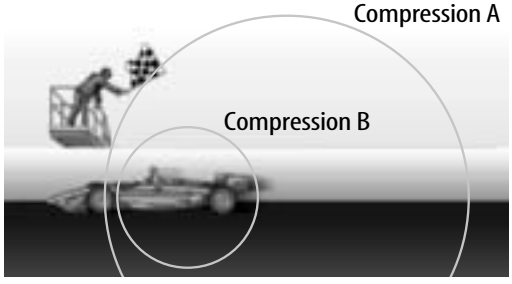
The Doppler Effect

Suppose that you are standing beside a racetrack. Race cars are zooming past. As a car moves toward you, the pitch of its engine becomes higher. As it moves away from you, the pitch becomes lower. The **Doppler effect** is a change in pitch or wave frequency because a wave source is moving.

What happens when a sound source moves?

As a race car moves, it sends out sound waves. The sound waves are made up of compressions and rarefactions. Look at the first figure. The race car creates a compression, labeled compression A. Compression A moves through the air toward the flagger. Now look at the second figure. By the time compression B leaves the race car, the car has moved forward. Compressions A and B are closer together than they would be if the car had stayed still. Because the compressions are closer together, more compressions pass by the flagger each second than if the car were at rest. So the flagger hears a higher pitch. Look at the second figure again. You can see that the compressions behind the moving car are farther apart. This means the sound of the car has a lower frequency and a lower pitch as the car moves away from the flagger.





What happens when a listener moves?

You also can notice the Doppler effect when you are moving past a sound source that is standing still. Suppose you pass a building with a ringing bell. The pitch of the bell sounds higher as you get closer to the building. The bell sounds lower as you get farther from the building. The Doppler effect happens any time position changes. The change can be the position of the source of a sound or of the listener. The faster the change in position, the greater the change in frequency and pitch.

How is the Doppler effect used?

The Doppler effect also occurs with other kinds of waves, such as electromagnetic waves. Radar guns with electromagnetic waves are used to measure the speed of cars. The radar gun sends radar waves toward a moving car. The waves reflect from the car. The frequency of the waves changes, depending on the speed and direction the car is moving. The radar gun measures the change and finds the speed of the car. Weather radar also uses the Doppler effect to show the movement of winds in storms.

Picture This

7. Draw and Label In the space below, draw and label a diagram that explains the Doppler effect.

Reading Check

8. Explain When does the Doppler effect happen?

After You Read

Mini Glossary

decibel: the unit for measuring sound intensity

Doppler effect: when pitch or wave frequency changes because a wave source is moving

intensity: the amount of energy that flows through a certain area in a specific amount of time

loudness: how humans understand sound intensity

pitch: how high or low a sound is

1. Review the vocabulary terms and their definitions in the Mini Glossary above. What is the difference between intensity and loudness?

_____

_____

2. Fill in the blanks below with the following words to make correct statements about the material you read in this section: *intensity*, *high-amplitude*, *decibel*, *subsonic*, *frequency*.

As the _____ of a sound wave increases, the pitch increases.

In a _____ sound wave, the compressions are dense.

The _____ is the unit for measuring how intense a sound is.

As the _____ of a sound wave increases, the loudness increases.

3. Mark the Text As you read this section, you highlighted the headings that are questions. Will this strategy help you remember what you read in the section? Why or why not?

_____

_____

_____

End of Section