Name ____________ Class ____________ Date ____________

Chapter 26 Sound

Summary

THE BIG IDEA **Sound is a form of energy that spreads out through space.**

26.1 The Origin of Sound

All sounds originate in the vibrations of material objects.

- Sound is produced when a vibration stimulates the vibration of something larger or more massive. This vibrating material then sends a disturbance through a surrounding medium, usually air, in the form of longitudinal waves. Under ordinary conditions, the frequency of the sound waves produced equals the frequency of the vibrating source.
- We describe our subjective impression about the frequency of sound by the word **pitch.** A high-pitched sound has a high vibration frequency, while the low-pitched sound has a low vibration frequency.
- A young person can normally hear pitches with frequencies from 20 to 20,000 hertz. As we grow older, our hearing range shrinks, especially at the high-frequency end.
- Sound waves with frequencies below 20 hertz are called **infrasonic,** and those with frequencies above 20,000 hertz are called **ultrasonic.** We cannot hear infrasonic or ultrasonic sound waves.

26.2 Sound in Air

As a source of sound vibrates, a series of compressions and rarefactions travels outward from the source.

- A sound pulse goes out in all directions from the source.
- When sound moves away from its source, each particle of air moves back and forth along the direction of motion of the expanding wave. A pulse of compressed air is called a **compression.** A pulse of low-pressure air is called a **rarefaction.**
- For all wave motion, it is not the medium that travels, but a *pulse* that travels.
- As a source of sound vibrates, a series of compressions and rarefactions is produced.

26.3 Media That Transmit Sound

Sound travels in solids, liquids, and gases.

- The speed of sound differs in different materials. In general, sound is transmitted faster in liquids than in gases, and still faster in solids.
- Sound cannot travel in a vacuum. The transmission of sound requires a medium. If there is nothing to compress and expand, there can be no sound. There may still be vibrations, but without a medium there is no sound.

26.4 Speed of Sound

The speed of sound in a gas depends on the temperature of the gas and the mass of the particles in the gas. The speed of sound in a material depends on the material's elasticity.

- During a thunderstorm, you hear thunder *after* you see the lightning. This is evidence that sound is much slower than light.
- The speed of sound in dry air at 0°C is about 330 meters per second, or about 1200 kilometers per hour.
- Water vapor in the air and increased temperatures increase the speed of sound in air slightly. For each degree increase in air temperature above 0°C, the speed of sound in air increases by about 0.60 m/s. In air at a normal room temperature of about 20°C, sound travels at about 340 m/s.
- The speed of sound in a gas also depends on the mass of its particles. Lighter gas particles move faster and transmit sound much more quickly than heavier gas particles.
- The speed of sound in a solid material depends not on the material's density, but on its elasticity. Elasticity is the ability of a material to change shape in response to an applied force, and then resume its initial shape once the distorting force is removed. Steel is very elastic; putty is inelastic.

26.5 Loudness

Sound intensity is objective and is measured by instruments. Loudness, on the other hand, is a physiological sensation sensed in the brain.

- The intensity of a sound is proportional to the square of the amplitude of a sound wave. The unit of intensity for sound is the decibel (dB).
- Starting with zero at the threshold of hearing for a normal ear, an increase of each 10 dB means that sound intensity increases by a factor of 10. A sound of 10 dB is 10 times as intense as sound of 0 dB. Likewise, 20 dB is not twice but 10 times as tense as 10 dB, or 100 times as intense as the threshold of hearing.
- Physiological hearing damage begins at exposure to 85 decibels. The extent of damage depends on the length of exposure and on frequency characteristics.

26.6 Natural Frequency

When any object composed of an elastic material is disturbed, it vibrates at its own special set of frequencies, which together form its special sound.

- An object's **natural frequency** is the frequency at which the object vibrates when it is disturbed. Natural frequency depends on the elasticity and shape of the object.
- Most things—from planets to atoms and almost everything else in between—have a springiness to them and vibrate at one or more natural frequencies.

- A natural frequency is one at which minimum energy is required to produce forced vibrations. It is also the frequency that requires the least amount of energy to continue this vibration.

26.7 Forced Vibration

Sounding boards are an important part of all stringed musical instruments because they are forced into vibration and produce the sound.

- A **forced vibration** occurs when an object is made to vibrate by another vibrating object that is nearby.
- The vibration of guitar strings in an acoustical guitar would be faint if they weren't transmitted to the guitar's wooden body. The mechanism in a music box is mounted on a sounding board. Without the sounding board, the sound would be barely audible.

26.8 Resonance

An object resonates when there is a force to pull it back to its starting position and enough energy to keep it vibrating.

- **Resonance** occurs when the frequency of a vibration forced on an object matches the object's natural frequency, causing a dramatic increase in amplitude.
- A common experience illustrating resonance occurs on a swing. Even small pumps or pushes, if delivered in rhythm with the natural frequency of the swinging motion, produce large amplitudes.
- When you tune a radio set, you are adjusting the natural frequency of the electronics in the set to match one of the many incoming signals. The set then resonates to one station at a time, instead of playing all the stations at once.

26.9 Interference

When constructive interference occurs with sound waves, the listener hears a louder sound. When destructive interference occurs, the listener hears a fainter sound or no sound at all.

- The crest of a transverse wave corresponds to a compression of a sound wave, and the trough of a transverse wave corresponds to a rarefaction of a sound wave.
- When the crests of one wave overlap the crests of another wave, there is constructive interference and an increase in amplitude. When the crests of one wave overlap the troughs of another wave, there is destructive interference and a decrease in amplitude.
- Destructive sound interference is a useful property in antinoise technology.

26.10 Beats

When two tones of slightly different frequency are sounded together, a regular fluctuation in the loudness of the combined sounds is heard.

- The periodic variation in the loudness of sound is called **beats.**
- Beats can be heard when two slightly mismatched tuning forks are sounded together. When the combined waves reach your ears in step, the sound is a maximum. When the forks are out of step, in the sound is a minimum.
- Beats can occur with any kind of wave and are a practical way to compare frequencies. When wave frequencies are identical, beats disappear.