

Chapter 17 Mechanical Waves and Sound

Summary

17.1 Mechanical Waves

➤ A mechanical wave is created when a source of energy causes a vibration to travel through a medium.

- A **mechanical wave** is a disturbance in matter that carries energy from one place to another.
- The material through which a wave travels is called a **medium**.

➤ The three main types of mechanical waves are transverse waves, longitudinal waves, and surface waves.

- A **transverse wave** causes the medium to vibrate at right angles to the direction in which the wave travels.
- The highest point above the rest position is the **crest** of a transverse wave.
- The lowest point below the rest position is the **trough**.
- A **longitudinal wave** causes the medium to vibrate parallel to the direction the wave travels.
- In a longitudinal wave, an area where the particles in a medium are spaced close together is called a **compression**.
- An area where the particles in a medium are spread out is called a **rarefaction**.
- A **surface wave** is a wave that travels along a surface separating two media.
- In a surface wave, particles of the medium move up and down, and back and forth. When these two motions are combined, the particles move in circles.

17.2 Properties of Mechanical Waves

➤ A wave's frequency equals the frequency of the vibrating source producing the wave.

- Any motion that repeats at regular time intervals is called **periodic motion**.
- The time required for one cycle, a complete motion that returns to its starting point, is called the **period**.
- Any periodic motion has a **frequency**, which is the number of complete cycles in a given time.
- Frequency is measured in cycles per second, or **hertz (Hz)**.

➤ Increasing the frequency of a wave decreases its wavelength.

- **Wavelength** is the distance between a point on one wave and the same point on the next cycle of the wave.

- The wavelength of a transverse wave is the distance from one crest or trough to the next. The wavelength of a longitudinal wave is the distance from one compression or rarefaction to the next.
- **If you assume that waves are traveling at a constant speed, then wavelength is inversely proportional to frequency.**
- **The more energy a wave has, the greater is its amplitude.**
 - The **amplitude** of a wave is the maximum displacement of the medium from its rest position.

17.3 Behavior of Waves

- **Reflection does not change the speed or frequency of a wave, but the wave can be flipped upside down.**
 - **Reflection** occurs when a wave bounces off a surface that it cannot pass through.
- **When a wave enters a medium at an angle, refraction occurs because one side of the wave moves more slowly than the other side.**
 - **Refraction** is the bending of a wave as it enters a new medium at an angle.
- **A wave diffracts more if its wavelength is large compared to the size of an opening or obstacle.**
 - **Diffraction** is the bending of a wave as it moves around an obstacle or passes through a narrow opening.
- **Two types of interference are constructive interference and destructive interference.**
 - **Interference** occurs when two or more waves overlap and combine together.
 - **Constructive interference** occurs when two or more waves combine to produce a wave with a larger displacement.
 - **Destructive interference** occurs when two or more waves combine to produce a wave with a smaller displacement.
- **A standing wave forms only if half a wavelength or a multiple of half a wavelength fits exactly into the length of a vibrating cord.**
 - A **standing wave** is a wave that appears to stay in one place—it does not seem to move through the medium.
 - A **node** is a point on a standing wave that has no displacement from the rest position.
 - An **antinode** is a point where a crest or trough occurs midway between two nodes.

17.4 Sound and Hearing

➡ Many behaviors of sound can be explained using a few properties—speed, intensity and loudness, and frequency and pitch.

- **Sound waves** are longitudinal waves—compressions and rarefactions that travel through a medium.
- Sound is carried by longitudinal waves.
- Speed is how fast sound travels. Sound waves travel fastest in solids, slower in liquids, and slowest in gases.
- **Intensity** is the rate at which a wave's energy flows through a given area. It depends on the wave's amplitude and the distance from the sound source.
- Sound intensity levels are measured in decibels. The **decibel** (dB) is a unit that compares the intensity of different sounds.
- **Loudness** is a physical response to the intensity of sound, modified by physical factors.
- The frequency of a sound wave depends on how fast the source of the sound is vibrating.
- **Pitch** is how high or low a sound seems to a listener.

➡ **Ultrasound is used in a variety of applications including sonar and ultrasound imaging.**

- **Sonar** is a technique for determining the distance to an object under water.
- The **Doppler effect** is a change in sound frequency caused by motion of the sound source, motion of the listener, or both.

➡ **As a source of sound approaches, an observer hears a higher frequency. When the sound source moves away, the observer hears a lower frequency.**

➡ **The outer ear gathers and focuses sound into the middle ear, which receives and amplifies the vibrations. The inner ear uses nerve endings to sense vibrations and send signals to the brain.**

- The ear is the organ that responds to sound.
- The ear has three main regions: the outer ear, the middle ear, and the inner ear.

➡ **Sound is recorded by converting sound waves into electronic signals that can be processed and stored. Sound is reproduced by converting electronic signals back into sound waves.**

➡ **Most musical instruments vary pitch by changing the frequency of standing waves.**

- Musical instruments often use resonance to amplify sound.
- **Resonance** is the response of a standing wave to another wave of the same frequency. Resonance can dramatically amplify sound.