CHAPTER 12 Highlights

KEY IDEAS

Section 1 Sound Waves

- The frequency of a sound wave determines its pitch.
- The speed of sound depends on the medium.
- The relative motion between the source of waves and an observer creates an apparent frequency shift known as the Doppler effect.

Section 2 Sound Intensity and Resonance

- The sound intensity of a spherical wave is the power per area.
- Sound intensity is inversely proportional to the square of the distance from the source because the same energy is spread over a larger area.
- Intensity and frequency determine which sounds are audible.
- Decibel level is a measure of relative intensity on a logarithmic scale.
- A given difference in decibels corresponds to a fixed difference in perceived loudness.
- A forced vibration at the natural frequency produces resonance.
- The human ear transmits vibrations that cause nerve impulses. The brain interprets these impulses as sounds of varying frequencies.

Section 3 Harmonics

- Harmonics are integral multiples of the fundamental frequency.
- A vibrating string or a pipe open at both ends produces all harmonics.
- A pipe closed at one end produces only odd harmonics.
- The number and intensity of harmonics account for the sound quality of an instrument, also known as timbre.

Variable Symbols

Quantities		Units	
	sound intensity	W/m^2	watts/meters squared
	decibel level	dB	decibels
f_n	frequency of the nth harmonic	Hz	Hertz = s^{-1}
L	length of a vibrating string or an air column	m	meters

KEY TERMS

compression (p. 408)

rarefaction (p. 408)

pitch (p. 409)

Doppler effect (p. 412)

intensity (p. 414)

decibel (p. 417)

resonance (p. 419)

fundamental frequency (p. 422)

harmonic series (p. 423)

timbre (p. 428)

beat (p. 430)

PROBLEM SOLVING

See **Appendix D: Equations** for a summary of the equations introduced in this chapter. If you need more problem-solving practice, see **Appendix I: Additional Problems.**