Section Summary

14.1 Speed of Sound, Frequency, and Wavelength

- Sound is one type of wave.
- Sound is a disturbance of matter that is transmitted from its source outward in the form of longitudinal waves.
- The relationship of the speed of sound v, its frequency f, and its wavelength λ is given by $v = f\lambda$, which is the same relationship given for all waves.
- The speed of sound depends upon the medium through which the sound wave is travelling.
- In a given medium at a specific temperature (or density), the speed of sound v is the same for all frequencies and wavelengths.

14.2 Sound Intensity and Sound Level

- The intensity of a sound is proportional to its amplitude squared.
- The energy of a sound wave is also proportional to its amplitude squared.
- Sound intensity level in decibels (dB) is more relevant for how humans perceive sounds than sound intensity (in $\mathrm{W/m^2}$), even though sound intensity is the SI unit.
- Sound intensity level is not the same as sound intensity—it tells you the *level* of the sound relative to a reference intensity rather than the actual intensity.
- Hearing is the perception of sound and involves that transformation of sound waves into vibrations of parts within the ear. These vibrations are then transformed into neural signals that are interpreted by the brain.
- People create sounds by pushing air up through their lungs and through elastic folds in the throat called vocal cords.

14.3 Doppler Effect and Sonic Booms

- The Doppler effect is a shift in the observed frequency of a sound due to motion of either the source or the observer.
- The observed frequency is greater than the actual source's frequency when the source and the observer are moving closer together, either by the source moving toward the observer or the observer moving toward the source.
- A sonic boom is constructive interference of sound created by an object moving faster than sound.

14.4 Sound Interference and Resonance

- A system's natural frequency is the frequency at which the system will oscillate if not affected by driving or damping forces.
- A periodic force driving a harmonic oscillator at its natural frequency produces resonance. The system is said to resonate.
- Beats occur when waves of slightly different frequencies are superimposed.

- In air columns, the lowest-frequency resonance is called the fundamental, whereas all higher resonant frequencies are called overtones. Collectively, they are called harmonics.
- The resonant frequencies of a tube closed at one end are $f_n = n\frac{v}{4L},\ n = 1, 3, 5...$, where f_1 is the fundamental and L is the length of the tube.
- The resonant frequencies of a tube open at both ends are $f_n = n\frac{v}{2L},\ n = 1, 2, 3...$