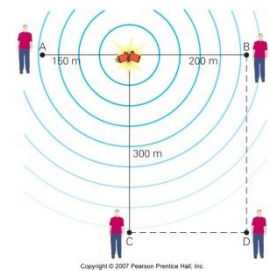## 14.2 The Speed of Sound

1. **MC** A sound wave with a frequency of 15 Hz is in what region of the sound spectrum: (a) audible, (b) infrasonic, (c) ultrasonic, or (d) supersonic? (b)
2. **MC** A sound wave in air (a) is longitudinal, (b) is transverse, (c) has longitudinal and transverse components, (d) travels faster than a sound wave through a liquid. (a)
3. **MC** The speed of sound is generally greatest in (a) solids, (b) liquids, (c) gases, (d) a vacuum. (a)
4. **MC** The speed of sound in air (a) is about 1/3 km/s, (b) is about $1/5\,\text{mi/s}$, (c) depends on temperature, (d) all of the preceding. (d)
5. **CQ** Suggest a possible explanation of why some flying insects produce buzzing sounds and some do not. sounds not all in our audible range
6. **CQ** Explain why sound travels faster in warmer than in colder air. warmer air molecules vibrate faster
7. **CQ** Two sounds that differ in frequency are emitted from a single loudspeaker. Which sound will reach your ear first, the one with the lower or the higher frequency? same time
8. **CQ** The speed of sound in air depends on temperature. What effect, if any, should humidity have? speed increases with increasing humidity
9. ● The thunder from a lightning flash is heard by an observer 3.0 s after she sees the flash. What is the approximate distance to the lightning strike in (a) kilometers and (b) miles? (a) 1.0 km (b) 0.60 mi
10. ● What is the speed of sound in air at (a) 10°C and (b) 20°C? (a) 337 m/s (b) 343 m/s
16. ●● Particles approximately 3.0×10^{-2} cm in diameter are to be scrubbed loose from machine parts in an aqueous ultrasonic cleaning bath. Above what frequency should the bath be operated to produce wavelengths of this size and smaller? 5.0×10^{6} Hz
17. ●● Medical ultrasound uses a frequency of around 20 MHz to diagnose human conditions and ailments. (a) If the speed of sound in tissue is $1500\,\text{m/s}$, what is the smallest detectable object? (b) If the penetration depth is about 200 wavelengths, how deep can this instrument penetrate? (a) 7.5×10^{-5} m (b) 1.5×10^{-2} m
21. ●● A freshwater dolphin sends ultrasonic sound to locate a prey. If the echo off the prey is received by the dolphin 0.12 s after being sent, how far is the prey from the dolphin? 90 m

14.3 Sound Intensity and Sound Intensity Level

28. **MC** If the air temperature increases, would the sound intensity from a constant-output point source (a) increase, (b) decrease, or (c) remain unchanged? (c)
29. **MC** The decibel scale is referenced to a standard intensity of (a) $1.0\,\text{W/m}^2$, (b) $10^{-12}\,\text{W/m}^2$, (c) normal conversation, (d) the threshold of pain. (b)
30. **MC** If the intensity level of a sound at 20 dB is increased to 40 dB, the intensity would increase by a factor of (a) 10, (b) 20, (c) 40, (d) 100. (d)
32. **CQ** The Richter scale, used to measure the intensity level of earthquakes, is a logarithmic scale, as is the decibel scale. Why are such scales used? to compress a large physical range into a smaller numerical scale
33. **CQ** Can there be negative decibel levels, such as $-10\,\text{dB}$? If so, what would these mean? yes, an intensity below the intensity of threshold of hearing
47. ●● In a neighborhood challenge to see who can climb a tree the fastest, you are ready to climb. Your friends have surrounded you in a circle as a cheering section; each individual alone would cause a sound intensity level of 80 dB at your location. If the actual sound level at your location is 87 dB, how many people are rooting for you? five
51. ●● At a Fourth of July celebration, a firecracker explodes (Fig. 14.19>). Considering the firecracker to be a point source, what are the intensities heard by observers at points B, C, and D, relative to that heard by the observer at A? $I_B = 0.563I_A$, $I_C = 0.250I_A$, $I_D = 0.173I_A$

14.4 Sound Phenomena *and* 14.5 The Doppler Effect

56. **MC** Constructive and destructive interference of sound waves depends on (a) the speed of sound, (b) diffraction, (c) phase difference, (d) all of the preceding. (c)
57. **MC** Beats are the direct result of (a) interference, (b) refraction, (c) diffraction, (d) the Doppler effect. (a)
58. **MC** Police radar makes use of (a) refraction, (b) the Doppler effect, (c) interference, (d) sonic boom. (b)
63. ● Two adjacent point sources, A and B, are directly in front of an observer and emit identical 1000-Hz tones.

To what closest distance behind source B would source A have to be moved for the observer to hear no sound? (Assume that the air temperature is 20°C and ignore the falling off of intensity with distance.) 0.172 m

64. ● A violinist and a pianist simultaneously sound notes with frequencies of 436 Hz and 440 Hz, respectively. What beat frequency will the musicians hear? 4 Hz

68. ●● While standing near a railroad crossing, you hear a train horn. The frequency emitted by the horn is 400 Hz. If the train is traveling at 90.0 km/h and the air temperature is 25°C, what is the frequency you hear (a) when the train is approaching and (b) after it has passed? (a) 431 Hz (b) 373 Hz

79. ●●● Bats emit sounds of frequencies around 35.0 kHz and use echolocation to find their prey. If a bat is moving with a speed of 12.0 m/s toward a hovering, stationary insect, (a) what is the frequency received by the insect if the air temperature is 20°C? (b) What frequency of the reflected sound heard by the bat? (c) If the insect were initially moving directly away from the bat, would this affect the frequencies? Explain. (a) 36.3 kHz (b) 37.6 kHz (c) yes

14.6 Musical Instruments and Sound Characteristics

81. MC Given open and closed pipes of the same length, which would have the lowest natural frequency: (a) the open pipe, (b) the closed pipe, or (c) both have the same low frequency? (b)

82. MC The human ear can hear tones best at (a) 1000 Hz, (b) 4000 Hz, (c) 6000 Hz, (d) all frequencies. (b)

83. MC Equal loudness curves vary with sound (a) quality, (b) harmonics, (c) waveform, (d) pitch. (d)

84. MC The quality of sound depends on its (a) waveform, (b) frequency, (c) speed, (d) intensity. (a)

85. CQ (a) After a snowfall, why does it seem particularly quiet? (b) Why do empty rooms sound hollow? (c) Why do people's voices sound fuller or richer when they sing in the shower? see ISM

96. ●● An organ pipe that is closed at one end is 1.10 m long. It is oriented vertically and filled with carbon dioxide gas (which is denser than air and thus will stay in the pipe). A tuning fork with a frequency of 60.0 Hz can be used to set up a standing wave in the fundamental mode. What is the speed of sound in carbon dioxide? 264 m/s