KEY EQUATIONS

14.1 Speed of Sound, Frequency, and Wavelength

speed of sound $v = f\lambda$

14.4 Sound Interference and Resonance

beat frequency $f_B = |f_1 - f_2|$

resonant frequencies of a closed-pipe resonator $f_n = n\frac{v}{4L},\ n = 1, 3, 5...$

resonant frequencies of an open-pipe resonator $f_n = n\frac{v}{2L},\ n = 1, 2, 3...$

CHAPTER REVIEW

Concept Items

14.1 Speed of Sound, Frequency, and Wavelength

1. What is the amplitude of a sound wave perceived by the human ear?

a. loudness
b. pitch
c. intensity
d. timbre

2. The compressibility of air and hydrogen is almost the same. Which factor is the reason that sound travels faster in hydrogen than in air?

a. Hydrogen is more dense than air.
b. Hydrogen is less dense than air.
c. Hydrogen atoms are heavier than air molecules.
d. Hydrogen atoms are lighter than air molecules.

14.3 Doppler Effect and Sonic Booms

6. Two sources of sound producing the same frequency are moving towards you at different speeds. Which one would sound more high-pitched?

a. the one moving slower
b. the one moving faster

7. When the speed of the source matches the speed of sound, what happens to the amplitude of the sound wave? Why?

a. It approaches zero. This is because all wave crests are superimposed on one another through constructive interference.
b. It approaches infinity. This is because all wave crests are superimposed on one another through constructive interference.
c. It approaches zero, because all wave crests are superimposed on one another through destructive interference.
d. It approaches infinity, because all wave crests are superimposed on one another through destructive interference

12. What is the natural frequency of a system?

a. The natural frequency is the frequency at which a system oscillates when it undergoes forced vibration.
b. The natural frequency is the frequency at which a system oscillates when it undergoes damped oscillation.
c. The natural frequency is the frequency at which a system oscillates when it undergoes free vibration without a driving force or damping.
d. The natural frequency is the frequency at which a system oscillates when it undergoes forced vibration with damping.

Critical Thinking Items

14.1 Speed of Sound, Frequency, and Wavelength

14. A scientist notices that a sound travels faster through a solid material than through the air. Which of the following can explain this?

a. Solid materials are denser than air.
b. Solid materials are less dense than air.
c. A solid is more rigid than air.
d. A solid is easier to compress than air.

14.2 Sound Intensity and Sound Level

15. Which property of the wave is related to its intensity? How?

a. The frequency of the wave is related to the intensity of the sound. The larger-frequency oscillations indicate greater pressure maxima and minima, and the pressure is higher in greater-intensity sound.
b. The wavelength of the wave is related to the intensity of the sound. The longer-wavelength oscillations indicate greater pressure maxima and minima, and the pressure is higher in greater-intensity sound.
c. The amplitude of the wave is related to the intensity of the sound. The larger-amplitude oscillations indicate greater pressure maxima and minima, and the pressure is higher in greater-intensity sound.
d. The speed of the wave is related to the intensity of the sound. The higher-speed oscillations indicate greater pressure maxima and minima, and the pressure is higher in greater-intensity sound.

14.3 Doppler Effect and Sonic Booms

19. When the source of sound is moving through the air, does the speed of sound change with respect to a stationary person standing nearby?

a. Yes
b. No

14.4 Sound Interference and Resonance

22. When does the amplitude of an oscillating system become maximum?

a. When two sound waves interfere destructively.
b. When the driving force produces a transverse wave in the system.
c. When the driving force of the oscillator to the oscillating system is at a maximum amplitude.
d. When the frequency of the oscillator equals the natural frequency of the oscillating system.

23. How can a standing wave be formed with the help of a tuning fork and a closed-end tube of appropriate length?

a. If the tube is just the right length, the reflected sound arrives back at the tuning fork exactly half a cycle later, and it interferes constructively with the continuing sound produced by the tuning fork.
b. If the tube is just the right length, the reflected sound arrives back at the tuning fork exactly half a cycle later, and it interferes destructively with the continuing sound produced by the tuning fork.
c. If the tube is just the right length, the reflected sound arrives back at the tuning fork exactly one full cycle later, and it interferes constructively with the continuing sound produced by the tuning fork.
d. If the tube is just the right length, the reflected sound arrives back at the tuning fork exactly one full cycle later, and it interferes destructively with the continuing sound produced by the tuning fork.

24. A tube open at both ends has a fundamental frequency of 500 Hz. What will the frequency be if one end is closed?

a. 1000 Hz
b. 500 Hz
c. 125 Hz
d. 250 Hz

Problems

14.1 Speed of Sound, Frequency, and Wavelength

25. A bat produces a sound at 17, 250 Hz and wavelength 0.019 m. What is the speed of the sound?

a. 1.7×10^{6} m/s
b. 8.6×10^{5} m/s
c. 1.15×10^{-6} m/s
d. 3.28×10^{2} m/s

14.4 Sound Interference and Resonance

31. What is the length of an open-pipe resonator with a fundamental frequency of 400.0 Hz? (Assume the speed of sound is 331 m/s.)

a. 165.1 cm
b. 82.22 cm
c. 20.25 cm
d. 41.38 cm

32. An open-pipe resonator has a fundamental frequency of 250 Hz. By how much would its length have to be changed to get a fundamental frequency of 300.0 Hz? (Assume the speed of sound is 331 m/s.)

a. 77.32 cm
b. 44.09 cm
c. 32.16 cm
d. 11.03 cm

TEST PREP

Multiple Choice

14.1 Speed of Sound, Frequency, and Wavelength

36. A tuning fork oscillates at a frequency of $512\ \text{Hz}$, creating sound waves. How many waves will reach the eardrum of a person near that fork in 2 seconds?

a. 512
b. 128
c. 256
d. 1024

14.2 Sound Intensity and Sound Level

39. Which of the following terms is a useful quantity to describe the loudness of a sound?

a. intensity
b. frequency
c. pitch
d. wavelength

40. What is the unit of sound intensity level?

a. decibels
b. hertz
c. watts

14.3 Doppler Effect and Sonic Booms

44. In which of the following situations is the Doppler effect absent?

a. "he source and the observer are moving towards each other.
b. "he observer is moving toward the source.
c. "he source is moving away from the observer.
d. Neither the source nor the observer is moving relative to one another.

47. How will your perceived frequency change if the source is moving towards you?

a. The frequency will become lower.
b. The frequency will become higher.

14.4 Sound Interference and Resonance

50. What is the fundamental frequency of an open-pipe resonator?

a. $3\ v/2\ L$
b. $2\ v/L$
c. v/L
d. $v/2\ L$

51. What is the beat frequency produced by the superposition of two waves with frequencies $300\ \text{Hz}$ and $340\ \text{Hz}$?

a. $640\ \text{Hz}$
b. $320\ \text{Hz}$
c. $20\ \text{Hz}$
d. $40\ \text{Hz}$

Short Answer

14.1 Speed of Sound, Frequency, and Wavelength

53. What is the frequency of a sound wave as perceived by the human ear?

a. timbre
b. loudness
c. intensity
d. pitch

14.3 Doppler Effect and Sonic Booms

66. How will your perceived frequency change if you move away from a stationary source of sound?

a. The frequency will become lower.
b. The frequency will be doubled.
c. The frequency will be tripled.
d. The frequency will become higher.

67. True or false—The Doppler effect also occurs with waves other than sound waves.

a. False
b. True

68. A source of sound is moving towards you. How will what you hear change if the speed of the source increases?

a. The sound will become more high-pitched.
b. The sound will become more low-pitched.
c. The pitch of the sound will not change.

14.4 Sound Interference and Resonance

72. What is the actual frequency of the wave produced as a result of superposition of two waves?

a. It is the average of the frequencies of the two original waves that were superimposed.
b. It is the difference between the frequencies of the two original waves that were superimposed.
c. It is the product of the frequencies of the two original waves that were superimposed.
d. It is the sum of the frequencies of the two original waves that were superimposed.

75. What is the possible number of nodes and antinodes along one full wavelength of a standing wave?

a. 2 nodes and 3 antinodes or 2 antinodes and 3 nodes.
b. 2 nodes and 2 antinodes or 3 antinodes and 3 nodes.
c. 3 nodes and 3 antinodes or 2 antinodes and 2 nodes.
d. 6 nodes and 4 antinodes or 6 antinodes and 4 nodes.

76. In a pipe resonator, which frequency will be the least intense of those given below?
   a. second overtone frequency
   b. first overtone frequency
   c. fundamental frequency
   d. third overtone frequency

77. A flute is an open-pipe resonator. If a flute is 60 cm long, what is the longest wavelength it can produce?
   a. 240 cm
   b. 180 cm
   c. 60 cm
   d. 120 cm

78. What is the frequency of the second overtone of a closed-pipe resonator with a length of 22.0 cm? (Assume the speed of sound is 331 m/s.)
   a. 7520 Hz
   b. 1510 Hz
   c. 376 Hz
   d. 1880 Hz

79. An open-pipe resonator has a fundamental frequency of 220 Hz when the speed of sound is 331 m/s. What will its fundamental frequency be when the speed of sound is 350 m/s?
   a. 690 Hz
   b. 470 Hz
   c. 110 Hz
   d. 230 Hz

Extended Response

14.1 Speed of Sound, Frequency, and Wavelength

82. Is the speed of sound dependent on its frequency?
   a. No
   b. Yes

14.3 Doppler Effect and Sonic Booms

87. True or false—The Doppler effect occurs only when the sound source is moving.
   a. False
   b. True

89. You are driving alongside a train. You hear its horn at a pitch that is lower than the actual frequency. What should you do to match the speed of the train? Why?
   a. In order to match the speed of the train, one would need to increase or decrease the speed of his/her car because a lower pitch means that either the train (the source) is moving away or that you (the observer) are moving away.
   b. In order to match the speed of the train, one would need to drive at a constant speed because a lower pitch means that the train and the car are at the same speed.

14.4 Sound Interference and Resonance

92. True or false—An open-pipe resonator has more overtones than a closed-pipe resonator.
   a. False
   b. True

93. A flute has finger holes for changing the length of the resonating air column, and therefore, the frequency of the note played. How far apart are two holes that, when closed, play two frequencies that are apart, if the first hole is away from the mouthpiece of the flute?
   a.
   b.
   c.
   d.