16 & 17 WAVES & SOUND

PROBLEMS

1. What is the speed of sound in air at (a) 27.0°C, (b) 100°C, (c) 200°C?

2. What is the intensity level in decibels of a sound wave of intensity (a) 10^{-6} W/m^2 and (b) 10^{-5} W/m^2?

3. What is the intensity of a sound whose intensity level is (a) 40 dB and (b) 100 dB?

4. The dB level at a distance of 2.0 m from a sound source is 100 dB. What is the dB level at distances of (a) 4.0 m, (b) 6.0 m, (c) 8.0 m?

5. A rock group is playing in a room. Sound emerging from the door spreads uniformly in all directions. If the intensity level of the music is 80.0 dB at a distance of 5.00 m from the door, at what distance is the music just barely audible to a person with a normal threshold of hearing? Disregard absorption.

7. The sound level 3.0 m from a point source is 120 dB. At what distance will the sound level be 100 dB?

8. A string 50.0 cm long has a mass per unit length equal to 20.0×10^{-5} kg/m. To what tension should this string be stretched if its fundamental frequency is to be (a) 20.0 Hz and (b) 4500 Hz?

9. A stretched string is 160 cm long and has a linear density of 0.0150 g/cm. What tension in the string will result in a wave with two "bumps" and a frequency of 460 Hz?

11. A closed organ pipe is 3.00 m long. At what frequencies between 20.0 Hz and 20,000 Hz will this pipe resonate? (hint: don't try to calculate all 350+ frequencies, find the first few and then try to find a general formula for the others)

12. The range of a certain pipe organ is from 8.00 Hz to 30,000 Hz. What range of pipe lengths is necessary if they are (a) opens at both ends and (b) closed at one end? (Assume that the speed of sound is 343 m/s and that the pipes all resonate at their fundamental frequency)

13. A piano tuner strikes a 440-Hz tuning fork at the instant she strikes a piano key that should emit a tone of 440 Hz and hears a beat frequency of 2 Hz. What are the possible frequencies the piano key could be emitting?

14. What is the lowest frequency of the standing wave of sound that can be set up between two walls that are 8.00 m apart if the temperature is 22.0°C?

15. A standing wave is established in a string that is 240 cm long and fixed at both ends. The string vibrates in four segments when driven at 120 Hz. (a) Determine the wavelength. (b) What is the fundamental frequency?

16. A stretched string of length L is observed to vibrate in five equal segments when driven by a 630-Hz oscillator. What oscillator frequency will set up a standing wave so that the string vibrates in three segments?

17. A train moving at 70 m/s sounds a whistle with a frequency of 256 Hz. What is the frequency heard by: a) a stationary person directly in front of the train? b) a stationary person directly behind of the train? c) a person on another train moving at 70 m/s in front of and moving toward the other train ? d) the person on the other train after the two trains pass each other ?

Equations: $f_{beat} = | f_1 - f_2 |$ $\quad v = f\lambda$ $\quad I_o = 1 \times 10^{-12}$ w/m^2

$$v = (331 \text{ m/s})\sqrt{1 + \frac{T_C}{273}}$$

$$\beta = 10 \log\left(\frac{I}{I_o}\right)$$

intensity

Decibel sound level

power

Speed of wave on a string

Tension

$$I = \frac{P}{A} = \frac{P}{4\pi r^2} \qquad v = \sqrt{\frac{F}{m/L}}$$

Distance from sound source

Mass per length

Perceived frequency

Original frequency

Observer velocity

$$f_s = f_o\left(\frac{v \pm v_o}{v \mp v_s}\right)$$

Wave velocity

Source velocity

CHAPTER 14 Answers

1. (a) v = 347 m/s (b) v = 387 m/s (c) v = 436 m/s
2. (a) β = 60 dB

   (b) β = 70 dB
3. (a) $I = 10^{-8}$ W/m^2.

   (b) $I = 10^{-2}$ W/m^2.
4. (a) β = 94 dB (b) β = 90.5 dB (c) β = 88 dB
5. $R = 5.00 \times 10^4$ m.
6. (a) v_s = 537 m/s (b) v_s = 690 m/s
7. r = 30 m
8. (a) $F = 8.00 \times 10^{-2}$ N (b) $F = 4.05 \times 10^3$ N
9. F = 813 N
10. f = 3450 Hz
11. f_1 = 28.8 Hz f_n =(28.8 Hz)n where n = any odd integer between 1 and 694.
12. (a) longest L = 21.4 m shortest $L = 5.72 \times 10^{-3}$ m (b) longest L = 10.7 m shortest $L = 2.86 \times 10^{-3}$ m
13. 442 Hz and 438 Hz.
14. f = 21.5 Hz
15. (a) λ = 120 cm

    (b) f = 30 Hz
16. f' = 378 Hz
17. a) f = 321 hz b) f = 213 hz c) f = 387 hz d) f = 169 hz