KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS
DEPARTMENT OF PHYSICS
PHYSICS 102 TERM 002

HOME WORK SOLUTION
CHAPTER 18

Q.18-9P A man strikes a long aluminum rod at one end. Another man, at the other end with his ear close to the rod, hears the sound of the blow twice (once through air and once through the rod, with a 0.120 s interval between. How long is the rod?

18-9P It is known that for sound

$v_{al} > v_{air}$

because $L = vt \Rightarrow t_{air} > t_{al}$

$v_{air} = 343 \frac{m}{s}$, $v_{al} = 6420 \frac{m}{s}$ (see table 18.1)

$\Delta t = 0.12 = t_{air} - t_{al} = \frac{l}{343} - \frac{l}{6420}$

$= l\,(2.76 \times 10^{-3} \frac{s}{m})$

$\Rightarrow l = \underline{\underline{43.5\ m}}$

Q.18-19P Two sound waves, from two different sources with the same frequency, 540 Hz, travel at a speed of 330 m/s. The sources are in phase. What is the phase difference of the waves at a point that is 4.40 m from one source and 4.00 m from the other? The waves are traveling in the same direction.

18-19P given that $\left.\begin{array}{l} f_1 = f_2 = 540\ HZ \\ v_1 = v_2 = 330\ \frac{m}{s} \end{array}\right\} \lambda = \frac{v}{f} = \frac{330}{540} = 0.61 \frac{m}{s}$

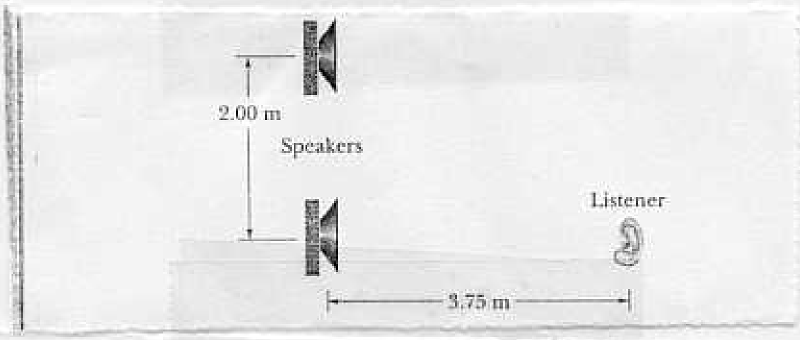
$l_1 = 4.40\ m, \quad l_2 = 4.00\ m$

Eqn (18-21)

$$\Delta\phi = \frac{\Delta l}{\lambda}(2\pi) \quad , \text{where } \Delta l = l_1 - l_2 = 0.40\ m$$

$$\therefore \Delta\phi = \frac{0.40}{0.61} = \underline{\underline{4.11\ rad}} = 235.6^\circ$$

Q.18-21P In the figure, two loudspeakers, separated by a distance of 2.00 m, are in phase. Assume the amplitudes of the sound from the speakers are approximately the same at the position of a listener, who is 3.75 m directly in front of one of the speakers. (a) For what frequencies in the audible range (20-20000 Hz) does the listener hear a minimum signal? (b) For what frequencies the signal is a maximum?



18-21P

$\Delta L =$

fully destructive

$(m+\frac{1}{2})\lambda$, $m = 0, 1, 2, ..$ 18-25

or $m\frac{\lambda}{2}$, $m = 1, 3, 5, ..$

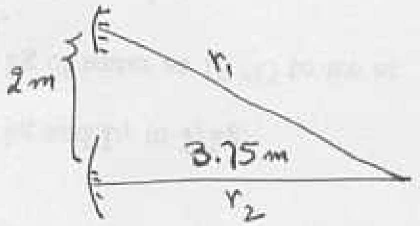
full Constructive

18-24 ← $m\lambda$, $m = 0, 1, 2, ..$

$m\frac{\lambda}{2}$, $m = 0, 2, 4$

(a) for destructive Interference

$$\Delta L = (m + \tfrac{1}{2}\lambda) = (m + \tfrac{1}{2})\frac{v}{f}$$



$$m = \frac{f\Delta L}{v} - \frac{1}{2}$$

$$m_{max} = \frac{20000 \times 0.5}{334} - \frac{1}{2}$$

$$= 28.65 \Rightarrow m_{max} = 28$$

$$\Delta L = r_1 - r_2 = \sqrt{2^2 + (3.75)^2} - 3.75 = 0.5\,m$$

(b) for Constructive (maximum) Interference.

$$\Delta L = m\lambda = m\frac{v}{f} \Rightarrow m = \frac{f\Delta L}{v} = \frac{20000 \times 0.5}{334}$$

$$= 29.15$$

$$\therefore m_{max} = 29.15$$

Q.18-39P Find the ratios of (a) the intensities, (b) the pressure amplitudes, and (c) the particle displacement amplitudes for two sounds whose sound levels differ by 37 dB.

18-39P Eq. 18-29 i

$$\beta_i = 10 \log\left(\frac{I_i}{I_0}\right), \quad I_0 = 10^{-12} \frac{W}{m^2}$$

given that $\beta_2 - \beta_1 = 37\ dB$

But

$$\beta_2 - \beta_1 = 10 \log\left(\frac{I_2}{I_0}\right) - 10 \log\left(\frac{I_1}{I_0}\right) = 10 \log\left(\frac{I_2}{I_1}\right)$$

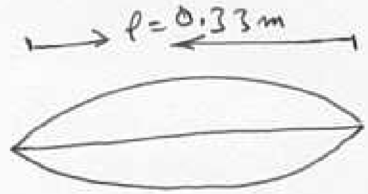
(a) $$\therefore \frac{I_2}{I_1} = 10^{\frac{\beta_2 - \beta_1}{10}} = 10^{3.7} = \underline{\underline{5011.87}} = 5.0 \times 10^3$$

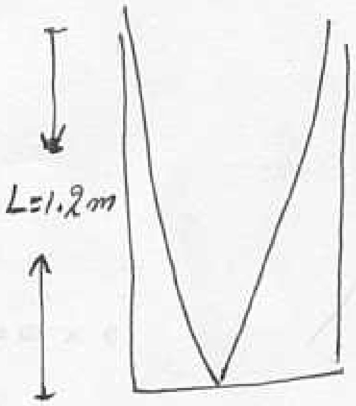
(b) from 18-15 $\Delta P \propto S_m \propto \sqrt{I}$ using Eq. 18-27

$$\therefore \frac{\Delta P_1}{\Delta P_2} = \sqrt{\frac{I_1}{I_2}} = 70.79$$

(c) $I \propto S_m^2 \Rightarrow \frac{S_{2m}}{S_{1m}} = \sqrt{\frac{I_2}{I_1}} = \underline{\underline{70.79}}$

Q.18-58P A tube 1.20 m long is closed at one end. A stretched wire is placed near the
open end. The wire 0.330 m long and has a mass of 9.60 g. It is fixed at both ends and vibrates in its fundamental mode. By resonance, it sets the air column in the tube into oscillation at that column's fundamental frequency. Find (a) that frequency and (b) the tension in the wire.





18-58P

for the wire

$l = 0.33\,m\,,\quad m = 9.6\,g$

(a) for the tube $L = 1.2\ m$

Eq. 18.38 $\Rightarrow \frac{\lambda}{4} = L = 1.2$

$\therefore \lambda = 4 \times 1.2 = 4.8\ m$

$$f_1 = \frac{v}{\lambda} = \frac{343}{4.8} = \underline{71.5\ Hz}$$

(b) for the wire

$$f_n = \frac{n}{2l}\sqrt{\frac{\tau}{\mu}} \Rightarrow \tau = (2l f_1)^2 \mu$$

$$\tau = (2 \times 0.33 \times 71.5)^2 \times \left(\frac{9.6 \times 10^{-3}}{0.33}\right)$$

$$= \underline{64.8\ N}$$

Q.18-80P A person on a railroad car blows a trumpet 440 Hz. The car is moving towards a wall at 20.0 m/s. Calculate (a) the frequency of the sound as received at the wall and (b) the frequency of the reflected sound arriving back at the source.

18-80P $f_o = f_s \left(\dfrac{v \pm v_o}{v \mp v_s} \right)$

$\rightarrow f_1 = 440 Hz$ wall

$v_c = 20 \frac{m}{s}$

(a) wall = observer $v_o = 0$

Car = Source $v_c = 20 \frac{m}{s}$, $f_s = f_1 = 440 Hz$

$\therefore f_{wall} = 440 \left(\dfrac{343 + 0}{343 - 20} \right) \approx 467 Hz$

f_{wall}

f_{wall}

(b) wall = source $v_s = 0$

$v_c = 20 \frac{m}{s}$

Car = observer $\Rightarrow v_o = 20 \frac{m}{s}$

$f_s = f_{wall} = 467 Hz$

$f'_{car} = 467 \left(\dfrac{343 + 20}{343} \right) = 494 Hz$