Ch 17: Waves II

4- A column of soldiers, marching at 120 paces per minute, keep in step with the beat of a drummer at the head of the column. The soldiers in the rear end of the column are striding forward with the left foot when the drummer is advancing with the right foot. What is the approximate length of the column?

4) 120 pace/min $\Rightarrow$ 120 pace $\rightarrow$ 60 se.

1 pace takes 1 $\rightarrow$??

$\frac{60}{120} = 0.5$ sec.

$\Delta x = vt = 343 * 0.5 \cong \underline{171\ m}$.

•**12** The pressure in a traveling sound wave is given by the equation

$$\Delta p = (1.50\ \text{Pa}) \sin \pi[(0.900\ \text{m}^{-1})x - (315\ \text{s}^{-1})t].$$

Find the (a) pressure amplitude, (b) frequency, (c) wavelength, and (d) speed of the wave.

12 (a) $\Delta P_m = 1.5\ \text{Pa}$

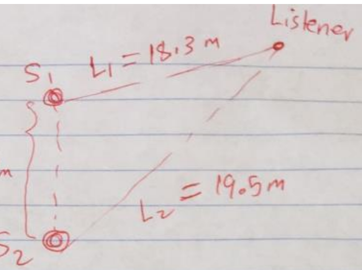
(b) $f = \frac{\omega}{2\pi} = \frac{315\pi}{2\pi} \cong 158\ \text{Hz}$

(c) $\lambda = \frac{2\pi}{k} = \frac{2\pi}{0.9\pi} = 2.2\ \text{m}$

(d) $v = \frac{\omega}{k} = \frac{315\pi}{0.9\pi} = 350\ \text{m/}$

••**17** Two loud speakers are located 3.35 m apart on an outdoor stage. A listener is 18.3 m from one and 19.5 m from the other. During the sound check, a signal generator drives the two speakers in phase with the same amplitude and frequency. The transmitted frequency is swept through the audible range (20 Hz to 20 kHz). (a) What is the lowest frequency $f_{min,1}$ that gives minimum signal (destructive interference) at the listener's location? By what number must $f_{min,1}$ be multiplied to get (b) the second lowest frequency $f_{min,2}$ that gives minimum signal and (c) the third lowest frequency $f_{min,3}$ that gives minimum signal? (d) What is the lowest frequency $f_{max,1}$ that gives maximum signal (constructive interference) at the listener's location? By what number must $f_{max,1}$ be multiplied to get (e) the second lowest frequency $f_{max,2}$ that gives maximum signal and (f) the third lowest frequency $f_{max,3}$ that gives maximum signal?

(17) $\Delta L = 19.5 - 18.3 = 1.2\,m$



Destructive Interference occurs if:

$\Delta L = \left(n + \frac{1}{2}\right)\lambda$, $n = 0, 1, 2, 3, \ldots$

$n = 0$:

$\Delta L = \frac{\lambda}{2} \Rightarrow \lambda = 2\Delta L = 2 * 1.2 = 2.4\,m$

$f_{n=0} = \frac{v}{\lambda} = \frac{343}{2.4} = 143\,Hz$.

$n = 1$: $\Delta L = \frac{3}{2}\lambda \Rightarrow \lambda = \frac{2}{3}\Delta L = \frac{2}{3} * 1.2 = 0.8\,m$

$f_{n=1} = \frac{v}{\lambda} = \frac{343}{0.80} = 429\,Hz$

i.e. $f_{n=1} = 3 f_{n=0}$

$n = 2$

$f_{n=2} = 517\,Hz$ i.e. $= 5 f_{n=0}$

Constructive Interference:

if $\Delta L = 0$ (Trivial), $\lambda, 2\lambda, 3\lambda, \ldots$ $[\Delta L = n\lambda,\ n = 0, 1, 2, 3, \ldots]$

$\Delta L = \lambda = 1.2\,m$

$f = \frac{v}{\lambda} = \frac{343}{1.2} = 286\,Hz$

$\Delta L = 2\lambda \Rightarrow \lambda = \frac{1.2}{2} = 0.6\,m$

$f = \frac{343}{0.6} = 572\,Hz$ $\{$i.e. $= 2 f_{n=1}\}$

•27 A certain sound source is increased in sound level by 30.0 dB. By what multiple is (a) its intensity increased and (b) its pressure amplitude increased?

(27) $\Delta\beta = 30\ dB$

$\beta_f - \beta_i = 30\ dB$

$10\log\frac{I_f}{10^{-12}} - 10\log\frac{I_i}{10^{-12}} = 30$

$10\left\{\log\frac{I_f}{I_i}\right\} = 30$

$\log\frac{I_f}{I_i} = 3$

$\frac{I_f}{I_i} = 10^3 \Rightarrow \underline{I_f = 10^3 I_i}$

(b) $I \propto (\Delta P_m)^2$

$\Rightarrow \Delta P_m \propto \sqrt{I}$

ΔP_m increases by $\sqrt{1000} \approx \underline{32\ \text{times}}$

•28 Two sounds differ in sound level by 1.00 dB. What is the ratio of the greater intensity to the smaller intensity?

(28) $\Delta\beta = 1 \text{ dB}$

$$10 \log \frac{I_2}{10^{-12}} - 10 \log \frac{I_1}{10^{-12}} = 1$$

$$10 \log \frac{I_2}{I_1} = 1$$

$$\frac{I_2}{I_1} = (10)^{0.1} = 1.26$$

$$I_2 = 1.26\, I_1$$

•39 (a) Find the speed of waves on a violin string of mass 800 mg and length 22.0 cm if the fundamental frequency is 920 Hz. (b) What is the tension in the string? For the fundamental, what is the wavelength of (c) the waves on the string and (d) the sound waves emitted by the string?

39 (a) $v = \lambda f$, $\lambda = 2L$ "fundamental frequency"

$$V = 2Lf = 2 * 22 \times 10^{-2} * 920$$

$$V = 405 \text{ m/s}$$

(b) $v = \sqrt{\frac{\tau}{\mu}} \Rightarrow \tau = V^2 \mu = V^2 \frac{M}{L}$

$$\tau = (405)^2 * \frac{800 \times 10^{-6}}{22 \times 10^{-2}} = 596 \text{ N}$$

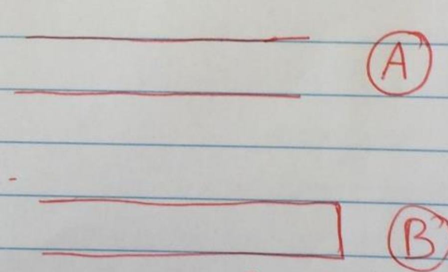
(c) $\lambda = 2L = 2 * 22 \text{ cm} = 44 \text{ cm} = 0.44 \text{ m}$

(d) $\lambda = \frac{\overset{\text{sound in air}}{V}}{f} = \frac{343}{920} = 0.373 \text{ m}$.

•40 Organ pipe *A*, with both ends open, has a fundamental frequency of 300 Hz. The third harmonic of organ pipe *B*, with one end open, has the same frequency as the second harmonic of pipe *A*. How long are (a) pipe *A* and (b) pipe *B*?

40

$f_{2A} = f_{3B}$



Pipe A: $f_{nA} = \frac{nV}{2L_A}$, $n = 1, 2, 3, \ldots$

$f_{1A} = \frac{V}{2L_A}$

Pipe B: $f_{nB} = \frac{nv}{4L_B}$, $n = 1, 3, 5, \ldots$

third harmon

$300 = \frac{343}{2L_A} \Rightarrow L_A = \frac{343}{600} = 0.572\,m$

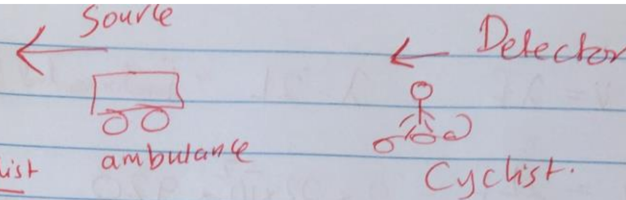
$\frac{\cancel{2}\cancel{V}}{\cancel{2}L_A} = \frac{3\cancel{V}}{4L_B} \Rightarrow 3L_A = 4L_B$

$L_B = \frac{3}{4}L_A = \frac{3}{4} * 0.572$

$\boxed{L_B = 0.43\,m}$

•56 An ambulance with a siren emitting a whine at 1600 Hz overtakes and passes a cyclist pedaling a bike at 2.44 m/s. After being passed, the cyclist hears a frequency of 1590 Hz. How fast is the ambulance moving?

(56)



$$f' = f\,\frac{V + V_{cyclist}}{V + V_{ambulance}}$$

$$1590 = 1600\,\frac{343 + 2.44}{343 + V_{amb}}$$

$$\Longrightarrow V_{amb} = 4.61\ \text{m/s}$$