KING FHAD UNIVERSITY OF PETROLEUM & MINERALS
DEPARTMENT OF PHYSICS

PHYSICS 102 (992)
SOLUTION (CHAPTER 17)

Q.1 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?

$$t_{al} = \frac{d}{v_{al}}, \quad t_{air} = \frac{d}{v_{air}} \qquad (al = \text{Aluminum})$$

Speed of sound in aluminum = 5100 m/s

Speed of sound in air = 343 m/s

$$t_{air} - t_{al} = \frac{d}{v_{air}} - \frac{d}{v_{al}} = d\left(\frac{1}{343} - \frac{1}{5100}\right) = 0.120\,s$$

$$d = \frac{0.120}{0.00271} = 44.3 \text{ m}.$$

$$\boxed{d = 44.3 \text{ m}.}$$

Q.2 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 37dB.

$$\Delta\beta = \beta_2 - \beta_1 = 10 \log \frac{I_2}{I_0} - 10 \log \frac{I_1}{I_0}$$

$$\Delta\beta = 10 \log \frac{I_2}{I_1} = 37$$

(a) $10 \log \frac{I_2}{I_1} = 37$

$$\log \frac{I_2}{I_1} = 3.7 \Rightarrow \boxed{\frac{I_2}{I_1} = 5.01 \times 10^3}$$

(b) $\Delta P_m \propto S_m$, $I \propto S_m^2$, $\Delta P_m \propto \sqrt{I}$

Ratio of pressure amplitudes $= \sqrt{\frac{I_2}{I_1}} = \sqrt{5.01 \times 10^3} = 71$

(c) Ratio of particle displacement amplitudes
= ratio of pressure amplitudes = 71

Q.3 A French submarine and a U.S submarine move head-on during maneuvers in motionless water in the North Atlantic (Figure 17.3). The French sub moves at 50.0 km/h and the U.S. sub at 70.0 km/h. The French sub sends out a signal (sound waves in water) at 1000 Hz. Sonar waves travel at 5470 km/h. (a) What is the signal's frequency as detected by the U.S. sub? (b) What frequency as detected by the French sub. In the signal reflected back to it by the U.S. sub?

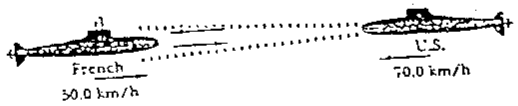


FIG. 17.3

$$v_{FR} = 50 \text{ km/h} \quad , \quad v_{USA} = 70 \text{ km/h}$$

(a) $f_{USA} = f_{FR}\left(\frac{v + v_{USA}}{v - v_{FR}}\right) = 1000\left(\frac{5470+70}{5470-50}\right)$

f_{USA} ↓ Received by USA Sub. f_{FR} ↓ Received by FRENCH Sub.

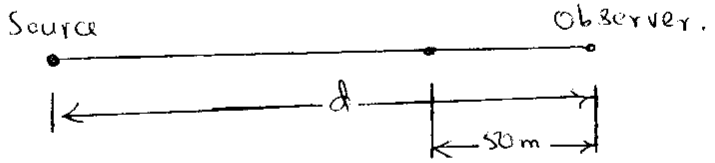
$$\boxed{f_{USA} = 1022 \text{ Hz}}$$

(b) $f_{FR} = 1022\left(\frac{5470+50}{5470-70}\right) = 1040 \text{ Hz}$

f_{FR} ↓ Received by French Sub. after reflected by U.S.A Sub.

$$\boxed{f_{FR} = 1040 \text{ Hz}}$$

Q.4 You are standing at a distance d from a source that emits sound waves equally in all directions. You walk 50.0 m toward the source and observe that the intensity of the waves has doubled. Calculate the distance d.



$$I_0 = \frac{P}{4\pi d^2} \quad , \quad 2I_0 = \frac{P}{4\pi (d-50)^2}$$

$$2\frac{P}{4\pi d^2} = \frac{P}{4\pi (d-50)^2}$$

$$2(d-50)^2 = d^2$$

$$\sqrt{2}\,(d-50) = \pm d$$

Choose +d, $(\sqrt{2}-1)d = \sqrt{2}(50) \Rightarrow d = 171$ m.

if one chooses $-d$, he will get 29.2 m. which is less than 50 m thus it is NOT acceptable.

Q.5 An ambulance with a siren emitting a whine at 1600 Hz overtakes and passes a cyclist pedaling a bike 8.00 ft/s. After being passed, the cyclist hears a frequency of 1590 Hz. How fast is the ambulance moving?

Source is ambulance, $f = 1600\ Hz$

observer is the cyclist, $v_o = 8\ ft/s$

Source is receding from the observer and the observer is approaching the source.

$$f' = f\left(\frac{v + v_o}{v + v_s}\right)$$

$v = 343\ m/s$,

$v = 1125\ ft/s$

$$(v + v_s) f' = f(v + v_o)$$

$$v_s = \frac{f}{f'}(v + v_o) - v$$

$$v_s = \frac{1600}{1590}(1125 + 8) - 1125$$

$$v_s = 15.1\ ft/s = 4.60\ m/s = 16.6\ km/h = 10.3\ mi/h$$