Recitation 3

•2 What is the bulk modulus of oxygen if 32.0 g of oxygen occupies 22.4 L and the speed of sound in the oxygen is 317 m/s?

$$B = \rho v^2 = \left(\frac{32.0 \times 10^{-3}\mathrm{kg}}{22.4 \times 10^{-3}\mathrm{m}^3}\right)(317\ \mathrm{m/s})^2 = 1.44 \times 10^5\ \mathrm{Pa}$$

•11 SSM Diagnostic ultrasound of frequency 4.50 MHz is used to examine tumors in soft tissue. (a) What is the wavelength in air of such a sound wave? (b) If the speed of sound in tissue is 1500 m/s, what is the wavelength of this wave in tissue?

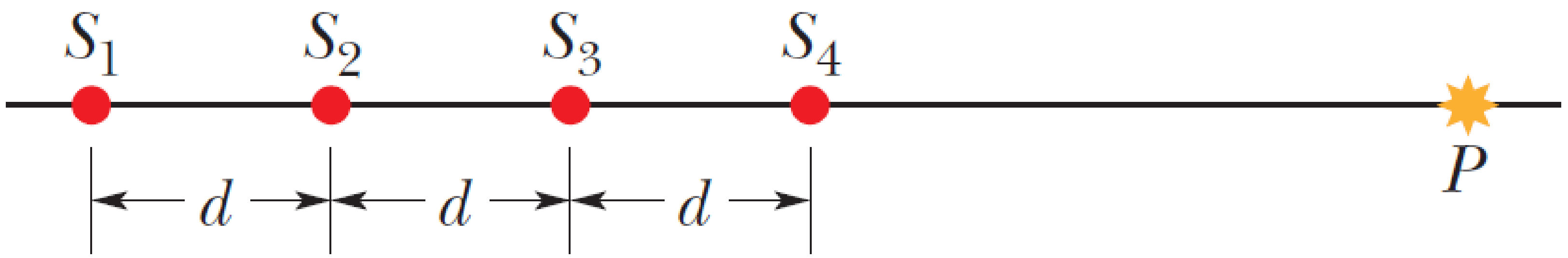
a)

$$\lambda = \frac{v}{f} = \frac{343\ \mathrm{m/s}}{4.50 \times 10^{6}\mathrm{Hz}} = 7.62 \times 10^{-5}\mathrm{m} = 76.2\ \mu\mathrm{m}.$$

b)

$$\lambda = \frac{v}{f} = \frac{1500\ \mathrm{m/s}}{4.50 \times 10^{6}\mathrm{Hz}} = 3.33 \times 10^{-4}\mathrm{m} = 333\ \mu\mathrm{m}.$$

••20 Figure 17-35 shows four isotropic point sources of sound that are uniformly spaced on an x axis. The sources emit sound at the same wavelength λ and same amplitude s_m, and they emit in phase. A point P is shown on the x axis. Assume that as the sound waves travel to P, the decrease in their amplitude is negligible. What multiple of s_m is the amplitude of the net wave at P if distance d in the figure is (a) $\lambda/4$, (b) $\lambda/2$, and (c) λ?



a) The path length difference between S_1 and S_3 is $\lambda/2$ and thus their interference at P is fully destructive. The same is true from S_2 and S_4. Therefore,

$$s'_m = 0.$$

b) The path length difference between S_1 and S_2 is $\lambda/2$ and thus their interference at P is fully destructive. The same is true from S_3 and S_4. Therefore,

$$s'_m = 0.$$

c) The four sources are exactly in phase. Thus,

$$s'_m = 4s_m.$$

•27 SSM WWW 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?

a)

$$I = I_0 10^{\frac{\beta}{10\ \mathrm{dB}}}$$

$$\frac{I_2}{I_1} = 10^{\frac{\beta_2 - \beta_1}{10\ \mathrm{dB}}} = 10^{\frac{30\ \mathrm{dB}}{10\ \mathrm{dB}}} = 1000.$$

b)

$$\frac{\Delta p_{m2}}{\Delta p_{m1}} = \frac{v\rho\omega s_{m2}}{v\rho\omega s_{m1}} = \frac{s_{m2}}{s_{m1}} = \frac{\sqrt{\frac{2I_2}{v\rho\omega^2}}}{\sqrt{\frac{2I_1}{v\rho\omega^2}}} = \sqrt{\frac{I_2}{I_1}} = \sqrt{1000} = 31.6$$

••35 A point source emits 30.0 W of sound isotropically. A small microphone intercepts the sound in an area of 0.750 cm^2, 200 m from the source. Calculate (a) the sound intensity there and (b) the power intercepted by the microphone.

a)

$$I = \frac{P_s}{4\pi r^2} = \frac{30.0\ \text{W}}{4\pi(200\ \text{m})^2} = 5.97 \times 10^{-5}\ \text{W/m}^2.$$

b)

$$P = IA = (5.97 \times 10^{-5}\ \text{W/m}^2)(0.750 \times 10^{-4}\ \text{m}^2) = 4.48 \times 10^{-9}\ \text{W}.$$

••47 A well with vertical sides and water at the bottom resonates at 7.00 Hz and at no lower frequency. (The air-filled portion of the well acts as a tube with one closed end and one open end.) The air in the well has a density of $1.10\ \text{kg/m}^3$ and a bulk modulus of 1.33×10^5 Pa. How far down in the well is the water surface?

$$f_1 = \frac{v}{4L} = \frac{\sqrt{B/\rho}}{4L}$$

$$L = \frac{\sqrt{B/\rho}}{4f_1} = \frac{\sqrt{\dfrac{1.33 \times 10^5\ \text{Pa}}{1.10\ \text{kg/m}^3}}}{4(7.00\ \text{Hz})} = 12.4\ \text{m}.$$

•**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?

$$f' = f\frac{v + v_D}{v + v_S}$$

$$v_S = \frac{f}{f'}(v + v_D) - v = \frac{1600\ \mathrm{Hz}}{1590\ \mathrm{Hz}}\left(343\frac{\mathrm{m}}{\mathrm{s}} + 2.44\frac{\mathrm{m}}{\mathrm{s}}\right) - 343\frac{\mathrm{m}}{\mathrm{s}} = 4.61\ \mathrm{m/s}$$