6. Let ℓ be the length of the rod. Then the time of travel for sound in air (speed v_s) will be $t_s = \ell / v_s$. And the time of travel for compressional waves in the rod (speed v_r) will be $t_r = \ell / v_r$. In these terms, the problem tells us that

$$t_s - t_r = 0.12\,\mathrm{s} = \ell\left(\frac{1}{v_s} - \frac{1}{v_r}\right).$$

Thus, with $v_s = 343$ m/s and $v_r = 15v_s = 5145$ m/s, we find $\ell = 44\,\mathrm{m}$.

10. Without loss of generality we take $x = 0$, and let $t = 0$ be when $s = 0$. This means the phase is $\phi = -\pi/2$ and the function is $s = (6.0 \text{ nm})\sin(\omega t)$ at $x = 0$. Noting that $\omega = 3000$ rad/s, we note that at $t = \sin^{-1}(1/3)/\omega = 0.1133$ ms the displacement is $s = +2.0$ nm. Doubling that time (so that we consider the excursion from –2.0 nm to +2.0 nm) we conclude that the time required is 2(0.1133 ms) = 0.23 ms.

13. (a) The period is $T = 2.0$ ms (or 0.0020 s) and the amplitude is $\Delta p_m = 8.0$ mPa (which is equivalent to 0.0080 N/m^2). From Eq. 17-15 we get

$$s_m = \frac{\Delta p_m}{v\rho\omega} = \frac{\Delta p_m}{v\rho(2\pi/T)} = 6.1 \times 10^{-9}\text{ m}.$$

where $\rho = 1.21$ kg/m^3 and $v = 343$ m/s.

(b) The angular wave number is $k = \omega/v = 2\pi/vT = 9.2$ rad/m.

(c) The angular frequency is $\omega = 2\pi/T = 3142$ rad/s $\approx 3.1 \times 10^3$ rad/s.

The results may be summarized as $s(x, t) = (6.1\text{ nm}) \cos[(9.2\text{ m}^{-1})x - (3.1 \times 10^3\text{ s}^{-1})t]$.

(d) Using similar reasoning, but with the new values for density ($\rho' = 1.35$ kg/m^3) and speed ($v' = 320$ m/s), we obtain

$$s_m = \frac{\Delta p_m}{v'\rho'\omega} = \frac{\Delta p_m}{v'\rho'(2\pi/T)} = 5.9\times10^{-9}\text{ m}.$$

(e) The angular wave number is $k = \omega/v' = 2\pi/v'T = 9.8$ rad/m.

(f) The angular frequency is $\omega = 2\pi/T = 3142$ rad/s $\approx 3.1\times10^3$ rad/s.

The new displacement function is $s(x, t) = (5.9\text{ nm}) \cos[(9.8\text{ m}^{-1})x - (3.1 \times 10^3\text{ s}^{-1})t]$.

25. (a) Let I_1 be the original intensity and I_2 be the final intensity. The original sound level is β_1 = (10 dB) log(I_1/I_0) and the final sound level is β_2 = (10 dB) log(I_2/I_0), where I_0 is the reference intensity. Since $\beta_2 = \beta_1$ + 30 dB which yields

$$(10\text{ dB})\log(I_2/I_0) = (10\text{ dB})\log(I_1/I_0) + 30\text{ dB},$$

or

$$(10\text{ dB})\log(I_2/I_0) - (10\text{ dB})\log(I_1/I_0) = 30\text{ dB}.$$

Divide by 10 dB and use log(I_2/I_0) – log(I_1/I_0) = log(I_2/I_1) to obtain log(I_2/I_1) = 3. Now use each side as an exponent of 10 and recognize that $10^{\log(I_2/I_1)} = I_2/I_1$. The result is I_2/I_1 = 10^3. The intensity is increased by a factor of 1.0×10^3.

(b) The pressure amplitude is proportional to the square root of the intensity so it is increased by a factor of $\sqrt{1000} = 32$.

38. The frequency is f = 686 Hz and the speed of sound is v_{sound} = 343 m/s. If L is the length of the air-column, then using Eq. 17–41, the water height is (in unit of meters)

$$h = 1.00 - L = 1.00 - \frac{nv}{4f} = 1.00 - \frac{n(343)}{4(686)} = (1.00 - 0.125n)\ \text{m}$$

where n = 1, 3, 5,… with only one end closed.

(a) There are 4 values of n (n = 1,3,5,7) which satisfies $h > 0$.

(b) The smallest water height for resonance to occur corresponds to n = 7 with $h = 0.125$ m.

(c) The second smallest water height corresponds to n = 5 with h = 0.375 m.

42. (a) Using Eq. 17–39 with n = 1 (for the fundamental mode of vibration) and 343 m/s for the speed of sound, we obtain

$$f = \frac{(1)v_{\text{sound}}}{4L_{\text{tube}}} = \frac{343\,\text{m/s}}{4(1.20\,\text{m})} = 71.5\,\text{Hz}.$$

(b) For the wire (using Eq. 17–53) we have

$$f' = \frac{nv_{\text{wire}}}{2L_{\text{wire}}} = \frac{1}{2L_{\text{wire}}}\sqrt{\frac{\tau}{\mu}}$$

where $\mu = m_{\text{wire}}/L_{\text{wire}}$. Recognizing that $f = f'$ (both the wire and the air in the tube vibrate at the same frequency), we solve this for the tension τ:

$$\tau = (2L_{\text{wire}}\,f)^2\left(\frac{m_{\text{wire}}}{L_{\text{wire}}}\right) = 4f^2 m_{\text{wire}}L_{\text{wire}} = 4(71.5\,\text{Hz})^2(9.60\times10^{-3}\,\text{kg})(0.330\,\text{m}) = 64.8\,\text{N}.$$