1 PSE6 17.CQ.012

Normal conservation (Table 17.2 from the textbook).

2 PSE6 17.P.001

This problem is very similar to the S and P waves problem from Chapter 16. The distance $d$ travelled by sound waves and light waves is the same. Assume the time required by the light wave is $t_l$, then the time required by the sound wave is $t_s = t_l + \Delta t$. We have

$$d = v_l t_l = v_s t_s$$
$$d = v_l t_l = v_s (t_l + \Delta t)$$

Solve for $t_l$ and then multiply this value by the speed of light to get the total distance.

3 PSE6 17.P.002

$$v = \sqrt{\frac{B}{\rho}}$$

4 PSE6 17.P.007

$$\lambda = \frac{v}{f}$$

5 PSE6 17.P.010

The pressure amplitude $\Delta P_{\text{max}}$ is given by the following equation

$$\Delta P_{\text{max}} = \rho v \omega s_{\text{max}}$$

Where $s_{\text{max}}$ is the displacement amplitude of the wave. Therefore

$$s_{\text{max}} = \frac{\Delta P_{\text{max}}}{\rho v \omega} = \frac{\Delta P_{\text{max}}}{\rho v 2\pi f}$$
6  PSE6 17.P.011

a. the amplitude of the wave is the constant in front of the cos term. The wavelength is $\lambda = \frac{2\pi}{k}$. And the speed of the wave can be found using $v = \frac{\omega}{k}$.

b. To find the instantaneous displacement, just plug the given $x$ value and $t$ value into the wave equation and do the calculation.

c. The maximum speed of an element’s oscillatory motion refers to the speed of a single point in the y-direction. It is given by $v_{\text{max}} = \omega A$.

7  PSE6 17.P.016

a. The additional sound pressure required to break the copper bar is

$$\Delta P_{\text{max}} = (1 - \%) P$$

Where $\%$ is the percentage of the tensile stress and $P$ is the elastic breaking point pressure. From problem 5 we have

$$s_{\text{max}} = \frac{\Delta P_{\text{max}}}{\rho v \omega} = \frac{\Delta P_{\text{max}}}{\rho v 2\pi f}$$

b. $v_{\text{max}} = \omega A = (2\pi f) s_{\text{max}}$

c. $I = \frac{\Delta P_{\text{max}}^2}{2\rho v}$

8  PSE6 17.P.019

The sound level $\beta$ is given by the equation

$$\beta = 10\log\left(\frac{I}{I_0}\right)$$

where $I_0$ is the reference intensity have the value $1.00 \times 10^{-12}$W/m$^2$.

9  PSE6 17.P.027

For a sound to be painful to the ear, it should have an intensity of $I = 1.00$W/m$^2$. Since the sound waves radiate outward spherically, the area equals $4\pi r^2$. From the definition of intensity, we have

$$I = \frac{P}{4\pi r^2}$$
Rearrange the terms get

\[ r = \sqrt{\frac{P}{4\pi I}} \]

10 PSE6 17.P.030

For both observers, we have \( \beta = 10\log\left(\frac{I}{I_0}\right) \). Therefore,

\[ \beta_B - \beta_A = 10\log\left(\frac{I_B}{I_0}\right) - 10\log\left(\frac{I_A}{I_0}\right) = 10\log\left(\frac{I_B}{I_A}\right) \]

Also, express the intensities in terms of radius (distance between the observer and the speaker), we have

\[ I_A = \frac{P}{4\pi r_A^2} \quad I_B = \frac{P}{4\pi r_B^2} \]

Take the ratio of \( I_B \) and \( I_A \) and plug into the earlier expression yields

\[ \beta_B - \beta_A = 10\log\left(\frac{r_A}{r_B}\right)^2 = 20\log\left(\frac{r_A}{r_B}\right) \]

Also, the total distance between two observers is \( r_A + r_B \), which is given in the problem. Therefore we have two equations with two unknowns. Solve for \( r_A \) and \( r_B \).

11 PSE6 17.P.033

a. We know that the power of the source is given by the expression \( P = 4\pi r^2 I \).

Since the power is not changed,

\[ 4\pi r_1^2 I_1 = 4\pi r_2^2 I_2 \]

\[ r_2 = r_1 \sqrt{\frac{I_1}{I_2}} \]

Figure out the intensities from the given sound levels and plug into the previous equation to determine \( r_2 \).

b. Same as part (a).

12 PSE6 17.P.035

a. From the given value of \( \beta \), calculate the sound intensity \( I \) inside the church using the equation

\[ \beta = 10\log\left(\frac{I}{I_0}\right) \]
Assume that sounds come perpendicularly out through the windows and doors. Then from the definition of intensity we know that the radiated power is $P = IA$. Therefore, the total energy radiated by the sound is

$$E = Pt = IA t$$

Remember to convert the time into seconds when doing the calculation.

b. The sound that radiates downward got reflected by the ground. Therefore, we get a hemisphere instead of a sphere for the total area, $A = 2\pi r^2$. The power $P$ is already calculated in part (a). So the intensity of the sound at given distance ($r$) is $I = P/A$ and the sound level is $\beta = 10\log(I/I_0)$. 