Physics 260 Homework Assignment 4

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

$$d = v_l t_l = v_s ts$$

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

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 ΔP_{max} is given by the following equation

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

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

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

6 PSE6 17.P.011

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

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 $v_{max} = \omega A$.

7 PSE6 17.P.016

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

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

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

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

b.

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

c.

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

8 PSE6 17.P.019

The sound level β is given by the equation

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

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

9 PSE6 17.P.027

For a sound to be painful to the ear, it should have an intensity of $I = 1.00\mathrm{W/m^2}$. 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 $\beta = 10\log(\frac{I}{I_0})$. Therefore,

$$\beta_B - \beta_A = 10\log(\frac{I_B}{I_0}) - 10\log(\frac{I_A}{I_0}) = 10\log(\frac{I_B}{I_A})$$

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

$$I_A = \frac{P}{4\pi r_A^2} \qquad\qquad I_B = \frac{P}{4\pi r_B^2}$$

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

$$\beta_B - \beta_A = 10\log(\frac{r_A}{r_B})^2 = 20\log(\frac{r_A}{r_B})$$

Also, the total distance between two observer 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 β, calculate the sound intensity I inside the church using the equation

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

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

$$E = Pt = IAt$$

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 $\beta = 10\log(I/I_0)$.