Physics 260 Homework Assignment 5

1 PSE6 18.CQ.008

Damping and non-linear effects in the vibration turn the energy of vibration into internal energy.

2 PSE6 18.P.004

First, change the given phase angle ϕ into to radians. The wave functions are $y_1 = A\sin(kx - wt)$ and $Y_2 = A\sin(kx - wt + \phi)$. Using the trigonometry identity

$$\sin a + \sin b = 2\cos\left(\frac{a-b}{2}\right)\sin\left(\frac{a+b}{2}\right)$$

The resultant wave function reduces to

$$y = 2A\cos\left(\frac{\phi}{2}\right)\sin\left(kx - wt + \frac{\phi}{2}\right)$$

Hence, the amplitude of the resultant wave is $2A\cos\left(\frac{\phi}{2}\right)$.

3 PSE6 18.P.013

The wavelength can be found from the wave number, which is the constant in front of x ($\lambda = 2\pi/k$). Similarly, frequency is found using the constant in front of t, $f = \omega/2\pi$. The speed of the wave is then $v = \lambda f = w/k$.

4 PSE6 18.P.015

From the given frequency and speed of sound, we can calculate the wavelength, $\lambda = v/f$. The distance between adjacent nodes is half of the wavelength, and the distance between adjacent node and antinode is a quarter of the wavelength. Since the speakers are in phase, the midpoint between two speakers is an antinode. Add or subtract $1/4\lambda$ to the position of the midpoint to get the adjacent nodes and then add and subtract half the wavelength the get the next two nodes and so on until you found all the nodes.

5 PSE6 18.P.028

We know that

$$L_G = \frac{v}{2f_G} \qquad\qquad L_A = \frac{v}{2f_A}$$

So,

$$L_A = \frac{f_G}{f_A}$$

which gives the distance from the bridge. From $L_A = v/2f_A$ get

$$L_A = \frac{1}{2f_A}\sqrt{\frac{T}{\mu}}$$

The changes in tension (dT) correspond to the changes in the length (dL_A), which is the half width of the finger. Take the derivative of L_A with respect to T, get

$$dL_A = \frac{1}{2}\frac{dT}{2f_A\sqrt{T\mu}}$$

Now, divide both sides by L_A get

$$\frac{dL_A}{L_A} = \frac{dT}{4f_A L_A\sqrt{T\mu}} = \frac{dT}{2v\sqrt{T\mu}} = \frac{1}{2}\frac{dT}{T}$$

Therefore the maximum allowable percentage change in the string tension is

$$\frac{dT}{T} = 2\frac{dL_A}{L_A}$$

6 PSE6 18.P.052

a. Possible frequencies are $f_1 = f_0 + f_{beat}$ and $f_2 = f_0 - f_{beat}$

b. Tightening the string increases the tension, which means the speed and frequency are also increased. Since the beat frequency increases, we must have f_1 as the original frequency. And the new frequency of the string is f_0 plus the new beat frequency f_{beat}, $f_n = f_0 + f_{beat}$.

c. From $f = \frac{1}{2L}\sqrt{\frac{I}{\mu}}$ yields

$$\frac{f_n}{f_0} = \sqrt{\frac{T_n}{T_0}}$$

$$T_n = \left(\frac{f_n}{f_0}\right)^2 T_0$$

So the percentage change is $\frac{T_0 - T_n}{T_0}$. The tension should be reduced.

7 PSE6 18.P.066

a. We want to first find out the frequency of the vibrating wire. The linear wire density μ can be determined from the given mass and length of the wire. Also, the tension in the string is given. So we can calculate the speed of the wave in the wire ($v = \sqrt{T/\mu}$). Since the wire vibrates in its simplest mode, there is only one antinode on the string. Therefore, the wavelength is twice the length of the wire. From the expression $v = \lambda f$, we get

$$f = \frac{v}{v} = \frac{\sqrt{\frac{TL}{M}}}{2L} = \sqrt{\frac{T}{4ML}}$$

So the possible frequencies are

$$f_{small} = f - f_{beat} \qquad\qquad f_{large} = f + f_{beat}$$

b. Smaller tension correspond to smaller frequency. Combine the following two equations and solve for T

$$v = \lambda f \qquad\qquad v = \sqrt{\frac{T}{\mu}}$$

$$T = \lambda^2 f^2 \mu$$

8 PSE6 18.QQ.002

The string forms a straight line and is not moving.

9 PSE6 18.QQx.002

Fundamental wavelength.

10 PSE6 18.QQ.009

Continue to tighten the string.