NAME: Answers, Sect. #______

Physics 109 **Homework # 3** due Monday, October 1, 2001

formulae:

$$\lambda = \frac{v}{f} \qquad v = \sqrt{\frac{T}{\rho}} = \sqrt{\frac{T}{m/\ell}} \qquad f_1 = \frac{v}{2L} = \frac{1}{2L}\sqrt{\frac{T}{m/\ell}}$$

speed of sound in air: 340 m/s.

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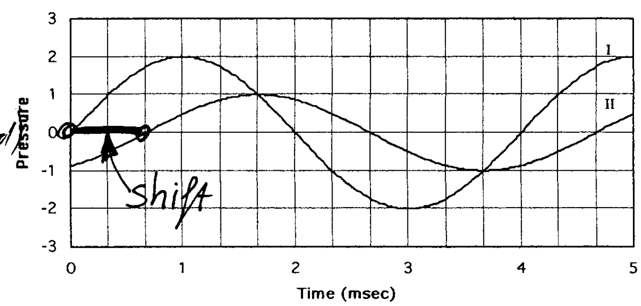
1. Find the phase shift between the two oscillations shown in the graph:



12 divisions = 360° (1 period)
1 division = 360/12 = 30°
shift here: 2 division

phases shift = 60°

2. Wave length:
   a)The range of hearing extends from about 20 Hz to 20,000 Hz.

   The wave length of the lowest frequency you can hear about 17 m.

   $\lambda = v/f = 340/20 \text{ m} = 17 \text{ m}$

   The wave length of the highest frequency you can hear is about 0.017 m.

   $\lambda = v/f = 340/20{,}000 \text{ m} = 0.017 \text{ m} = 1.7 \text{ cm}$

   b) find the frequency of a tone whose wave length is 0.75 m.

   $f = v/\lambda = \frac{340 \text{ m/s}}{0.75 \text{ m}} = 453 \text{ Hz}$ f = 453 Hz.

3. Speed of propagation on String:

at the Steinway factory, a worker finds that 500 m of piano wire on a spool weigh 2 kg.

a) find the mass per unit length.

$\rho = m/\ell = 2 \text{ kg}/500 \text{ m} = 4\times10^{-3} \text{ kg/m}$

b) find the speed of propagation on this wire for a tension of 40N

$v = \sqrt{T/\rho} = \sqrt{40/4\times10^{-3}} = \sqrt{10^4} = 100 \text{ m/s}$

c) how much tension is required to double the speed of propagation?

4× larger tension (since $\sqrt{4T} = \underline{2}\sqrt{T}$)

$\underline{\underline{T = 160N}}$

4. The 60 cm long string of a viola is tuned to 200 Hz.

   a) The musician can change the frequency of the string by pressing the string against the finger board, so that the vibrating length becomes shorter.

   How long should the vibrating length of the same string be to obtain a frequency of 400 Hz? (hint: use proportions – how many times higher is f?)

$$\frac{L_2}{L_1} = \frac{f_1}{f_2} = \frac{200Hz}{400Hz} = \frac{1}{2} \qquad L_2 = \frac{1}{2}L_1 = \frac{1}{2}\,60\,cm = 30\,cm$$

length = 30 cm

what length would produce 300 Hz?

$$L_2 = L_1\frac{f_1}{f_2} = 60\,cm \times \frac{200\,Hz}{300\,Hz}$$

length = 40 cm

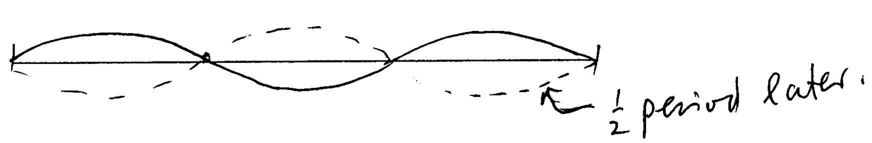
   b) How many times greater or smaller should I make the tension on the string to change the fundamental frequency from 200 Hz to 400 Hz?

2x higher f → higher Tension $\qquad$ $\underline{\underline{T = 4\times \text{greater}}}$

   c) What is the frequency of the third mode of the original 200 Hz string?

$3\times 200\,Hz = \underline{\underline{600\,Hz}}$

make a drawing showing the shape of the string oscillating in the third mode



5. Consider two loudspeakers oscillating in phase playing the same tune. Your ear is 6.0 m from one speaker and 5.4 m from the other.

   Which frequencies will you hear very little (cancell)? path difference must be $\frac{1}{2}\lambda$, or $1\frac{1}{2}\lambda$, or $2\frac{1}{2}\lambda$ etc. Here path difference = 0.6m

$\frac{1}{2}\lambda = 0.6m \rightarrow \lambda = 1.2\,m \rightarrow f = v/\lambda = \underline{\underline{283\,Hz}}$; or $\frac{3}{2}\lambda = 0.6m \rightarrow \lambda = 0.4m$ $\quad f = \underline{\underline{850\,Hz}}$

   Which frequencies would be loud?

path diff = λ (or 2λ, 3λ etc)

$\lambda = 0.6m \rightarrow f = \frac{340}{0.6} = \underline{\underline{566\,Hz}}$; or $2\lambda = 0.6m \rightarrow f = \frac{340}{0.3}Hz = \underline{\underline{1133\,Hz}}$