IC19: 11/23 In Class –Wave practice problems

This is our last meeting before the final. You have this IC19 and IC18 on SHM to cover the new material. Then you have the three midterm exams for both sections (on Moodle under Exam Info) and also the review problems for each of the three exams. I'd use the old exams to study for old material first. Cover sheets for each exam are also in that section.

Summary and review of waves:

A traveling wave has a function given by:

$$y = A\sin(\frac{2\pi}{\lambda}x - \omega t) \qquad \text{or} \qquad y = A\cos(\frac{2\pi}{\lambda}x - \omega t)$$

for waves traveling in the $+x$ direction.

All the variables such as A (amplitude), f, frequency, ω angular frequency, and T period, have the same definitions as they did for SHM.

There are two new quantities we defined last week: wavelength (λ) (distance for one complete cycle) and the speed of the wave, $v = \frac{\lambda}{T}$.

There is another way to calculate the speed of a wave on a string.

$$v = \sqrt{\frac{F_T}{\mu}}$$

where F_T is the tension in the string, and μ is the mass per unit length of the string.

We also worked out the expression to find the resonant, or harmonic, frequencies for standing waves with nodes on both ends:

$$f_n = n\frac{v}{2L}$$

1. A guitar string has $\mu = 50$g/m and is under tension of 30N. If you pluck the string, what will be the speed of the wave?

2. A wave on a string has an equation of motion given by:
   $y = .05\sin(4\pi x - \frac{\pi}{3}t)$

   (a) What is the amplitude of the motion?

   (b) What is the period of the motion?

   (c) What is the wavelength of the motion?

(d) What is the speed of the wave?

(e) If the mass of the string is 15g and it is 2m long, what is the tension in string?

(f) Write an expression for the velocity of a particle of the medium at $x = 0$.

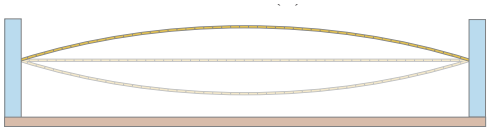
(g) What is the maximum velocity of a particle of the medium?

3. A wave has an amplitude of 10cm, a frequency of 3Hz, and a wavelength of 15cm.

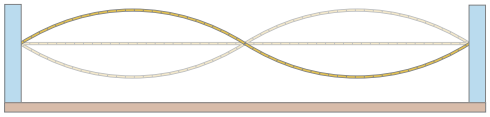
   (a) Write an expression for the wave, assuming that it is a sin wave.

   (b) What is the period of the motion?

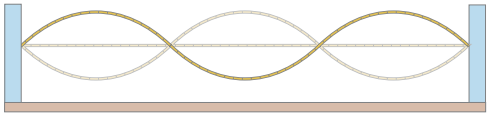
   (c) What is the speed of the wave?



Fundamental or first harmonic, f_1



First overtone or second harmonic, $f_2 = 2f_1$



Second overtone or third harmonic, $f_3 = 3f_1$

4. In class last time, I drew pictures like the ones shown above. These patterns, with nodes on both ends, correspond to waves on a string that is fixed at both ends, and also columns of air that are closed on both ends. Both of length L. You make the sketches for the version that has antinodes on both ends, and work out the equations. The ones you will draw would work for the waves on a string free to move at both ends (we saw the wave machine do this pattern in one of the videos), or a column of air that is open on both ends. Use n to correspond to the number of nodes=number of the harmonic, and λ_n for the wavelength of the nth harmonic.

5. Using what you know about the speed of a wave on the same string, v, find he relationship between each frequency, speed, and length of the string. Again, it should have the n for number of nodes/harmonic. (You should solve for f_n.)

6. A pipe organ tube that is open on both ends and has a length of 85cm can play a note with the speed of the wave 340.

   (a) What is the wavelength of the first harmonic ?

   (b) What is the frequency of the first harmonic?

   (c) What is the frequency of the second harmonic?

   (d) What is the frequency of the third harmonic?