Review Problems on Ch. 14

- Express values to the proper number of significant figures, and use significant figures correctly in calculations.
- Show your work as requested on each part of each problem.
- Listed below are the only acceptable equations that you may use as starting points. Equations such as $f_n = (v/2L)n$ and $f'/f = (1 +/- u/v)^{-1}$ are *not* acceptable starting points.

$\lambda = v/f$

$v = (F_T/\mu)^{0.5}$

$f = 1/T$

$v = \Delta d/\Delta t$

$y = A\cos[2\pi(x/\lambda +/- t/T)]$

$v_{sound} = 331$ m/s + [0.6 (m/s)/°C)]τ, where τ is the temperature of the air in C°.

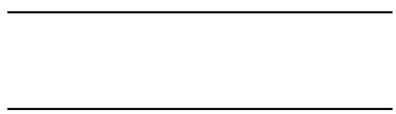
Condition for constructive interference: path difference = $n\lambda$, where n = integer

Condition for destructive interference: path difference = $(n - ½)\lambda$, where n = integer

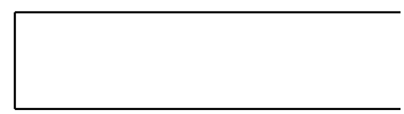
1. The 2nd harmonic (n = 2) of an open pipe has a frequency of 115 Hz. The 3rd harmonic (n = 3) of a closed pipe has exactly the same frequency. The temperature of the air in the pipes is 23 °C.

   a. How long is each pipe? Begin with a diagram of the standing wave in each pipe. Then express each wavelength in terms of the length of the corresponding pipe. Finally, solve for each length.

OPEN PIPE



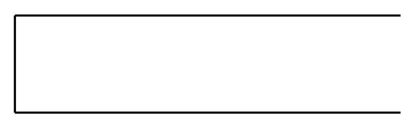
CLOSED PIPE



   b. If the 3rd harmonic of the open pipe (n = 3) and the 5th harmonic (n = 5) of the closed pipe are played at the same time, what will the beat frequency be? Begin with a diagram of the standing wave in each pipe. Then express each wavelength in terms of the length of the corresponding pipe. Carry on from there.

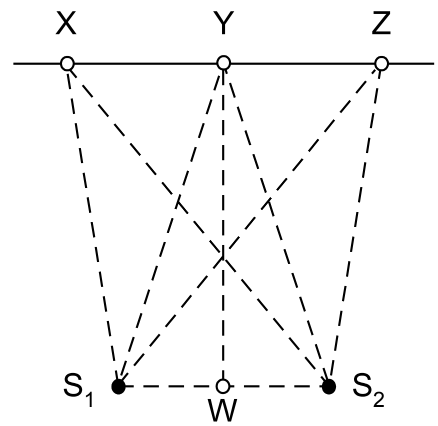
OPEN PIPE

CLOSED PIPE



c. We have assumed up to this point that both pipes are stationary with respect to the listener. Describe how the sound from one or both of the pipes could be Doppler-shifted so that the harmonics of part b would be heard with the same frequency at the same time. Include a calculation of any relevant speed.

2. Two sources of sound of equal frequency oscillate in phase at positions S_1 and S_2. The air temperature is 23 °C. An observer walking from X to Z along the line XYZ hears a minimum intensity at X and Z and a maximum intensity at Y. There are no other minima or maxima between X and Z. The following distances are given:



$S_1S_2 = 2.80$ m $S_1X = S_2Z = 4.30$ m $S_1W = S_2W$
$S_1Y = S_2Y = 4.50$ m $S_1Z = S_2X = 5.50$ m $YW = 4.25$ m

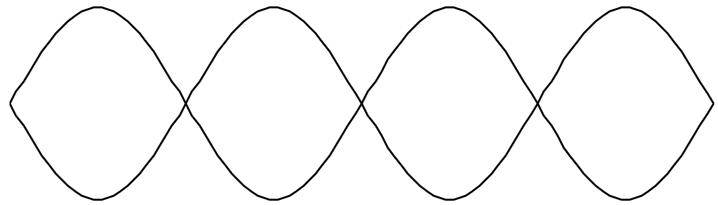
a. Given the information above, describe in words how to determine the wavelength of the sound emitted by the sources. Also explain why your method will work.

b. Carry out the method that you just described and determine a value for the wavelength of the sound.

c. Suppose the sources are moved so that they are 1.00 m apart but still equally-spaced from point W. Do the points of minimum intensity on line XYZ stay in the same places, get closer together, or spread apart? An explanation is not needed.

d. Now suppose that the sources are returned to their original positions but their frequencies, while always equal to each other, may be adjusted to values different from the original value. Give two possible frequencies for which X and Z are points of maximum sound intensity. Show how you obtain your answers.

3. A string with linear density, 0.016 kg/m, is fixed at both ends and stretched to a constant tension. The distance between fixed ends is held constant at 0.75 m. The string is then put into oscillation in a standing wave pattern of frequency 120 Hz. The standing wave pattern is shown to the right.



   a. Determine the speed of the waves on the string.

   b. The string is now replaced with one that has a linear density one-fourth that of the first string. The tension, length, and frequency are not changed. In which harmonic will the string vibrate? Explain your answer using words and/or equations. Include a diagram of the standing wave.

   c. Determine the length of a closed pipe that resonates at the same frequency as the string. How long must the pipe be if the standing wave produced in the pipe is the third harmonic, i.e., the next harmonic above the fundamental? Explain your answer using the applicable equations. Include a diagram of the standing wave pattern.

4. A transverse wave traveling in the direction of the –x axis on a rope has a wavelength of 0.48 m, frequency of 6.8 Hz, and amplitude of 0.25 m.

   a. Write the equation of motion of the wave.

   b. Describe in words the motion of a single point of the rope. Then write the equation of motion of that point. You'll need to include and arbitrary phase factor, ϕ.