Assignment IV, PHYS 150 (Physics of Sound and Music)
Resonances of Closed and Open Pipes
Due January 31, 2014

Please don't forget to put your answers on a separate sheet of paper.

1. Describe, in detail, the difference between harmonics, overtones, and partials.
2. A system has the following resonant frequencies (in Hz): 50, 222, 111, 82, 333, 267, 360, 420, 135, 37, 147. (By the way, if you combine these frequencies and listen to it – say in Audacity – it sounds horrible).
   a) What is the fundamental frequency?
   b) Identify all of the overtones.
   c) Identify all of the partials.
   d) Identify all of the harmonics.
3. What is a sympathetic vibration?
4. Our department has meter-sticks that are hollow and take the shape of a square pipe. (If you look at them end-on, you see a square, not a circle). The side-length of the square is about 1.6 cm.
   a) What is the fundamental of this meter-stick (open on both ends)? (Since the end correction is not given in your text for a square cross-section, assume that for an open square cross section the total end correction is approximately 1.22 multiplied by the side length).
   b) What are the first two overtones?

More on back!

5. I have four circular cylindrical pipes made of various materials in my office. (Really. We Physics folks have stuff like that sometimes). I just measured them. Here are their properties:

Pipe Number	Pipe Length (cm)	Pipe inner diameter (cm)
1	153	2.0
2	153	2.2
3	76	3.5
4	61	2.5

   a) Calculate the fundamental frequency of each of the four pipes (assume both ends are open to the atmosphere).

   b) Calculate the first two overtones of pipe 1 (again, assume both ends are open to the atmosphere).

   c) Calculate the fundamental frequency of pipe 3 (if one end is plugged).

   d) What would your answer to part (c) above have been if you had forgotten the end correction?

   e) Calculate the first two overtones of pipe 3 (if one end is plugged) (with the proper end correction).

6. Our department has meter-sticks that are hollow and take the shape of a square pipe. (If you look at them end-on, you see a square, not a circle). The side-length of the square is about 1.6 cm.

   a) What is the fundamental of this meter-stick (open on both ends)? (Since the end correction is not given in your text for a square cross-section, assume that for an open square cross section the total end correction is approximately 1.22 multiplied by the side length).

   b) What are the first two overtones?

7. One of the reasons that we're focusing so much on pipe resonance is that all of the wind instruments use these resonances in different ways. There's another reason we're studying them, too. Your ear can be reasonably well modeled as a pipe. Assume that the outer ear canal is a cylindrical pipe 3 cm long, closed at one end (by the eardrum). Calculate the fundamental resonant frequency of this pipe.

8. Examine Figure 5.1 in your text and comment on it, giving particular attention to the frequency you found in the previous problem. Does this make sense? Why or why not?