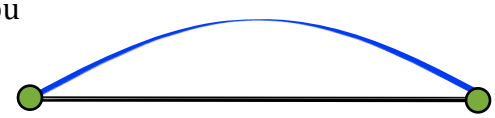
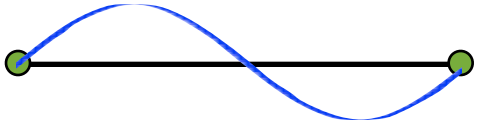
PM Quiz practice problems. Section 4-3, 2-11-09

1. Consider a string whose fundamental frequency is 100 Hz. Draw what the string would look like vibrating in its first four harmonics and label each corresponding frequency. The first one is done for you

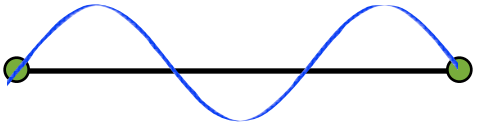
a) 1st harmonic: (fundamental) f = 100 Hz



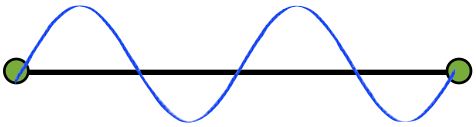
b) 2nd harmonic: f = 200 Hz



c) 3rd harmonic: f = 300 Hz



d) 4th harmonic: f = 400 Hz



2. A particular instrument has a resonant frequency of 150 Hz in its 3rd harmonic. List the first 5 resonant frequencies of this instrument:

If the 3rd harmonic is 150 Hz, then the fundamental is 50 Hz. So the first 5 resonant frequencies would be: 50 Hz, 100 Hz, 150 Hz, 200 Hz, and 250 Hz

3. If you are given a resonant frequency of a string and the harmonic that it corresponds to, is that enough information to know ALL of the resonant frequencies of the string? Explain:

Yes. If we know the frequency of a given harmonic, then we can always figure out what the fundamental frequency is (i.e. dividing the frequency by its harmonic number gives the fundamental). From the fundamental frequency, we know all of the resonant frequencies since they are just 2x 3x 4x ... etc. the fundamental

4. Recall that two pitches are separated by an octave if their corresponding frequencies differ by a factor of 2, i.e. a pitch is an octave higher than another pitch if its frequency is twice as great. Orchestras tune their instruments to the note A3, which corresponds to a frequency of 440 Hz.

a) What would be the frequency of A5, which is TWO octaves higher?

Each octave doubles the frequency. One octave higher would be 2 x 440 Hz = 880 Hz, and two octaves would be 2 x 880 Hz = 1760 Hz.

b) If an instrument's fundamental frequency is an A3, what harmonic corresponds to A5 (the note two octaves above)?

Two octaves corresponds to the 4th harmonic.

Bonus question (if you have time):

a) Shown below are two strings. The first has a fundamental frequency of 80 Hz. The second has a fundamental frequency of 60 Hz. What is the lowest frequency that could be used to cause both strings to resonate (hint: it may help to list the first few resonances of each string)?

Listing the first few harmonics in each string gives:
80 Hz: 80 Hz, 160 Hz, 240 Hz, 320 Hz ...
60 Hz: 60 Hz, 120 Hz, 180 Hz, 240 Hz ...

We see that 240 Hz, is the first resonance that the two strings have in common.

b) What harmonic does this frequency correspond to on each of the two strings?

240 Hz is the 4th harmonic of the 60 Hz string, and the 3rd harmonic of the 80 Hz string.

c) Draw the resonance pattern that this frequency would make on each of the two strings. Do you notice something peculiar about the relationship of these patterns to each other? Explain.

Notice that the three humps on the 80 Hz string line up with the first three humps on the 60 Hz string. It turns out that "resonance" can be alternatively stated as the frequency that creates the correct "hump" spacing that fits geometrically on the string. More on this later.