Physics 123 section 2 CID _____

Homework 23

Score _____ / 30

1. (8 pts) While you are practicing the piano, a car races past outside. You notice that as the car approached, the engine made a noise which was almost exactly in tune with a middle A (440.0 Hz). After the car passed, the pitch dropped down two half steps to a G. How fast was the car going? Assume that the piano is tuned to an equal temperament scale and that the speed of sound is 343.0 meters per second.

2. (10 pts) Guitar players often tune their instrument using harmonics. Imagine that I use an electronic tuner to tune my low E string to 164.814 Hz, precisely the correct frequency for an equal temperament scale referenced to a frequency for middle A of 440 Hz. Now I tune my next string, the A string which is 5 half-steps higher in frequency, using harmonics. I do this by lightly touching the E string 1/4 of the way from the end of the string and lightly touching the A string 1/3 of the way from the end of the string. I then play both strings and adjust the A string to make the beat frequency as low as possible. If I tune the beats completely away, how far off (in Hz) will the frequency of the A string be from the ideal frequency for this string according to the equal temperament scale?

3. (6 pts) The lowest string on a 6-string guitar is usually tuned to an E at a frequency of 82 Hz (to two significant digits). (a) If this E is referenced to an equal temperament scale for which middle A is 440 Hz, what is the frequency of this E to three significant digits? (b) Sometimes guitar players will loosen the tension in this string to drop it down two half-steps to a D to hit lower notes in a particular song. This is known as "drop D tuning." What is the frequency of the D just below the E you found above? (c) By what factor do you need to reduce the tension in the string to go from the E down to the D?

4. (6 pts) Find a big building with a very flat wall on one side which is far from other buildings (the Tanner building could be a good choice). Stand outside the building a good distance from the flat wall. Clap your hands. If you can't hear the echo you are too far away. If the echo comes back too fast, you may need to move further away from the building. Now start clapping at a regular rate, and adjust the rate of your clap such that the echo returns exactly half way between your claps (so that you hear a regular rhythm of clap-echo-clap-echo-clap-echo, etc.). Now use a watch to measure the time for 30 clap-echo pairs, and estimate the distance from you to the wall. Use this to calculate the speed of sound.

Extra problems I recommend you work (not to be turned in)

- Find a piano. Push down the sustain pedal. Clap your hands and listen to see which is the highest note excited by your clap. Now use the uncertainty principle to estimate the duration of your clap.

- Find a piano. Push lightly on one of the lower notes such that it doesn't make a sound. While holding down that key, briefly strike the note which is one octave higher. You should now hear the lower strings oscillating at the fundamental frequency of the higher strings. Now strike and hold the higher note. Chances are you will hear beats. Why?