Name: _____

Other group members: _____

Tutorial #1

PHYS 1240: Sound and Music

Wednesday, July 10, 2019

Instructions: Work in groups of 3 or 4 to answer the following questions. Write your solutions on this copy of the tutorial—each person should have their own copy, but make sure you agree on everything as a group. When you're finished, keep this copy of your tutorial for reference—no need to turn it in (grades are based on participation, not accuracy).

1. Estimate the total number of pianos keys in the US. Aim at a number within a factor of 10 or so from the correct one. (This question (known as a "Fermi problem") may seem strange and, in a sense, it is. It is however a classic and it's been known to be used at job interviews for business consulting positions and graduate school admissions in physics, among other places.)

2. If the frequency of a sound wave in water increases by a factor of 4, what happens to its wavelength?

3. How many meters will sound travel in 60 seconds in standard atmospheric conditions? How far in an hour? How far in 0.002 seconds?

4. While watching a fireworks display, you realize that there's about a five-second delay between when you see each firework and when you can hear it. About how far away are the fireworks from you? (*Hint:* we can treat light as travelling instantaneously here, since its speed is almost a million times faster than sound.)

5. An ocarina is an ancient instrument that we can describe with the same model as blowing over a bottle. To play the instrument, you blow into the mouthpiece (the bottom hole shown below), producing oscillations within the air cavity of the ocarina.

   a) First, assume all twelve holes on the top are covered, so the ocarina truly is just a container with one opening. Draw what the air oscillations would look like (using the shape below as a guide), showing a plug of air acting as a moving "mass" and drawing rebounding air acting as a "spring."

   b) With all twelve holes on top still covered, what would happen to the pitch if you increase the size of the ocarina? Explain this by relating it back to your mass-and-spring model.

   c) Now, let's allow some of the top holes to be open, creating a "leaky bottle." The result is that the more area that's open, the more air that leaks out, so less air is able to bounce back and contribute to the oscillations. How does this affect the elasticity or springiness of the oscillator? Therefore, if you increase the number of open holes, how will this affect the pitch?