Assignment XI, PHYS 111 (General Physics I)
Fall 2016
Due 11/30/16 at start of class

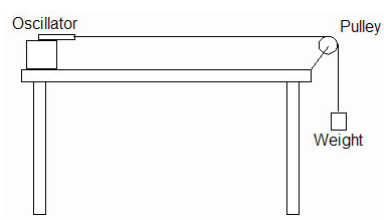
As always, please put your clearly written answers on separate paper.

1. I Googled the properties of some random string and found that a spool of this string weighs 0.3 ounces and has a length of 475 feet. Assume, for the sake of this problem, that the string is inextensible. The string is utilized in a laboratory setup like that shown below, where the oscillator shakes one end of the string up and down, creating forced nodes at both the pulley and the oscillator. (Technically speaking, there is not a node at the oscillator since it moves, but for simplicity, we will assume that the string does not move at the oscillator to keep the math simpler).

   a) If I attach a mass of 135 g to the free end of the string, what is the speed of wave transmission down the string?

   b) If I attach a mass of 135 g to the free end of the string, what is the lowest frequency for a stable state if the distance between the oscillator and the pulley is 1.24 meters?

   c) If I attach a mass of 135 g to the free end of the string, what is the frequency associated with a standing wave pattern that has 4 nodes *between* the post and the pulley if the distance between the post and the pulley is 1.24 meters?



2. The speed of sound in (dry) air can be approximated with the equation:

$$v_{\text{air}} \approx (331.3 \text{ m/s})\sqrt{\left(1 + \frac{\theta}{273.15°\text{C}}\right)}$$

   where θ is the air temperature (in degrees Celcius).

   a) In a 10 degree Celcius room, what is the wavelength of the main tuning note for most Orchestras (A-440, which has a frequency of 440 Hz)?

   b) How long would a tube closed at one end need to be so that it would have its lowest resonant frequency at A-440 in a 10 degree Celcius room?

3. A train horn has many frequencies (that's why you hear this weird cluster of sounds when you hear a train horn). I did some homework and broke down the real sound into its component frequencies. Turns out, one train has two main frequencies at 439 Hz and 523 Hz. For this problem, assume that the air is dry and the temperature outside is 20°C.

   a) Let's say you are stationary and the train is coming at you moving at 20 m/s. What two frequencies do you hear?

   b) As soon as the train passes by you and heads in the other direction, you hear a new pair of frequencies. As the train moves away from you at 20 m/s, what frequency do you hear now?

   c) The musical interval made by the pitches in the train whistle result from the ratio of frequencies. Do you hear a larger interval (larger ratio) when the train is coming toward you, when the train is going away from you, or is it essentially the same ratio?

4. A little googling told me that it takes about 6.5 GPa of pressure to crush a human skull. (I'm sure I'm on a watch-list now). Some more googling told me that it takes about 300 psi to completely crush a (full) soda can. The depth of the ocean at its deepest point is about 11000 meters.

   a) If we believe the numbers above, is it possible to crush a human skull by bringing it to the bottom of the ocean? Justify your answer with an appropriate calculation.

   b) How deep would you have to place a full soda-can in the ocean so that it would be crushed?

   c) How deep would have have to go in the ocean so that the total pressure above you (atmospheric + water pressure) would equal twice standard atmospheric pressure?

5. The density of aluminum is about 2700 kg/m^3. The density of glycerol is about 1250 kg/m^3. An uniform aluminum sphere with *diameter* 4.0 cm is submerged in glycerol and dropped.

   a) What is the magnitude of the buoyant force on the aluminum sphere?

   b) What is the *net* force on the sphere of aluminum in the glycerol, assuming no drag force?

   c) In reality, there is a drag force on such a sphere falling in glycerol, and it depends on the speed of the sphere. An object is said to be falling at its "terminal velocity" if the total net force on the object is equal to 0. Let us assume the drag force on a sphere with diameter D to be $3\pi\mu Dv$ with μ equal to the viscosity of the fluid (for glycerol this is 1.412 kg/(m s)) and v the fall velocity of the sphere. The force is directed against the direction of the movement so – in this case – the drag force would point upward (against the direction of the sphere's fall). Find the terminal fall-velocity of the 4 cm diameter aluminum sphere in glycerol.