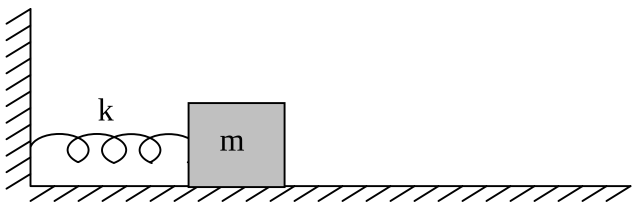
Physics 206a

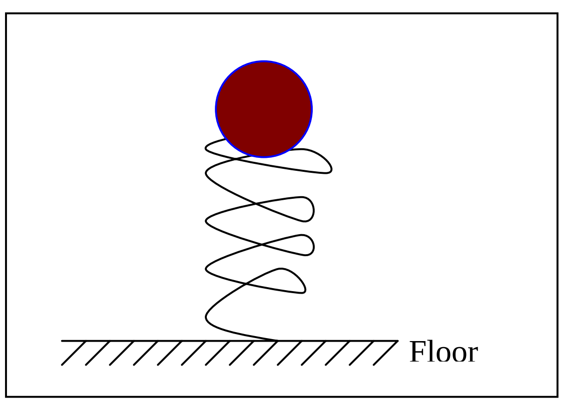
Homework Assignment XIV

Not Graded

This assignment will not be graded. You will not hand it in. I will post the solutions to it shortly, so that you can check your answers against the "correct" ones. The material covered on this assignment is "Fair Game" for the Final Exam, so I ***implore*** *you to treat it seriously and put a full allotment of effort into it. As you can guess, I'm not certain we'll cover all of the material on this assignment in the time remaining. I will let you know on the last day of class which of these I expect you to be able to do.*



1. A 2 kg mass rests on a frictionless, horizontal surface. It is attached to a spring connected to a wall, as shown above. It is pulled 11 cm from its equilibrium position before being released. The spring constant is $k = 15\frac{\text{Newtons}}{\text{meter}}$. If there were a coefficient of sliding friction between the surface and the mass, μ_k, what value would this coefficient need to have for the mass to come to a complete stop upon reaching its equilibrium position after being released?



2. One end of a spring is attached to the floor. The spring constant of it is $k = 23\frac{\text{Newtons}}{\text{meter}}$. A ball with a mass of 210 gram rests on the spring in its equilibrium position, as shown in the picture above. (The ball simply rests on the spring. They are not attached.) The spring is compressed from its equilibrium position by ½ meter and then released. How high does the ball fly?

3. By hand (i.e., don't use Excel or some other graphing program), sketch the following functions. Take the frequency to be $\omega = \pi \frac{1}{s}$ (that can be read "pi radians per second" or "180 degrees per second"). Make sure your plot extends over at least 4 seconds. Use whatever scale is convenient for the *y* axis.:

   a. $y = 5 \times \sin(\omega t)$

   b. $y = 5 \times \sin(\omega t + \frac{\pi}{2})$

   c. $y = 5 \times \cos(\omega t)$

   d. $y = 5 \times \cos(\omega t - \frac{\pi}{2})$

4. Again by hand, plot the following functions as a function of x. Again take the frequency to be $\omega = \pi \frac{1}{s}$. Take $k = \frac{1}{3} cm^{-1}$. Make sure that your plot extends over at least 12 cm.

   a. $y = 5 \times \sin(kx - \omega t), \quad t = 0s$

   b. $y = 5 \times \sin(kx - \omega t), \quad t = \frac{1}{2}s$

   c. $y = 5 \times \sin(kx - \omega t), \quad t = 1s$

   d. $y = 5 \times \sin(kx - \omega t), \quad t = 1.5s$

5. What is the speed of the wave you plotted in problem #4?

6. Briefly (a paragraph or two) distinguish between bulk motion and wave motion. Also distinguish between longitudinal waves and transverse waves.

7. A very long guitar string has a linear density of $4.466 \frac{\text{grams}}{\text{meter}}$. It is strung with a tension of 97 Newtons. If it is plucked, with what speed will the disturbance travel down the length of the string?

8. A string which has a linear density of $7 \frac{\text{grams}}{\text{meter}}$ is suspended from the ceiling. A mass of 1 kg is hung from the end of the string. The string is 2 meters long. A fly is sitting on the string near where it attaches to the ceiling. The fly's wings beat with a frequency of 197 Hz. What is the length of the waves generated in the string by the fly? (Neglect the contributions of the weight of the string and the weight of the fly to the tension of the string.)

9. A string with a length of 10.0 m and linear density $25\,\frac{\text{grams}}{\text{meter}}$ is suspended from the ceiling. An object of mass 0.200 kg is hung from the string. What is the speed with which a disturbance in the string will propagate near (a)the bottom of the string, (b)midway up the string, and (c)near the top of the string? (Do *not* neglect the contribution of the weight of the string to the tension in the string!)

10. A 64 cm long guitar string has a linear density of $4.466\,\frac{\text{grams}}{\text{meter}}$. At what tension must it be strung if it is to have a fundamental frequency of 110 Hz? (This is the tone identified by musicians as "A".)

11. A man blows across the mouth of a bottle of soda shortly after the bottle has been opened, creating a flute-like sound. The space in the bottle above the liquid is initially filled with carbon dioxide due to the fizz in the soda. He sets the bottle aside and comes back several days later and tries blowing again. Now, the CO_2 has been replaced by air. (Treat the bottle as a pipe. The reality is that the odd shape of a bottle changes the resonant frequencies dramatically, as we saw/heard in class. Neglect this for this problem.) (By the way, this would be tough to do in reality—the man's breath would really screw things up. Neglect that effect in the problem.)

   a. By what factor will the frequency of the "toot" change?

   b. If the height of the gas is 10 cm, what was the frequency of the tone with the CO_2?

   c. What is the frequency with the air?

   d. What are the wavelengths in the two cases?

12. A spider makes a web across the inside of an organ pipe which is open at both ends. The web is fine but still creates a small dissipative force (drag) for any air molecules moving at its location. The web is built at the exact midpoint along the length of the pipe. Which overtones (harmonics) of the pipe will be most affected by the presence of the web? Which overtones (harmonics) will be least affected by the web? Explain.

13. An organ pipe is open at one end. It is designed to play a frequency of 440 Hz. If the pipe is designed to operate at a temperature of 23° C, what frequency will it play if the temperature of the air is reduced to 8°C? (Neglect expansion of the pipe itself.)

14. Guitars are built such that the twelfth fret (usually a bar of metal on the neck of the guitar) is exactly midway along the lengths of the strings. Guitarists have learned that touching the string *very gently* at this fret will force a node to occur at that point. A guitar string which is 64 cm long with a linear density of $4.466\,\frac{\text{grams}}{\text{meter}}$ is strung with a tension of 88.5 Newtons. If a guitarist applies gentle pressure on the twelfth fret under such a string, what frequency will it produce?

15. An ambulance is headed directly towards a man standing in the middle of the street. The ambulance's siren has a frequency of 600 Hz. It is a lovely day (for everyone except the person for whom the ambulance was dispatched) with a temperature of 24° C and no wind. The ambulance is traveling at $27\,\frac{meters}{second}$.

a. What frequency is perceived by the man?

b. Another man is on the same street but riding a bicycle traveling in the same direction as the ambulance at a speed of $7\,\frac{meters}{second}$. What frequency does he perceive?

c. What frequencies are perceived by each of the two people above when the ambulance is moving *away* from them?