Please answer at least 3 of the following 4 problems. Written answers (no typing necessary) are due at the end of the class period. If you like, you may work in groups of 2 people.

1. One of the most important (and least appreciated) functions of a city government is the creation and enforcement of a building code. Without a standard code, people would be at the mercy of possibly unscrupulous construction contractors who might cut corners in terms of safety to reduce costs.

   An example of this code is regulations on where and how holes can be bored in the joists that hold up the floors of a house. Figure 1 shows examples of safe, and unsafe holes drilled into two joists.

   Question: Why are these holes are comparatively safe or dangerous?

   Solution: In a beam, the edges of the board stretch or compress considerably more than the center of the board. This stretching/compression is what gives a beam its strength. If you cut holes in the edge of a board, the board is weakened, because it can no longer stretch along the edge. City code generally says that holes can only be cut out of the center third of a board for this reason.

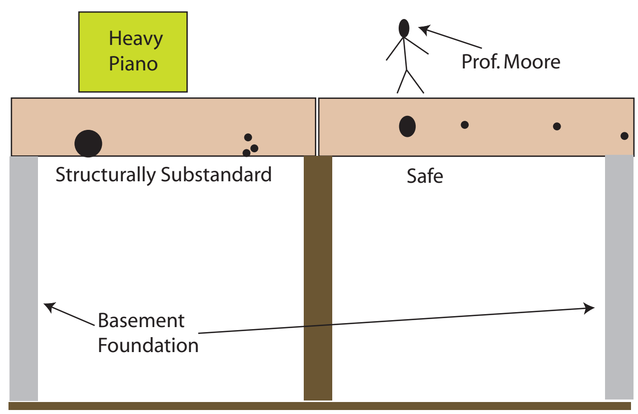

Figure 1: This not-to-scale model of a house shows safe and unsafe examples of holes that can be bored in floor joists.

2. One of your friends, who is majoring in sculpture at WSU, wants to make a sculpture that swings back and forth with a tunable frequency, essentially a grandfather clock that keeps variable time. After hearing about the work you've done lately in this class, he asks you for your help in designing the sculpture.

   Question: The specific question he has is how to design a clock pendulum which has variable oscillation time, ie, a person can make the clock cycle every 2 seconds, 3 seconds, 10 seconds, etc. To make your advice useful, provide a detailed description of how the clock should be configured if it is to give a clock cycle time of "T" seconds.

Solution: If you took data in class, you would have seen that the time it takes a pendulum of length L to swing through a cycle, T, scales as, $T \propto \sqrt{L}$. Your friend would need to find the proportionality constant and then use this equation to design a pendulum.

3. **Question:** If you put 6 pennies in a closed film container and the drop the container in water, how will you know when the film container reaches its equilibrium position?

   Solution: when the film canister stops moving, it will be in equilibrium.

   Question: If you want to add pennies to see how the equilibrium state of the canister changes, what variable or coordinate will you use to describe the equilibrium? (Be sure to explain why your choice is a good one!)

   Solution: If you want to measure how equilibrium changes, you need to figure out which of the things that change with the system can be measured accurately. The height of the canister in the water is fairly easy to measure, but because of the odd shape of the container, it would be mathematically challenging to relate its depth to equilibrium. A better choice would be the height of the water the container floats in, as this can be accurately measured, and also is easy to relate to the density of the container (which determines the equilibrium position).

   Question: What forces create this equilibrium? How do you know that these forces are the ones creating the equilibrium (ie what experimental test could you perform to show that they're the relevant ones)?

   Solution: Equilibrium is made by forces that balance. The downward forces of the weight of the pennies and the weight of the container are balanced by the upward forces of the weight of the water the container displaces (which is equivalent to the water pressure at the bottom of the container). To see that these are indeed the correct forces, you'd have to perform a controlled experiment, in which only one variable was changed (ie the number of pennies) and then the height of the water column (the equilibrium position) changed in the way you predicted it to change.

   Question: If you dropped the film container in corn oil rather than water, how would the equilibrium position compare to that of the film container in water?

   Solution: As corn oil floats on water, it is less dense than water. Since the upward force on the container is the weight of the fluid displaced by the container, and since oil is less dense than water, the upward force from the oil would be smaller, and the equilibrium position would be lower in the water.

4. One day last year in Physics 221 I brought in a pair of running shorts (size large) and suspended them from a horizontal bar. I attached a mass hanger to the bottom of the shorts and measured the extension of the waistband as the suspended mass changed. The results of that measurement are shown in figure 2.

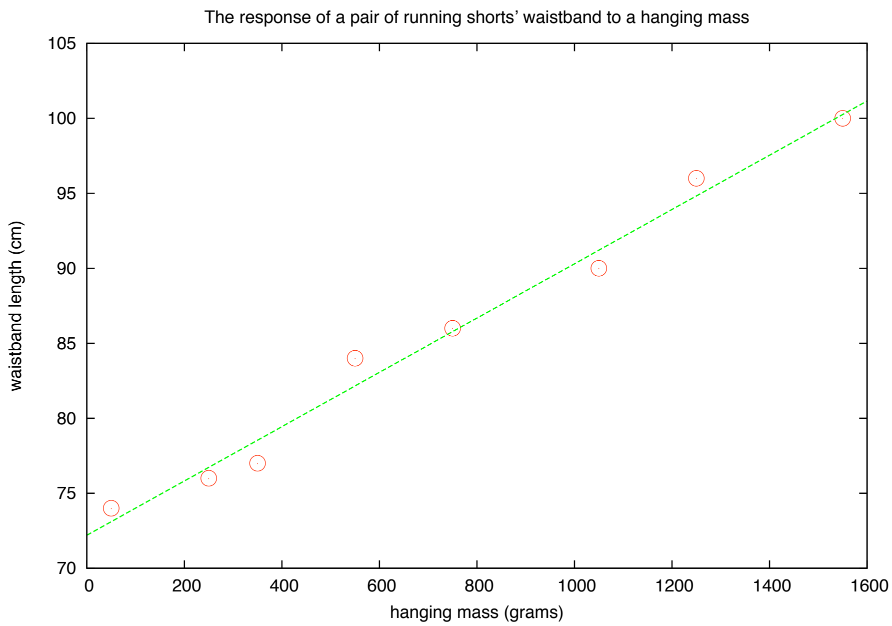

Figure 2: You may have made a similar figure while investigating springs. The "spring" being analyzed is actually the waistband of a pair of running shorts which is quite Hookean at small extensions.

The line of best-fit included in this figure is,

$$w = am + b$$

where,

$$\begin{aligned} w &= \text{the waistband length (cm)} \\ a &= 0.0181 \text{ cm/gram} \\ m &= \text{the hanging mass, (grams)} \\ b &= 72.24 \text{ cm} \end{aligned}$$

Question: If you were to perform the same experiment with a pair of shorts, size small, how would the graph change?

Solution: To understand how the graph changes, you first have to understand the graph. When there is no weight on the shorts, they don't stretch. From the graph then, you see that the relaxed length of the waistband is the y-intercept of the fit line, $b = 72.24cm$. Since small shorts have a shorter waistband, one can assume that the same sort of graph for small shorts would have a y-intercept that's closer to the x-axis (perhaps $b = 65cm$). Would the slope of the graph be the same? The best way to see is to perform some experimental measurements.

Question: Why is it hard to put on clothes that are too small? Be specific in terms of your understanding of elasticity.

Solution: An item of clothing that is too small has to stretch more to accommodate the same sized body. As you may have seen experimentally, the force exerted by a spring grows as the spring is stretched, so a bigger stretch means a larger force is required.