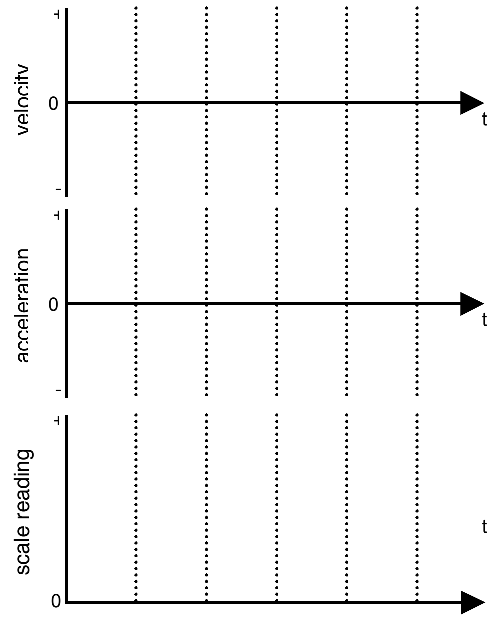
FORCES LAB

Part 1: The elevator

In this short experiment, you will discover what happens as you ride an elevator. You will place a mass on a scale and observe what happens to the scale's reading as you ride the elevator. Before coming to lab, make some predictions:

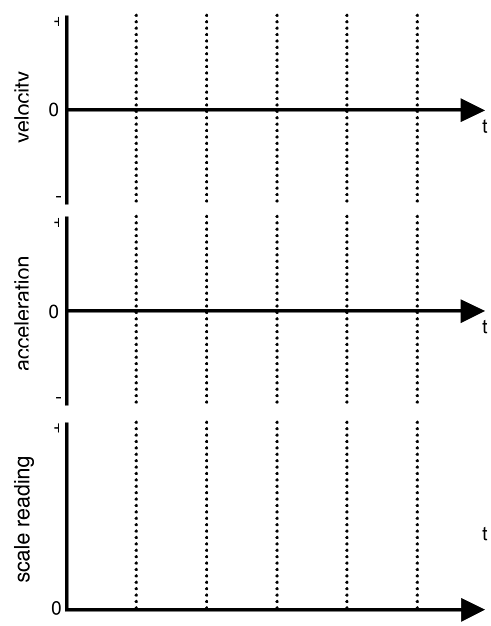
Going up:

Sketch your prediction of velocity, acceleration and scale reading as a function of time for a ride from the 1st floor to the 2nd floor from the time the elevator starts moving until it is at rest on the second floor on the axes provided. Label important events (such as "elevator starts moving," "elevator stops speeding up") on your graph. Explain the reasoning behind your predictions for acceleration and scale reading.



Going down:

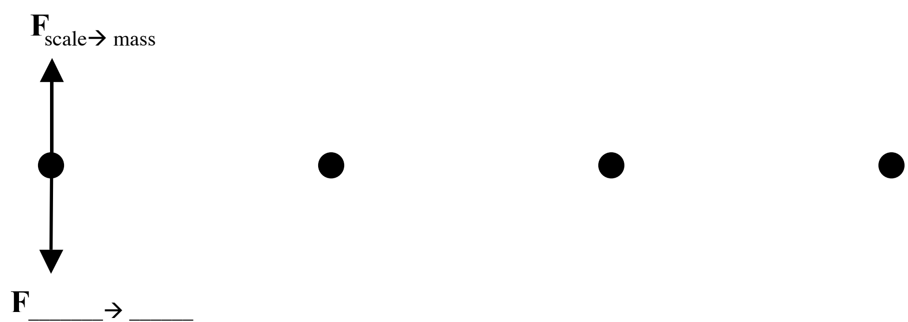
Sketch three prediction graphs for a downward ride from the 2nd floor to the 1st.



Before lab, sketch a free body diagram for the mass sitting on the scale during each phase of the upward ride. (There should be three diagrams). Label each force completely. Each force label should clearly indicate the object being pushed (or pulled) and the object doing the pushing (or pulling). For example, the force of the scale pushing on the mass would be written as $F_{scale \rightarrow mass}$ (see example below). Each arrow should indicate the direction of the force. The length of the arrow should indicate the strength of the force. Keep the same scale for all three force diagrams; two forces of equal magnitude should be drawn the same length, even if the two arrows appear on different diagrams. Complete the force diagrams below.

Force diagrams during different parts of an upward ride (prediction):

Scale at rest **Speeding up** **Constant speed** **Slowing down**



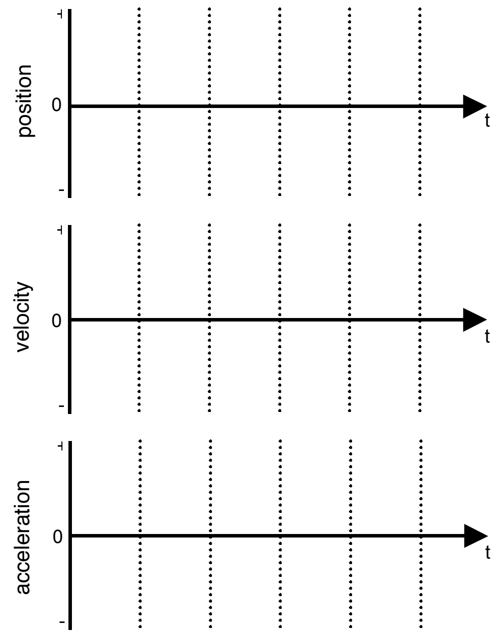
Before lab, think about what the scale measures. Some students think the scale measures net force. Is this correct? Explain. (Hint: Can you think of any situations where the scale reads something even though the net force on the scale is zero?) What does the scale actually measure? Explain your answers.

Take data to test your prediction concerning the scale's reading. Record the scale's readings. Compare your data to your prediction. If your observations do not match your predictions, figure out why.

Use your data to estimate the acceleration of the elevator during each phase of the two rides. Are these values consistent with your predictions? If your observations do not match your predictions, figure out why.

Can you estimate the speed of the elevator using the scale's readings? Explain.

Part 2: A single coffee filters



In this short experiment, you will investigate the flight of a falling coffee filter. Before you come to lab, make some predictions:

Single coffee filter

A single coffee filter is dropped from rest. Sketch your prediction of velocity, acceleration and position as a function of time for the filter, from the time is released until the filter is at rest on the ground. Label important events on your graph. Explain the reasoning behind your prediction for acceleration.

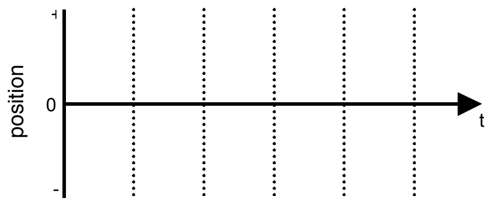
Before lab, sketch a free body diagram for the single coffee falling through the air at three different instants:

- immediately after release
- after release, but before the filter stops speeding up, and
- after the filter stops speeding up.

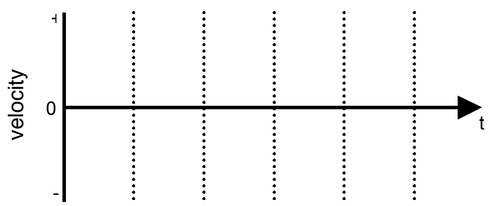
As before, label each force vector completely. Clearly label each force by indicating the object being pushed/pulled and the object doing the pushing/pulling (e.g. $F_{earth \rightarrow filter}$).

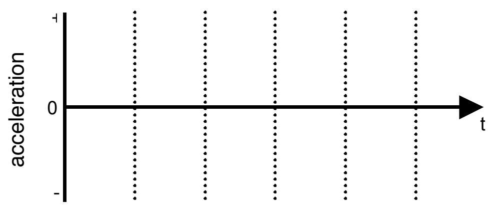
Make sure each vector has a length that corresponds to the strength of the force. Use the same scale for your vectors on all three diagrams. Are your force diagrams consistent with your predictions about the acceleration of the filter? Explain.

To check your predictions, you will use an ultrasonic position detector connected to a computer. Double click on the file “coffee.ds” to set up the computer. Position the coffee filter under the detector and click the green start button. Release the coffee filter. Click on the stop button after the filter hits the ground. Check the data against your prediction. Explain any discrepancies. (Note: The computer gives you position versus time data, not velocity versus time). Sketch the position versus time graph the computer displays on the axis below. Try to include all important features.



Use the position versus time graph to fill in velocity vs. time and acceleration vs. time graphs below. (You should be able to this without any calculations).





Notes about the ultrasonic detector: The detector works by emitting a sound and “listening” for the reflection. The “position” reported by the detector is simply the distance from the object to the detector. The detector is not reliable for distances less that about 15 cm or for distances beyond about 2 m.

Part 3: Stacks of coffee filters

Which takes longer to fall: a single coffee filter or a stack of coffee filters? The answer seems obvious, but how can you support this claim with actual data? In this part of the lab, you will learn how to use data to justify a claim.

All measurements are uncertain (to some extent). Even if the same measurement is taken twice, it's unlikely that the result will be exactly the same each time. Repeating a measurement gives valuable information:

- Repeats give a better estimate of the measurement than just taking the measurement once.
- Repeats provide valuable information about how reliable the measurement process is.

Both of these are important. The first one is common sense. The second one is crucial for justifying scientific claims. In order to claim that two numbers are different, a scientist must establish that the data is reliable enough to support the claim.

Before taking data to find out if a single filter takes more time to fall a given distance that a stack of two filters, think about how to get the best data. Should you time the filters over a large distance or a small one? Explain your reasoning. How many times should you make each measurement? Explain the reasoning behind your choice.

Take data. Use your data to support (or refute) the following claim: One filter takes the same amount of time to fall a certain distance as a stack of two filters.

If there's time…

What is the mathematical relationship between the final velocity of the filter and the number of coffee filters in the stack? In this section, you'll take data to answer this question.

Take time data for stacks of filters, varying the number of filters in the stack. Take data for five to ten different stacks. Use your data to make a graph of velocity* versus number of filters. Is the graph linear? a parabola? a square root curve? How do you know? How can you support this claim?

* You can only estimate the final velocity of the stack. The simplest method is to calculate the average velocity. (Why is this method only approximate? Will this estimate of the final velocity be too low or too high? Explain.)