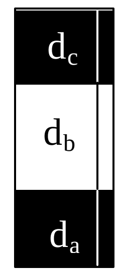
Lab A3: *FREE FALL ACCELERATION*

8/29/03

Goal: To use the definition of acceleration to directly measure an object's free fall acceleration

Introduction: A direct measurement of the free fall acceleration requires the measurement of the velocity of a falling object at two instants of time as well as the measurement of the time interval between these two instants. If the two velocities are denoted $\mathbf{v_i}$ (which occurs at time $\mathbf{t_i}$) and $\mathbf{v_f}$ (which occurs at time $\mathbf{t_f}$), the acceleration is given by $\mathbf{a} = (\mathbf{v_f} - \mathbf{v_i})/(\mathbf{t_f} - \mathbf{t_i})$.



In practice, $\mathbf{v_i}$ and $\mathbf{v_f}$ must each be determined by timing the fall of the object through a short distance. In this experiment, the timing is left to a computer, triggered by the passage of the object through a photogate. The object is a strip of Plexiglas divided into three regions (see diagram). Two opaque regions of lengths, d_a and d_c, are separated by a longer transparent region of length, d_b. The strip is held vertically and dropped through a photogate, consisting of a diode which emits infrared radiation and a transistor which detects that radiation. As the strip falls through the photogate, the light path is first blocked, then unblocked, then blocked, then unblocked.

The time intervals measured by the computer will be denoted as follows:

Δt_a = the time interval from the instant when edge O passes through the photogate to the instant when edge A passes through the photogate,
Δt_b = the time interval from the instant when edge A passes through the photogate to the instant when edge B passes through the photogate,
Δt_c = the time interval from the instant when edge B passes through the photogate to the instant when edge C passes through the photogate.

Prepare the pre-lab individually as you would a homework assignment. During the lab, each student will take two trials each of their own data and will write their own report. This is an individual--not a group--lab.

Pre-lab: Answer the questions thoroughly so that you will be prepared to take data and be able to complete your report within a single class period.

Use the symbols Δt_a, Δt_b, Δt_c , d_a, d_b and d_c as defined above.

1) The velocity $\mathbf{v_i}$ is determined by dividing the width of the region d_a by Δt_a. The velocity $\mathbf{v_f}$ is determined by dividing the width of the region d_c by the corresponding time interval Δt_c. Are these velocities, $\mathbf{v_i}$ and $\mathbf{v_f}$, average or instantaneous velocities? Explain.

2) Why are we choosing to measure average velocities here in this lab instead of instantaneous velocities (which is what we need in the formula for acceleration above)?

3) Now imagine that a clock starts running (t = 0) at the instant that edge O passes by the photogate. Assume that the clock reads time=0 initially. Using the symbols Δt_a, Δt_b, Δt_c as defined above, what time does the clock read when
a) edge A passes by the photogate?
b) edge B passes by the photogate?
c) edge C passes by the photogate?

4) Even though $\mathbf{v_i}$ is an average velocity, the strip actually has this velocity at a certain instant of time (as read by the clock). At what instant $\mathbf{t_i}$ (in terms of Δt_a, Δt_b, Δt_c) does the strip have this velocity? Explain your answer and use a v-t graph as well as words.

5) According to the clock, at what time $\mathbf{t_f}$ (in terms of Δt_a, Δt_b, Δt_c) does the strip have velocity $\mathbf{v_f}$? Explain your choice.

6) Combining your results from questions 1,4 and 5 and using the definition of acceleration, write an equation for the acceleration of the strip in terms of d_a, d_c, Δt_a, Δt_b, Δt_c only.

Setup: The photogate should be connected to the DIG/SONIC1 port of a LabPro interface box. . Follow the instructions below to use the computer.

1) Open the Logger Pro 3.1 software

2) Click on the LabPro button. In the popup window, double click on the DIG/SONIC1 box, Choose Sensors, and select Photogate. Click on Done.

3) Under Experiments, go to Data Collection and change the sampling rate to 10,000 samples/sec.

You are now ready to collect data.

Data collection procedure:

1) Sketch the strip the way you will hold it before dropping. Note which end is labeled "1". Measure the lengths of the three regions on the strip to the nearest 0.0005 m and record them next to the corresponding regions on your sketch.

2) Place a piece of foam or a soft-bottom box on the floor where you intend to drop the Plexiglas strip. This is to keep the strip from breaking when hitting the floor. Hold the strip vertically just above the gate. Click on the Collect button. Release the strip and note the four times that appear in the data table on the screen. Record the results in a data table like the one below, then do another drop and record the new data. If, for either drop, the strip does not fall vertically, ignore the data and try again. Once you have data for two good drops, go on to the analysis.

Time (s):	Drop 1	Drop 2
1		
2		
3		
4		

3) The times you recorded are the clock times when edges O, A, B and C passed through the photogate. In your lab book, show how you use these clock times to calculate the time intervals Δt_a, Δt_b and Δt_c. Record your results in a table like the one below.

Time (s):	Δt_a	Δt_b	Δt_c
Drop 1			
Drop 2			

Analysis:

1) Restate your formula for acceleration from pre-lab #6.

2) Using your three time intervals and the formula that you obtained in the pre-lab, calculate the acceleration of the strip. Show your substitutions clearly, and round your results to the correct number of significant figures.

3) Find the % difference between the expected value for the free fall acceleration and your experimental value. Give one reason each why your experimental result might be (a) lower or (b) higher than the expected value. Explain why/how your reasons result in a value lower or higher than expected. Avoid giving minor reasons and things that you could have easily corrected (such as mistakes in calculations, breaking the beam prematurely).

Summary:

Include a concise summary/conclusion to your lab, as always.