

# General Science 1110L Lab

## Lab 2: Acceleration of Gravity Lab (Picket Fence)

**Object:** To measure the acceleration of a freely falling body due to gravitational attraction.

**Apparatus:** IBM compatible computer running Windows 7, LoggerPro 3.8.\* data acquisition software, LabPro interface box, Photogate, and picket fence.

### Theory:

A. Object in Free Fall

B. Please refer to the theory section in the Human Response Time Lab handout.

C.) The photogate and the picket fence

Provided for this experiment will be a computer-controlled photogate and a "picket fence." The photogate is an instrument (see figure) that senses if an object that absorbs light is located between the two arms of the instrument. Essentially, one arm has a light emitting diode that's presence is detected by a photodiode located in the other arm. (A light emitting diode is an electronic device used in many electronic components. In TVs, VCRs computers, etc., LEDs are use to indicate whether the power is on or off. They come in many colors. Blue ones are used to read the information on DVDs and BluRay disks.

If something blocks the flow of light, the photogate alerts its computer controller of this fact. The picket fence is simply a strip of alternating dark-and-clear plastic. If one, for example, drops the picket fence between the arms of the photogate, then the photogate would alternately report to the computer either that the gate was blocked, or unblocked depending on how far the picket fence had fallen. This simple experiment will be the key to measuring  $g$ .

The picket fence is a piece of clear plastic with black stripes painted on it at different intervals along the plastic. The distance from the leading edge of one stripe to the next leading edge is 5 cm.



PICKET FENCE

## PHOTOGATE



### THE EXPERIMENTAL STUP



### PROCEDURE

1. Turn on the computer. Ask for assistance, if there are difficulties with this step. Now, please plug the photogate into the LabPro channel one. Make sure that the LabPro interface is plugged into its power supply and is turned on. It is important that this be done before the LoggerPro application is loaded.
2. After the computer is turned on, and Windows desktop it has completely booted, do the following: Load the LoggerPro 8.3.\* application, by double clicking on its icon.
- 3 Once LoggerPro 8.3.\* has loaded we need to load the proper experiment file.
4. **To load the correct experiment.** Choose Open from the File menu option. When the next window opens choose **Physics with Vernier** from the list of files that can be opened. From the list of possible experiments in the Physics with Vernier folder select **Exp. 05 Picket Fence Free Fall**.

5. If at this point, the computer asks if you would like to save any changes, please say "NO". This is usually what needs to be done, so if this question is asked again, please just say "NO". If you have any questions, just ask for assistance.

6. After Picket Fence Free Fall is loaded, a set of instructions of where to plug in the photogate and helpful advice will appear. Please read them, and when you are finished click the "OK" button.

7. Using the mouse click on the Insert menu and choose table. A data table will appear. Now choose the Page menu and choose Auto Arrange and the data table will be placed to the left of the two graphs. One graph is the Distance vs. Time graph and the other is the Velocity vs. Time Graph.

8. Now that everything is up and running, test out your apparatus to be sure that the photogate is working properly. First, look at the bottom of the screen and find the words "Gate 1: Unblocked." Now, put your hand between the arms of the photogate. The words should now read, "Gate 1: Blocked." Remove your hand, and the words should change back to "Unblocked." When the gate is blocked, a red LED light, located on the side of one of the photogate's arms, should illuminate. If you feel there is something wrong with the equipment, please ask for assistance.

9. Now that the equipment checks out, you are ready to begin the actual experiment. Before you begin, here are some cautionary words. You will be essentially dropping the plastic picket fences. Notice that the floor of the lab is concrete. **THE PICKET FENCES WILL BREAK IF DROPPED FROM THE HEIGHT OF THE TABLE TO THE FLOOR.** Please put the cardboard box provided with each experimental setup on the floor to break their fall. This box has soft material in it for this purpose

10. Now, position the photogate so that it hangs over the side of the table above cardboard box with the soft material. Now, using the mouse to press the green button labeled "Collect" on the top of the screen. Wait a few seconds (the button will turn red), and then drop the picket fence through the photogate. (Hold the picket fence about an inch above arms of the photogate and release it cleanly) (If it was not done automatically, now press the "Stop" button located where the "Collect" button previously was. There should be data points in both windows, as well as numbers in your data table.

11. **Do not let the picket fence brush the arms of the photogate as it drops through.**

12. **Make sure the stripes are horizontal as the picket fence falls through the arms of the photogate.**

13. You **CAN NOT** wait an infinite amount of time to drop the picket fence through the arms of the photogate. The computer will get tired of waiting for this to happen and will time out after about 15 seconds.

**14. Note the approximate shape of each of the two curves (in the Distance vs. Time and Velocity vs. Time windows). Do they have the same shape? Are they linear, parabolic or exponential fits of your data or something else? Record your opinions in the results section of your report.**

## DATA ANALYSIS

1. Ask the computer to analyze the data. Click on "Velocity vs. Time" graph. Click the "ANALYZE" menu option. Choose the "Curve Fit" option.
2. Choose a Linear fit equation from the list of possible fit equations  $\{y=mt+b\}$ . Using the mouse, click on the "TRY FIT" Button.
3. The coefficients  $m$  and  $b$  that fit your data will appear in the boxes in the window.
4. Close the window.
5. The Best Fit equation to your data set will appear in a small window on top of your graph.
6. Record the value for the slope  $m$  and the  $y$  intercept  $b$  into your data table Number 1.
7. Drop the picket fence through the photogate 5 more times, recording the values for  $m$  and  $b$  each time. **For only one of your six trials record the time and velocity data from the data table on the computer screen into a second data table [Table #2] in your lab notebook.**
8. Find the average value of  $g$  (which is the average value of the slope  $m$ ) using the individual values given to you by the computer. Find the error in  $g$  using the method for finding the standard deviation given to you in section 7 of the handout of Errors and Data Analysis.  
Report this value as  $g_{\text{avg}} \pm \Delta g$  in your results section.
9. Compare the experimental value,  $g_{\text{avg}}$  to the true value for  $g$  ( $9.81 \text{ m/s}^2$ ). Is the agreement good?  
Find the percentage difference between you data and the accepted value for  $g_{\text{avg}}$ . (See how you found a per cent difference between an experimental result compared to a true result from the Human Response Time lab). Report this value in the results section.
10. Take the Velocity and Time data from Table #2 and plot the Velocity data on the Y axis (Dependent Variable) and the Time data on the X axis (Independent Variable) of your 10mm to the cm graph paper.. Using two points on the straight line (**NOT ORIGINAL DATA POINTS**) calculate the slope of the straight line. Compare this value for  $g$  to the average value for  $g$  obtained from the computer. Include this value for  $g$  in your results section of the report. Fold the graph paper in half and tape into your lab notebook on a clean sheet.



## Lab Report Format:

Your lab report for this experiment should contain the following sections:

1. Title of experiment in center of the first page. Date to the left of the title. Experimenters name with partners name(s) under experimenters name to the right of the title.
2. Objective
3. Apparatus
4. Original Data: Neatly filled out data page.
5. Sample calculations and Graph: For this lab an example (ONE) calculation needs to be shown for each of the following:  $m_{\text{average}}$  ( $g_{\text{average}}$ ),  $b_{\text{average}}$ , slope of best fit straight line to the hand plotted Velocity vs. Time data for one of your 6 trials,  $\Delta g$ , the % difference between  $g_{\text{average}}$  and the true value of  $g$  given in the handout.
6. Results: State your results (in the form of very short sentences). Make sure the numerical results are properly rounded and have the correct number of significant digits. Give your experimental value for  $g$  ( $g_{\text{avg}}$ ) and its error ( $\Delta g$ ) from the computer. How does your experimental value for  $g$  compare to the true value given in the hand out (% error). How does is the value for  $g$  from the hand plotted data compare to the value of  $g$  obtained by the computer from the same data set?
7. Conclusions: Address the answers to the three discussion questions below.

## Questions

1. What are the most important error sources in this experiment? Give type and examples that apply to this particular experiment?
2. The intercept of the velocity plot is usually non-zero. Give two possible reasons for the non-zero intercept. What does the Y intercept represent?
3. How is it going to affect your results for  $g$  if the strips of the picket fence are not kept horizontal during free fall?

## PROPER MATERIALS, ETC. FOR YOUR REPORTS

1. ALL DATA IS TO BE RECORDED DIRECTLY IN YOUR LAB NOTEBOOK. **NO SCRATCH PAPER IS TO BE USED.**

2. YOU ARE TO USE BLUE OR BLACK INK ONLY FOR RECORDING DATA AND DOING YOUR REPORTS IN YOUR NOTEBOOK.

3. REMEMBER, ONLY THE FRONT OF THE PAGES IN YOUR LAB NOTEBOOK ARE

**TO BE USED FOR DOING YOUR LAB REPORT. I WILL NOT LOOK AT ANY INFORMATION ON THE BACKSIDE OF THE NOTEBOOK PAGES.**

**4. DO NOT TEAR OUT ANY PAGES FROM YOUR NOTBOOK.**

**1. DO NOT ERASE OR USE WHITEOUT FOR MISTAKES!!!!**

**All observations taken under the same experimental condition are equally valid and should be retained for analysis. Do not erase readings. If you must change a reading, draw a single line through it and then record the new measurement next to the old one.**