PHYSICS 183
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 98SE, LoggerPro data acquisition software, ULI interface box, picket fence and photogate.

Theory:
A) Object in Free Fall
We say an object is in *free fall* when the only force acting on it is the earth's gravitational force. No other forces can be acting; in particular, air resistance must be either absent or so small as to be ignored. When the object in free fall is near the surface of the earth, the gravitational force on it is nearly constant. As a result, an object in free fall accelerates downward at a constant rate. This acceleration is usually represented with the symbol *g*.

Physics students measure the acceleration due to gravity using a wide variety of timing methods. In this experiment, you will have the advantage of using a very precise timer connected to the computer and a Photogate. The Photogate has a beam of infrared light that travels from one side to the other. It can detect whenever this beam is blocked. You will drop a piece of clear plastic with evenly spaced black bars on it, called a Picket Fence. As the Picket Fence passes through the Photogate, the computer will measure the time from the leading edge of one bar blocking the beam until the leading edge of the next bar blocks the beam. This timing continues as all eight bars pass through the Photogate. From these measured times, the program will calculate the velocities and accelerations for this motion and graphs will be plotted.

B) **Also please refer to the identically named section in your lab manual and textbook**.

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 Infrared LED (Diode) that's presence is detected by a photodiode located in the other arm. 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.
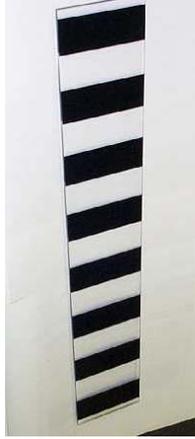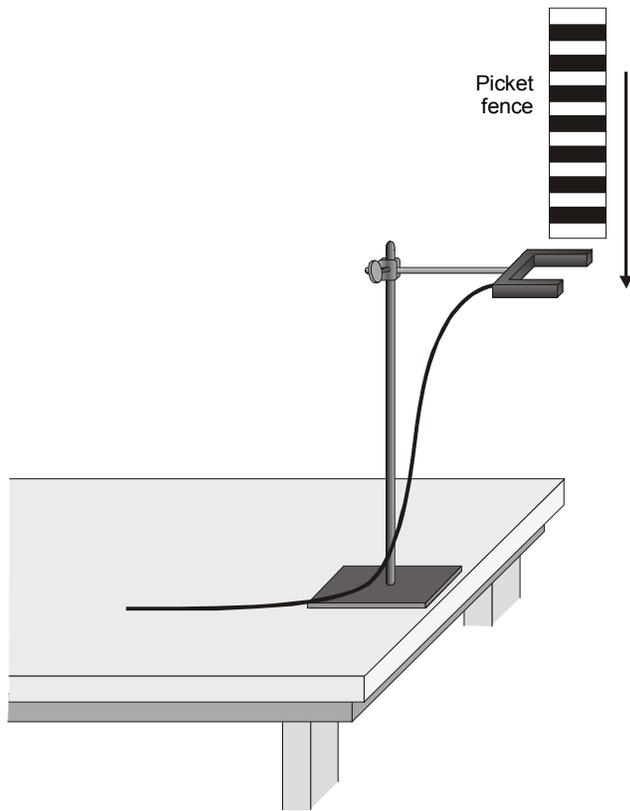
Picket fence

Photogate
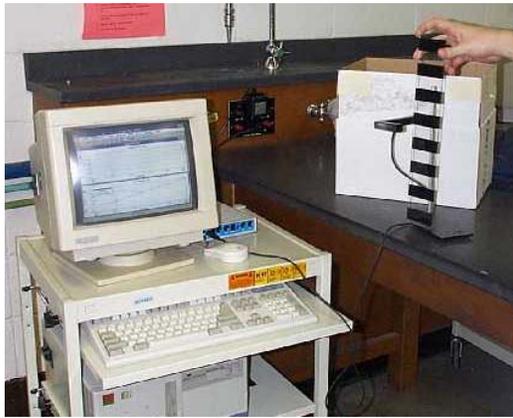
The experimental set-up

PRELIMINARY QUESTIONS

1. Inspect your Picket Fence. You will be dropping it through a Photogate to measure *g*. The distance, measured from one edge of a black band to the same edge of the next band, is 5.0 cm. What additional information will you need to determine the average speed of the Picket Fence as it moves through the Photogate?

2. If an object is moving with constant acceleration, what is the shape of its velocity *vs.* time graph?

3. Does the initial velocity of an object have anything to do with its acceleration? For example, compared to dropping an object, if you throw it downward would the acceleration be different after you released it?

PROCEDURE

1. Turn on the computer. Ask for assistance, if there are difficulties with this step. Now, please plug the photogate into the ULI box's DG1 port. Finally, be sure that the ULI box 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 98 desktop it has completely booted, do the following: Double click on the Vernier Software icon. Once the Vernier Software window has popped up, load the LoggerPro application, by again, double clicking on its icon.

3 Once LoggerPro 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 Computers** from the list of files that can be opened. From the list of possible experiments in the Physics With Computers 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 and helpful advice will appear. Please read them, and when you are finished click the "OK" button.

7. Next go to the Window menu at the top of the page and select. New Tall Window and then select Table. This is a table of time versus distance, velocity and acceleration values that the computer records when you drop the picket fence through the photogate. You will need this data from one of your six trials to plot the Velocity vs. Time data by hand.

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 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 button labeled "Collect" on the top left of the screen. Wait a few seconds, and then drop the picket fence through the photogate. 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. 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, exponential or something else? Record your opinions.

DATA ANALYSIS

12. Ask the computer to analyze the data. Click on "Velocity vs. Time" graph. Click "ANALYZE" menu option. Choose "LINER FIT" option.

13. As a result of the analysis you will see a box with equation **y=mx+b**. Record the values for **m and Δm** and **b and Δb**. in Table #1 in your lab notebook What do these quantities represent?

14. Drop the picket fence through the photogate 5 more times, recording the values for m and Δm, and b and Δb each time. **For 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 manual.**

15. Find the average value of g. using the individual values given to you by the computer. Find the average error in g using the 6 values for Δm. Report the experimental value of the Acceleration of Gravity as $g_{avg} \pm \Delta g_{avg}$ in the results section of your report.

16. Compare the experimental value, g_{avg} to the "true" value for g (9.81 m/s^2). Is the agreement good? Find the percentage difference/error between you data and the accepted value for g. Report this value in the results section of your report.

$$\text{Percent error} = \{(9.81 \text{ m/s}^2 - g_{average} \text{ m/s}^2) / 9.81\text{m/s}^2\} \text{ X } 100\%$$

17. Plot you Velocity (Y variable) vs. Time (X variable) data a piece of 10 mm to the cm linear graph paper. Find the slope of a straight line drawn through your data points. Report this value in the results section. **(NOTE: DO NOT USE ORIGINAL DATA POINTS TO CALCULATE THE SLOPE)** How does the value for g obtained by this method compare to $g_{average}$ calculated from your computer data? Do another percent error calculation using the computer average value of g as the "true" value. Report this value in the results section of your report too.

Questions

1. The intercept of the velocity plot is usually non-zero. Give two reasons for the non-zero intercept.

2. How is it going to affect your results if the strips of the picket fence is not kept horizontal during free fall? You might want to find out the answer by purposely dropping the picket fence diagonally.

DATA TABLE #1 Acceleration of Gravity

Trial #	(Slope and error in slope) m & Δm	Y intercept and error in y intercept b and Δb
1		
2		
3		
4		
5		
6		

Data Table #2 Velocity vs. Time for Trial No._____

Velocity	Time