

Activity P05: Acceleration of a Freely Falling Picket Fence (Photogate)

Concept	<i>DataStudio</i>	<i>ScienceWorkshop (Mac)</i>	<i>ScienceWorkshop (Win)</i>
Linear motion	P05 Free Fall.ds	P06 Free Fall Picket Fence	P06_FALL.SWS

Equipment Needed	Qty	Equipment Needed	Qty
Photogate/Pulley System (ME-6838)	1	Universal Table Clamp (ME-9376)	1
Picket Fence (ME-9377A)	1		

What Do You Think?

The purpose of this activity is to determine the acceleration due to gravity by measuring the time of fall of a picket fence dropped through a photogate. Can an object have an increasing velocity and a constant acceleration? Can the velocity of an object be zero at the same instant its acceleration is non zero?



Take time to answer the 'What Do You Think?' question(s) in the Lab Report section.

Background

Neglecting air resistance, an object falls a distance proportional to the square of the time.

$$d \propto t^2$$

Galileo was the first to derive this mathematical relationship. He asserted that for a given location on Earth, all objects fall with the same uniform acceleration. This acceleration is commonly referred to as the **acceleration due to gravity**, and it is given the symbol ***g***. This value is approximately $g = 9.8 \text{ m/s}^2$.



SAFETY REMINDER

- Follow all safety instructions.

THINK SAFETY
ACT SAFELY
BE SAFE!

For You To Do

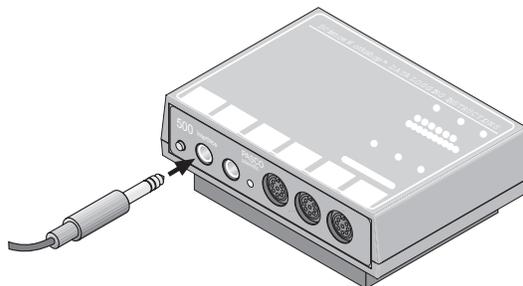
Drop a "Picket Fence" (a clear plastic strip with uniformly spaced opaque bands) through a Photogate. Each opaque band on the 'Picket Fence' blocks the Photogate beam and the time from one blockage to the next becomes increasingly shorter. Knowing the distance between the leading edge of each opaque band, the *DataStudio* or *ScienceWorkshop* program calculates the average speed of the Picket Fence from one band to the next. The slope of the graph of average speed versus time gives the acceleration of the falling object.

 Prediction: Sketch a prediction below of a velocity vs. time graph for a freely falling object.



PART I: Computer Setup

1. Connect the *ScienceWorkshop* interface to the computer, turn on the interface and then turn on the computer.
2. Connect the Photogate's stereo phone plug to Digital Channel 1 on the interface.
3. Open the document titled as shown:

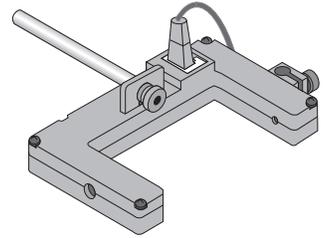


<i>DataStudio</i>	<i>ScienceWorkshop</i> (Mac)	<i>ScienceWorkshop</i> (Win)
P05 Free Fall.ds	P06 Free Fall Picket Fence	P06_FALL.SWS

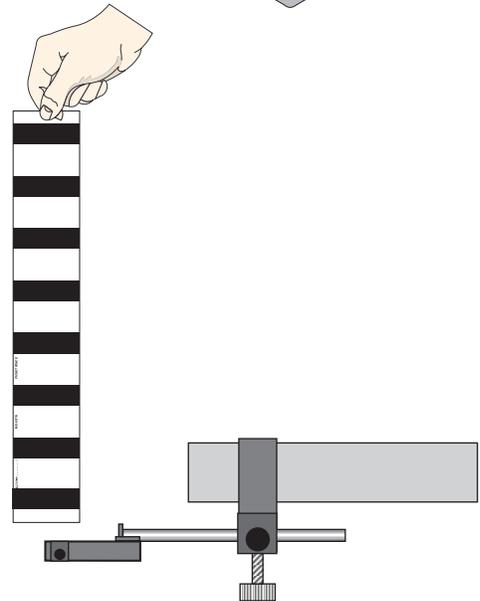
- The *DataStudio* document has a Workbook display. Read the instructions in the Workbook.
- The *ScienceWorkshop* document opens with a Graph display that has plots of Position and Velocity versus Time and a Table of Position, Velocity, and Acceleration versus Time.

PART II: Sensor Calibration and Equipment Setup

- You do not need to calibrate the Photogate.
1. The program assumes a 5 centimeter (0.05 m) spacing, leading-edge-to-leading-edge, for the opaque bands on the Picket Fence. To change the default setting to another value, double-click on the Photogate & Picket Fence icon in the Experiment Setup window to open the Sensor Setup window. Enter the correct value for the spacing of the opaque bands on your Picket Fence. Click OK to return to the Experiment Setup window.
 2. Set up the equipment as shown. Mount the Photogate on the Pulley Mounting Rod. Turn the Photogate head sideways so that you can drop a Picket Fence vertically from above the Photogate and have the Picket Fence move through the Photogate's opening without hitting the Photogate.

**Trial Run of Data**

1. Before recording data for later analysis, experiment with the Photogate and Picket Fence.
 - It is recommended that an old article of clothing, carpet sample, or piece of cardboard be placed on the floor directly below the Photogate, so the Picket Fence has a soft place to land.
2. When everything is ready, start recording data. Drop the Picket Fence vertically through the Photogate. Data recording begins when the Photogate beam is first blocked. **Stop** the recording once the Picket Fence has passed completely through the Photogate.
3. Rescale the data to fill the Graph window.
4. Erase your trial run of data.



PART III: Data Recording

1. Prepare to drop the Picket Fence through the Photogate beam again. Hold the Picket Fence at one end between your thumb and forefinger so the bottom edge of the Picket Fence is just above the Photogate beam.
2. Start recording data and then drop the Picket Fence through the Photogate beam. Remember, data collection begins when the Photogate beam is first blocked.
3. After the Picket Fence passes completely through the beam, stop recording.

Analyzing the Data

1. Set up your Table display so it shows the values of position, velocity, and acceleration.
2. If necessary, rescale the Graph to fit the data.
3. Examine the plot of Velocity versus Time in the Graph display. Determine the slope of the 'best fit' line for velocity versus time.
 - Hint: In *DataStudio*, select 'Linear' from the 'Fit' menu (). In *ScienceWorkshop*, click the 'Statistics' button and then select 'Curve Fit, Linear Fit' from the Statistics menu ().
4. Apply Statistics to each column in the Table display to determine the 'Mean' value of acceleration.
 - Hint: In *DataStudio*, select 'Mean' from the 'Statistics' menu (). In *ScienceWorkshop*, click the 'Statistics' button (.
5. Record the value for the Mean of the acceleration, and the slope of the velocity vs. time in the Lab Report section.

Record your results in the Lab Report section.

Lab Report - Activity P05: Free Fall**What Do You Think?**

Can an object have an increasing velocity and a constant acceleration? Can the velocity of an object be zero at the same instant its acceleration is non zero?

Prediction: Sketch a prediction below of a velocity vs. time graph for a freely falling object.

**Data Table**

Item	Value
slope of velocity versus time	
acceleration (mean)	

Questions

1. How does the slope of your velocity versus time graph compare to the accepted value of the acceleration of a free falling object ($g = 9.8 \text{ m/s}^2$)?

- Reminder: percent difference = $\left| \frac{\text{accepted value} - \text{experimental value}}{\text{accepted value}} \right| \times 100\%$

2. How does the mean of the acceleration from the table compare to the accepted value of the acceleration of a free falling object ($g = 9.8 \text{ m/s}^2$)?

3. What factors do you think may cause the experimental value to be different from the accepted value?

Optional

- Determine whether releasing the Picket Fence from just above the Photogate or from several inches above the Photogate makes any difference in the value of the acceleration. Note that the Table and Graph displays will show the most recently recorded run of data. To view a different run of data, click on the DATA menu and select the data run you want from the list.

- Sketch a graph of velocity vs. time for an object falling from rest, taking into account air resistance.

