

## Experiment P06: Measuring the Acceleration of a Freely Falling Picket Fence (Photogate)

| Concept       | Time | SW Interface | Macintosh® file            | Windows® file |
|---------------|------|--------------|----------------------------|---------------|
| linear motion | 30 m | 500 or 700   | P06 Free Fall Picket Fence | P06_FALL.SWS  |

| EQUIPMENT NEEDED              |                          |
|-------------------------------|--------------------------|
| • Science Workshop™ Interface | • picket fence           |
| • photogate or Smart Pulley   | • table clamp (optional) |

### PURPOSE

The purpose of this laboratory activity is to determine the acceleration due to gravity by measuring the time of fall of a “picket fence” dropped through a photogate.

### THEORY

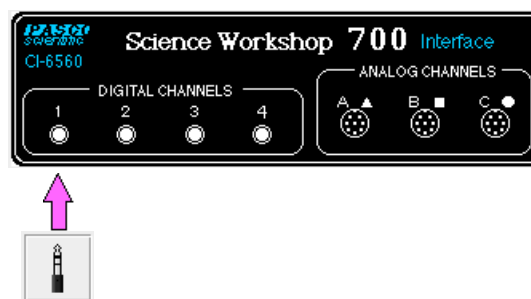
As an object falls freely, it accelerates due to the applied net force. If air resistance is neglected, and the speed of the object is measured over several short, consecutive intervals as it falls, the differences in the speed of the object can be used to determine the acceleration due to gravity.

### PROCEDURE

In this activity, a “picket fence” (a clear plastic strip with uniformly spaced opaque bands) drops through a photogate. The photogate beam is blocked by each opaque band and the time from one blockage to the next becomes increasingly shorter. Knowing the distance between the leading edge of each opaque band, the *Science Workshop* 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.

### PART I: Computer Setup

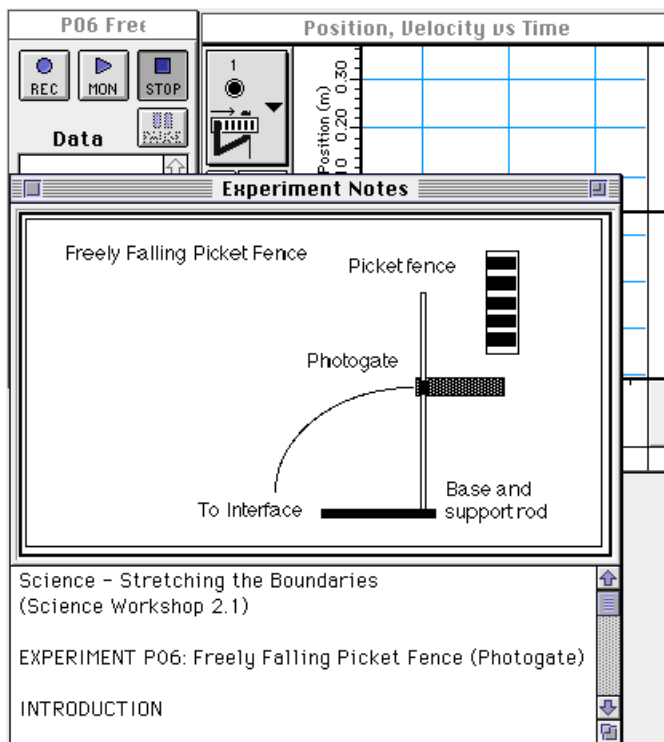
1. Connect the *Science Workshop* interface to the computer, turn on the interface and then turn on the computer.
2. Connect the photogate’s stereo phone plug to Digital Channel 1 on the interface.



3. Open the *Science Workshop* file titled as shown;

|                            |              |
|----------------------------|--------------|
| Macintosh                  | Windows      |
| P06 Free Fall Picket Fence | P06_FALL.SWS |

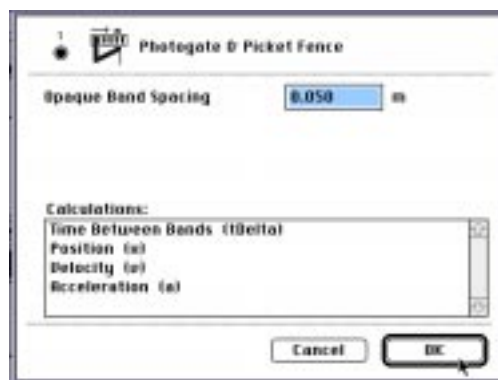
- The document opens with a Graph display that has plots of Position and Velocity versus Time and a Table of Position, Velocity, and Acceleration versus Time.
- Note: For quick reference, see the Experiment Notes window. To bring a display to the top, click on its window or select the name of the display from the list at the end of the Display menu. Change the Experiment Setup window by clicking on the **Zoom** box or the **Restore** or **Maximize** button in the upper right hand corner of that window.



- The **Sampling Options...** for this experiment are: **Periodic Samples = Fast at 10 Hz** and **Digital timing = 10000 Hz**.

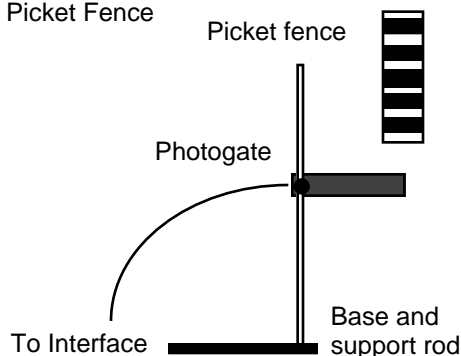
## PART II: Sensor Calibration and Equipment Setup

- You do not need to calibrate the photogate.
- The *Science Workshop* 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.






1. Turn the photogate head of the accessory photogate 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.

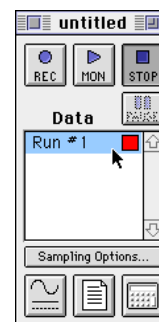
Freely Falling Picket Fence




(If you are using a Smart Pulley photogate, you may want to put the Smart Pulley's mounting rod horizontally in a table clamp and then fasten the clamp on the edge of a table. Again, turn the Smart Pulley photogate so that a picket fence can be dropped through the photogate's opening.)


### Preparing to Record Data

- Before recording any data for later analysis, experiment with the photogate and picket.
- Click the **REC** button () in the Experiment Setup window. Drop the picket fence vertically through the photogate. Data recording begins when the photogate beam is first blocked. Click the **STOP** button () to end recording of your sample data. Click the **Autoscale** button () in the Graph display.
- Erase your trial run of data. Select **Run #1** in the Data list in the Experiment Setup window...  
...and press the “Delete” key on the keyboard.




### PART III: Data Recording

1. Prepare to drop the picket fence through the photogate beam. 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. Click the **REC** button () and then drop the picket fence through the photogate beam. Remember, data collection begins when the photogate beam is first blocked.


3. When the picket fence is through the beam, click **STOP** () to end recording .
- The position, velocity, and acceleration values will appear in the Table display and **Run #1** will appear in the Data Sets list.

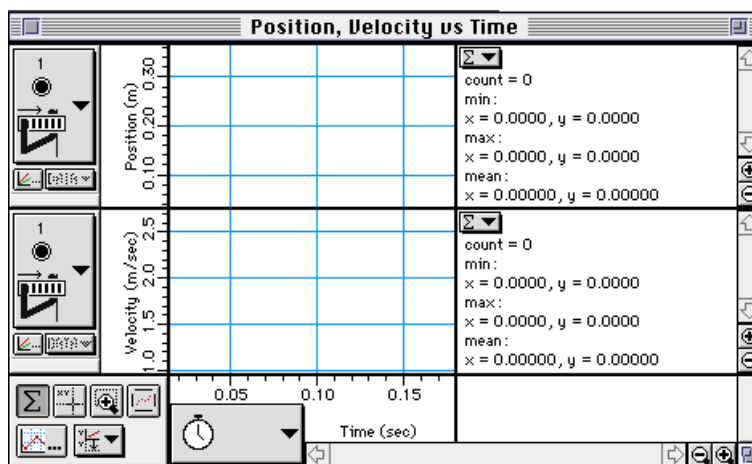
## ANALYZING THE DATA


1. Click the **Autoscale** button

() in the Graph display.  
The graph will automatically rescale to fit the data for position, velocity, and acceleration.

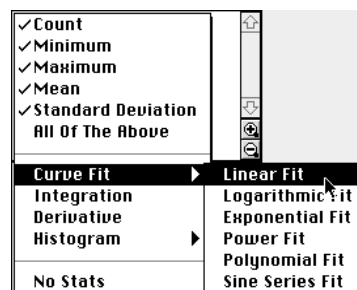
2. Click the **Statistics** button

() in the Graph display.  
The Statistics area opens on the right hand part of the graph.

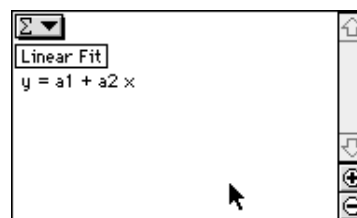


3. Examine the plot of Velocity versus Time in the Graph display. Determine the slope of the 'best fit' line for velocity versus time. To do this, click the **Statistics Menu** button () in the Stats area.


4. Select **Curve Fit, Linear Fit** from the Statistics Menu.



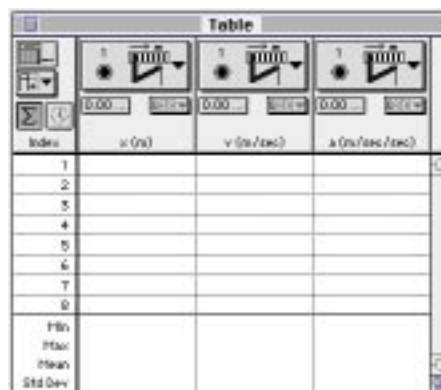
- The formula for the 'best fit' line ( $y = a_1 + a_2 x$ ) will appear in the Stats area.
5. The **a2** coefficient is the slope of the 'best fit' line. This slope is the value of the acceleration of the falling picket fence. Record this value in the Data Table.



6. Click the Table display. Click the **Statistics** button

() Statistics for Min (minimum), Max (maximum), Mean, and Std. Dev (standard deviation) will appear in the bottom rows of each table column.

7. Record the value for the Mean of the acceleration of the picket fence in the Data section.



| Index   | x (m) | v (m/sec) | a (m/sec/sec) |
|---------|-------|-----------|---------------|
| 1       |       |           |               |
| 2       |       |           |               |
| 3       |       |           |               |
| 4       |       |           |               |
| 5       |       |           |               |
| 6       |       |           |               |
| 7       |       |           |               |
| 8       |       |           |               |
| Min     |       |           |               |
| Max     |       |           |               |
| Mean    |       |           |               |
| Std Dev |       |           |               |

## DATA TABLE


slope of velocity versus time = \_\_\_\_\_ (from Graph display)

acceleration (mean) = \_\_\_\_\_ (from Table display)

## QUESTIONS

1. How does the slope of your velocity versus time plot 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

If time permits, repeat the data recording procedure several more times. Experiment with different methods for releasing the picket fence. 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.