# Freefall Picket Fence

## Introduction

A Picket Fence is a clear plastic strip with uniformly spaced opaque bands. Each opaque band blocks the photogate beam, and the time from one blockage to the next becomes shorter as the velocity of the falling Picket Fence increases. Using the known distance between the leading edge of each band, and the time interval between photogate blocks, the student calculates the average velocity of the Picket Fence for each interval. The slope of the graph of average velocity versus time gives the acceleration of the falling object.

## Equipment

| Qty | Items | Part Number |
|---|---|---|
| 1 | Photogate | ME-9498A |
| 1 | Picket Fence | ME-9377A |
| 1 | Mounting Rod | SA-9242 |
| 1 | Table Clamp | ME-9472 |
| 1 | Multi-Clamp | ME-9507 |
| 1 | 90-cm Rod | ME-8783 |
| 1 | No Bounce Pad | SE-7347 |

*Figure 1. Dropping a Picket Fence*

## Set-up

1. Fasten the Table Clamp and the 90 cm Rod to the edge of the table as shown in Figure 1.

2. Use the Multi-Clamp to fasten the Photogate to the vertical rod. The Mounting Rod (see Fig. 2) screws directly into the side of the Photogate. Make sure that the Photogate is high enough so that the Picket Fence can pass completely through before it reaches the table.

3. Plug the Photogate cord into Digital Input #1.

4. Position the yellow No-Bounce Pad (see Fig. 1) below the Photogate to protect the falling Picket Fence when it reaches the table.

5. Practice dropping the Picket Fence through the Photogate. Hold the Picket Fence at one end between thumb and forefinger, as shown in Figure 3. The Picket Fence must hang vertical, so that when it is released, it will fall straight without rotating. Make sure the bottom edge of the Picket Fence is just above the Photogate beam when you let go.

   Note: The procedure is easier if one person handles the Picket Fence and another operates the computer.

6. There is a built-in timer that will record the times that each opaque band blocks the photogate beam. Click on Timer Set-up in the palette at the left of the screen to view the set-up.

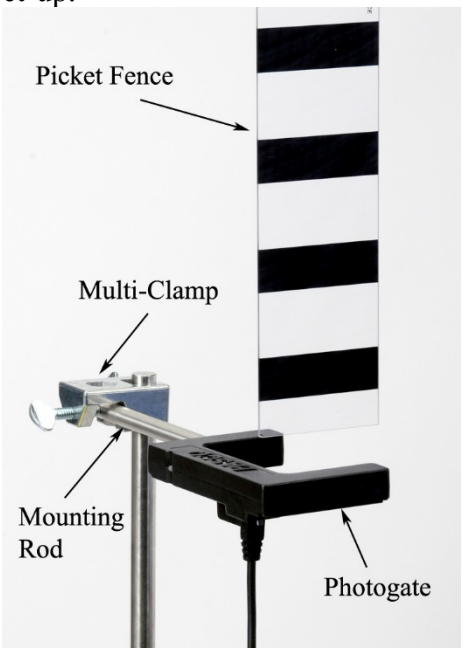


*Figure 2. Picket Fence Initial Position*

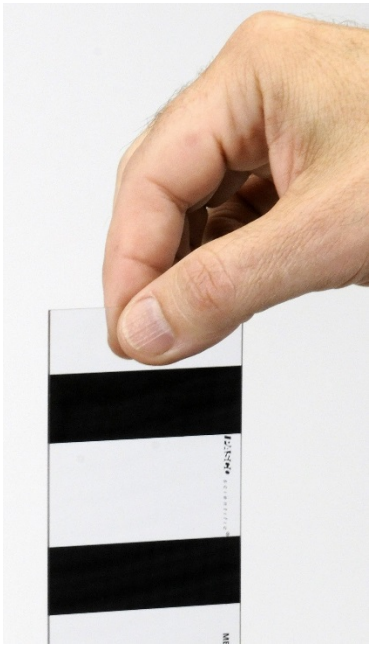

*Figure 3. Hold in Center*

Hold the Picket Fence at one end between thumb and forefinger, as shown. The Picket Fence must hang vertical, so that when it is released, it will fall straight without rotating. Make sure the bottom edge of the Picket Fence is just above the Photogate beam when you let go.

## Procedure

1. Taking Data
   a. Make a table and put the Block Times in the first column. Then create a user-entered data set named "Δt" with units of seconds. (Remember that you can get a Δ in Capstone by right-clicking where you are typing.) Create a new column and create another user-entered data set called "Average Time" with units of seconds. Create another column with another user-entered data set called "v=Δx/Δt" with units of m/s.
   b. Start recording data, then drop the Picket Fence through the Photogate. Stop recording data.

   c. If the Picket Fence hits the Photogate, or if it rotates too much, you should take another run. You should have seven entries in the data table. These are the times that each of the seven bands on the Picket Fence broke the Photogate beam.

2. Calculations
   a. Calculate the difference (Δt) between block times and enter them into the column in the table. Note that you may have to increase the number of decimal places in each column to see the difference between the numbers. You can do this using the tool at the top of the graph.
   b. Calculate the average speed of the Picket Fence during the time between the first and second block.
   $$v = \frac{\Delta x}{\Delta t} = \frac{\Delta x}{t_2 - t_1}$$
   where t is the time each block occurred. Δx is the spacing between the bands on the Picket Fence, and is measured from the beginning of one band to the beginning of the next. You can measure over several bands to get a more accurate value of Δx. Enter your calculated average speeds into the table. You will end up with only six average speeds in your table.
   c. To calculate the time that the average velocity actually occurred, calculate the average time between the Block Times. Add adjacent Block Times and divide by two. Enter these times into the table under Average Time.

3. Slope
   a. Create a graph of the user-entered v vs. Average Time. You may want to turn off the connected lines in the graph and perhaps make the data points bigger.
   b. Select a Linear Curve Fit from the graph toolbar.
   c. What is the physical meaning of the slope? Does it have units? What is the uncertainty in your value?
   d. Compare to the accepted value using the % error calculation.
   $$\%\ difference = \frac{Measured - Accepted}{Accepted} \times 100\%$$
   e. Was your value too high or too low? What might account for that?

## Analysis

In the previous sections, you used the Photogate only to measure the time of block, and then calculated the speeds by hand. The computer can also be configured to calculate these speeds automatically, allowing you to take multiple runs in a short period of time. This is set up in the Timer Setup, which you can open at the left of the screen to view.

1. Create a graph Speed (from the Picket Fence) vs. Time (listed under time in the drop-down list.

2. Start recording data, then drop the Picket Fence through the Photogate as before. Stop recording data.

3. The speed vs. time data for this run will be graphed at right. Select a Linear Curve Fit to find the acceleration as before.

4. Repeat several times to get an average value. Also record your highest value.

5. In the set-up procedure, you were instructed to start the Picket Fence as low as possible. This decreases the speed and lowers the amount of air drag. Try letting go of the Picket Fence higher up to see if you can affect the measured acceleration. Do you get a lower value?