

Free Fall Motion Lab

Introduction

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 either be 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 g .

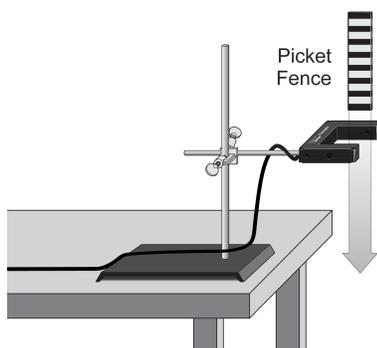
Materials

Computer
Graphical Analysis
Picket Fences
Vernier Photogate Picket Fence Clamp/Ring Stand
iPhone

Procedure

Part 1: The Picket Fence

1. Fasten the Photogate rigidly to a ring stand so the arms extend horizontally, as shown in the diagram. The entire length of the Picket Fence must be able to fall freely through the Photogate.

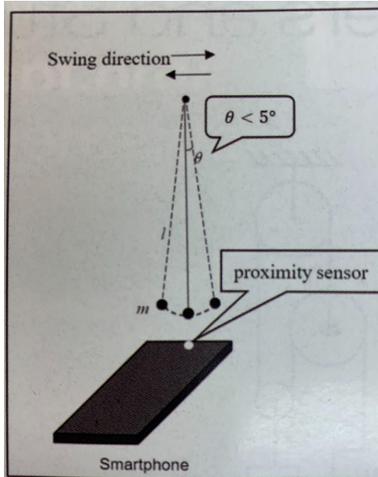


2. Connect the Photogate to your laptop, either by using the connection or through Bluetooth..
3. Open **Graphical Analysis**.
4. Click **COLLECT** to prepare the Photogate. Hold the top of the Picket Fence and drop it through the Photogate, releasing it from your grasp completely before it enters the Photogate. It must not touch the sides of the Photogate as it falls and it needs to remain vertical.
5. Examine your graphs. The slope of a velocity versus time graph is a measure of the acceleration. If the velocity graph is approximately a straight line of constant slope, then the acceleration is constant. If the acceleration of your Picket Fence appears constant, use a linear fit for your data.
7. To establish the reliability of your slope measurement, repeat the Picket Fence drop four more

times. Do not use drops in which the Picket Fence hits or misses the Photogate. Record the slope values in the Data Table.

Part 2: Mobile Device

1. Set up the pendulum apparatus so that the pendulum swings freely over the lab counter.



- 3. You will be using the small angle regime, where you vertically displace the pendulum by no more than 5 degrees. You do not need to measure this using a protractor.
- 4. Using your phone, record the time for 10 oscillations.
- 6. Note: One person should video your experiment. You should also screen shot your data.
- 7. Repeat for pendulum lengths of 0.4 m, 0.3 m, and 0.2 m.

Data

Part 1: Picket Fence

Trial	Slope (m/sec ²)
1	
2	
3	
4	
5	
Average	
Percent Error	

Part 2: Pendulum

Length (m)	Time, t (10 oscillations, sec)	Period, T (1 oscillation, sec)	T ² (sec ²)
0.5			
0.4			
0.3			
0.2			

Analysis

Part 1: Picket Fence

Note: Written responses should be no more than three sentences.

1. What is the shape of your position versus time graph? Is it consistent with the graph for an accelerating object?
2. What is the shape of your velocity versus time graph? Is it consistent with the graph for an accelerating object?
3. Use the position versus time graph and a parabolic fit to determine the experimental value for g. Enter the value in the data table below.
4. Use the velocity versus time graph and a linear fit to determine the experimental value for g. Enter the value in the data table below.
5. Would dropping the Picket Fence from higher above the Photogate change any of the parameters you measured? Why or why not?
6. Would throwing the Picket Fence downward, but letting go before it enters the Photogate, change any of your measurements. How about throwing the Picket Fence upward?

Part 2: Mobile Device

1. Using Graphical Analysis, Excel or Google sheets, create a graph of T² (sec²) v length (m).
2. Determine the slope of the best fit line.
3. Insert your graph below.
4. The period of a pendulum is given by the equation

$$T = 2\pi\sqrt{\frac{L}{g}}$$

The slope of the best fit line is equivalent to the expression:

$$T^2 = \left(\frac{2\pi}{f}\right)^2 L$$

$$y = m x$$

Use this expression to determine the experimental value for g. Enter your value in the table below.

Synthesizing Your Data

Experiment	Experimental Value of g	Percent Error
Graphical Analysis of Motion (Dropping the Tennis Ball)		
Picket Fence Lab (x v t)*		
Picket Fence Lab (v v t)*		
Mobile Device*		

* From picket fence and pendulum analysis.

1. Which experiment gave you the lowest percent error?
2. Are there any systemic errors that appear across all experiments?