

Main Topic	Motion
Subtopic	Acceleration due to Gravity
Learning Level	High
Technology Level	Low-High
Activity Type	Lab

Description: Measure the acceleration due to gravity in up to three different ways.

Required Equipment	Physics Workshop Gravity Lab, Workshop Stand, Stopwatch, Meter stick, Datalogger with Photogates
Optional Equipment	Motion Sensor

Educational Objectives

- Measure the acceleration due to gravity.
- Use different levels of technology for increasing accuracy.

Key Question

- What is the acceleration of an object in freefall?

Concept Overview

The first experiment will use very basic equipment to measure an important quantity, the acceleration of an object in freefall. This is also known as the acceleration due to gravity, or g . The acceleration due to gravity is nearly the same at all points on the earth's surface, 9.8 m/s^2 . You will compare your result to this accepted value.

The second experiment will use a datalogger and photogates to measure the acceleration due to gravity. The "picket fence" has been used since photogates were developed to measure acceleration. The "pickets" block the photogate in sequence, giving a series of velocity readings. Using the velocities and the times between those velocities, the datalogger (or the student) can calculate the acceleration of the picket fence.

The third experiment will use a datalogger and motion sensor (or sonic ranger) to measure the acceleration due to gravity.

Lab Tips

The second experiment requires dropping the picket fence as close to vertical as possible. If the fence deviates from vertical, the true length of the pickets passing through the photogate is changed and can drastically affect the calculations.



Gravity: Measuring g with a Stopwatch

Objective: To find the acceleration of an object in freefall.

Materials: Yellow ball, meter stick, stopwatch, calculator.

Background:

This experiment will use very basic equipment to measure an important quantity, the acceleration of an object in freefall. This is also known as the acceleration due to gravity, or g . The acceleration due to gravity is nearly the same at all points on the earth's surface, 9.8 m/s^2 . You will compare your result to this accepted value.

Procedure:

1. Choose one person to be the ball dropper.
2. Devise a way for the dropper to consistently drop the ball from one height (as high as you can; 4-5m if possible!) Record this height in every line of the left column in the table below.
3. Choose another person to be the timer, and a third to be the recorder.
4. Drop the ball from the designated height ten times, recording the time for each drop in the chart below. Be sure to time exactly from when the ball is released to when it strikes the floor.

Trial	Drop Distance (m)	Time (s)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

5. Find the average time. _____

Acceleration Due to Gravity
Gravity 1

Name: _____

6. When an object's moves with constant acceleration from rest, its displacement can be found by using the following equation:

$$d = \frac{1}{2}at^2$$

Manipulate the equation and solve for *a*.

7. Use the distance and average time from your experiment to find the ball's acceleration.

8. The accepted value for the acceleration due to gravity is 9.8 m/s². How does your experimental value compare to the accepted value? Calculate the percent difference.

$$\%difference = \frac{\text{experimental_value} - \text{accepted_value}}{\text{accepted_value}} * 100\%$$

9. Describe some probable sources of error in this experiment.



Gravity: Measuring g with a Photogate

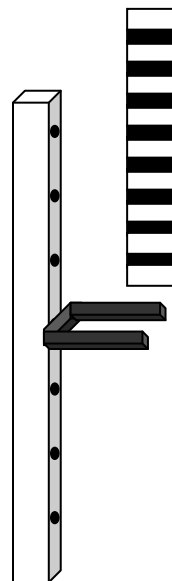
Objective: To find the acceleration of an object in freefall.

Materials: Picket Fence, Datalogger, Photogate, Workshop Stand or Ring Stand, Ruler, Computer, Calculator.

Background:

This experiment will use a datalogger and photogates to measure an important quantity, the acceleration of an object in freefall. This is also known as the acceleration due to gravity, or g . The acceleration due to gravity is nearly the same at all points on the earth's surface, 9.8 m/s^2 . You will compare your result to this accepted value.

The “picket fence” has been used since photogates were developed to measure acceleration. The “pickets” block the photogate in sequence, giving a series of velocity readings. Using the velocities and the times between those velocities, the datalogger (or the student) can calculate the acceleration of the picket fence.



Procedure:

1. Mount the photogate so that the picket fence can be dropped vertically through it.
2. If possible, program the datalogger to measure the velocity for 8 events and the total time since the first picket started to pass through the gate. For “length of flag,” enter the width of each picket (2cm). Record the velocities and times in the table below. (If this measurement is not possible with your datalogger, ask your teacher for sample data.)
3. Calculate the acceleration for each subsequent picket.

$$a = \frac{v_2 - v_1}{t}$$

Acceleration Due to Gravity
Gravity 2

Name: _____

Picket	Velocity (m/s)	Total time (s)	Acceleration (m/s ²)
1		0	n/a
2			
3			
4			
5			
6			
7			
8			

4. Find the average acceleration. _____
5. The accepted value for the acceleration due to gravity is 9.8 m/s². How does your experimental value compare to the accepted value? Calculate the percent difference.

$$\%difference = \frac{\text{experimental_value} - \text{accepted_value}}{\text{accepted_value}} * 100\%$$

6. One of the best ways to reduce errors in an experiment is to do many trials. Now program the datalogger to calculate the acceleration for the picket fence. Enter all of the relevant information and conduct six trials, recording the acceleration for each trial below.

Trial	Acceleration (m/s ²)
1	
2	
3	
4	
5	
6	

7. Cross out any obvious outlier values. (Outliers are experimental values that clearly reflect some type of error. For example, if your acceleration values

**Acceleration Due to Gravity
Gravity 2**

Name: _____

were 9.0, 9.2, 8.7, 8.8, 9.3, and 12.5, the last value can be eliminated from the average.)

8. Find the average acceleration. _____
9. The accepted value for the acceleration due to gravity is 9.8 m/s^2 . How does your experimental value compare to the accepted value? Calculate the percent difference.

$$\% \text{ difference} = \frac{\text{experimental_value} - \text{accepted_value}}{\text{accepted_value}} * 100\%$$

10. Compare the accuracy of this measurement method to the stopwatch method from the previous lab.

11. Describe some probable sources of error in this experiment. When possible, explain whether the error would cause the value for acceleration to be too high or too low.



Gravity: Measuring g with a Motion Sensor

Objective: To find the acceleration of an object in freefall.

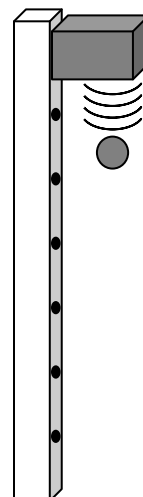
Materials: Yellow Ball, Datalogger, Motion Sensor, Workshop Stand or Ring Stand, Measuring Tape, Computer, Calculator.

Background:

This experiment will use a datalogger and motion sensor (or sonic ranger) to measure an important quantity, the acceleration of an object in freefall. This is also known as the acceleration due to gravity, or g . The acceleration due to gravity is nearly the same at all points on the earth's surface, 9.8 m/s^2 . You will compare your result to this accepted value.

Procedure:

1. Mount the motion sensor at least 1.5m above the floor, so that it points straight down.
2. Program the datalogger to record distance data for about 20 seconds and display the results as a line graph.
3. Hold the ball about 10cm below the motion sensor. Start the program and drop the ball, taking care to keep your hand out of the measurement path.
4. Pick up the ball and repeat the experiment several times, until the 20 seconds is up.
5. Inspect the resulting graph and choose one trial that has smooth, uninterrupted results. Select and display only that block of data.
6. Use the Function Wizard to create graphs of velocity and acceleration vs. time for that block of data.
7. Inspect the values for acceleration during the trial.
8. Select the part of the Acceleration graph that appears to be approximately constant (after the release and before impact). Use the Average tool (under Analysis) to find the average value for acceleration. Record the average acceleration _____.
9. Print a copy of the graph for each group member. Attach the graph to this worksheet.



Acceleration Due to Gravity
Gravity 3

Name: _____

10. The accepted value for the acceleration due to gravity is 9.8 m/s^2 . How does your experimental value compare to the accepted value? Calculate the percent difference.

$$\% \text{ difference} = \frac{\text{experimental_value} - \text{accepted_value}}{\text{accepted_value}} * 100\%$$

11. Compare the accuracy of this measurement method to the stopwatch method from the previous labs.

12. Describe some probable sources of error in this experiment. When possible, explain whether the error would cause the value for acceleration to be too high or too low.

