Acceleration Due to Gravity

**Physics 1050
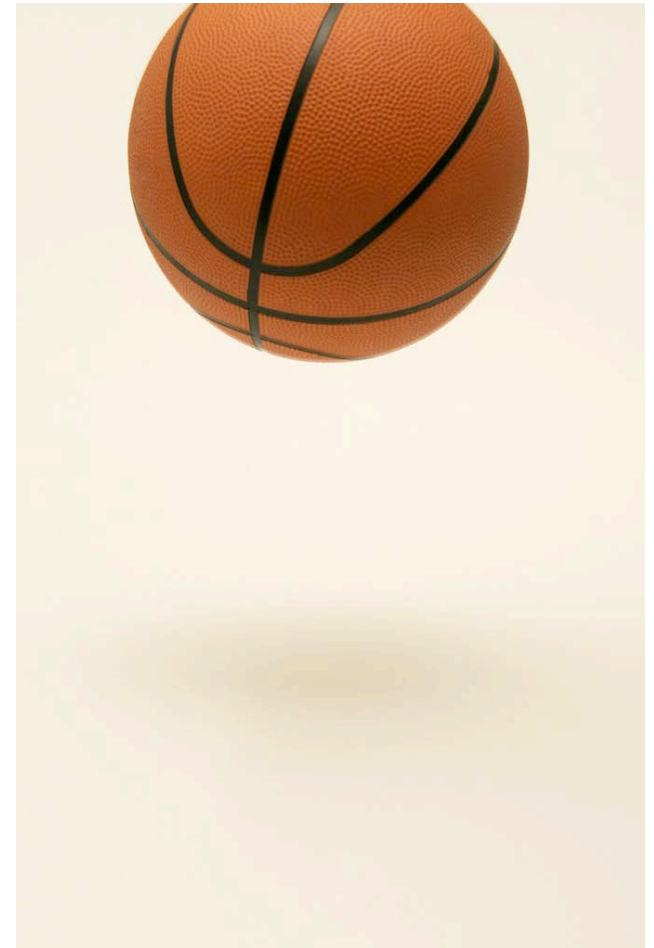Experiment 2**

Prelab Questions

These questions need to be completed before entering the lab.

Show all workings.

Prelab 1:

For a falling ball which bounces, draw the expected shape of the vertical position vs time graph.

Prelab 2:

From the position vs time graph of an object moving with constant acceleration, how could you find the instantaneous velocity?

Prelab 3:

Write, in a sentence or two, the objective of this experiment.

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Experiment 2**

Part I: Introduction

In this experiment you will study the motion of a falling ball which experiences constant acceleration.

You will use a *Motion Detector* to measure the position of the ball as a function of time. The motion detector is connected to the computer through a *LabPro* interface and controlled using *Logger Pro*. You will use this combination of hardware and software to generate graphs of distance, velocity, and acceleration as functions of time. The goals of this experiment are:

To represent the motion of an object through graphs of position, velocity, and acceleration versus time.

To investigate the relationship between displacement versus time, velocity versus time, and acceleration versus time representations of a given motion.

Part II: Apparatus

The apparatus for this experiment includes the following:

- Ball
- Balloon
- Motion detector
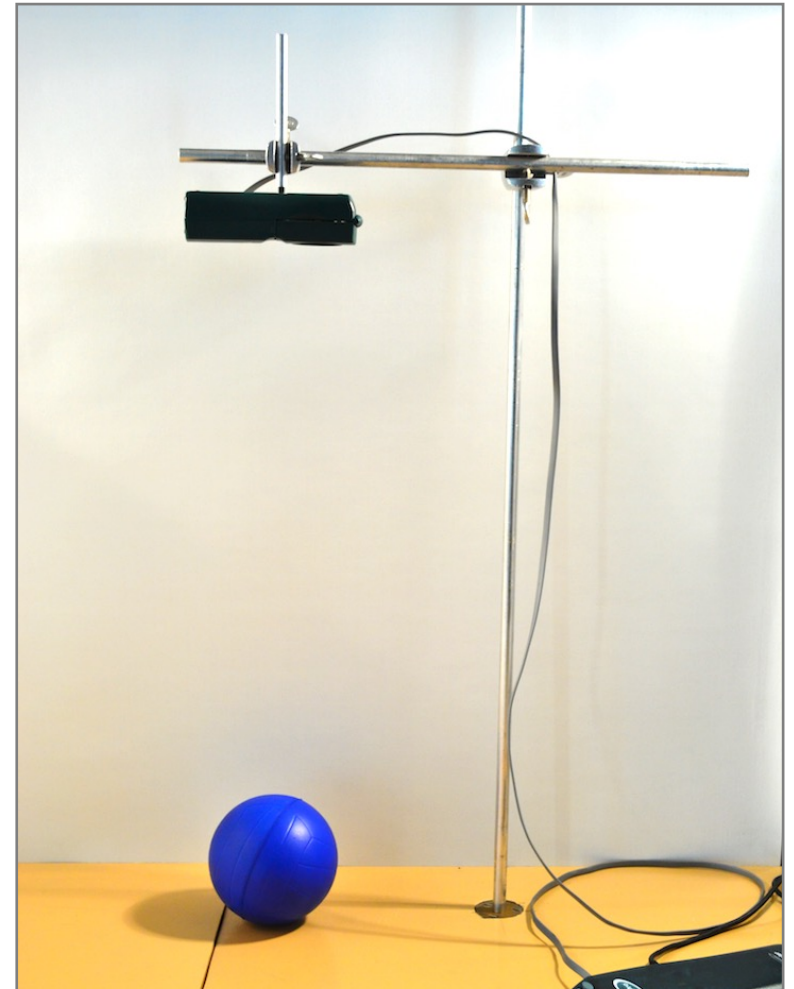- Support rods
- Clamps

Part II: Apparatus Setup

Assemble your apparatus as shown.

The motion detector only records position within a range of 0.15 - 6 m.

Be sure to remain within this range during the experiment.

Part III: Data Acquisition

Make sure that the LabPro is connected to the computer and that the motion detector is plugged into DIG/SONIC 1.

Click the icon to launch Logger Pro.

Logger Pro should open three graphs:

position *vs* time,

velocity vs time, and

acceleration vs time.

The time axis should have a maximum value of 3 seconds.

If *Logger Pro* does not contain these graphs, consult an instructor.

Part III: Data Acquisition

Before collecting data:

It's important to **zero** the motion detector relative to the benchtop. This allows *Logger Pro* to measure the distance the detector to the benchtop and use this as the zero position.

> Make sure the path from the detector to benchtop is
> clear of any obstructions.

Click **Experiment** then **Zero** from the menu at the top of the screen.

Part III: Data Acquisition

Hold the ball under the motion detector at a minimum distance of $0.15\ m$. Click the Collect button ▶ in *Logger Pro*.

Logger Pro will begin to collect data
(collection begins when the detector begins to "click" rapidly).

Release the ball smoothly directly underneath the motion detector and ensure your hands are clear of the path of the detector.

Logger Pro should now display three graphs representing the ball's motion: *position vs time*, *velocity vs time*, and *acceleration vs time*.

Do not print your graph yet!
Printing instructions are on the following slides.

Part IV: Data Analysis

Examine your data. Are they reasonable?

If not, repeat the experiment or consult an instructor.

Autoscale each graph by clicking on it then clicking ![autoscale icon] .

When you are happy with your data, save it!

Click **File**, **Save As**, and save the file to the **Desktop**.

CP | Have an instructor check your graph and initial your lab report.
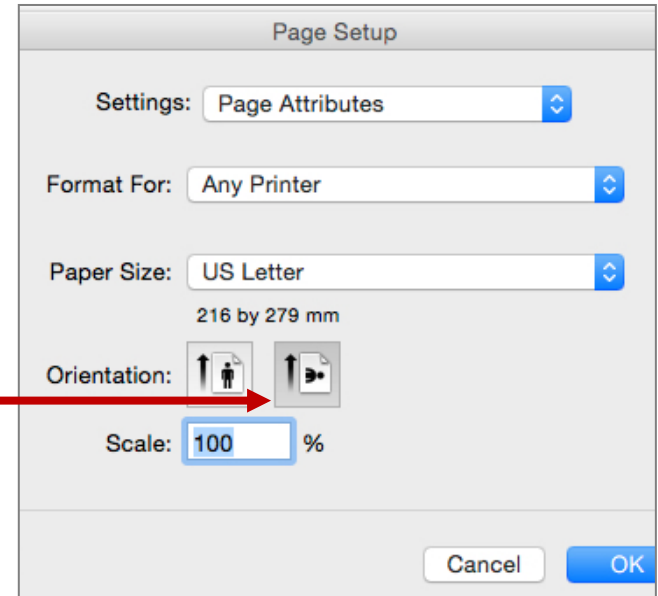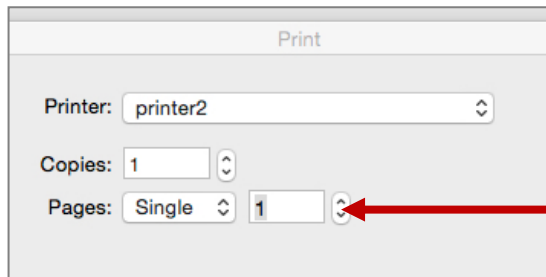
Q **QUESTION 1:** Did the shape of your position vs time graph on *Logger Pro* match your predicted graph from Prelab Question 1? Explain any differences.

Printing Your Graph

Click **File** then **Page Setup** and choose the landscape orientation.

Click **File** then **Print**.

To select the only necessary page:

Click Pages and choose Single.

Page Setup

Settings: Page Attributes

Format For: Any Printer

Paper Size: US Letter

216 by 279 mm

Orientation:

Scale: 100 %

Cancel   OK

Print

Printer: printer2

Copies: 1

Pages: Single   1

P

Staple your graph in your workbook.

Part IV: Data Analysis

In *Logger Pro*:

Display the coordinates in a box on the graph:

- Click on **a** graph to activate it.

- Click **Analyze** then **Examine** or click .

- Repeat for each graph.

Now, wherever you hover your mouse in the graph, a vertical line appears on the graph and a small pop-up window identifies the data values. This allows you to more precisely identify your data points.

Part IV: Data Analysis

LW On each of all three graphs, identify where the ball hits the table for the first time. **Label this A**.

LW On the position vs time graph and the velocity vs time graph, circle <u>one</u> region where the ball is in free fall and moving down. **Label this B**.

LW On the position vs time graph and the velocity vs time graph, identify <u>one</u> region where the object is in free fall and moving up. **Label this C.**

LW On each of all three graphs, identify <u>one </u>region where the motion changes from moving down to moving up. **Label this D.**

LW On each of all three graphs, identify one region where the motion changes from moving up to moving down. **Label this E.**

Part IV: Data Analysis

Click on any graph to activate it and use the **Analyze** then **Examine** function to:

Q **QUESTION 2:** Examine your position vs time graph and record the time, t_1, at which the ball first hits the table.

Also record t_2, the time at which the ball hits the table for the second time.

Q **QUESTION 3:** What are the position and velocity at time t_1?
Are these values expected? Comment.

By examining the velocity vs time graph in the region ***between t_1 and t_2***:

Q **QUESTION 4:** What is the maximum upward velocity?
What is the maximum downward velocity?
Are these two velocities related? Is this result expected?

Part IV: Data Analysis

The vertical displacement of a object in free fall is given by

$$y_f = y_i + v_{yi}t - \frac{1}{2}gt^2$$

This may be rearranged:

$$y_f = -\frac{1}{2}gt^2 + v_{yi}t + y_i$$

where y_i is the initial vertical displacement, v_{yi} the initial vertical velocity, g is the acceleration due to gravity.

You are going to fit your data points to a smooth quadratic curve of the form

$$y = At^2 + Bt + C$$

The above equations will serve as a guide in analyzing your results.
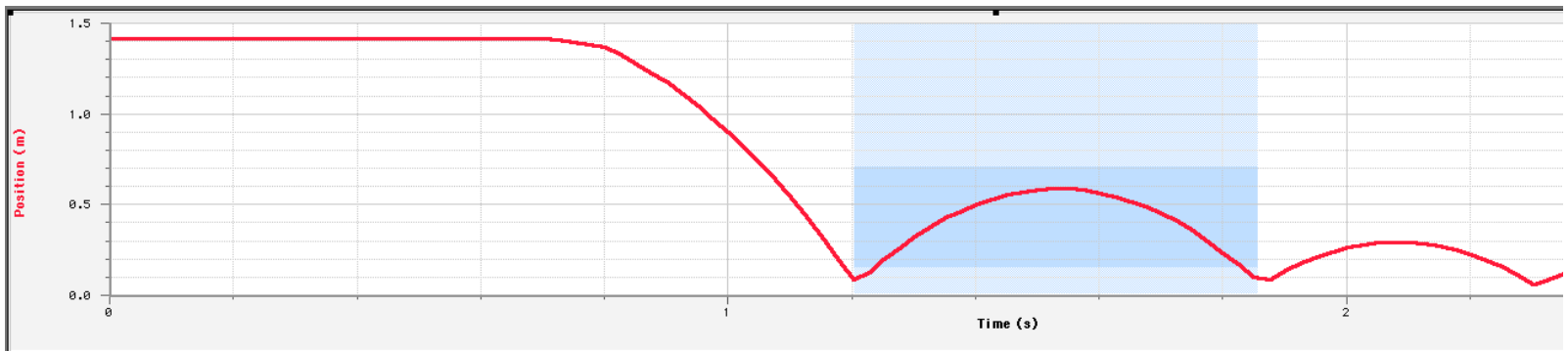
Part IV: Data Analysis

Q **QUESTION 5:** To what physical parameter does A in the fit equation $(y = At^2 + Bt + C)$ correspond? Explain or show your workings.

LW What value do you expect for parameter **A** (including units)? Record this value in **Table 1**.
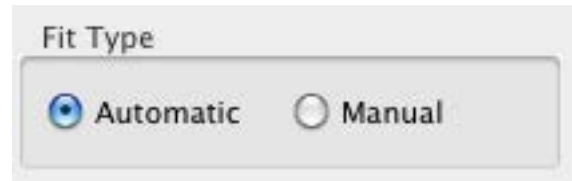
Click on your distance vs time graph to activate it.

Highlight the region between t_1 and t_2, i.e. the first "bump".

Part IV: Data Analysis

Click **Analyze** then **Curve Fit**.

Under **Options: Fit Type** select "Automatic"

Select *Quadratic* from the **General Equation** list and click **Try Fit**.

If the fit is satisfactory, click on **OK**. Enter the value of the Automatic best fit parameter **A** in **Table 1**.

Edit the title of the graph by double-clicking in the whitespace and entering an appropriate title.

LW

Part IV: Data Analysis

Q

QUESTION 6: How does your expected value of **A** match the displayed value of the automatic curve fit? Comment on any differences.

Q

QUESTION 7: From your automatic curve fit, what is the value of g and its uncertainty?

P

Print your graph (with fit parameters)
and include it with your lab report.

Part V: Data Acquisition and Analysis

Inflate your balloon until it is close to a round shape.

Repeat your experiment using the balloon, i.e., drop the balloon and use the computer to record the position as a function of time. You may need to lower the initial drop height of the balloon to capture its path.

Use *Logger Pro* to create an automatic fit to the position vs time data as before.

Do not print this graph!

Record your automatic fit parameter A in **Table 2**.

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Part VI: Summary

Q **QUESTION 8:** From your automatic curve fit, what is the value of the balloon's acceleration and its uncertainty? How does this value compare with the acceleration of the ball?

Q **QUESTION 9**: Write the range of the value of g found in Questions 7 and 8. How do these values compare with the accepted value of $g = 9.81m/s^2$? Comment on any differences.

Q **QUESTION 10**: Why do the ball and balloon have different accelerations?
Hint: Think carefully about the forces acting on each object.

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Part V: Summary

Q **QUESTION 11:** List at least three uncertainties in this experiment. Classify them as random or systematic.

Q **QUESTION 12:** Write a brief paragraph summarizing the experiment and your findings. Comment on how we use uncertainty to determine if values are in agreement.

Ensure that you have completed all **Tables** and answered all **Questions** completely.

Attach your printed **graphs** to the appropriate pages.

Submit your workbook to the appropriate shelf/box as directed.