Acceleration Due to Gravity

Kinematics: linear motion, acceleration, free fall, graphing	GLX setup file: **free fall**

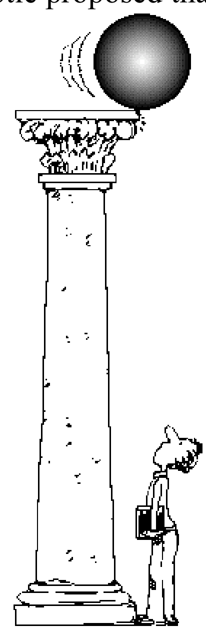
Qty	Equipment and Materials	Part Number
1	PASPORT Xplorer GLX	PS-2002
1	PASPORT Motion Sensor	PS-2103
1	Large Base and Support Rod	ME-9355
1	Rod, 45 cm	ME-8736
1	Double Rod Clamp	ME-9873
1	Tape Measure, 1.5 m	PM-8761
1	Ball, rubber	

Purpose

The purpose of this activity is to measure the acceleration due to gravity of a falling object.

Background

Over twenty-two centuries ago, a Greek philosopher and scientist named Aristotle proposed that there is a natural force that causes heavy objects to fall toward the center of Earth. He called this force “gravity”. In the seventeenth century, the English scientist Isaac Newton was able to show that gravity is a universal force that extends beyond Earth. It is the force that causes the moon to orbit the Earth and the Earth to orbit the Sun.



When an object is in “free fall”, the only force acting on it is the force of gravity. As an object falls freely, it accelerates. For a falling object near the surface of Earth, the rate of change of velocity is a constant value. This value is the acceleration due to gravity. If you ignore air resistance, a falling ball accelerates as if it is in free fall. You can measure the motion of the falling ball to find the value of the acceleration due to gravity.

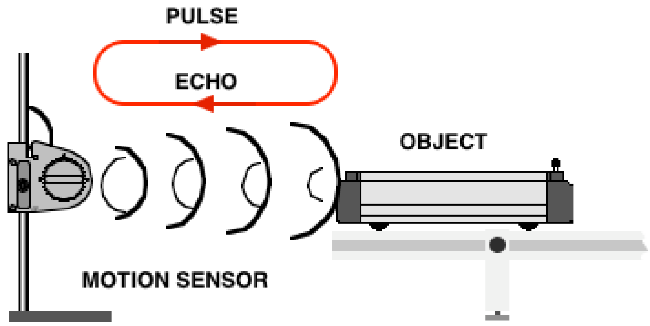
Safety Precautions

- Follow all directions for using the equipment.

Preview

Use the Motion Sensor to measure the motion of a ball as it falls and bounces.
Use the Xplorer GLX to record the motion and display and analyze the position and velocity of the ball. Use the velocity versus time graph to find the acceleration of the ball.

About the Motion Sensor



The Motion Sensor sends out pulses of ultrasound and picks up the echoes of ultrasound that bounce back from objects in front of it.

The software program keeps track of the time when the pulses go out and the time when the echoes come back. One-half of the round trip time is the time that it took for the ultrasound to reach the object. Since ultrasound travels at the speed of sound (about 344 meters per second or about 770 miles per hour), the program figures out how far away the object is as follows:

$$\text{distance to object} = \frac{\text{round-trip time}}{2} \times \text{speed of sound}$$

The speed of sound through air depends on several factors, including the temperature of the air. Because the temperature of air can change, the speed of sound can change. You can calibrate the Motion Sensor so it uses an accurate measurement of the speed of sound.

Procedure

GLX Setup

Fig. 1: Motion Sensor setting

1. Turn on the GLX (⏻) and open the GLX setup file titled **free fall** (check the Appendix at the end of this activity).

- The Graph screen opens with a graph of Position (m) versus Time (s). The setup file is set to measure position at 40 Hz (40 measurements per second).

2. Connect the Motion Sensor to one of the sensor ports on the top end of the GLX. Put the range selection switch on the top end of the Motion Sensor to the 'far' (person) setting.

Equipment Setup

1. Make sure that the floor is level. If it is not, put a hard flat surface on the floor and put pieces of paper or shims under the edges of the hard flat surface to level it.
2. Adjust the position of the Motion Sensor on the support rod so that the sensor is about 1.5 meters above the floor. Aim the sensor at the floor.

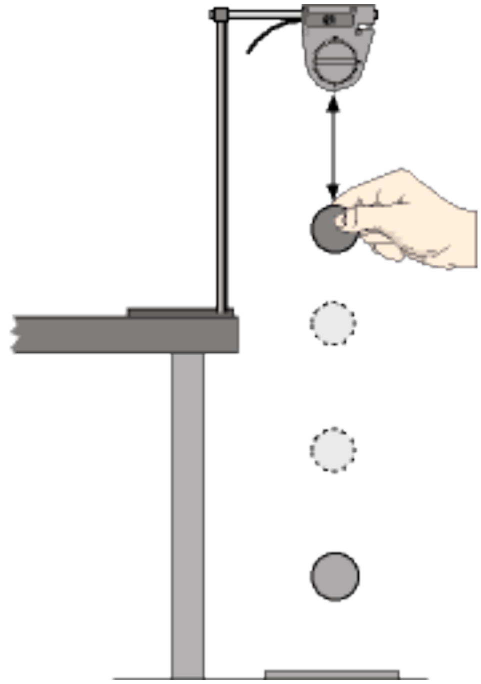


Fig. 2: Equipment setup

Record Data

1. Prepare to drop the ball so it falls straight down beneath the Motion Sensor. Hold the ball between your finger and thumb under the Motion Sensor no closer than 15 cm (about 6 inches) below the Motion Sensor.
2. Press Start to start recording data. Drop the ball. Let the ball bounce several times.

- NOTE: Be sure to move your hand out of the way as soon as you release the ball.

3. After the ball bounces several times on the floor, press to stop recording data.

Analysis

- The Graph screen shows a "mirror image" of a ball bouncing on a flat surface.

1. Change the Graph screen to show Velocity versus Time. Press to activate the vertical axis menu. Press to open the menu. Select 'More', press to open the submenu, and select 'Velocity'. Press to activate your choice.
2. Notice in the velocity plot that the velocity of the ball is positive part of the time (above the x-axis) and negative part of the time (below the x-axis). The Motion Sensor records motion away from it as positive and motion toward it as negative.
3. Use the right-left arrow keys to move the cursor to the point of the graph that is the beginning of one of the bounces.
4. Press *F3* (F3) to open the 'Tools' menu, select 'Linear Fit', and press to activate your choice. If needed,

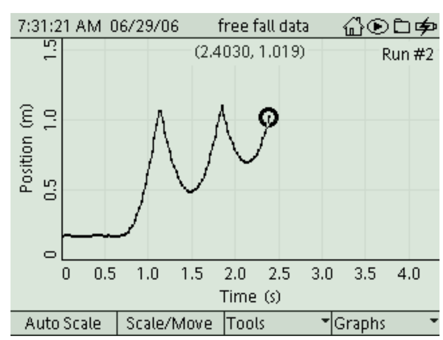


Fig. 3: Position graph

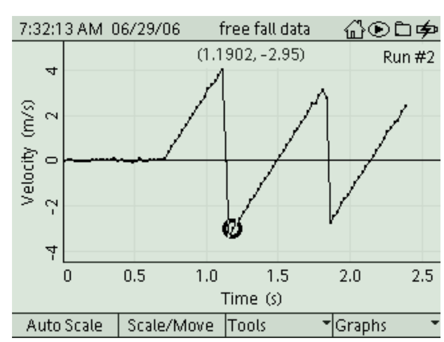


Fig. 4: Velocity graph

adjust the selected region of the graph so the 'Linear Fit' line fits just one bounce. (Press F3 and select 'Swap Cursor' from the 'Tools' menu.)

- The *Slope* of the 'Linear Fit' line is the acceleration of the ball while it is in the air.

5. Record the value of the slope in the Data Table. This is the value for the acceleration due to gravity on the falling object.

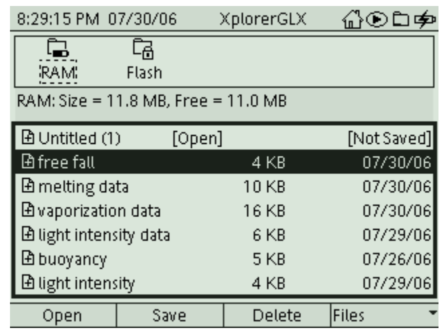
Record your results in the Lab Report section.

Appendix

Opening a GLX File

To open a specific GLX file, go to the Home Screen (press). In the Home Screen, select Data Files and press the Activate () button. In the Data Files screen, use the cursor keys to navigate to the file you want. Press *F1* (F1) to open the file. Press the Home button to return to the Home Screen. Press *F1* to open the Graph screen.

Data Files Icon

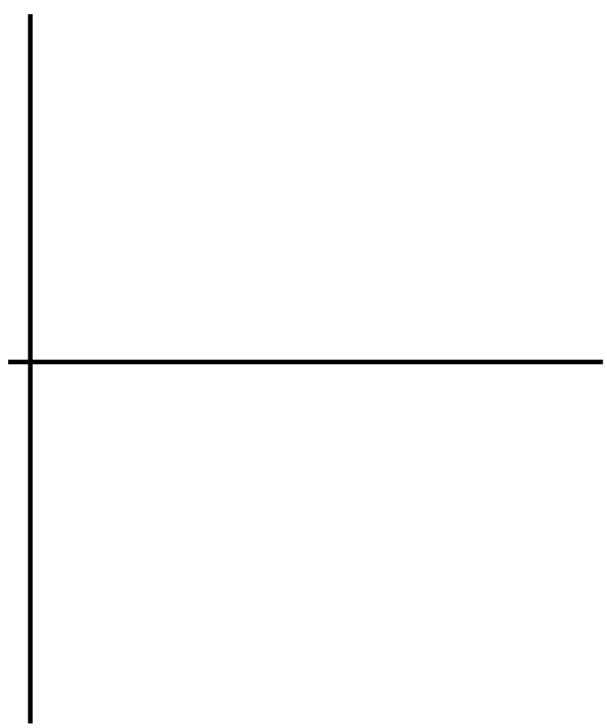


Lab Report – Activity 5: Acceleration Due to Gravity

Name ________________________________ Date ___________

Data

Sketch your graph of data from the Motion Sensor for position versus time and for velocity versus time for the ball. Include labels and units for your y-axes and x-axes.



Data

'g' (slope of velocity versus time) = _________

Questions

1. How does your value for 'g' (slope of velocity versus time) compare to the accepted value of the acceleration of a free falling object (9.8 m/s^2)?

- Reminder: percent difference = $\left|\frac{\text{accepted value - experimental value}}{\text{accepted value}}\right| \text{x100\%}$

2. What factors do you think may cause the experimental value to be different from the accepted value?

