Motion: Acceleration Due to Gravity

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Introduction

Here's a simple question: What happens to an object when you drop it? Everyone knows that the object will fall to the floor. Now the real question is what makes this object fall to the floor instead of fly upwards when it is released? The answer is gravity. Gravity is a force that ***accelerates*** an object towards the center of the earth. The effects of gravity are seen in everyday life; whether it is Allen Iverson shooting a 3-point shot or a thrill-seeker who goes skydiving. Gravity is the most important factor when we want to study the motion of a ***freely-falling*** object. In this lab, we will determine the value of the earth's gravitational acceleration.

Properties of Motion

The most classical topic in physics is motion. The motion of an object is how the object moves from one point to another. If you had just bought an expensive car and the dealer told you that the car can go from 0 to 80 meters per second in 4.3 seconds; what is the dealer trying to tell you? What the dealer is trying to explain to you is that this car has tremendous ***acceleration***. We can say that the ***acceleration*** is the "rate of the velocity." Using math, we can define the ***acceleration*** as:

$$\bar{a} = \frac{\Delta v}{\Delta t} \qquad (1)$$

Where $\bar{a}$ is the average ***acceleration***, Δv is the change in the ***velocity*** and Δt is the change in the time. Let's find out the acceleration of the car you just bought from the information that the dealer just gave you:

$$\bar{a} = \frac{80m/\sec - 0m/\sec}{4.3\sec - 0\sec} = 18.6m/\sec^2$$

So what does the above example tell us? It tells us that for ever second that passes, the car's velocity increases at a rate of 18.6.

Velocity is a property of motion that tells us how fast and in what direction an object is going. Basically, the velocity tells us how much an object has ***displaced*** covered over a certain amount of time. Mathematically, we can express the velocity of an object in the following way:

$$\bar{v} = \frac{\Delta s}{\Delta t} = \frac{v_0 + v_f}{2} \qquad (2)$$

Where $\bar{v}$ is the average velocity of an object, Δs is the displacement of the object and Δt is the change in the time. v_0 and v_f represent the initial and final velocity of an object.

Displacement is the measure of how far and in what direction an object has moved from its starting point. ***Distance*** is the measure of how far an object has moved in total regardless of what direction it is traveling in. For example, you start from a point and walk one meter to the left, then you walk one meter in to the right, you end up at the same point from which you started right? This means that your total ***displacement*** is 0. However, the total ***distance*** you walked was not 0 but 2 meters! You must always be careful when dealing with problems like this.

From equations (1) and (2), we can develop more equations that can be used for almost every problem that deals with motion. The following equations should be studied because most of the problems on the regents that involve motion can be solved with them. The equations of ***kinematics*** are:

$$v_f = v_0 + a\Delta t$$
$$v_f^2 = v_0^2 + 2a\Delta s$$
$$\Delta s = v_0\Delta t + \frac{1}{2}a\Delta t^2$$

Key Words: acceleration, displacement, velocity, kinematics, distance

Experiment Objective(s)

1. To determine the acceleration due to the force of gravity on earth.

Equipment List

- Computer with LoggerPro
- Vernier Photogate
- Ring stand
- Vernier DAQ unit
- A picket fence
- Clamps

Procedures

- Take the clamps, photogate and ring stand and arrange it like the picture in Figure 1 (Picture is on the top of the next page). Use the clamps to attach the photogate to the ring stand. Please make sure that the photogate is as straight as possible (check that it is not tilted in any way).

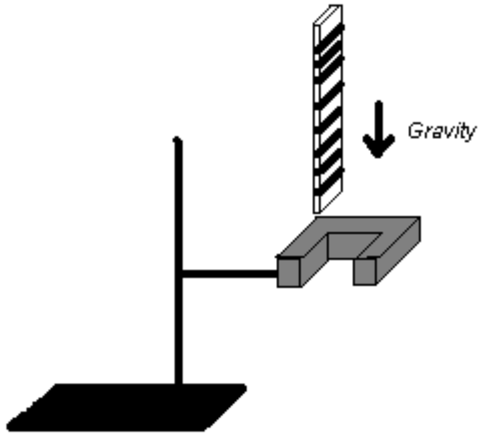
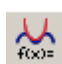


Figure 1.

- Make sure that the proper file is loaded on the computer (05picket fence free fall) and that you have two graphs: one for distance vs. time and the other for velocity vs. time. If this is not what you have, tell the teacher and he/she will help you.
- Make sure that your photogate is working. Take your hand and place it in the photogate and make sure that a red light is on when your hand is in the photogate. If the red light does not show up, tell a teacher right away.
- Take the picket fence and drop it through the photogate. Make sure you drop it straight through the photogate. Look at the velocity vs. time graph.
- Click on the curve fit icon  on the top toolbar of the LoggerPro program. Choose the linear fit. Record the slope of the line for this is your acceleration value of the trial.
- Obtain 5 acceleration values and record them in the Data table provided.
- Take the average of the 5 acceleration values and Record it in the Data section.

Experimental Data

Trial #	1	2	3	4	5
Acceleration					

Trial	1	2	3	4	5
% error					

Experimental Acceleration is:

Analysis

- One way to find out how well we perform experiments is to compare values received from an experiment and compare them to the real value. Calculate the % error for each trial of this experiment. The equation used for this problem is given below:

$$\%err = \frac{True - Experimental}{True} \times 100$$

- Calculate the percent error for each trial. Put your answer in the table provided in the Data section. The value for true is $9.81\ m/s^2$.
- Let's say after each trial you performed, you dropped the picket fence from a higher point than the last trial. Would this affect your acceleration values? Why or Why not?
- An astronaut on planet B would like to find the acceleration due to planet B's gravity. She drops a ball that is initially at rest and observes that it takes 18 seconds for the ball to drop 2 meters. What is the acceleration due to gravity on planet B? (Hint: Use the equations of kinematics discussed in this lab)
- The astronaut would like to know more about her experiment. What is the final velocity of the ball after it fell 2 meters?