Worksheet for Calculating g Activity

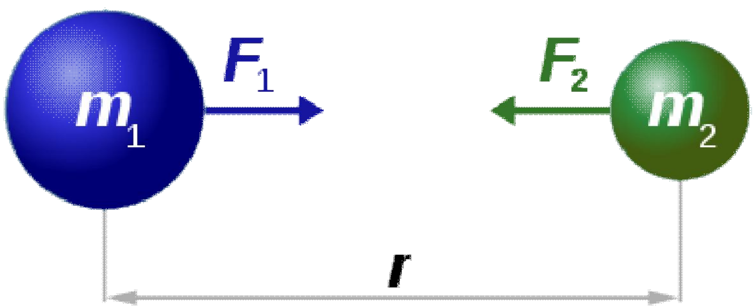
Define:

variable:

gravity:

sensor:

Newton's Universal Law of Gravitation:



$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

In our case $F_1=F_2=F=m_2g$ so the equation becomes $m_2g= G (m_1 \times m_2)/r^2 \rightarrow g= G (m_1)/r^2$.

g = gravitational acceleration, G = Gravitational constant, m_1= mass of Earth, r= radius of Earth

Look up values for G, m_1, and r and solve for theoretical value of g.

Free-fall equation:

$\Delta y = y_0 + v_0 t - 1/2 g t^2$

Describe what each variable means:

Δy:

y_0 :

v_0 :

t:

g:

How to conduct the experiment:

Design robot claw similar to one illustrated below in Figure 1. Be sure to test that the LEGO blue or red ball sits snugly within closed claw and is released quickly when claw is programmed to open.

Figure 1

Attach claw to the robot or a student could just hold the claw in position in line over the light sensor directly over the light path of the sensor. A long serial cable is needed for larger heights. The light sensor should be held firmly in place either with LEGO pieces or by a student (See Figure 2).

Experimental Setup:

1. The designated heights are 2 feet for 1st run, 3 feet for 2nd run and 4 feet for 3rd run. The heights are measured from the bottom of the ball down to the light path horizontal (See Figure 4). This is your $-\Delta y$ value.
2. Place a ball inside the claw. Set the robot arm at the designated height. Measure and record this height. Make sure that the path of the falling ball will cross the light sensor.

Figure 2

Experimental Procedure:

3. Run the Calculate Gravitational Acceleration robot program. The claw will open releasing the ball from the designated height and will cross the light sensor's path at time t. This time is detected on the Data Logging Software as a spike in the signal, see Figure 3 (by default this signal is shown in red). Remember to subtract the 5 second wait time from the time of the spike to get the time it took for the ball to hit the floor. Initial velocity of the ball is 0 ft/sec. (**v_0 = 0 ft/sec**). Initial height of ball is equal to height measured from floor to ball, measured to bottom of the ball. This is your value for y_0. See schematic in Figure 4 for important values students should measure and record.
4. Switch to Data Logging mode in LEGO Mindstorms and open last file corresponding to last run. From this graph, t_{apike} can be recorded. (Look at Figure 3).

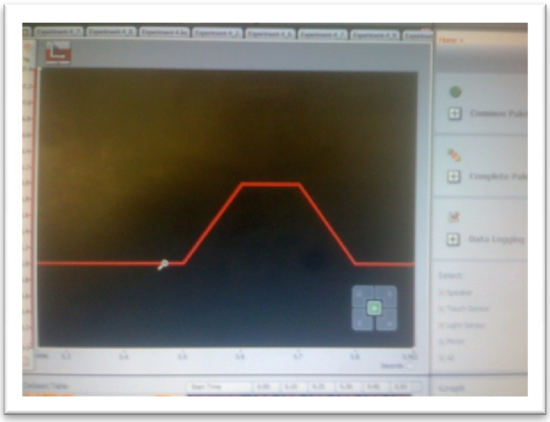


Figure 3

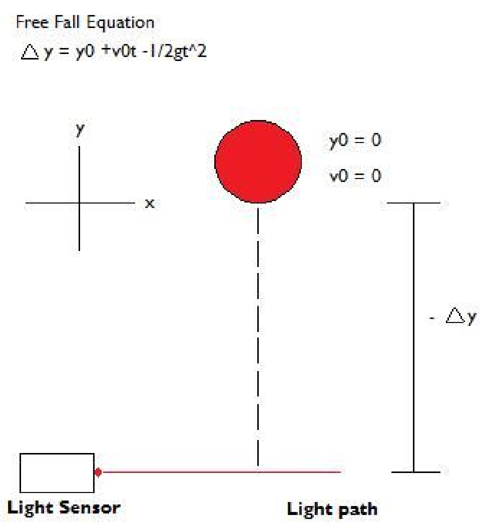


Figure 4

v_0 = 0 ft/sec

y_0 = 0

Time of Spike from Data Logging: **t_{spike} =**

Take this time and subtract 5 seconds: $t = t_{spike} - 5$ sec **t=**

This value is your value for t

Free Fall Equation :

$\Delta y = y_0 + v_0 t - 1/2gt^2$

Think about this equation. You have everything you need to solve for g.

Repeat experiment 3 times at each designated height and get an average value for g

(Accepted value for g: 32.185 ft/sec^2)

1st Height (2 feet=24 inches)

1st run:

2nd run:

3rd run:

Average value: $(g_1 + g_2 + g3)/3 =$

2nd Height (3 feet=36 inches)

1st run:

2nd run:

3rd run:

Average value: $(g_1 + g_2 + g3)/3 =$

3rd Height (4 feet=48 inches)

1st run:

2nd run:

3rd run:

Average value: $(g_1 + g_2 + g3)/3 =$

Sample Calculation :

Looking back at Figure 3, the stable horizontal line denotes when the light path remains unobstructed. Once there occurs a spike in the signal, in either direction, then a disturbance has occurred (ball crosses light path). From a trial run this occurred at $t_{spike} = 5.4$ sec. After subtracting 5 seconds ball initially remains in claw, t = 0.4 sec. Plugging this value along with $y_0 = 0$ ft and $\Delta y = -2.08$ ft (25 in) gives us a gravitational acceleration of ~ 26 ft/sec^2. This is reasonably close to the accepted theoretical value of 32.185ft/sec^2.

Place your answers for the appropriate sections in the space provided

Pre-Activity Assessment:

Guessing g:

Activity-Embedded Assessment:

Does Height Really Matter?

Post-Activity Assessment:

Now that's g:

Calculating % Error:

(Students value – Accepted value)/Accepted value X 100