PHYSICS 203

Measure Little g Simulation Lab

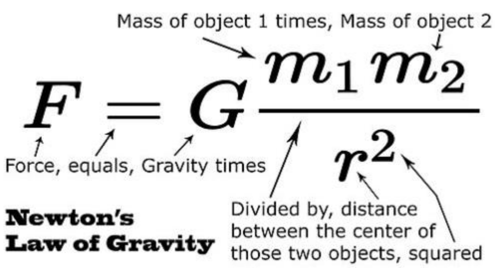
This lab uses The Physics Aviary Acceleration on a Planet Simulation:

https://www.thephysicsaviary.com/Physics/Programs/Labs/AccelerationOnPlanetLab/

Introduction

Newton's universal law of gravitation gives the force F_G, between two objects of mass m_1 and m_2, as shown in Fig. 1 below.

Figure 1- Newton's Universal Law of Gravitation



At Earth's surface our weight force is equal to this gravitational force of attraction. Therefore, weight force F_g = $mg = F_G$

$$mg = GM_Em/(r_E)^2$$

Where G is the universal gravitation constant, M_E is mass of Earth and r_E is radius of Earth.

Hence, acceleration due to gravity on Earth, $g = GM_E/(r_E)^2$

This expression can be used to determine acceleration due to gravity on any planet where mass of Earth, M_E is replaced by mass of planet, M_{Planet} and radius of Earth, r_E is replaced by radius of planet, r_{Planet}.

Procedure

Part I – Acceleration on different planets, each increasing in mass and radius.

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1. Click on url to open simulation lab page if you have not already done so: https://www.thephysicsaviary.com/Physics/Programs/Labs/AccelerationOnPlanetLab/
2. Click 'Begin' to start lab.
3. Click on 'Ball' at top of screen to change ball characteristics of your choice.
4. Click on 'Planet' at top of screen. Decrease mass and radius of planet to minimum possible. Choose name (and color if you wish) of planet. Record this information in Table 1 below.
5. Click 'Zoom in', then click on 'Ruler'. Click on ruler shown onscreen to place ball at 4.5 m height location.
6. Click on 'Drop' to begin first run of experiment.
7. Click on grid on bottom right of screen. Record data for velocity, $v_{1,}$ and time, t_1 in Table 1.
8. Click 'Reset' for opportunity to make another run of experiment with same planet mass and radius setting.
9. Click 'Drop' to get data for velocity, v_2 and time, t_2. Record data in Table 1.
10. Click 'Reset' followed by 'Zoom out'. Then click 'Planet' to increase both mass and radius by one upwards arrow click. Record new name of planet, mass, radius and density in Table 1.
11. Repeat steps 5 through 10 above until there are six different planets with associated mass, radius, density, velocity and time data in Table 1.

Table 1: Data for Planets with increasing mass and radius.

Planet				Velocity			Time		
Name	Mass [kg]	Radius [m]	Density [kg/m^3]	V_1 [m/s]	V_2 [m/s]	V_{avg} [m/s]	t_1 [s]	t_2 [s]	t_{avg} [s]

12. Plot a graph of V_{avg} versus t_{avg}. Determine the slope of this graph. What does the slope of this graph tell you?

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13. Plot a graph of Planet Mass Versus Planet Radius². Determine the slope of this graph. What is the significance of (slope) * G ? What happens to acceleration due to gravity on a planet as it becomes larger?

Part II – Exploring acceleration due to gravity on Planets with same radius but different mass.

1. Click on ‘Planet’ at top of screen. Decrease mass and radius of planet to minimum possible. Choose name (and color if you wish) of planet. Record this information in Table 1 below.
2. Click ‘Zoom in’, then click on ‘Ruler’. Click on ruler shown onscreen to place ball at 4.5 m height location.
3. Click on ‘Drop’ to begin first run of experiment.
4. Click on grid on bottom right of screen. Record data for velocity, v_1, and time, t_1 in Table 2.
5. Click ‘Reset’ for opportunity to make another run of experiment with same planet mass and radius setting.
6. Click ‘Drop’ to get velocity, v_2 and time, t_2. Record data in Table 2.
7. Click ‘Reset’ followed by ‘Zoom out’. Then click ‘Planet’ to increase mass by one upwards arrow click. Record new name of planet, mass and density in Table 2.
8. Repeat steps 2 through 7 above until there are six different planets with associated mass, density, velocity and time data in Table 2.

Table 2: Data for Planets with increasing mass constant radius.

Planet				Velocity			Time		
Name	Mass [kg]	Radius [m]	Density [kg/m³]	V_1 [m/s]	V_2 [m/s]	V_{avg} [m/s]	t_1 [s]	t_2 [s]	t_{avg} [s]
		4.0 E6							
		4.0 E6							
		4.0 E6							

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9. By increasing planet mass but maintaining a constant radius of 4.0 E6 m, you were in effect increasing the planet's density. What effect did this increase in density have on the average time for ball to fall through 4.5m?
10. Plot a graph of V_{avg} versus t_{avg} and determine the slope of this graph. What does the slope of this graph tell you concerning the relationship between acceleration due to gravity on a planet and increased density?
11. What is the name of such a body (planet or star) which is so dense that it is difficult or impossible to escape its gravitational force of attraction?
12. Check accuracy of your data points in the graph produced from Table 2, by using linear equation of motion, $d_y = v_i t_{avg} + 1/2 g_{planet}(t_{avg})^2$, where d_y is the vertical distance fallen, v_i is initial velocity and t, is time to fall to ground level (0 meters). In our experiment the ball was dropped 4.5 m, meaning initial velocity v_i is zero. Therefore, $d_y = 1/2 g_{planet}(t_{avg})^2$
    This makes $g_{planet} = 2d_y /(t_{avg})^2$

Table 3. Comparison of acceleration due to gravity values

Planet			
Name	Mass [kg]	g_{planet} [m/s^2]	V_{avg}/t_{avg} [m/s^2] (from Table 2)