Experiment 5

Determination of Value of Universal Gravitational Constant

Time for activity 40-60 minutes

Resources

The Virtual Lab https://phet.colorado.edu/sims/html/gravity-force-lab/latest/gravity-force-lab_en.html

Paper. Pencil, Calculator

Software Requirements

The new HTML5 sims can run on iPads and Chromebooks, as well as PC, Mac, and Linux systems.

iPad:
iOS 11+ Safari
iPad compatible sims

Android:
Not officially supported. If you are using the HTML5 sims on Android, we recommend using the latest version of Google Chrome.

Chromebook:
Latest version of Google Chrome
The HTML5 and Flash PhET sims are supported on all Chromebooks.
Chromebook compatible sims

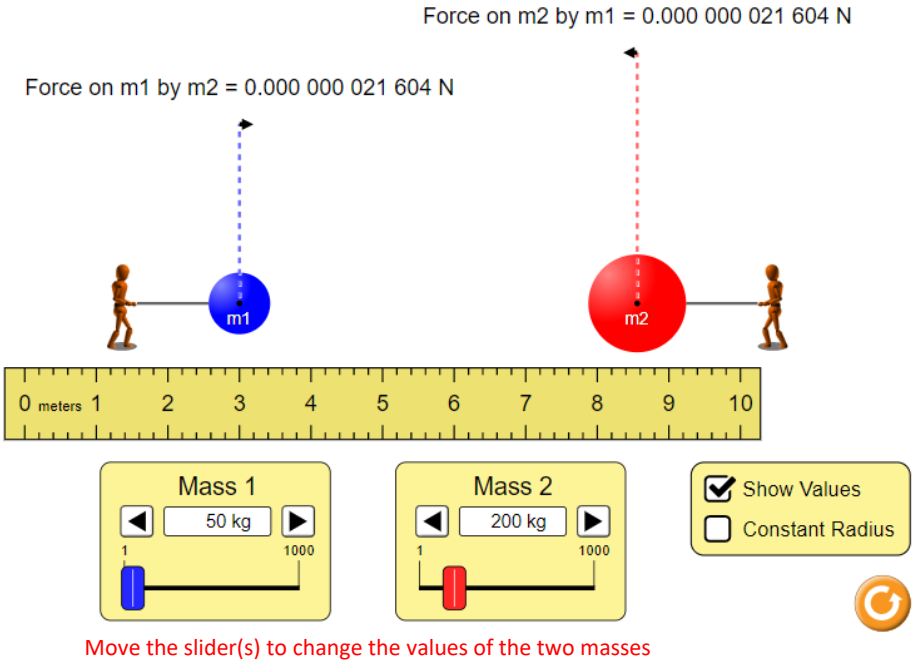
Windows Systems:
Microsoft Edge and Internet Explorer 11, latest version of Firefox, latest version of Google Chrome.

Macintosh Systems:
macOS 10.9.5+, Safari 9+, latest version of Chrome.

Linux Systems:
Not officially supported. Please contact phethelp@colorado.edu with troubleshooting issues.

The Lab Environment

Spend a few minutes to understand/ explore the functionalities of the different tabs/components.



Instructions

1. Hold and drag the two masses to adjust the distance between the two masses. Let it is r
2. Drag the sliders to adjust the two masses. Let these masses are m_1 and m_2.
3. Note down the values of the forces exerted by the two masses on one another. Since these forces will be equal in magnitude and opposite in direction, select any one and let it is F_{12}, that is force on mass 2 because of the mass 1. It can be noted that the force exerted by the mass 2 on mass 1 will be F_{21} and is of the same magnitude.

Gravitational force depends on the masses and the distance.
Newton developed the following equation to describe quantitatively the magnitude of the gravitational force if distance r separates masses m_1 and m_2:

Newton's Law of Universal Gravitation

$$F_g = G\frac{m_1 m_2}{r^2}$$

$$\text{gravitational force} = \text{constant} \times \frac{\text{mass 1} \times \text{mass 2}}{(\text{distance between masses})^2}$$

G is called the *constant of universal gravitation*. The value of G was unknown in Newton's day, but experiments have since determined the value to be as follows:

$$G = 6.673 \times 10^{-11}\,\frac{\text{N}\cdot\text{m}^2}{\text{kg}^2}$$

4. We can make the G as subject of formula, that is

$$F_{12} = G\frac{m_1 m_2}{r^2} \qquad \Rightarrow \qquad \boxed{G = \frac{F\ r^2}{m_1\ m_2}}$$

5. Using the above relation, find the value of the constant. Write your answer in scientific notation.

6. Compare the calculated value of G with $G = 6.673\times10^{-11}\ \frac{N.m^2}{kg^2}$ and calculate the %age error.

Experiment 1

Determination of Value of Universal Gravitational Constant

Student's Name_____ **Grade** ___

Observations and calculations

No. of Obs	Mass M_1	Mass m_2	r	F_{12}	$G = \frac{F\ r^2}{m_1\ m_2}$	
1						
2						
3						
4						

Average $G =$ _____

%age Error

Calculated Value of $G =$ _____

Actual Value of $G =$ _____

%age Error $= \frac{\left| Actual\ value\ of\ G - Calculated\ value\ of\ G \right|}{Actual\ value\ of\ G} \times 100 =$ _____ %