



Virtual Learning

# Physics

## Determining “G”

May 11, 2020

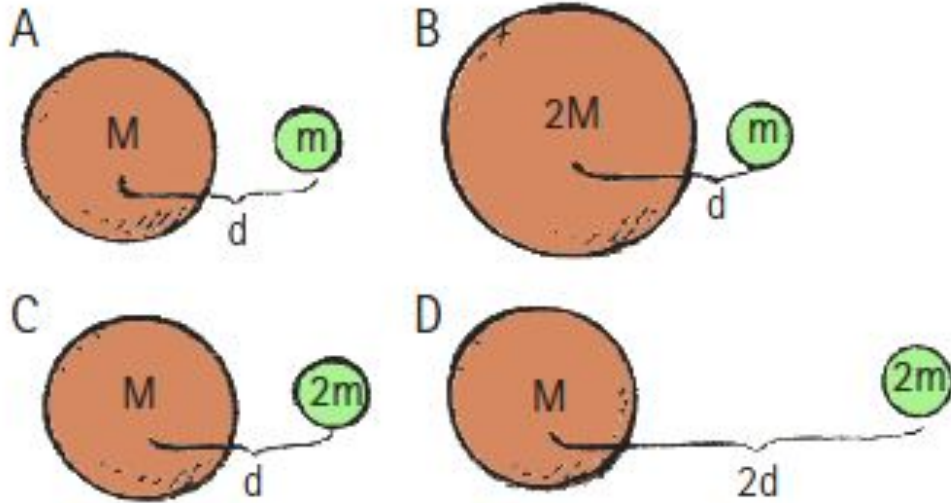
# Physics

**Determining “G”:** May 11, 2020

**Objective/Learning Target:**

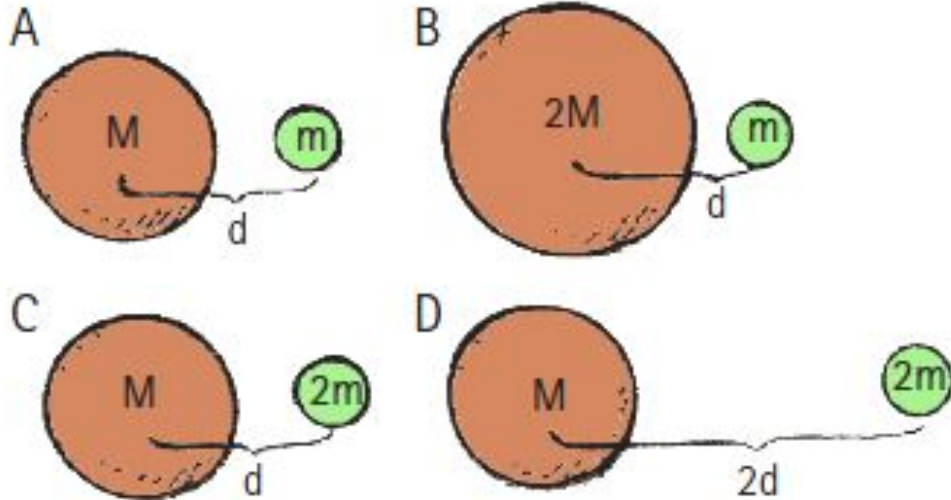
Students will use a computer simulation and graphing techniques to determine the gravitational constant “G”

## Quick Review #1



The planet and its moon gravitationally attract each other. Rank the forces of attraction between each pair, from greatest to least.

# Quick Review #1 Answer

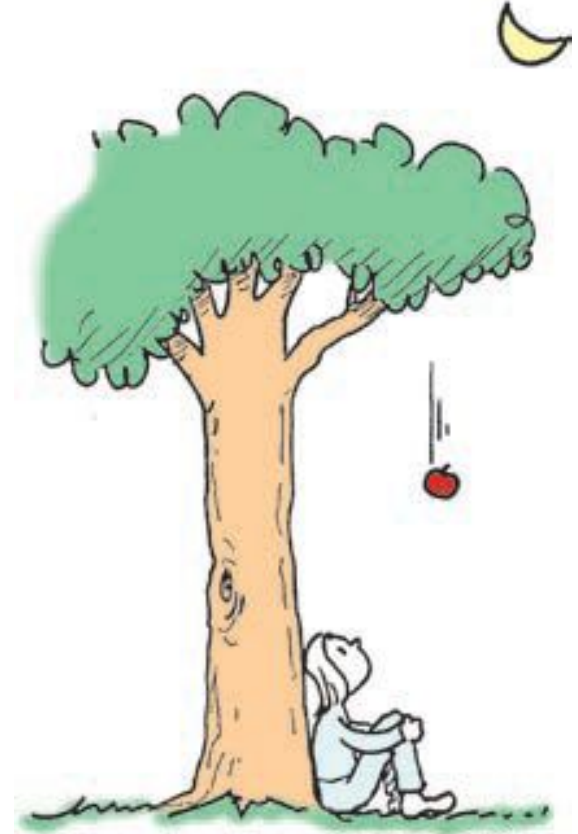


The forces of attraction ranked from greatest to least.

B=C, A, D

## Quick Review #2

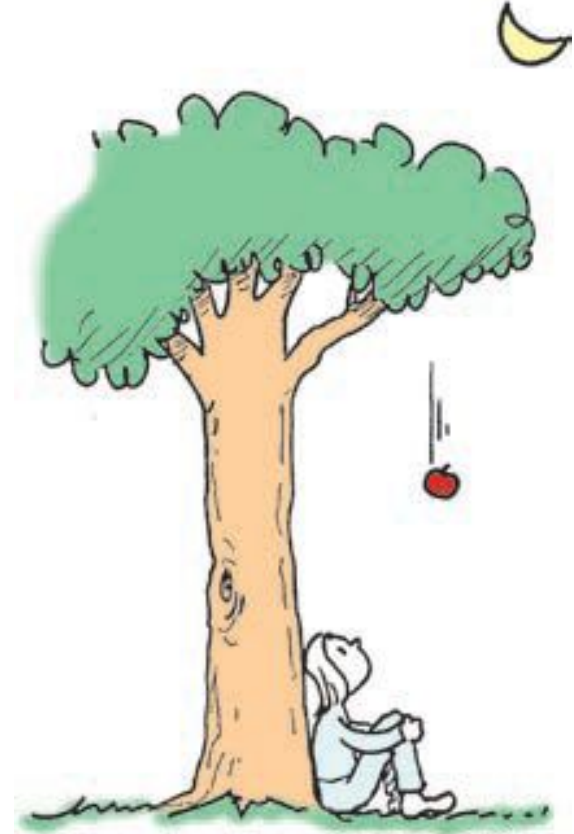
Suppose that an apple at the top of a tree is pulled by Earth's gravity with a force of 1 N. If the tree were twice as tall, would the force of gravity on the apple be only  $\frac{1}{4}$  as strong?



## Quick Review #2

No, because the twice-as-tall apple tree is not twice as far from Earth's center. The taller tree would have to have a height equal to the radius of Earth (6370 km) before the weight of the apple would reduce to  $1/4$  N.

Before its weight decreases by 1%, an apple or any object must be raised 32 km—nearly four times the height of Mt. Everest, the tallest mountain in the world. So as a practical matter we disregard the effects of everyday changes in elevation.



# Newton's Law of Gravitation and "G"



## Introduction

You will use a computer simulation today to reinforce your ideas of Newton's Universal Law of Gravitation and to determine "G". Since this is "inquiry based", you're not supposed to know everything going in, but learn as we walk through the lesson. **You must read the following slides carefully.** Let's get started!

# Newton's Law of Gravitation and "G"

The simulation will let you vary distances and masses, and then shows the forces between them. Leaving "G" as the only unknown.

The force of gravity between two normal-sized objects is much too small to measure even in most college laboratories, hence this is a good simulation.

$$F = G \frac{mM}{r^2}$$



# Newton's Law of Gravitation and "G"

Newton's Law of Gravitation sets up nicely for us to use a linear equation to find "G".

$$F = G \frac{mM}{r^2}$$

$$Y = mx + b$$

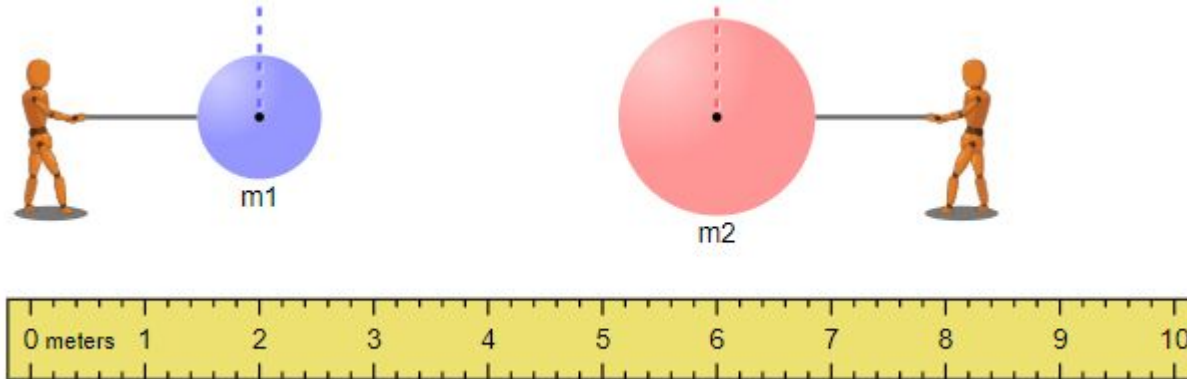
Y intercept will be close to zero

# Newton's Law of Gravitation and "G"

Website: [Gravitational Force Simulation](#)

Make sure to use the HTML5 version.

Select Download to get started..



# Newton's Law of Gravitation and "G"

1. Vary the masses and distance between the masses, record all your data along with the gravitational force that is given in the Sim. Record all sig figs.
2. Do this for ten different scenarios recording each in the data table. Make sure to use the entire range possible for all the parameters.

The ruler is movable so you can get the distances more exactly. This will be your least accurate measurement. Make it as carefully as you can.

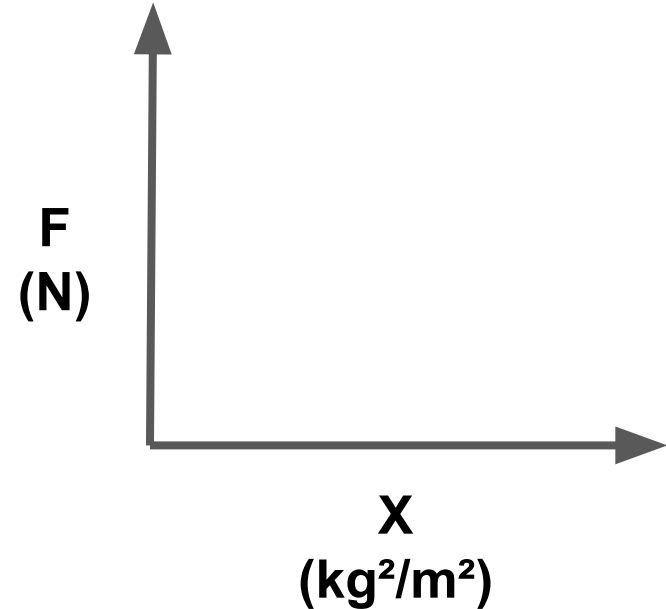
[illegible]

- $$X = \frac{M_1 M_2}{r^2}$$

[illegible]

# Newton's Law of Gravitation and "G"

4. Plot a F vs. "X" graph and calculate the slope.
5. The slope is your experimental value for "G". Calculate the percent error.



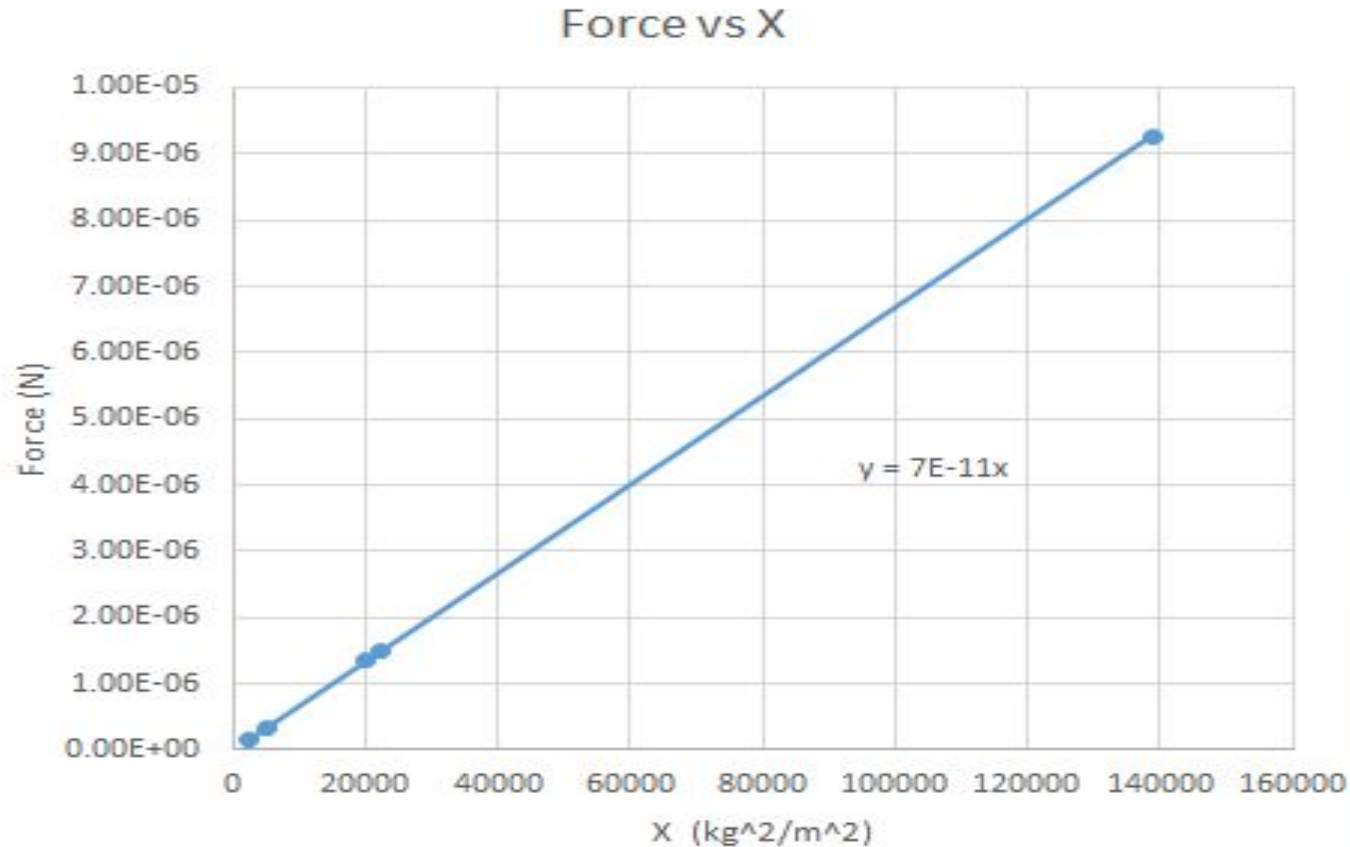
Actual value:

$$G = 6.673 \times 10^{-11} \text{Nm}^2/\text{kg}^2$$

# Simulation example answers

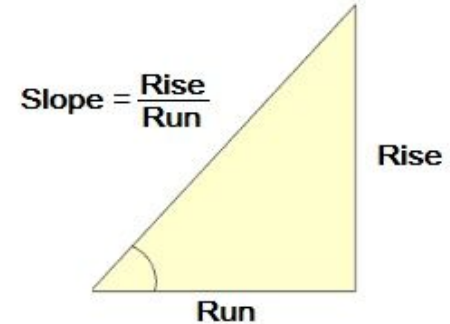
M <sub>1</sub> (kg)	M <sub>2</sub> (kg)	r (m)	F (N)	$X = \frac{M_1 M_2}{r^2}$
100	400	4.0	$1.66852 \times 10^{-7}$	2500
200	400	4.0	$3.33704 \times 10^{-7}$	5000
800	400	4.0	$1.334816 \times 10^{-6}$	20000
800	1000	2.4	$9.269556 \times 10^{-6}$	138888.9
800	1000	6.0	$1.483129 \times 10^{-6}$	22222.22
800	1000	9.6	$5.79347 \times 10^{-7}$	8680.556
10	10	9.6	$7.24 \times 10^{-11}$	1.085069
50	500	7.0	$3.4051 \times 10^{-8}$	510.2041
60	120	8.0	$7.508 \times 10^{-9}$	112.5
350	80	8.9	$2.3592 \times 10^{-8}$	353.4907

# Simulation example answers



# Simulation example answers

$$\begin{aligned}
 4. \quad \text{Slope} &= \frac{\text{Rise}}{\text{Run}} = \frac{(y_2 - y_1)}{(x_2 - x_1)} \\
 &= \frac{(1.66853 \times 10^{-7} - 7.508 \times 10^{-9})\text{N}}{(2500 - 112.5)\text{kg}^2/\text{m}^2} \\
 &= 6.67409424 \times 10^{-11} \text{Nm}^2/\text{kg}^2
 \end{aligned}$$



$$\begin{aligned}
 5. \quad \%err &= \frac{(\text{experimental value} - \text{accepted value})}{\text{accepted value}} \times 100\% \\
 &= \frac{6.674 \times 10^{-11} - 6.673 \times 10^{-11}}{6.673 \times 10^{-11}} \times 100\% = 0.1 \%
 \end{aligned}$$



# Additional Practice

Return to the simulation and practice using Newton's Law of Gravitation by picking mass values and a distance and calculating the Force between them using the formula and checking your answer with the simulation.

$$F = G \frac{mM}{r^2}$$

