Steve Cooperman **Physics** 2016-2017

The Gravitational Constant Lab

So far this year, we've made a single, indirect measurement of "g", the gravitational acceleration caused by the Earth: when we used scales to determine that W= mg (weight = mass x acceleration of gravity). Soon, we'll do the same with pendulums.

But what causes gravity? Why is the acceleration of gravity for Earth --- or any other world – its own particular value?

In this lab, you'll use an on-line source to gather data about *Newton's Law of Universal Gravitation*: the "action-at-a-distance" force. The website, below, will show you how it works by allowing you to vary distances and masses, and then calculate its proportionality constant, "G" (CAPITAL G). We'll do it with a spreadsheet at first (Excel or Google Sheets, whichever works on your computer), but then we'll also try it with our calculators. (Not all TI-operating systems will give you a good value; that's why we're doing the spreadsheets, first.). You know that "g" = -9.81 m/s^2 at Earth's surface. But that acceleration is due to the force of gravity acting on your mass. (F=ma)

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. You will also practice scientific notation on your TI's.

Procedure:

- Go to: http://phet.colorado.edu/sims/html/gravity-force-lab/latest/gravity-force-lab_en.html
- Vary the masses and distance between the masses, and record all your data and the gravitational force to fill the table below and on your Excel/Google Sheets spreadsheet. Try it also on your TI at home. We'll talk about it in class later.
  - 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.
  - Record the force in scientific notation, in 4 sig fig. (Note the forces are equal and opposite. So don't worry about "which value to record" – they're the same.) Scientific Notation will have the form: **d.ddd x 10^{-ee}**. (You can do that automatically on your calculator by setting the **MODE** to **Sci 3**.)
  - Note that the larger the masses, the larger the force; the larger the distance between the masses, the smaller the force.
- **<u>If you're doing it by calculator:</u>** When you are done collecting your data in the table below, calculate "X". If you've recorded your columns in LISTS in your calculator (L_1, L_2, L_3, and L_4, OR make new lists that are M_1, M_2, R, and F), then it will be easy (and a time saver!) to calculate the last column from the 1st three columns USING the LISTS. Go back to your main screen and do that. Store the values in the X-list.

M_1 (kg)	M_2 (kg)	R (m)	$X = \dfrac{M_1 M_2}{R^2}$	F (N) (given in the simulation; use ALL the sig. fig.)

(over for analysis)

<table>
<tr><td>Get a Trendline (STATPLOT on your TI) of your data, F on the y-axis and X on the X-axis.
(These are the same variables we'll use in an upcoming Spring Force lab.)

<u>What kind of regression will you use to find the relationship between F and X</u>?</td><td colspan="2"></td></tr>
<tr><td>You'll notice that what we called "X" is most of Newton's Universal Law of Gravitation. It's just missing the constant "G". We can use our calculators to calculate G, because it is the slope when the Force is Y and X is x. The y-intercept, b, should be small.</td><td colspan="2">$F = G\left(\frac{M_1 M_2}{R^2}\right)$
$y \ = m \qquad X$</td></tr>
<tr><td>What is the value of G, and what is its percentage error (or difference) from the real G= 6.673 x 10^{-11} Nm^2/kg^2?

Record your value of G and the %-error below.</td><td colspan="2">$\%\text{-error} = \frac{(\text{experimental value - accepted value})}{\text{accepted value}} \text{ x } 100\%$</td></tr>
<tr><td>G=</td><td colspan="2">%-error =</td></tr>
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