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# Gravity Force Lab

In this experiment, you will use a simulation to measure the gravitation force between two masses. You'll determine how the strength of the force of gravity depends on the two masses and the distance between them. You'll also determine a value for the Universal Gravitation constant,  $G$ .

To run the simulation, go to [phet.colorado.edu/en/simulation/gravity-force-lab](https://phet.colorado.edu/en/simulation/gravity-force-lab) and click on Run Now.

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## PART 1. QUALITATIVE OBSERVATIONS

1. Use the slider on the right-hand side of the screen to increase the mass of  $m_1$ . Does the gravitational force between the two masses *increase, decrease, or remain the same*?
2. Decrease the mass of  $m_1$ . Does the gravitational force *increase, decrease, or remain the same*?
3. Use the second slider to increase the mass of  $m_2$ . Does the gravitational force *increase, decrease, or remain the same*?
4. Decrease the mass of  $m_2$ . Does the gravitational force *increase, decrease, or remain the same*?
5. Click on either one of the two masses and drag it so they are closer together. Does the gravitational force *increase, decrease, or remain the same*?
6. Drag either mass so they are farther apart. Does the gravitational force *increase, decrease, or remain the same*?
7. In any of your observations so far, have the two gravitational forces (on  $m_1$  from  $m_2$  and on  $m_2$  from  $m_1$ ) ever been different from each other? Why?

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## PART 2. QUANTITATIVE MEASUREMENTS

### Changing Mass 1

1. Click "Reset All" to get everything back to the original values.
2. In this part, you will be changing  $m_1$ , but keeping  $m_2$  and the distance between them constant. On your page, record the mass of  $m_2$ . Use the on-screen ruler to measure the distance between the centers of  $m_1$  and  $m_2$ , and record it on your page.
3. Make a data table to record the mass of  $m_1$  (in kg) and force (in newtons).
4. For at least 12 different data points, change the mass of  $m_1$ , and then record the mass and gravitational force in your data table.

### Changing Mass 2

1. Click "Reset All" to get everything back to the original values.
2. In this part, you will be changing  $m_2$ , but keeping  $m_1$  and the distance between them constant. On your page, record the mass of  $m_1$ . Use the on-screen ruler to measure the distance between the centers of  $m_1$  and  $m_2$ , and record it on your page.
3. Make a data table to record the mass of  $m_2$  (in kg) and force (in newtons).
4. For at least 12 different data points, change the mass of  $m_2$ , and then record the mass and gravitational force in your data table.

## Changing Distance

1. Click "Reset All" to get everything back to the original values.
2. In this part, you will be keeping the masses of  $m_1$  and  $m_2$  constant but changing the distance between them. On your page, record the masses of  $m_1$  and  $m_2$ .
3. Make a data table to record the distance between the centers of the masses (in meters) and force (in newtons). Leave room for a third column, which you'll fill in later.
4. Move  $m_1$  to the left side of the screen. Place the on-screen ruler so that the zero mark lines up with the center of  $m_1$ .
5. For at least 12 different data points, move  $m_2$  to a different location, and then record the distance between the masses' centers, along with gravitational force, in your data table.

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## PART 3. ANALYSIS

You will have a total of four graphs to draw for this lab.

- Graph 1 uses your data from "Changing Mass 1". Put mass 1 (in kg) on the horizontal axis and gravitational force (in N) on the vertical axis.
- Graph 2 uses your data from "Changing Mass 2". Put mass 2 (in kg) on the horizontal axis and gravitational force (in N) on the vertical axis.
- Graph 3 uses your data from "Changing Distance". Put distance (in m) on the horizontal axis and gravitational force (in N) on the vertical axis.
- Graph 3 is not a straight line, so we need to draw Graph 4 to straighten it out so we can analyze it. For all your data points from "Changing Distance", calculate 1 divided by the distance squared, and write that number in the blank third column in your data table. Graph 4 will have  $(1/\text{distance}^2)$  on the horizontal axis and gravitational force on the vertical axis.

For each of the straight-line graphs (1, 2, and 4), you should draw a best-fit line and calculate the slope and y-intercept.

Now let's figure  $G$ , the Universal Gravitation constant.

- For Graph 1, take your slope, multiply it by the distance squared, and divide it by the mass of  $m_2$ .
- For Graph 2, take your slope, multiply it by the distance squared, and divide it by the mass of  $m_1$ .
- For Graph 4, take your slope, divide it by the mass of  $m_1$ , then divide it by the mass of  $m_2$ .

The three numbers you get should be very close to each other. Average them and write them on your lab report.