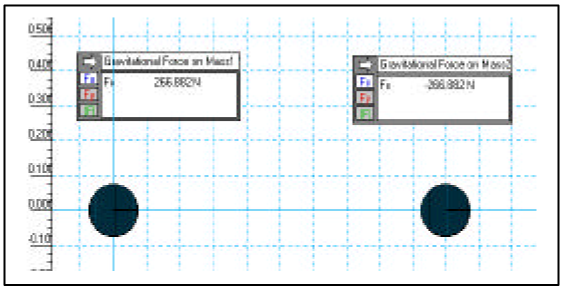
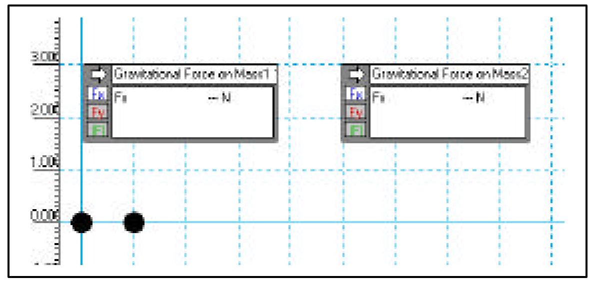
Honors Physics - Discovering Newton's Universal Law of Gravitation 1-29-02 Mr. Ward and Mr. Gener

Name ___________________________ Per_______

You will discover Newton's Universal Law of Gravitation by taking data under two different situations using ***Interactive Physics,*** a simulation program. This lab is difficult to do without such a simulation.

- In the first, "ChangeMassGrav", you will vary the masses of two isolated spheres and observe the effect this has on the gravitational force between them. The center-to-center distance will be held constant.
- In the second, "ChangeDistGrav", you will keep the masses constant and vary the distance between them.
- You will then analyze the two sets of data to determine relationships among masses, distance, and force. You will also solve numerically for G, the gravitational constant, and for the units on G.





ChangeMassGrav

1. Open "ChangeMassGrav". You will see two "planets". (These planets are made of very dense material so we can make them small and put them close together -- one meter in this exercise. This material does not exist in nature!) Double click on mass1 and make sure it is at (0,0) meters and has a mass of one million kilograms. Mass2 should be at (1,0) meters and should also have a mass of one million kilograms. Fix them if needed.

2. In the lower left corner, the frame counter will read 0. Click on the right advance arrow (the one with the bar) to set the frame counter at 1. You will see the gravitational force on each planet. They will have the same magnitude but opposite directions. In the table below, RECORD mass1, mass2, and the magnitude of the force.

3. Before you can make changes to the simulation, you must first click RESET.

4. Next, increase mass2 only (but don't change the distance) to obtain three different values. A good pattern to follow would be 1, 3, and 5 million kilograms but you can choose your own. Just keep the values reasonable because you will be analyzing them and you want a nice even spread. Record both masses and the force each time you change mass2. Keep all sig figs reported by IP for the force.

   (If you RUN one of these simulations instead of just looking at the first frame, what happens to the forces and why?)
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5. Now, change mass1 to a new value (three different ones). A good pattern might be 1, 2, and 4. Each time you change mass1, you need to run through the mass2 series again. For example, using the suggested values, the following mass pairs would be tested: (1,1) (1,3) (1,5) (2,1) (2,3) (2,5) (4,1) (4,3) (4,5). If you choose your own, make sure you don't do any repeat pairs such as (1,3) and (3,1) since these will read the same force. (You might want to check that, though).

m_1 (x 10^6 kg)	m_2 (x 10^6 kg)	r (m)	F_g (N)
1	1	1	
1	3	1	
1	5	1	
2	1	1	
2	3	1	
2	5	1	
4	1	1	
4	3	1	
4	5	1	

6. When nine data pairs have been measured, explain the pattern that relates each pair of masses to the force between them. **Write a proportionality relationship starting with F_g a _______.**

ChangeDistGrav

7. When you are finished with "ChangeMassGrav", close it, do not save any changes, and open "ChangeDistGrav". You will again see two planets. This time the scale is changed but you should see on the ruler scale that they are still the same mass and 1 meter apart. Also, mass1 is anchored so it can't move. Double click on mass1 and make sure it is at (0,0) meters and has a mass of one million kilograms. Mass2 should be at (1,0) meters and should also have a mass of one million kilograms. Fix them if needed.

8. Click the frame advance arrow to frame 1. Record the distance apart, and the magnitude of the force. Keep all sig figs reported by IP for the force.

9. Now increase the distance (but don't change the masses) by double clicking on mass2 and changing its x-coordinate in the properties box. You can also drag the masses, but be certain you don't change the y-coordinate! A good series of values would be 1, 2, 3,…, 9, 10 meters. Again, you may choose your own, but be reasonable. Choose whole numbers. If you exceed 10, you may have to change the scale by clicking on "View" and then on "View size".

m_1 (x 10^6 kg)	m_2 (x 10^6 kg)	r (m)	F_g (N)
1	1	1	
1	1	2	
1	1	3	
1	1	4	
1	1	5	
1	1	6	
1	1	7	
1	1	8	
1	1	9	
1	1	10	

10. When you have ten data sets measured, explain the pattern that relates each distance to the force between the planets? **Write a proportionality relationship starting with F_g a _______.**

11. If you have found the pattern for both parts of the lab, write an equation for $\mathbf{F_g}$ in terms of $\mathbf{m_1}$, $\mathbf{m_2}$, and **r** by combining the proportionalities. If you need to use a proportionality constant, use the letter **G**. What you now have, if done correctly, is Newton's Universal Law of Gravitation. (a) **What is the numerical value you found for G?** (b) **What are the units on G?** (c) **Write an explanation of what your F_g equation means. In other words, describe it to someone.**