Physics Problems: Name: _____
Gravitational Interactions Date: _____ Period: _____

The equation for the Law of Universal Gravitation is: $$F = \frac{G m_1 m_2}{d^2}$$

where F is the force of attraction between masses m_1 and m_2, separated by a distance of d, and G is the universal gravitation constant (and relates to the masses and distances just as the constant π relates the circumference of a circle to its diameter. By substituting changes to any variables into this equation, we can predict how the others change. For example, we can see how the force changes if we know how either or both of the masses change, or how the distance between their centers changes.

Suppose, for example, that one of the masses is somehow doubled. Then substituting $2m_1$ for m_1 in the equation gives:

$$F_{new} = \frac{G 2 m_1 m_2}{d^2} = 2\left(\frac{G m_1 m_2}{d^2}\right) = 2 F_{Old}$$

So we see that the force doubles also. Or suppose, instead that the distance of separation is doubled. Then substituting 2d for d in the equation gives:

$$F_{new} = \frac{G m_1 m_2}{(2d)^2} = \frac{1}{4}\left(\frac{G m_1 m_2}{d^2}\right) = \frac{1}{4} F_{Old}$$

We now see that the force is only 1/4_ as much.

Use this method to solve the following problems. Write the equation and make the appropriate substitutions.

1. If both masses are doubled, what happens to the force ?

2. If the masses are not changed, but the distance of separation is 1/2_ of the original distance, what happens to the force ?

3. If the masses are not changed, but the distance of separation is 1/4_ of the original distance, show what happens to the force.

4. If both masses are doubled and the separation is doubled, what happens to the force ?

5. If One of the masses is doubled, the other remains unchanged, and the distance of separation is tripled, show what happens to the force.

6. Consider a pair of binary stars that pull on each other with a certain force. Would the force be larger or smaller if the mass of each star was 3 times as great and if their distance apart were 3 times as far ? Show what the new force will be compared to the first one.

7. An astronaut who normally weighs 160 pounds at the earth's surface travels away from the earth. What would the astronaut weigh at the following distances from the **surface** of the earth? Consider the earth's radius to be approximately 4000 miles. (You can just show the answer in the blank, since the calculation is just one simple step on the calculator once you understand the problem.)

a. 4000 miles: _____

b. 8000 miles: _____

c. 12,000 miles: _____

d. 16,000 miles: _____

e. 20,000 miles: _____

8. Use the following approximate information to compare the gravitational force the Sun exerts on Jupiter with the gravitational force the Sun exerts on Earth. (Show your method.)

Mass of Jupiter = 300 times the mass of Earth

Distance between Jupiter and Sun = 5 times the distance between Earth and Sun

(Even though you don't need to know this to do the problem, it might be of interest to note that the mass of the Sun is 330,000 times the mass of Earth.)