Physics Universal Gravitation – Enrichment Mr. McMullen
Name _____ Date _____ Period ____

Universal Gravitation – Enrichment

It is often convenient to look at an equation and be able to predict what will happen to one variable in an equation if another is changed by a factor of two or, perhaps, by a factor of one half. For example, what will happen to the magnitude of the gravitational force between two objects if the distance between their centers is doubled? Newton's law of universal gravitation is

$$F = G\frac{m_1 m_2}{r^2}$$

Since r is in the denominator and it is squared, we call this an inverse square relationship. If the value of r is doubled, the denominator is increased by a factor of four. Therefore, the force will be decreased by a factor of four.

You can also predict how the value of the variable changes by substituting in the equation. In this example the value of r increases to 2r.

$$F = G\frac{m_1 m_2}{r^2}$$

$$F' = G\frac{m_1 m_2}{(2r)^2} = G\frac{m_1 m_2}{4r^2} = \frac{1}{4}G\frac{m_1 m_2}{r^2}$$

$$F' = \frac{1}{4}F$$

The value of F will decreases by a factor of 4 if r is doubled.

Use the above method to solve the following problems. Write the equations that you used.

1. If the distance is between two objects is decreased to one fourth the original distance, what happens to the force?

2. If you double the mass of each object and double the distance between the centers of the two objects, what happens to the force?

3. If you double the mass of each object and double the distance between them, what happens to the force?

4. The radius of the sun is about 110 times that of the earth, its mass is 330,000 times as great. What would 1.0 kg of matter weigh at the sun's surface?

5. An experiment showed that the attraction between a 5.00 kg mass and a 5770 kg mass was 5.77 x 10-6 N. The centers of the spheres were 0.569 m apart. What is the experimental value of G?

6. If a small planet were located ten times as far from the sun as the earth is from the sun, how many years would it take the planet to orbit the sun?

7. Imagine a line drawn from the earth to the center of the moon. At some point on this line the magnitude of the gravitational attraction of the moon on a space vehicle would be equal to the magnitude of the earth's gravitational attraction on the vehicle. If the distance from the earth to the moon is about 4.0 x 106 km and the mass of the moon is about 1/80th that of the earth, at what distance from the earth's center will be resultant force acting on the space vehicle be zero?