11 Gravity and the Solar System

Name________________________________

Worksheet

Inquiry Physics

1. Use Newton's First Law of Motion to describe how a planet would move if the inward force of gravity from the sun were to suddenly disappear. ANSWER IN COMPLETE SENTENCES

The equation for the law of universal gravitation is:

$$F_g = \frac{Gm_1m_2}{d^2}$$

where **F** is the force of attraction between masses $\mathbf{m_1}$ and $\mathbf{m_2}$, the centers of which are separated by a distance **d**, and **G** is 6.67×10^{-11} Nm^2/kg^2.

SHOW ALL WORK WITH PROPER EQUATIONS, UNITS, AND SIGNIFICANT FIGURES

2. Calculate the weight of a 50.0 kg mass on the moon using Newton's Law of Universal Gravitation. (The mass of the moon is approximately 7.36×10^{22} kg; the radius is 1.738×10^{6} m.)

3. Now calculate the weight of the 50.0 kg mass on the moon using the special case of Newton's Second Law of Motion you derived in Unit 6. Remember that the acceleration due to gravity (g) on the moon is approximately 1/6 that of Earth.

Your answers to questions 2 and 3 should be very similar, as you were simply using different techniques to calculate the same quantity.

4. An 850. kg object is positioned on the surface of Mercury, which has a mass of 3.34×10^{23} kg and a radius of 2,440 kilometers (2.440×10^{6} meters). How much does the object weigh on Mercury?

PREDICTING HOW CHANGES IN MASS AND/OR DISTANCE WILL AFFECT GRAVITATIONAL FORCE

Changing the mass of an object or its distance from another object will affect the gravitational force that attracts the two objects. By substituting changes in any of the variables into the equation for the Law of Universal Gravitation, we can predict how the others change.

Suppose the distance of separation is reduced to one-third of its former value. Then substituting **1/3 d** for **d** in the equation gives:

$$F_{new} = \frac{Gm_1m_2}{(\frac{1}{3}d)^2} = \frac{Gm_1m_2}{\frac{1}{9}d^2} = \frac{9}{1}(\frac{Gm_1m_2}{d^2}) = 9F_{old}$$

And we see the force is increased nine-fold.

Suppose that the distance did not change, but one of the masses somehow is doubled. Then substituting $\mathbf{2m_1}$ for $\mathbf{m_1}$ in the equation gives:

$$F_{new} = \frac{G(2m_1m_2)}{d^2} = 2(\frac{Gm_1m_2}{d^2}) = 2F_{old}$$

So we see the force doubles.

Finally suppose that the distance of separation is doubled. Then substituting **2d** for **d** in the equation gives:

$$F_{new} = \frac{Gm_1m_2}{(2d)^2} = \frac{Gm_1m_2}{4d^2} = \frac{1}{4}(\frac{Gm_1m_2}{d^2}) = \frac{1}{4}F_{old}$$

And we see the force is only 1/4 as much.

Use this method to solve the following problems. Write the equation, making the appropriate substitutions.

5. If both masses are tripled, what happens to the force?

6. If the masses are not changed, but the distance of separation is reduced to 2/3 the original distance, what happens to the force?

7. If the masses are not changed, but the distance of separation is tripled, what happens to the force?

8. If **both** masses are doubled, and the distance of separation is tripled, show what happens to the force.

9. If one of the masses is doubled, the other remains unchanged, and the distance of separation is quadrupled, show what happens to the force.