

## Universal Gravitation Worksheet 4

### The Law of Universal Gravitation

The equation for the Law of Universal Gravitation is

$$F = G \frac{M_1 M_2}{r^2}$$

Where  $F$  is the attractive force between masses  $m_1$  and  $m_2$  separated by distance  $r$ .  $G$  is the universal gravitational constant (and relates  $G$  to the masses and separation as the constant  $\pi$  similarly relates the circumference of a circle to its diameter). By substituting changes in any of the 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 changes, or how the separation between their centers changes.

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

$$F_{\text{new}} = G \frac{2m_1 m_2}{r^2} = 2 \left( G \frac{m_1 m_2}{r^2} \right) = 2F_{\text{old}}$$

Therefore the force also doubles. Suppose instead that the separation distance is doubled. Then substituting  $2r$  for  $r$  in the equation gives

$$F_{\text{new}} = G \frac{2m_1 m_2}{(2r)^2} = G \frac{m_1 m_2}{4r^2} = \frac{1}{4} \left( G \frac{m_1 m_2}{r^2} \right) = \frac{1}{4} F_{\text{old}}$$

Hence the force is only  $\frac{1}{4}$  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 reduced to  $\frac{1}{2}$  the original distance, what happens to the force?
3. If the masses are not changed, but the distance of separation is increased to  $\frac{1}{2}$  the original distance, what happens to the force?
4. If both masses are doubled, and the distance of separation is doubled, show what happens to the force.



# Conceptual Physics Universal Gravitation Packet Answers

**John Clarke Slater**



## **Conceptual Physics Universal Gravitation Packet Answers:**

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