

# GRAVITATION

Name: \_\_\_\_\_ Section: \_\_\_\_\_

Partner: \_\_\_\_\_ Date: \_\_\_\_\_

**PURPOSE:** To explore the gravitational force and Kepler's Laws of Planetary motion.

**INTRODUCTION:** Newton's law of Universal Gravitation tells us that the gravitational attraction between two masses,  $m$  and  $M$ , is of magnitude

$$F = \frac{GmM}{R^2} \quad (1)$$

where  $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$  and  $R$  is their radial separation. In this experiment you will use the simulation program **Interactive Physics** to investigate a number of the consequences of this interaction. To make your calculations easier we will invent a universe where gravity is not the weakest of forces, but a very strong one; we will assume  $G = 1.0 \text{ N m}^2 \text{ kg}^{-2}$ .

For this simulation you will need to know the potential energy,  $U$ , of mass  $m$  due to the gravitational attraction of  $M$ ,

$$U = -\frac{GmM}{R} \quad (2)$$

and the relationship between the speed of  $m$  when in a circular orbit about  $M$  and the distance  $R$  between  $m$  and  $M$ . This is derived from Newton's second law:

$$F = \frac{GmM}{R^2} = ma = m\frac{v^2}{R}, \quad (3)$$

$$v^2 R = GM. \quad (4)$$

From this equation you can easily relate the kinetic energy to  $R$ .

**SIMULATIONS:** *Impact:* Open the **Interactive Physics** simulation **Escape**, which shows the two masses  $m$  and  $M$  separated by a distance  $R$ . Note the anchor on  $M$  which means it is pinned down and will not move during the simulation. Pull down the **Window** menu and click on **Properties**. Record the initial values below. To find  $G$  pull down the **World** menu and click on **Gravity**.

$m$ : \_\_\_\_\_  $x$ : \_\_\_\_\_  $y$ : \_\_\_\_\_  $G$ : \_\_\_\_\_  
 $M$ : \_\_\_\_\_  $x$ : \_\_\_\_\_  $y$ : \_\_\_\_\_

Calculate (predict) the initial potential energy: \_\_\_\_\_. (Show your work.)  
At what value of  $R$  is this energy equal to zero?









