Universal Law of Gravity & Satellite Motion Worksheet

Name: Key

Date:

Mod:

Directions: Answer the following questions below using information from the circular motion unit. Pay close attention to units and show all work.

$G = 6.673\times10^{-11}\ \frac{Nm^2}{kg^2}$

Radius of Earth = 6.37×10^{6} m

Mass of Earth = 5.98×10^{24} kg

1. The military wants to place a new spy satellite into orbit around the Earth at a height of 750 km above the Earth's surface. At what speed should the satellite be released from the rocket to achieve this orbit?

$$V=\sqrt{\frac{GM_E}{R+r}}=\sqrt{\frac{(6.673\times10^{-11})(5.98\times10^{24}\,kg)}{6.37\times10^{6}m+750{,}000m}}$$

$$V = 7486.37\ m/s$$

2. Dish Network sent a satellite into orbit about 36000km above the Earth's surface. What is the speed of the satellite in miles per hour?

$$V=\sqrt{\frac{GM_E}{R+r}}=\sqrt{\frac{(6.673\times10^{-11})(5.98\times10^{24}\,kg)}{6.37\times10^{6}m+3.6\times10^{7}m}}$$

$$V=\frac{3068.89\,m}{1\,s}\times\frac{100cm}{1m}\times\frac{1in}{2.54cm}\times\frac{1ft}{12in}\times\frac{1mi}{5280ft}\times\frac{3600sec}{1hr}=6.864.91\ mi/hr$$

3. Verizon has a satellite in an out of control orbit around the Earth traveling at a speed of 7095 m/s. What should the height of the satellite be off the surface of the earth in order to stabilize the orbit?

$$V=\sqrt{\frac{GM_E}{R+r}}$$

$$V^2=\frac{GM_E}{R+r}$$

$$V^2(R+r)=GM_E$$

$$R+r=\frac{GM_E}{V^2}$$

$$r=\frac{GM_E}{V^2}-R$$

$$r=\frac{(6.673\times10^{-11})(5.98\times10^{24}\,kg)}{(7095\,m/s)^2}-6.37\times10^{6}m$$

$$r = 1.56\times10^{6}m$$

4. A rocket scientist is trying to determine the mass of a mysterious planet in a nearby solar system. So a satellite is sent into orbit around the unknown planet and it achieves a speed of 5600 m/s at a height of 2500 m above the ground. If the radius of the planet is 3.78×10^{4} m, what is the mass of the unknown planet?

$$V=\sqrt{\frac{GM_E}{R+r}}$$

$$V^2=\frac{GM_E}{R+r}$$

$$\frac{V^2(R+r)}{G}=\frac{GM_E}{G}$$

$$M=\frac{V^2(R+r)}{G}=\frac{(5600\,m/s)^2(3.78\times10^{4}m+2500m)}{6.673\times10^{-11}}$$

$$M = 1.89\times10^{22}\,kg$$

5. Two students are sitting 1.5 m apart. One of the students has a mass of 90.0 kg and the other student has a mass of 73.0 kg.

   a. What is the gravitational force between the two students?

$$F_g = G\frac{m_1 m_2}{d^2} = 6.673\times10^{-11}\left(\frac{(90\text{kg})(73\text{kg})}{(1.5\text{m})^2}\right) = \boxed{F_g = 1.95\times10^{-7}\ N}$$

   b. If the distance between them is doubled, what would the force be then?

$$6.673\times10^{-11}\left(\frac{(90\text{kg})(73\text{kg})}{(3.0\text{m})^2}\right) = \boxed{F_g = 4.87\times10^{-8}\ N}$$

   c. How much smaller or larger is the force compared to the first value? (express in a ratio)

When the distance is doubled, the force is 4 times less

1:4

   d. Instead of doubling the radius, what is the force if the distance is cut in half?

$$6.673\times10^{-4}\left(\frac{(90\text{kg})(73\text{kg})}{(0.75\text{m})^2}\right) = \boxed{F_g = 7.79\times10^{-7}\ N}$$

   e. How much smaller or larger is the force compared to the first value? (express in a ratio)

When the distance is cut in half, the force is 4 times larger

4:1

6. The Sun has a mass of 1.99×10^{30} kg. What is the force of gravity between the Sun and the Earth if the radius between the two is 1.5×10^{8} km?

$$F_g = G\frac{m_1 m_2}{d^2} = 6.673\times10^{-11}\left(\frac{(1.99\times10^{30}\text{kg})(5.98\times10^{24}\text{kg})}{(1.5\times10^{11}\text{m})^2}\right)$$

$$\boxed{F_g = 3.53\times10^{22}\ N}$$