Name ________Answer Key__________ Date ____________________________
Physics Gravity/Circles/Kepler WS #6
Period _____________ Mrs. Nadworny

Universal Gravitation & Circular Motion REVIEW

1. A star with a mass of 2.13 x 10^{17} kg and planet Blue, which has a mass of 4.13 x 10^{22} kg, are separated by a distance of 4.8 x 10^{11} m.
   a. Calculate the gravitational attractive force between the star and Blue.

$$F_G = \frac{Gm_1m_2}{r^2} = \frac{(6.67\times10^{-11}\,\frac{N\cdot m^2}{kg^2})(2.13\times10^{17}\,kg)(4.13\times10^{22}\,kg)}{(4.8\times10^{11}\,m)^2} = 2.5\times10^{6}\,N \text{ toward}$$

   b. Calculate the acceleration due to gravity on planet Blue if it has a radius of 3.26 x 10^6 meters.

$$g = \frac{Gm_1}{r^2} = \frac{(6.67\times10^{-11}\,\frac{N\cdot m^2}{kg^2})(4.13\times10^{22}\,kg)}{(3.26\times10^{6}\,m)^2} = 0.259\,\frac{m}{s^2} \text{ down}$$

   c. What would the weight of an astronaut (m = 95 kg) who travels to planet Blue?

$$F_{grav} = mg = (95kg)(0.259\,\tfrac{m}{s^2}) = 25N \text{ down}$$

2. Two objects, m_1 and m_2, are separated by a distance r. What happens to the gravitational force between them when the following changes are made?
   a. M_1 is 9 times larger and the distance between them triples.

$$F_g = \frac{Gmm}{r^2} = \frac{(1)(9)(1)}{(3)^2} = \text{ no change}$$

   b. The distance is cut in fourth.

$$F_g = \frac{Gmm}{r^2} = \frac{(1)(1)(1)}{(1/4)^2} = \text{ 16x larger}$$

   c. M_1 is doubled and m_2 is 5 times larger.

$$F_g = \frac{Gmm}{r^2} = \frac{(1)(2)(5)}{1^2} = \text{ 10x larger}$$

3. A student whirls a 19.96 g rubber stopper above their head on a string with a radius of 0.318 meters. The stopper completes 10 revolutions in 4.89 seconds. The force on the stopper is 1.04 newtons.
   a. Calculate the Period of stopper.

$$T = \frac{time}{revolutions} = \frac{4.89s}{10} = 0.489s$$

   b. Calculate the speed of the stopper.

$$v = \frac{2\pi r}{T} = \frac{2\pi(0.318m)}{0.489s} = 4.09\,\frac{m}{s}$$

   c. Calculate the centripetal acceleration using the speed.

$$a_c = \frac{v^2}{r} = \frac{(4.09\,\frac{m}{s})^2}{0.318m} = 52.6\,\frac{m}{s^2} \text{ inward}$$

   d. Calculate the centripetal acceleration using the force.

$$a_c = \frac{F_c}{m} = \frac{1.04N}{0.01996kg} = 52.1\,\frac{m}{s^2} \text{ inward}$$

4. Two rocks are floating in deep space far from the influences of other celestial bodies. One rock has a mass of 4.32 kg and the other has a mass of 8.71 kg. The attractive force between them is 0.03427 newtons. How far apart are they?

$$d = \sqrt{\frac{Gm_1m_2}{F_G}} = \sqrt{\frac{(6.67\times10^{-11}\,\frac{N\cdot m^2}{kg^2})(4.32kg)(8.71kg)}{0.03427N}} = .000271m = 2.71 \times 10^{-4} m$$

5. A car is driving around a circular racetrack of radius 86.0 meters. It experiences a centripetal acceleration of 17.3 m/s² inward. What is the speed at which the car is traveling?

$$v = \sqrt{a_c r} = \sqrt{(17.3\,\tfrac{m}{s^2})(86.0m)} = 38.6m/s$$

6. An object of mass *m* is traveling around a circle of radius *r* with speed *v.*
   a. What happens to the centripetal force if the mass is five times larger?

$$F = \frac{mv^2}{r} = \frac{(5)(1^2)}{1} = \text{ 5x larger}$$

   b. What happens to the centripetal force if the speed is doubled?

$$F = \frac{mv^2}{r} = \frac{(1)(2)^2}{1} = \text{ quadrupled}$$

   c. What happens to the centripetal force if the radius is cut in quarters?

$$F = \frac{mv^2}{r} = \frac{(1)(1^2)}{(\frac{1}{4})} = \text{ 4x larger}$$

   d. What happens to the centripetal acceleration if the mass triples?

$$a = \frac{v^2}{r} = \text{ nothing}$$

   e. What happens to the centripetal acceleration if the radius is tripled?

$$a = \frac{v^2}{r} = \frac{1^2}{3} = \frac{1}{3} \text{ the size}$$

7. A 2.6 kg stopper is twirled in a circle of radius 1.24 meters with a constant speed of 3.39 m/s. What is the tension in the rope?

$$F_c = ma_c = \frac{mv^2}{r} = \frac{2.6kg(3.39\,\frac{m}{s})^2}{1.24m} = 24N \text{ inward}$$

8. What is the period of a ball being swung around in a circle of radius 6.71 meters at 6.4 m/s?

$$T = \frac{2\pi r}{v} = \frac{2\pi(6.71m)}{(6.4\,\frac{m}{s})} = 6.6s$$

Answers in size order: 0 or 1, 0 or 1, 2.71 x 10^{-4}, 0.259, 1/3, 0.489, 4, 4, 4.09, 5, 6.6, 10, 16, 24, 25, 38.6, 52.1, 52.6, 2.5 x 10^{6}