PreAP Physics - Gravity, Circular Motion, and Satellites

Newton's Law of Gravity: $F_g = \frac{GMm}{r^2}$

Centripetal Force: $F_c = \frac{mv^2}{r}$

For satellites, the centripetal force is gravity. Setting the two forces equal and solving for v, we get $v = \sqrt{\frac{GM}{r}}$

The value of G = 6.673 x 10^{-11} N m^2 kg^{-2}.

Example:

A small satellite of mass 150 kg is orbiting a planet with mass 2.58 x 10^{20} kg at a distance of 6.10 x 10^8 m from the planet's center. Find the linear speed of the satellite. Then find its angular frequency (aka angular speed).

$v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{(6.673E{-}11)(2.58E20)}{(6.10E8)}} = 5.31$m/s

$\omega = \frac{v}{r} = (5.31)/(6.10E8) = 8.71E - 9$ rad/s

You do these:

1. A satellite of mass 500 kg is orbiting a planet with mass 4.87E24 kg at a distance of 12.0E6 m from the planet's center. Find the linear speed of the satellite. Then find its angular frequency (aka angular speed).

2. A large satellite of mass 3000 kg is orbiting the Earth (mass of 5.98 x 10^{24} kg) in a perfectly circular orbit. The satellite is traveling at 5600 m/s. What is the radius of the orbit?

3. What is the centripetal acceleration of the satellite described in problem 2?

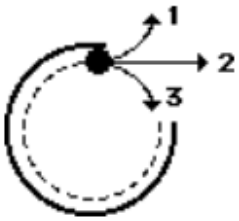
4. What is the centripetal force acting on the satellite described in problem 2?

5. What is the force of gravity between the Earth (m = 5.98×10^{24} kg) and the Sun (m = 1.99×10^{30} kg) if they are 1.498×10^{11} m apart (center-to-center)?

6. What is the force of gravity between John (m = 70 kg) and his truck (m = 2100 kg) if they are 5 m apart?

7. Sam has a ball on the end of a string and is swinging it above his head in a big circle. Jacy has a similar ball and is also swinging it above her head in a big circle of the same radius. Sam's ball is twice the mass of Jacy's, but Jacy's speed is twice that of Sam's. Who is providing a larger centripetal force, Sam or Jacy?

8. Noah Formula guides a golf ball around the outside rim of the green at the *Hole-In-One Putt-Putt Golf Course*. When the ball leaves the rim, which path (1, 2, or 3) will the golf ball follow? _____ (Note that this diagram depicts the *God's eye* view.) Explain why.



9. Suppose that you are a driver or passenger in a car and you travel over the top of a small hill in the road at a high speed. As you reach the crest of the hill, you feel your body still moving upward; your *gluts* might even be *pulled* off the car seat. It might even feel like there is an upward push on your body. This upward sensation is best explained by the _____.

a. tendency of your body to follow its original upward path
b. presence of an upward force on your body
c. presence of a centripetal force on your body
d. presence of a centrifugal force on your body

10. Darron Moore is on a *barrel ride* at an amusement park. He enters the barrel and stands on a platform next to the wall. The ride operator flips a switch and the barrel begins spinning at a high rate. Then the operator flips another switch and the platform drops out from under the feet of the riders. Darron is *plastered* to the wall of the barrel. This sticking to the wall phenomenon is explained by the fact that _____.

a. the ride exerts an outward force on Darron which pushes him outward against the wall
b. Darron has a natural tendency to move tangent to the circle but the wall pushes him inward
c. air pressure is reduced by the barrel's motion that causes a suction action toward the wall
d. the ride operator coats the wall with cotton candy that causes riders to stick to it