AP Physics – Angular Velocity

All of our motion studies thus far have dealt with straight-line stuff. We haven’t dealt with things changing direction during their travel. This type of motion is called ***motion***. A special case of angular motion is ***circular motion*** (when things travel around in circles).

We know that velocity and acceleration are both vectors. Recall that vectors have both magnitude and direction. Change either one and you have changed the motion. We know from the first law that objects in motion stay in motion unless an outside force acts to change that motion. We’ve studied all about forces that change the magnitude of the velocity. Now we’ll deal with forces that change the direction of a motion.

***Circular Motion:*** Objects that have circular motion are moving in a circular path around a central point which is called the ***axis*** or ***center of spin***. If the axis is within the body, we say it is ***rotating***. If the axis is outside the body, then the object is ***revolving***. The earth rotates around its axis, which causes day and night. The earth revolves around the sun, which causes the four seasons during the year (the time it takes the earth to revolve around the sun one time).

An object undergoing circular motion has an ***angular velocity*** and undergoes an ***angular*** ***displacement***.

Angular displacement can be measured in several units: revolutions (the number of times the thing makes a circle), degrees, or radians. These are the most common units. We will deal only with revolutions.

The angular velocity is the rate of change in angular displacement.

 

The Greek lower case letter omega is used as the symbol for angular velocity. Here is the equation:

  

The units for angular velocity we will use is: rpm ≡  .

* A record is rotating with an angular velocity of 45 rpm. If it rotates for 35 seconds, how many rotations does it make?



***Linear Speed and Circular Motion:***

When an object is rotating all points on the object have the same angular velocity. But at the same time each point is also tracing out a circle. If you divide the time it takes to make one revolution into the circumference of the circle that is traced out you get the speed of the point. We call this the ***linear*** or ***tangential speed***. The linear velocity is not constant as its direction changes every instant.

Calvin’s father is correct about the two points on a record. But, unlike Calvin, this should make perfect sense to you, the sophisticated advanced student of physics. The further a point is from the center of spin, the larger will be its linear speed.

This is true for the earth as well. You have a much larger linear speed if you are at the equator than you would have if you were at one of the poles.

We can figure out the linear speed of a point using the angular velocity.

Speed is distance divided by time, the time it takes to make one revolution is:

  Let the angular displacement be 1 revolution:

  This is the period of the rotation, the time it takes to make one revolution.

So we now have the time. Here is the equation for speed: 

The distance is the circumference of the circular path, . We plug this in and also the value we found for the time.

 

So the linear speed is given by: 

BASICALLY for Angular Velocity…. Here’s what you have to be able to do:

You should understand the uniform circular motion of a particle so you can:

1. Relate the radius of the circle and the speed or rate of revolution of the particle to the magnitude of the centripetal acceleration.

*You have this equation to work with: *

*In this equation, v is the linear speed, so it’s fairly easy to relate it to the radius (r) or to the centripetal acceleration (ac). You just use the old equation as it is given. If r gets bigger, then the centripetal acceleration gets smaller, etc.*

*The rate of revolution is the rate that the thing rotates. This would be the number of rotations divided by the time it took to do them. This is called the angular velocity, . Unfortunately, you don’t got no equation for this. Just remember that any rate is simply a quantity divided by time, so the angular velocity is simply:*

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*Where θ is the displacement, which will most likely be the number of revolutions that have been made?*

*What happens to the centripetal acceleration if the velocity is increased and you want to keep the same radius? If the radius increases, but the velocity stays the same, what happens to the centripetal acceleration?*

*You should be able to derive an equation that relates linear speed to angular velocity. We did that in your gravity handout. The Physics Kahuna showed you how to develop the equation: *

*Basically, the velocity is proportional to the angular velocity. So whatever happens when the linear speed increases also happens if the angular velocity increases.*