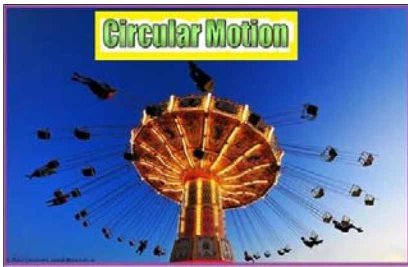


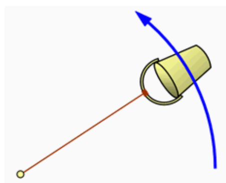
Unit 3: Circular Motion, Work, Energy

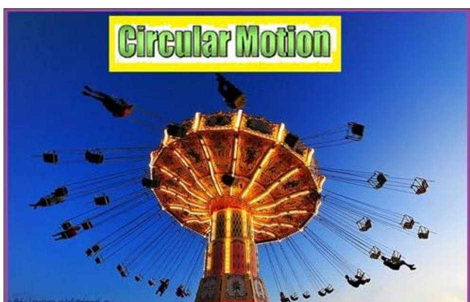
3.1 Uniform Circular Motion

With everything we have studied so far (Kinematics, Dynamics, Gravity), objects have always been moving in a straight line. Now we talking about circles.

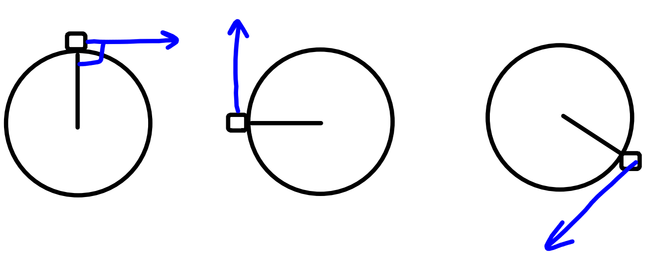
Uniform Circular Motion - constant circular movement

Eg. hammer throw, bucket of water on a string, fair rides, etc.

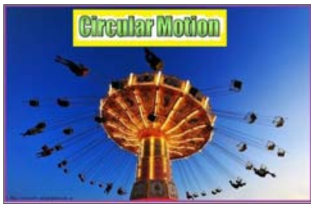


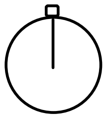


Let's analyze the bucket of water on a string. As long as SPEED stays the same we can say the object has uniform circular motion.



If we look at the velocity at different points in the path of the bucket, we will see the magnitude of velocity remains the same but direction changes.





The instantaneous velocity (velocity of the bucket at any given point in time) is always perpendicular to the radius of the circle and tangent to the circle.

So if velocity is ~~always changing~~ remains constant, we have:

$$\vec{v}_{ave} = \frac{\Delta \vec{d}}{\Delta t}$$

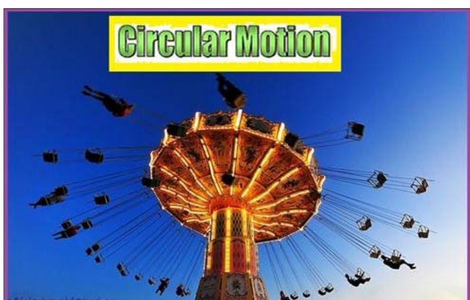
However, time means something different with circular motion. We use *T* to represent the time it takes to complete one revolution around the circle(called the period).

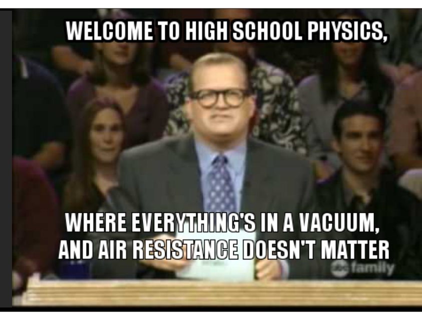
Now, distance will also mean something different when we go around a circle. Distance around a circle is circumference, or *2π*.

If we make all the substitutions to the formula to take into account the fact that we are moving around a circle, we get the formula for velocity of an object moving in a circle:

$$\left|\vec{v}_c\right| = \frac{2\pi r}{T}$$

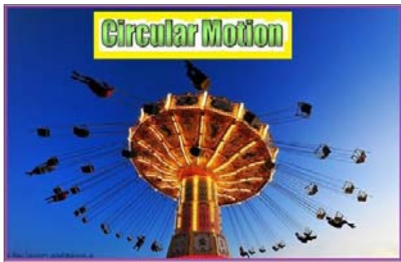
*formula found in Kinematics sections of formula sheet





Ex.) If the water bucket has a period of 1.5 s and the string is 1.25 m long, what is the magnitude of the buckets velocity?

$$\left|\vec{v}_c\right| = \frac{2\pi r}{T} = \frac{(2\pi \cdot 1.25)}{1.5} = \boxed{5.2 \text{ m/s}}$$



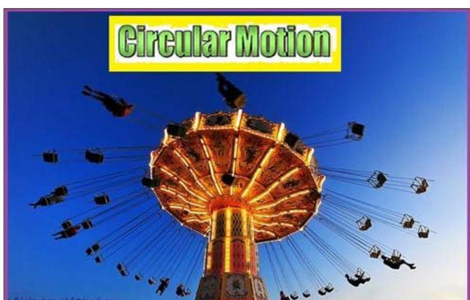
Ex.) A super-plane is flying at a height of 10 000 m above sea level in a circular path around the planet (assume it can hold enough fuel to do this in one trip). If the velocity of the super-plane is 150 m/s, how long does it take the super-plane to go around the world?

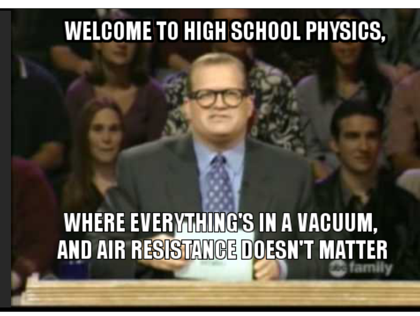
$r = 6.37\times10^6 + 10\,000$
$= 6\,380\,000$

$|\vec{v}_c| = \frac{2\pi r}{T}$

$T = \frac{2\pi r}{|\vec{v}_c|} = \frac{(2\pi\cdot 6\,380\,000)}{150} = 267\,245\text{ s}$

$267\,245\text{ s} \times \frac{1\text{ min}}{60\text{ s}} \times \frac{1\text{ h}}{60\text{ min}} = 74.2\text{ h}$

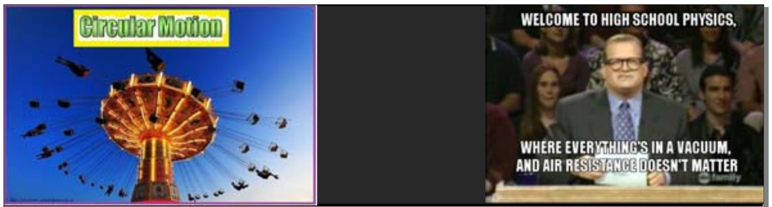




We've looked at velocity around a circle, now let's take a look at acceleration:

$$|\vec{a}_c| = \frac{v^2}{r}$$

Acceleration around a circle is called *centripetal acceleration.*

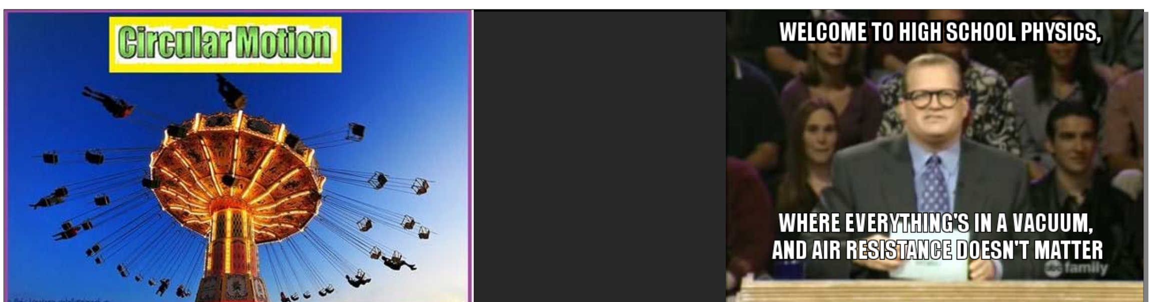


Two "forces" that are often confused in the Physics world are centripetal and centrifugal. Below are the differences:

FAKE

	Centrifugal Force	Centripetal Force
Meaning	Tendency of an object following a curved path to fly away from the center of curvature. Might be described as "lack of centripetal force."	The force that keeps an object moving with a uniform speed along a circular path.
Direction	Along the radius of the circle, from the center towards the object.	Along the radius of the circle, from the object towards the center.
Example	Mud flying off a tire; children pushed out on a roundabout.	Satellite orbiting a planet
Formula	Fc = mv2/r	Fc = mv2/r
Defined by	Chistiaan Hygens in 1659	Isaac Newton in 1684
Is it a real force?	No; centrifugal force is the inertia of motion.	Yes; centripetal force keeps the object from "flying out".

Important for this course: centripetal acceleration always points **towards** the centre of the circle.



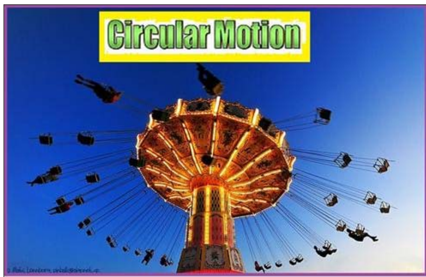
Ex.) A car takes a curve of radius 15 m at 45 km/h. What is the car's acceleration?

$\div 3.6$

$= 12.5\ m/s$

$$|\vec{a}_c| = \frac{v^2}{r} = \frac{12.5^2}{15}$$

$$= 10\ m/s^2 \text{ [towards the center]}$$



Newton's Second Law tells us that where there is acceleration, there is a force in the same direction.

If we have centripetal acceleration, it follows that we would have centripetal force:

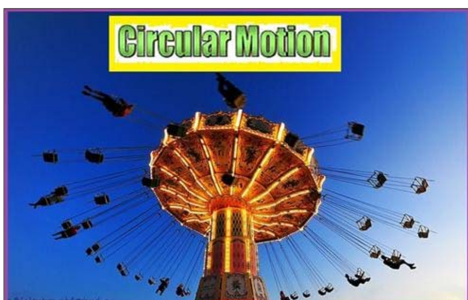
$$F_c = \frac{mv^2}{r}$$

$$F_c = \frac{mv^2}{r} = \frac{4\pi^2 rm}{T^2}$$

$$F_c = \frac{4\pi^2 rm}{T^2}$$

This centripetal force can be friction, tension, gravity...whatever.

latin for "centre seeking"



Read: Pg. 242-256.

https://www.youtube.com/watch?v=KvCezk9DJfk