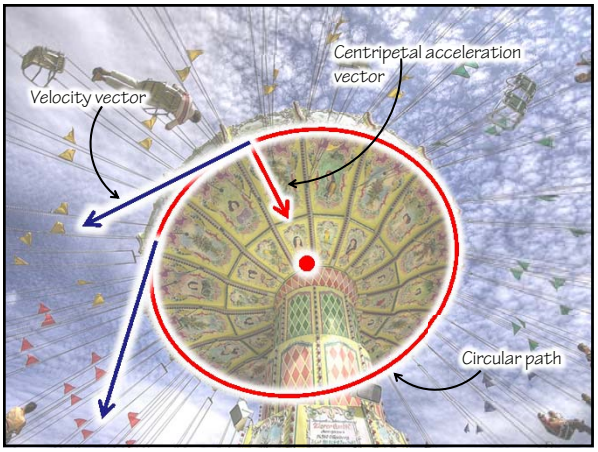
Circular Motion



Circular motion

An object that moves in a circle at constant speed is said to experience *uniform circular motion*.

- **The magnitude of the velocity remains constant.**
- **The direction of the velocity is continuously changing as the object moves around the circle.**
- **The object is accelerating because there is a change in velocity.**

This acceleration is called *centripetal acceleration* and it points towards the *center* of the circle.

Circular Velocity

$$v = \frac{2\pi r}{T}$$

v = velocity in a circle (m/s)
r = radius of the circle (m)
T = period (sec/ revolution)

Sometimes information is given in RPM (rev/min)
To convert RPM to sec / rev. . . . Flip and multiply by 60.
Example: The tachometer in you car reads 5000 RPM. What is the period?

$$T = \frac{1\,min}{5000\,rev} x \frac{60\,s}{1\,min} = 0.012\,s\,/\,rev$$

Sample problem

A rubber stopper on the end of a 0.5 meter long string completes 10 circles in 5 seconds. What is the velocity of the rubber stopper?

$$v = \frac{2\pi r}{T}$$

$$v = \frac{2\pi(0.5m)}{(5\,sec/10rev)}$$

$$v = 6.28\ m/s$$

Centripetal ACCELERATION

Change in **speed** OR **direction**.
Since an object moving in a circle is constantly changing direction it is constantly accelerating.
Centripetal acceleration always points to the center of the circle.

$$a_c = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$$

a_c = centripetal acceleration (m/s^2)
v = velocity (m/s)
r = radius (m)
T = period (sec/rev)

Sample Problem

A rubber stopper on the end of a 0.5 meter long string has a period of 0.5 seconds. What is the centripetal acceleration for the stopper?

$$a_c = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$$

$$a_c = \frac{4\pi^2(0.5m)}{(0.5s)^2}$$

$$a_c = 79.0\,m/s^2$$

Practice

NASA uses large centrifuges to study the effects of large forces on astronauts prior to their going into space. A subject in the 20-g (1g = 9.8 m/s^2) centrifuge, which has a radius of 8.9 m. What is the velocity of the astronaut?

a_c = (20g)*9.8 m/s^2 = 196 m/s^2

$$a_c = \frac{v^2}{r}$$

r = 8.9 m

$$196 m/s^2 = \frac{v^2}{8.9m} \qquad v = 41.77 m/s$$

Practice

A 205/75-R-15 inch tire (diameter = 27.106 in) rotates at 1600 rpms. What is the velocity in m/s of the tire at the outer edge?

T = (1/1600)*60 = 0.0375 s

$$v = \frac{2\pi r}{T}$$

r = 13.55 in = 0.344 m

$$v = \frac{2\pi\ 0.344\ m}{0.0375\ s} \qquad v = 57.64 m/s$$