Centripetal Force and Acceleration

To be able to calculate the centripetal acceleration of an object moving in a circle
To be able to calculate the centripetal force that keeps an object moving in a circle
To be able to explain why the centrifugal force does not exist

Moving in a Circle

For an object to continue to move in a circle a force is needed that acts on the object towards the centre of the circle. This is called the centripetal force and is provided by a number of things:

For a satellite orbiting the Earth it is provided by gravitational attraction.
For a car driving around a roundabout it is provided by the friction between the wheels and the road.
For a ball on a string being swung in a circle it is provided by the tension in the string.

Centripetal force acts from the body to the centre of a circle

Since $F=ma$ the object must accelerate in the same direction as the resultant force. The object is constantly changing its direction towards the centre of the circle.

Centripetal acceleration has direction from the body to the centre of the circle

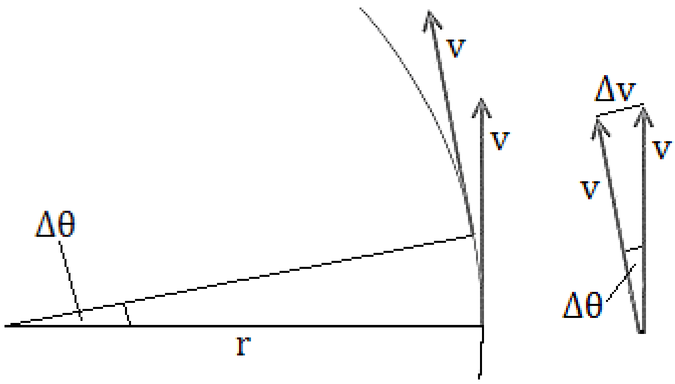
Centrifugal Force

Some people thought that an object moving in a circle would experience the centripetal force acting from the object towards the centre of the circle and the centrifugal force acting from the object away from the centre of the circle.
They thought this because if you sit on a roundabout as it spins it feels like you are being thrown off backwards.
If someone was watching from the side they would see you try and move in a straight line but be pulled in a circle by the roundabout.

The centrifugal force does not exist in these situations.

Centripetal Acceleration

The centripetal acceleration of an object can be derived if we look at the situation to the right. An object of speed v makes an angular displacement of $\Delta\theta$ in time Δt.



$$a = \frac{\Delta v}{\Delta t}$$

If we look at the triangle at the far right we can use

$\theta = \frac{s}{r}$ when θ is small. This becomes: $\Delta\theta = \frac{\Delta v}{v}$

We can rearrange this to give: $v\Delta\theta = \Delta v$

Acceleration is given by $a = \frac{\Delta v}{\Delta t}$ substitute the above equation into this one

$$a = \frac{v\Delta\theta}{\Delta t} \text{ this is the same as } a = v\frac{\Delta\theta}{\Delta t}$$

In lesson 3 (Circular Motion) we established that $\omega = \frac{\Delta\theta}{\Delta t}$, substitute this into the equation above

$$a = v\omega$$

If we use $v = r\omega$ we can derive two more equations for acceleration

$$\boxed{a = v\omega} \qquad \boxed{a = r\omega^2} \qquad \boxed{a = \frac{v^2}{r}}$$

Centripetal Acceleration is measured in metres per second squared, m/s^2 or m s^{-2}

Centripetal Force

We can derive three equations for the centripetal force by using $F = ma$ and the three equations of acceleration from above.

$$F = mv\omega \qquad F = mr\omega^2 \qquad F = m\frac{v^2}{r}$$

Centripetal Force is measured in Newtons, N