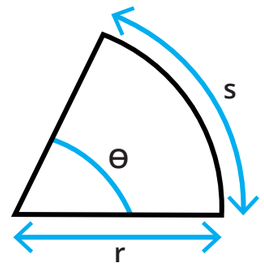
# GCE Physics Unit 3.1 Circular motion

## The radian:

The radian is defined as the angle subtended at the centre of a circle by an arc equal in length to the radius. It is equivalent to about 57.3°.

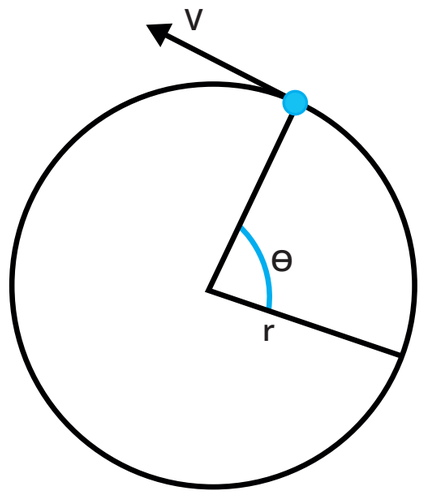
This means that one whole rotation travels through 2π radians.




## Angular velocity:

Motion in a circle or a cycle can be described by its time **period, $T$, the length of time for 1 cycle** and its **frequency, $f$, the number of cycles per second**.

$$T = \frac{1}{f}$$




For an object describing a circle at uniform speed, the **angular velocity**, $\omega$, is equal to the angle $\theta$ swept out by the radius in time $\Delta t$ divided by $t$.

$$\omega = \frac{\theta}{t}$$

As the time taken to complete a whole cycle, 2π, is $T$, the angular velocity can also be calculated by this equation:

$$\omega = \frac{2\pi}{T} = 2\pi f$$

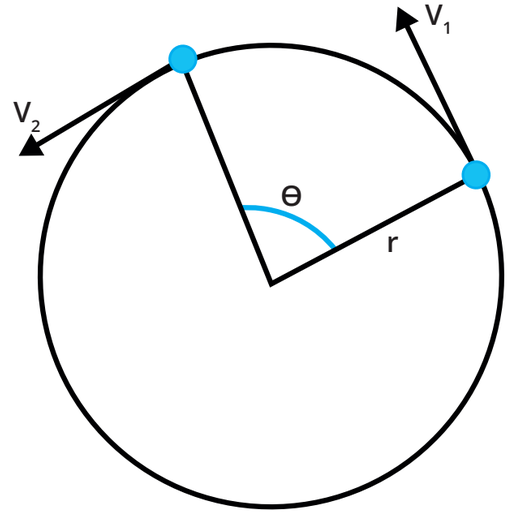
The relationship between the arc length and radius is arc length = $r\theta$ – this is the distance the object travels in time $t$. This means the speed of the object, $v$, can be calculated using this equation:

$$v = \omega r$$

## Centripetal acceleration and force:

This object is traveling with a constant speed, $v$, in a circular path. However, its **velocity** changes due to the **direction** changing. This means it must be accelerating due to a force acting on the object.

This is known as the **centripetal acceleration** as it is acting towards the centre of the circle.




It can be calculated in terms of $v$, and in terms of $\omega$.

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

From Newtons 2nd law; $F = ma$. Therefore, the force acting on the object can be calculated by these equations:

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

$v$ = velocity in m s$^{-1}$ $f$ = frequency in Hz $a$ = acceleration in m s$^{-2}$ $F$ = force in N

$T$ = period of one cycle in s $\omega$ = angular velocity in rad s$^{-1}$ $r$ = radius in m $m$ = mass in kg