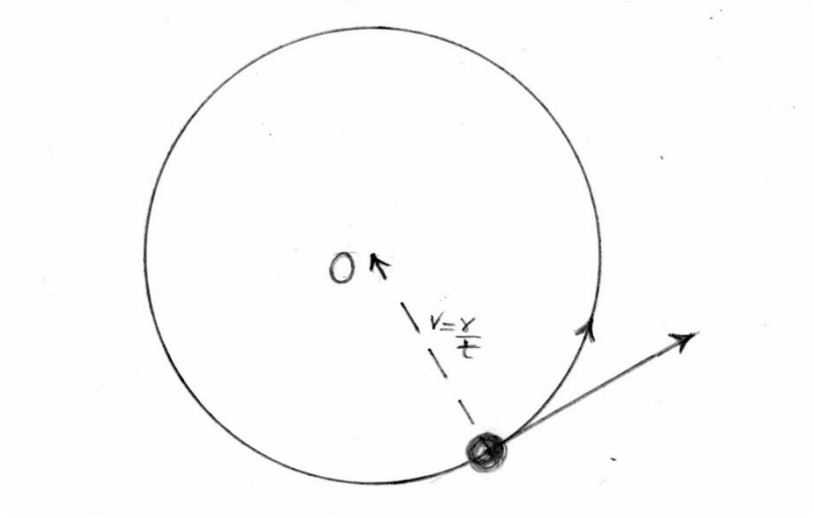
CIRCULAR MOTION

An object travelling along a circular path with a constant (or uniform) velocity is said to have a uniform circular motion. Although the object's speed is not changing, its direction of motion is continually changing. Therefore its velocity is constantly changing as it is a vector quantity, and hence the body is accelerating (due to direction).



Examples of such motion are:

- A stone tied to a string which is whirled in a horizontal or vertical circle;
- A satellite circling the earth;

- The earth moving round the sun;
- The planets moving round the sun.

The acceleration of the body on circular motion is directed towards the centre of the circular path and is called *centripetal acceleration*. Its magnitude *a* is given by:

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

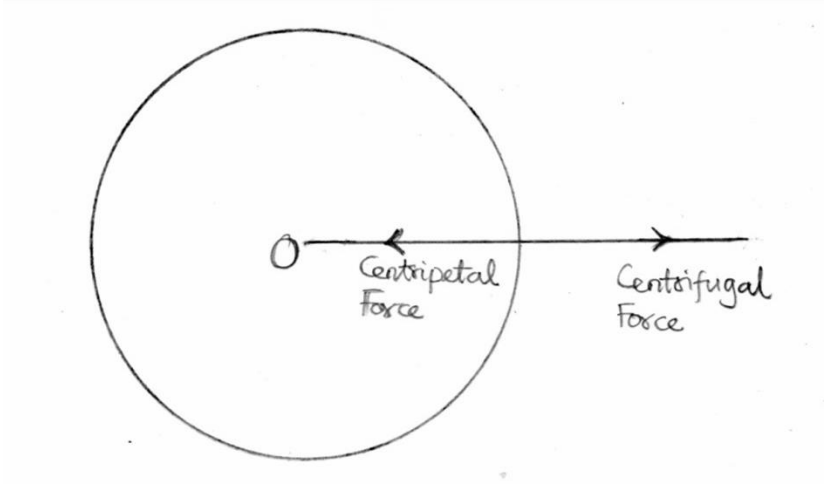
Where *v* is the uniform speed and *r* is the radius of the circular path. While *v* is always directed along the tangent to the circle at any point of the path, *a* is always directed towards the centre of the circle. This inwardly directed acceleration leads to a force known as *centripetal force* which is also directed towards the centre of the circle.

Centripetal Force F_T is defined as the inward force required to keep an object moving with a constant speed in a circular path. It is given by:

$$F_T = ma = \frac{mv^2}{r}$$

where m is the mass of the object moving with a uniform velocity v in a circular path or radius r.

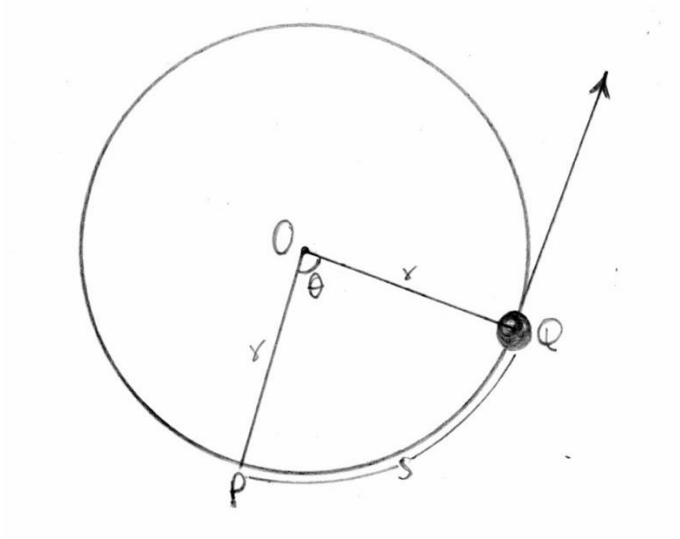
Since centripetal force must be applied to a body to restrain or keep it moving in a circular path, there must be according to Newton's third law of motion an equal and oppositely directed force. This force is known as *centrifugal force*.



An application of the effect of centrifugal force is the use of the centrifuge to separate particles from liquid in which they are suspended, or to separate two liquids of slightly different densities, e.g. cream and milk.

Angular Speed and Velocity

Consider the speed of a stone that is whirled on the end of a string. The stone moves in a circular path.



Suppose the stone moves from the point P to Q in t seconds so that the radius OP sweeps through an angle θ in the same time, i.e. angle $P\hat{O}Q = \theta^o$, the angular velocity of motion, *w* is defined by

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

Angular velocity (ω) is defined as the angle turned through, divided by the elapsed time. We can compare

this with the corresponding definition of linear velocity *v* given by:

$$v = \frac{s}{t}$$

where *s* is the length of the arc PQ. From $\omega = \frac{\theta}{t}$, we can see that the magnitude of angular velocity is defined in analogy with ordinary linear velocity. Instead of linear displacement, we use the angular displacement θ. If the angle θ is measured in radians, then it can be shown that:

$$\theta = \frac{s}{r}$$

Note: radian is a unit of angular measure and it is defined as the angle subtended by the arc of a circle whose length is equal to the radius of the same circle:

$$v = \frac{s}{t} = \frac{r\theta}{t} = r\omega$$

Linear velocity (v) is related to angular velocity (ω) by this formula, v = rω.