

CAIE Physics A-level

Topic 7: Motion in a Circle Notes

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7 - Motion in a Circle (A-level only)

7.1 - Kinematics of Uniform Circular Motion

Angles can be measured in units called **radians**. One radian is defined as the angle in the sector of a circle when the arc length of that sector is equal to the radius of the circle, as shown in the diagram below.

Considering a complete circle, its arc length is $2\pi r$, dividing this by r , you get 2π which is the angle in radians of a full circle. From this you can convert any angle from **degrees to radians** by **multiplying by $\frac{\pi}{180}$** , and from **radians to degrees** by **multiplying by $\frac{180}{\pi}$** .

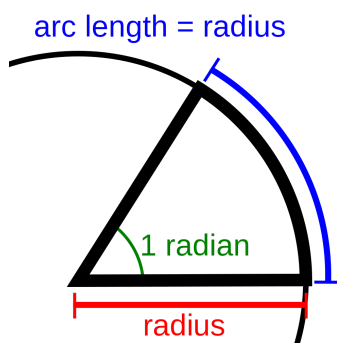


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Angular displacement (θ) is the **angle turned through** by an object in any given direction **in radians**.

Angular speed (ω) is the **angle an object moves through per unit time**. It can be found by dividing the object's linear speed (v) by the radius of the circular path it is travelling in (r), or by dividing the angle in a circle (in radians) by the object's time period (T).

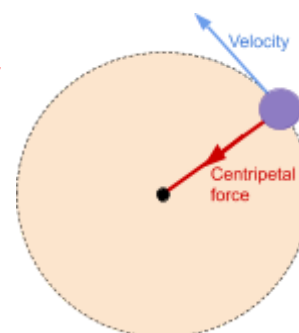
$$\omega = \frac{v}{r} = \frac{2\pi}{T} = 2\pi f \quad \text{as } f = \frac{1}{T}$$

You can calculate an object's **linear speed (v)** by finding the **product of its angular speed (ω) and the radius of its path (r)** as shown below:

$$v = r\omega$$

7.2 - Centripetal Acceleration and Centripetal Force

An object moving in a circular path at constant speed has a **constantly changing velocity** as velocity has both magnitude and direction, therefore the object must be **accelerating** (this is known as centripetal acceleration). We know from **Newton's first law** that to accelerate, an object must experience a resultant force, therefore an object moving in a circle must experience a force. This is known as the **centripetal force**, and it **always acts perpendicular to the motion of the object** (towards the centre of the circle).



Centripetal acceleration (a) can be found using the formula below:

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

Where v is linear speed, r is the radius of the path and ω is the angular speed.

Using **Newton's second law**, $F = ma$, we can derive the formula for **centripetal force (F)** from the formula above.

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

Where m is the mass of the object, v is linear speed, r is the radius of the path and ω is the angular speed.

