

# Circular Motion

## 1 Introduction to circular motion

For an object to be going in a circle a force is needed to accelerate the object. This is because in a circle an object is constantly changing velocity, even if it isn't changing speed.

Centripetal force is not an extra force, it is just the name for a resultant force.

For an object to be deflected towards the centre, there needs to be a force acting towards the centre.

### 1.1 Definitions

Quantity	Symbol	Unit	Definition
Period	T	Seconds,s	The time taken for an object to complete one revolution
Frequency	f	Hertz,hz	The number of revolutions per second
Angular velocity	$\omega$	$\text{rads}^{-1}$	The rate of change in angle(the angle covered per second)

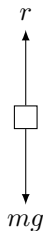
### 1.2 Formula not on formula book

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

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

Don't forget application of  $F = ma$  with the equations for force

## 2 Circular motion for going over a hump



For an object going over a hump the force of the weight is in the opposite direction to the reaction force. The object will leave the ground if  $mg > r$ .

### 2.1 Calculations

$$F_c = mg - R = \frac{mv^2}{r}$$

**Calculating the speed at which the car will leave the ground ( $R=0$ )**

$$mg = \frac{mv_0^2}{r} \quad V_0 = \sqrt{gr}$$

Once the car has left the ground, use SUVAT equations rather than circular motion.

## 3 Roundabouts

On a roundabout the centripetal force is provided by friction.

$$F_r = \frac{mv_0^2}{r}$$

To avoid slipping, the centripetal force must be less than the maximum possible for the car and road surface.

**Example question** The maximum possible force of friction between a car and the road is 800N, given a mass of 1000kg and a radius of 5m, what is the maximum speed the car can go without slipping

## 4 Banked motion

$N$  is the reaction force

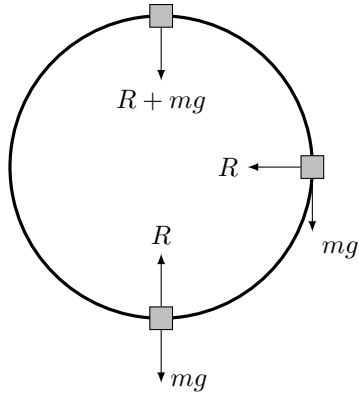
$n \sin \theta = \frac{mv^2}{r}$  - Force towards the centre of motion is equal to the centripetal force

$N \cos \theta = mg$  - The force vertically downwards is equal to the weight

$\tan \theta = \frac{v^2}{rg}$  - Combining the equations

$v^2 = gr \tan \theta$  - Re-write

## 5 Forces in a circle



Top: Centripetal force =  $R + W$

Side: Centripetal force =  $R$

Bottom: Centripetal force =  $R - W$

At the top of the loop  $v=0$

$v = \sqrt{gr}$