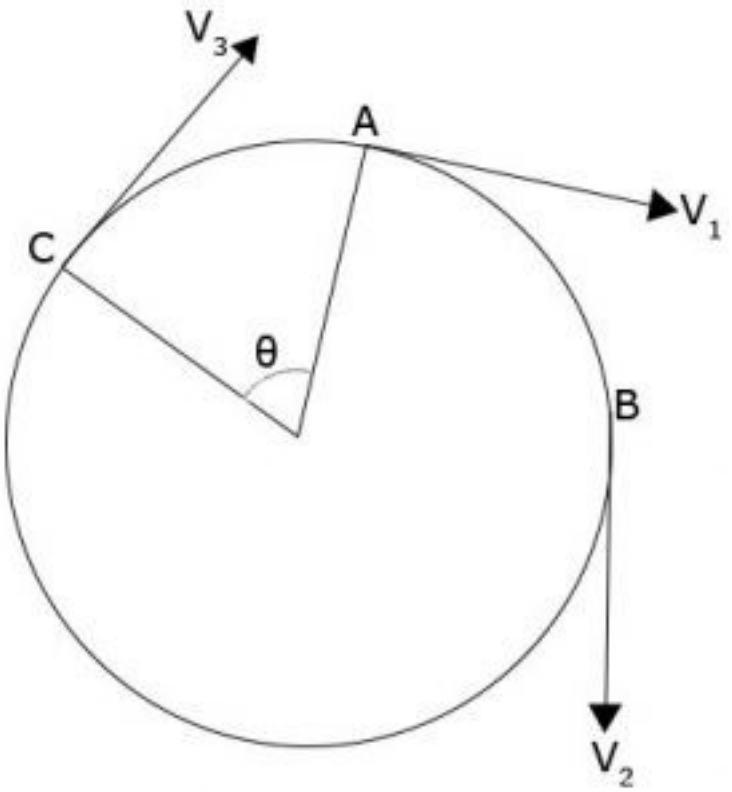
Physics: SS1 First Term

WEEK 6: Circular Motion

Meaning of Circular Motion

Circular motion is the motion of a body around a circle. The simplest form of circular motion is the uniform circular motion, where the speed is constant but the direction is changing.



Consider a body moving in a circular path center O with a constant speed.

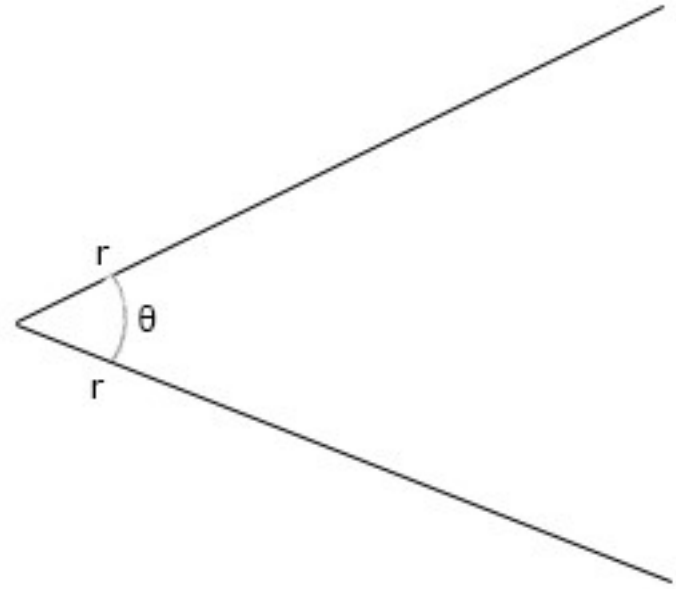
1. The direction at different points are not the same i.e. the direction at A is different from the direction at B. This leads to a change in velocity.
2. This difference in velocity produces an acceleration directed towards the center of the circle. This acceleration is called ***centripetal acceleration***.

3. Since there is an acceleration, there is a force directed towards the center of the circle called ***centripetal force.***
4. In addition to the centripetal force, there is an equal but opposite force which acts outwards from the center of the circle. This force is called the ***centrifugal force***. The centripetal and the centrifugal forces enable the object to move in the orbit.

Definition of Terms Used in Circular Motion

1. Angular velocity (ω):

The ratio of the angle turned through to the elapsed time.



ω= Angular velocity

ω=angular displacementtime=θt

The S.I unit is rad/sec

2. Tangential velocity (V):

This is the linear velocity whose direction is along the tangent to the circumference of the circle.

V=displacement(s)time(t)=st=rθt

But ω=θt

Then $V=r\omega$

The unit is m/s

3. Centripetal acceleration (a):

This can be defined as the acceleration of a body in uniform circular motion whose direction is towards the centre of the circle. It is given as:

a=V2r

The unit is m/s^2

But $V=r\omega$

Then $a=r\omega 2$

4. Centripetal force (F):

It is defined as that inward force that is always directed towards the centre of the circle required to keep an object moving with a constant speed in a circular path.

Centripetal force =mass×centripetal acceleration

F=mv2ror

$F=r\omega 2=\omega Vr=ma$

The unit is Newton

5. Centrifugal force:

This force is equal in magnitude to the centripetal force but opposite in direction. (it is always directed away from the centre of the circle)

$F=-mv2rorF=-r\omega 2$

6. Period (T):

This is the time taken for a body to complete one revolution round the circle.

Displacement = 2

Time = T

Velocity = v

v=displacementtime=2πrTT=2πrv

7. Frequency (f):

It is the number of revolutions in one second.

f=1TT=v2πr

The unit is Hertz or per seconds. (i.e Hz or s^{-1})

Calculations on Circular Motion

Question 1:

A stone of mass 2kg is attached to the end of an inelastic string and whirled round two times in a horizontal circular path of radius 3m in 3 sec, find:

(i) Angular velocity

(ii) Linear velocity

(iii) Centripetal acceleration

(iv) Centripetal force

(v) Centrifugal force

Solution

(i) ω=angular displacementtime=θt

Where is the angular displacement and **ω** is the **angular velocity**

θ=360×2=720o (ie two times)

π=180oθ=4πradω=4π3=1.33πrad/sec

(ii) v=rω=3×1.33π=3.99πm/s

(iii) a=v2ra=(3.99π)23a=5.31π2m/s2

(iv) $F=ma=2\times5.31\pi2=10.62\pi2N$

(v) $F=-mv2r=-10.62\pi2N$