4)

3) Centrifugal Force

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The Centrifugal force is also a fictitious force. It is a force which is arises from the body's inertia and appears to act on a body which is moving in a Circular Path and directed away from the Centre around which the body is moving. It is the tendency of an object that follows a Curved Path to move away from the Centre or axis. Mathematically it is written as :

$$F = -\frac{mv^2}{r}$$

where,

F = Centrifugal force ;

m = Mass of the object ;

v = velocity or Speed of the object ;

r = radius

According to frame S, a Centripetal force ($F_c = m\omega^2 r$) operates along $\vec{PO}$ on Particle P and no other force acts on it.

$\left(F = \frac{mv^2}{r}, \text{ also } v = r\omega \right)$

As Per the Spectator, in S' frame, the Particle P is at rest because S' is rotating with the same angular velocity as that of P.

An additional force ($m\omega^2 r$) is known as frame dependent force or centrifugal force. It works on the particle along $\vec{OP}$ (outwards) in addition to centripetal $F_c = m\omega^2 r$ along $\vec{PO}$ (inwards). Hence, P is at rest. It is a pseudo force or a fictitious force.

The term $F_{CF} = -m\omega \times (\omega \times \vec{r})$ generally arises due to the outcome of rotation of coordinate axes. The fictitious force that works on a particle at rest relative to a rotating frame of reference is called as centrifugal force. Mathematically, it is equivalent to the centripetal force but it operates in opposite direction, i.e. outwards and away from the rotational axis.

Its magnitude is specified as:

$$F_{CF} = m\omega^2 r$$

There are some example of centrifugal force as given below:

(i) Let a car that is in motion takes a sudden turn towards left, passengers in a car experiences an outward push to the right.

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This is due to the Centrifugal force acting on Passengers.

(i") When a bucket full of water is rotated in vertical Circle at a Particular speed, water dose not falls. This is because weight of water is balanced by the Centrifugal force acting on it.

EX- The Kinetic energy K of a Particle moving along a Circle of radius R depends on the distance Covered S is as $K = as^2$, Then Show that The force acting on the Particle is $2as\left(1+s^2/R^2\right)^{1/2}$.

Sol: we Know That there are two forces in non-uniform Circular Motion and This force will Work, on a Particle F_c and F_t.

Thus, the net force is given by

$$F_{Net} = \sqrt{F_c^2 + F_t^2} \longrightarrow (1)$$

The Centripetal force is given by

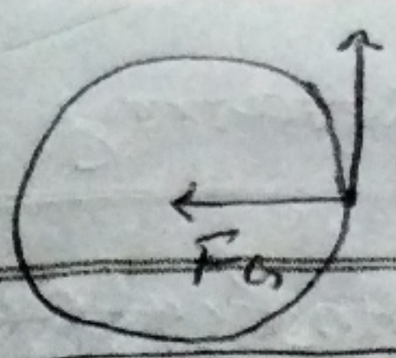
$$F_c = mv^2/R = 2as^2/R \longrightarrow (2)$$

we Know That $1/2\, mv^2 = as^2$

$$\Rightarrow v^2 = \frac{2as^2}{m} \Rightarrow v = s\sqrt{\frac{2a}{m}}$$

Tangential acceleration is given by

$$a_t = \frac{dv}{dt} = \frac{dv}{ds}\,\frac{ds}{dt}$$



$$a_2 = v\sqrt{\frac{2a}{m} - \frac{2as}{m}}$$

and $F_2 = ma_2 = 2as$ — (3)

Substitute the value of F_c and F_t in equation (1) we obtain.

Thus,

$$F_{Net} = \sqrt{\left(\frac{2as^2}{R}\right)^2 + (2as^2)^2} = 2as$$

$$= 2as\left(1 + \frac{s^2}{R}\right)^{1/2}$$

Ex Find the average recoil force on a machine gun firing 120 shots per second. The mass of each bullet is 10 gm and muzzle velocity is 800 m/sec.

Sol we have,

Mass of bullet $m = 10\,gm = 0.01\,Kg$

Nuzzle velocity $v = 800\ m/sec$,

Shots fired in one second $n = 120$ Shots Per/Sec, $t = 1$ sec

Since, $F = ma$ or $F = m\left(\frac{v}{t}\right)$

The force exerted by n bullets we have:

$$F = nm(v/t)$$

Recoil Force $F = \frac{nmv}{t}$

$$= \frac{0.01 \times 800 \times 120}{1} = \frac{800 \times 120}{100} = 960\ N$$