PUNJAB GROUP OF COLLEGESFAISALABAD

Chapter # 05

Chapter Name ,, Circular Motion

(Short Answers and Numericals)

Notice By ,

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CH # 05

Short Answers:-

5.1 1- * Tangential velocity:-

It is the linear velocity of a particle moving along a circle. The direction of linear velocity is always along Tangent to the circle, that's why it is called Tangential velocity.

* Angular velocity:-

The Rate of change of Angular displacement is called the angular velocity.

5.2:- The Force Required to bend a straight Path into circular Path, called centripetal force.

$$F_c = \frac{mv^2}{r}$$

without this force, No body can move in a circular Path. The direction of a body moving in a circular Path is always changing.

5.3:- Moment of Inertia:-

The Product of Mass of Particle and square of its perpendicular distance from its Axis of Rotation is called Moment of Inertia.

$$I = mr^2.$$

* Physical significance:-

For a body in Linear Motion, Newton IInd law of Motion is; $F = ma$.

$$F/a = m \text{ --- (i)}$$

Similarly;

For a body rotating about any axis, then;

$$\tau = I\alpha.$$

$$\tau/\alpha = I \text{ --- (ii)}.$$

comparing eq. (i) & (ii). It can be seen that the Moment of Inertia of rotating body is analogus to the Mass of body of Linear Motion.

5.4 * A Particle is said to Possess an angular momentum about a refrence Axis if it moves so that its angular position changes relative to that Refrence Axis.

$$\vec{L} = \vec{r} \times \vec{P} \qquad \because P = mv$$

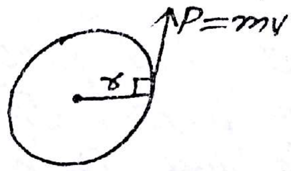
$$\vec{L} = rP\sin\theta \Rightarrow mrv\sin\theta.$$

* Law of conservation of angular Momentum:-

If No, external torque acts on a system the total angular momentum of the system remains Constant.

$$L_{Total.} = L_1 + L_2 + L_3 + \ldots\ldots = \text{constant.}$$

5.5 :- According to the defination of angular Momentum;



$$L_o = \vec{r} \times \vec{P}$$

$$L_o = rP\sin\theta.$$

$$\because P = mv$$

$$L_o = mrv\sin\theta \qquad \because \theta = 90^\circ$$

$$L_o = mrv\sin 90^\circ \qquad \because \sin 90^\circ = 1$$

$$\boxed{L_o = mrv}$$

5.6 When the Sattelite is moving in a circular orbit around the earth, the centripetal acceleration is provided given as;

$$a = \frac{v^2}{R} \qquad \because a = g$$

$$g = \frac{v^2}{R}$$

$$v = \sqrt{gR} \qquad \because v = \text{orbital velocity}$$

$$\because R = \text{Radius of earth.}$$

$$v = \sqrt{9.8 \times 6.4 \times 10^6}$$

$$v = 7.9\ Km/S$$

This is the minimum velocity required to put a Sattelite into the Orbit and called critical velocity

5.7:- The direction of angular Momentum and angular velocity will be along Axis of rotation, which Can be given by right hand Rule;

"curl the fingers of your right hand in the direction of rotation of the body, and then the erect thumb will gives the direction of angular velocity and momentum.

5.8:- (a) when an object is put into orbit around the earth then as a result of tangential velocity and the force of gravity. The body Starts moving in curved Path, around the earth. as the body continuous to fall around the earth, So it is Said to be freely falling object.

(b) when a body is freely falling, it is moving with an acceleration "g". And the body moving with acceleration "g" appear weightless.

$$T = mg - mg$$

$$\boxed{T = 0}$$

5.9:- when mud flies off the tyre of a moving bicycle, It always flies along the Tangent to the Tyre.

The force of adhesion Provides necessary centripetal force. when Speed increase then adhesion force will not be sufficient to Provide the required centripetal force. This is because the Linear velocity is always Tangent to the circle, and the mud will fly in the direction of Linear velocity.

(4)

(5.10):- The formulas of velocity of Disc and hoop are,

$$V_{Disc.} = \sqrt{\frac{4gh}{3}} \quad , \quad V_{hoop.} = \sqrt{gh} \quad \text{— (1)}$$

$$V_{Disc.} = \sqrt{\frac{4}{3}}\sqrt{gh} \Rightarrow 1.15\sqrt{gh} \quad \text{— (2)}$$

By eq. (1) & (2), the Disc will be moving with the greater speed on Reaching the Bottom.

$$V_{Disc.} > V_{Hoop.}$$

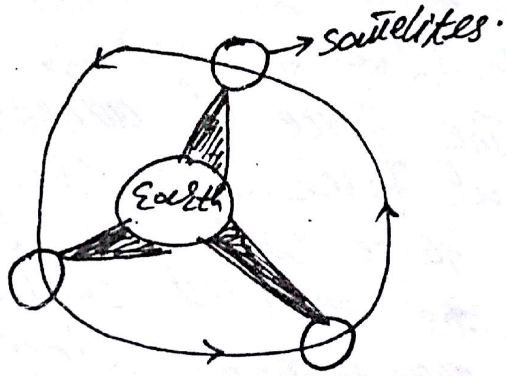
(5.11):- when the Diver Jumps from the diving board, his legs and arms are fully extended. The diver has a large moment of Inertia "I_1". But angular velocity ω_1 is Small. when diver curls his body, the Moment of Inertia reduces to "I_2". In order to conserve the angular momentum the value of angular velocity increases to ω_2,

$$L = I_1\omega_1 = I_2\omega_2 = \text{Constant.}$$

In this way he can make more Somersaults before entering the water.

~~(5.12)~~:-

(5.13):- A Geo-Stationary satellite covers 120° of longitude. So, the Minimum No. of geostationary required for global coverage of T.V transmission is three (3).



Numericals

CH # 05

5.1. Given data,

$S = 2.50m$, $r = 3.8 \times 10^8 m$

$\theta = ?$

As, $S = r\theta$

$\theta = \frac{S}{r} = \frac{2.50}{3.8 \times 10^8}$

$\theta = 6.6 \times 10^{-9}$ rad.

5.2. Given data,

$\omega_i = 0$, $t = 1.60$ sec.

$\omega_f = 45$ rev/min. $\Rightarrow \frac{45 \times 2\pi}{60}$ rad/sec

$\omega_f = 1.5\pi$ rad/s

$\alpha = ?$

As, $\alpha = \frac{\omega_f - \omega_i}{t}$

$\alpha = \frac{1.5\pi - 0}{1.6} = 2.95$ rad/s

5.3. Given data;

$I = 0.80$ kgm^2.

$\omega = 100$ rad/s, $L = ?$, $\tau = ?$

As, $L = I\omega$

$L = 0.80 \times 100 \Rightarrow 80$ Js

Also we know,

$\tau = I\alpha$.

Since ω is constant so $\alpha = 0$.

$\tau = I(0)$

$\tau = 0$

5.5. Given data;

$M = 2 \times 10^{30}$ kg

$r = 7 \times 10^5$ km $= 7 \times 10^8$ m.

$t = 20$ days

$= 20 \times 24 \times 60 \times 60$ s

$t = 1728000$ s

$L = ?$, $K.E = ?$

As, $L = I\omega$ — (i)

and, $I = \frac{2}{5} mr^2$.

$I = \frac{2}{5}(2 \times 10^{30})(7 \times 10^8)^2$

$I = 39.2 \times 10^{46}$ kgm^2.

$\omega = \frac{2\pi}{T} = \frac{2(3.14)}{1728000}$

$\omega = 3.63 \times 10^{-6}$ s^{-1}

Put in (i):

$L = (39.2 \times 10^{46})(3.63 \times 10^{-6})$.

$L = 1.4 \times 10^{42}$ Js.

and, $K.E = \frac{1}{2} I\omega^2$.

$= \frac{1}{2}(39.2 \times 10^{46})(3.63 \times 10^{-6})^2$

$K.E \Rightarrow 2.5 \times 10^{36}$ J.

5.6. Given data;

$m = 1000$ kg, $v = 144$ km/h.

$v = \frac{144 \times 1000}{3600}$ ms^{-1} $\Rightarrow 40$ ms^{-1}.

$r = 100$ m, $F_c = ?$

As, $F_c = \frac{mv^2}{r}$

$F_c = \frac{1000 \times (40)^2}{100}$

$F_c = 1.6 \times 10^4$ N.

5.7. Given data;

$r = 1$ km $= 1000$ m.

$g = 9.8$ ms^{-2}.

$v = ?$

As, $v = \sqrt{gR}$

$v = \sqrt{9.8 \times 1000}$

$v = \sqrt{9800}$

$v = 99$ ms^{-1}

5.9 Given data:

$T_1 = 24\ hr$

Radius of earth $= R_1$ — ① $\because \omega_1 = \frac{2\pi}{T_1}$

Let Radius of earth $= R_2 = \frac{R_1}{2}$ — ② $\because \omega_2 = \frac{2\pi}{T_2}$.

$T_2 = ?$

$I_1 = \frac{2}{5}MR_1^2$, $I_2 = \frac{2}{5}MR_2^2$

By eq. ②

$$I_2 = \frac{2}{5}M\left(\frac{R_1}{2}\right)^2$$

$$I_2 = \frac{2}{5}M\frac{R_1^2}{4}$$

By using law of conservation of Angular Momentum:

$$L_1 = L_2$$

$$I_1\omega_1 = I_2\omega_2.$$

$$\left(\cancel{\tfrac{2}{5}}\cancel{M}\cancel{R_1^2}\right)\left(\frac{\cancel{2\pi}}{T_1}\right) = \left(\cancel{\tfrac{2}{5}}\cancel{M}\frac{\cancel{R_1^2}}{4}\right)\left(\frac{\cancel{2\pi}}{T_2}\right)$$

$$\frac{1}{T_1} = \frac{1}{4T_2} \Rightarrow T_2 = \frac{T_1}{4} = \frac{24}{4}$$

$$T_2 = 6\ hours$$

5.10 Given data,

$r = 900\ Km = 900 \times 10^3\ m.$

$R_e = 6400\ Km = 6400 \times 10^3\ m.$

Radius of orbit $= r + R_e$

$$\Rightarrow (900 \times 10^3) + (6400 \times 10^3).$$

$$= 7.3 \times 10^6\ m.$$

$V_0 = ?$

As,

$$V_0 = \sqrt{\frac{GM}{R}} \Rightarrow \sqrt{\frac{6.67 \times 10^{-11} \times 6 \times 10^{24}}{7.3 \times 10^6}}$$

$$V_0 = 7.4 \times 10^3\ ms^{-1}.$$

$$V_0 = 7.4\ Km\,s^{-1}$$