ULTIMATE KCET

CRASH COURSE 2026

Physics | Lecture : 01

System of particles and Rotational motion

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Recap

of previous lecture

1. WORK AND ITS TYPES
2. WORK-ENERGY THEOREM
3. KINETIC ENERGY AND LINEAR MOMENTUM
4. POWER AND MCQ's+PYQ's

Topics

to be covered

1. UNIFORM CIRCULAR MOTION
2. VERTICAL CIRCULAR MOTION
3. COM & COLLISION
4. SYSTEM OF PARTICLES AND ROTATIONAL MOTION

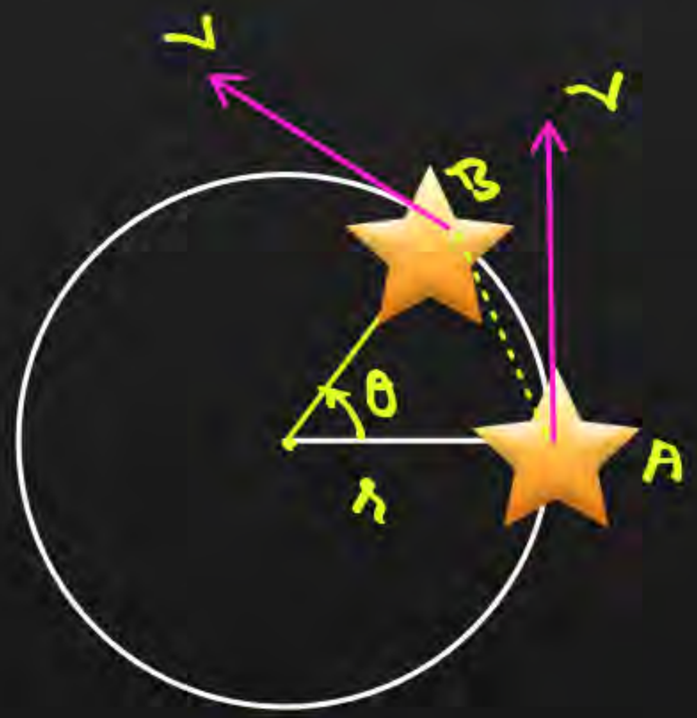
Circular Motion

- When an object moves in a circular path with constant speed is called Uniform circular Motion

- Angular displacement , $\theta = \frac{AB}{OA} = \frac{l}{r}$

$$\boxed{\theta = \frac{l}{r}} = \frac{2\pi r}{r} = \boxed{\theta = 2\pi} \text{ rad}$$

$$v = \frac{dx}{dt}$$



$L = 2\pi r.$

- Angular velocity $\boxed{\omega = \frac{d\theta}{dt}}$

$$\boxed{\omega = \frac{2\pi}{T}} \text{ rad/s}$$

$$\omega = \frac{\theta}{t} = \frac{2\pi}{T}$$

Circular Motion

$s, x \rightarrow \theta$

$v \rightarrow \omega$

$a \rightarrow \alpha$

- Angular acceleration

$$\boxed{\alpha = \frac{d\omega}{dt}}$$

$\hookrightarrow rad/s^2$

$$a = \frac{dv}{dt}$$

- Equation of motion

$v = u + at \longrightarrow \omega = \omega_0 + \alpha t$

$s = ut + \frac{1}{2}at^2 \longrightarrow \theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$v^2 = u^2 + 2as \longrightarrow \omega^2 = \omega_0^2 + 2\alpha\theta$

Circular Motion

- Time period

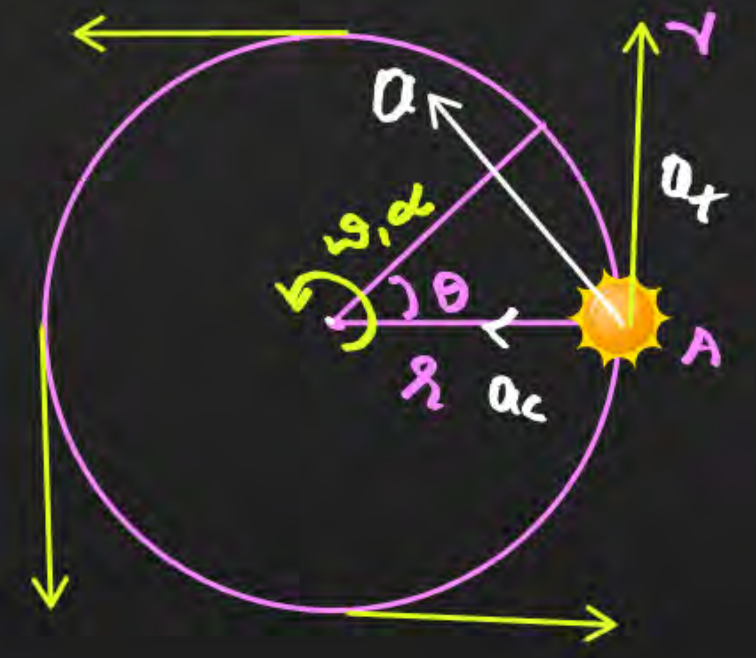
$\omega = \frac{2\pi}{T}$

$\boxed{T = \frac{2\pi}{\omega}}$

- Frequency

* $\boxed{f = \frac{1}{T}}$ $\boxed{\omega = 2\pi f}$

Circular Motion



Relation between Linear Velocity and Angular Velocity.

$$\vec{v} = \vec{\omega} \times \vec{r} \quad , \quad \boxed{v = \omega r}$$

Relation between tangential acceleration and angular acceleration.

a_t α

$$\vec{a_t} = \vec{\alpha} \times \vec{r} \quad , \quad \boxed{a_t = \alpha r}$$

$$a = \sqrt{a_t^2 + a_c^2}$$

Centripetal Acceleration OR Radial Acceleration.

$$\boxed{a_c = \omega^2 r}$$

QUESTION

Two particles A and B are moving in uniform circular motion in concentric circles of radii r_A and r_B with speed v_A and v_B respectively. Their $\boxed{\text{time period of rotation is the same}}$. The ratio of $\boxed{\text{angular speed}}$ of A to that of B will be:

$\omega = \frac{2\pi}{T}$ $\qquad T_A = T_B = T$

$\boxed{\frac{\omega_1}{\omega_2} = \frac{1}{1}} = \text{constant}$

A) $r_A : r_B$

B) $v_A : v_B$

C) $r_B : r_A$

D) $\boxed{1:1}$

QUESTION

A particle moves in a circle of radius 5 cm with constant speed and time period 0.2π s. The acceleration of the particle is

$a_c = \omega^2 r.$ $\omega = \frac{2\pi}{T} = \frac{2\cancel{\pi}}{0.2\cancel{\pi}} = \frac{2}{0.2}$

$a_c = (10)^2 \times 5 \times 10^{-2}$ $\omega = \frac{20}{2} = 10$ rad/s

$a_c = 10^2 \times 5 \times 10^{-2}$

$\boxed{a_c = 5 \text{ m/s}^2}$

(A) 15 m/s^2

(B) 25 m/s^2

(C) 36 m/s^2

(D) $\boxed{5 \text{ m/s}^2}$

QUESTION

r

A particle moves along a circle of radius $\left(\frac{20}{\pi}\right)$ m with constant $\boxed{\text{tangential acceleration.}}$ If the velocity of the particle is 80 m/s at the end of the $\boxed{\text{second}}$ revolution after motion has begun, the $\boxed{\text{tangential acceleration}}$ is:

(A) $\boxed{40\ \mathrm{ms}^{-2}}$

(B) $640\pi\ \mathrm{m}^{-2}$

(C) $160\pi\ \mathrm{ms}^{-2}$

(D) $40\pi\ \mathrm{ms}^{-2}$

$v^2 = u^2 + 2as$

$v^2 = (0)^2 + 2a_t \times 2 \times 2\pi r.$

$(80)^2 = 2 \times a_t \times 2 \times 2\cancel{\pi} \times \frac{20}{\cancel{\pi}}$

$640\cancel{0} = 16\cancel{0}\, a_t$

$\boxed{a_t = 40\ \mathrm{m/s^2}}$

QUESTION

Two particles having mass ' M ' and ' m ' are moving in a circular path having radius R and r respectively. If their time period are same then the ratio of angular velocity will be:

$\omega = \frac{2\pi}{T} = \text{constant}$

$\boxed{\frac{\omega_1}{\omega_2} = \frac{1}{1}}$

A. $\frac{r}{R}$

B. $\frac{R}{r}$

C. $\boxed{1}$

D. $\sqrt{\frac{R}{r}}$

QUESTION

A body is whirled in a horizontal circle of radius $\boxed{20\text{ cm}}$. It has an angular velocity of $\boxed{10\text{rad/s}}$. What is its $\boxed{\text{linear velocity}}$ at any point on its circular path?

r

ω

v

(A) 20 m/s

(B) $\sqrt{2}$ m/s

(C) 10 m/s

(D) $\boxed{2\text{ m/s}}$

$v = \omega r.$

$v = 10 \times 20 \times 10^{-2}$

$v = 200 \times 10^{-2}$

$\boxed{v = 2\text{ m/s}}$

QUESTION

The angular speed of a flywheel making $\boxed{\text{120 revolution/ minute}}$ is:

rpm

$f = \frac{N}{t} = \frac{120}{60} = 2\,Hz$

$= 2\,rps$

$\omega = \frac{2\pi}{T} = 2\pi f$

$\omega = 2\pi \times 2$

$\boxed{\omega = 4\pi\ rad/s}$

(A) $\boxed{4\pi\ \text{rad/s}}$

(B) $\pi\ \text{rad/s}$

(C) $4\pi^2\ \text{rad/s}$

(D) $2\pi\ \text{rad/s}$

QUESTION

$f = \frac{N}{T} = \frac{120}{60} = 2\ \text{rps}$

An electric fan has blades of length $\boxed{30\ \text{cm}}$ (r) measured from the axis of rotation. If the fan is rotating at $\boxed{120\ \text{rpm}}$ (f), the acceleration of a point on the tip of the blade is:

$a = \omega^2 r$ $\quad \omega = \frac{2\pi}{T} = 2\pi f$

(A) $1600\ \text{ms}^{-2}$

(B) $\boxed{47.4\ \text{ms}^{-2}}$

(C) $23.7\ \text{ms}^{-2}$

(D) $50.55\ \text{ms}^{-2}$

$a = (4\pi)^2 \times 30 \times 10^{-2}$ $\quad \omega = 2\pi \times 2$

$\boxed{\omega = 4\pi\ \text{rad/s}}$

$a = 16\pi^2 \times 30 \times 10^{-2}$

$a = 4732.60 \times 10^{-2}$

$\boxed{a = 47.32\ \text{m/s}^2}$

Vertical Circular Motion

- Motion in a vertical circle, Tension at any position of angular displacement (θ) along a vertical circle is given by

$$\boxed{T = \frac{mv^2}{r} + mg\cos\theta}\ *$$

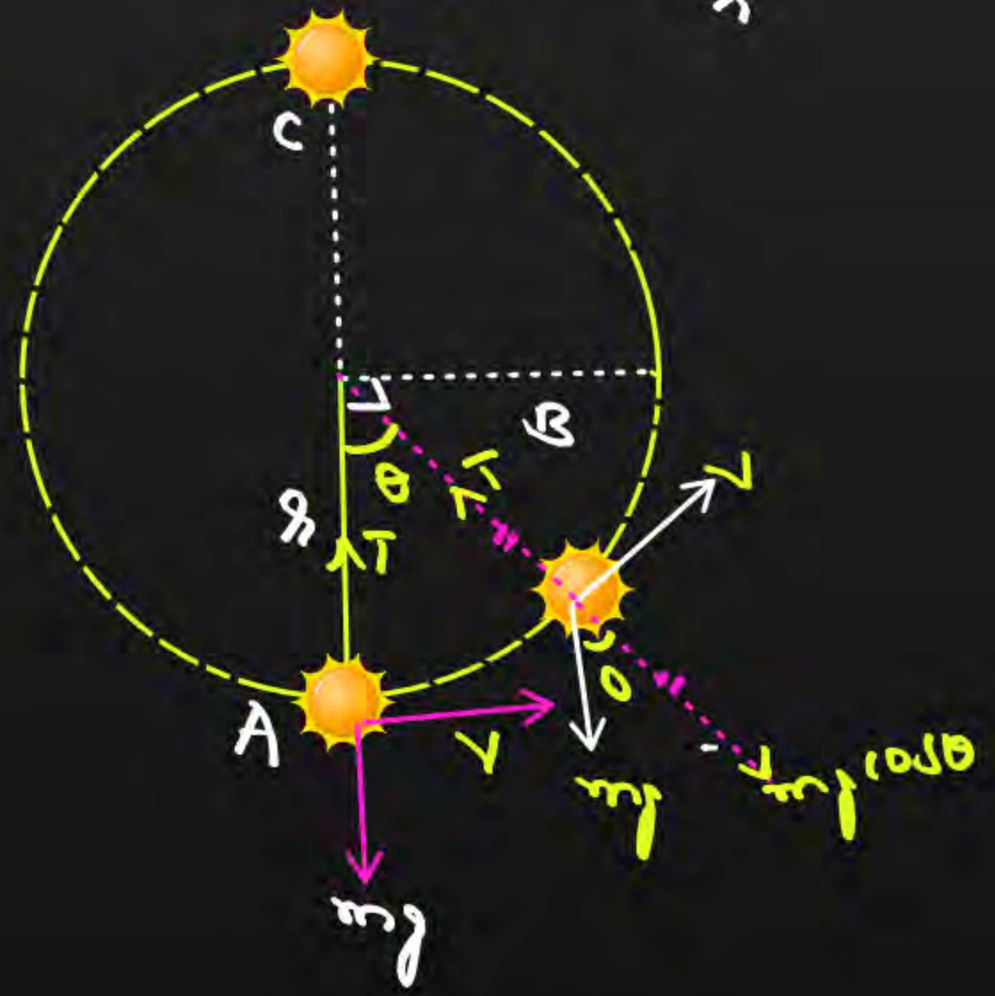
At B' : $T = \frac{mv^2}{r}$

- Tension at the lowest point ($\theta = 0°$) is given by , $\cos 0° = 1$

$$\boxed{T = \frac{mv^2}{r} + mg}$$

- Tension at the highest point ($\theta = 180°$)s given by , $\cos 180° = -1$

$$\boxed{T = \frac{mv^2}{r} - mg}$$



Vertical Circular Motion

- Minimum speed at the highest point,

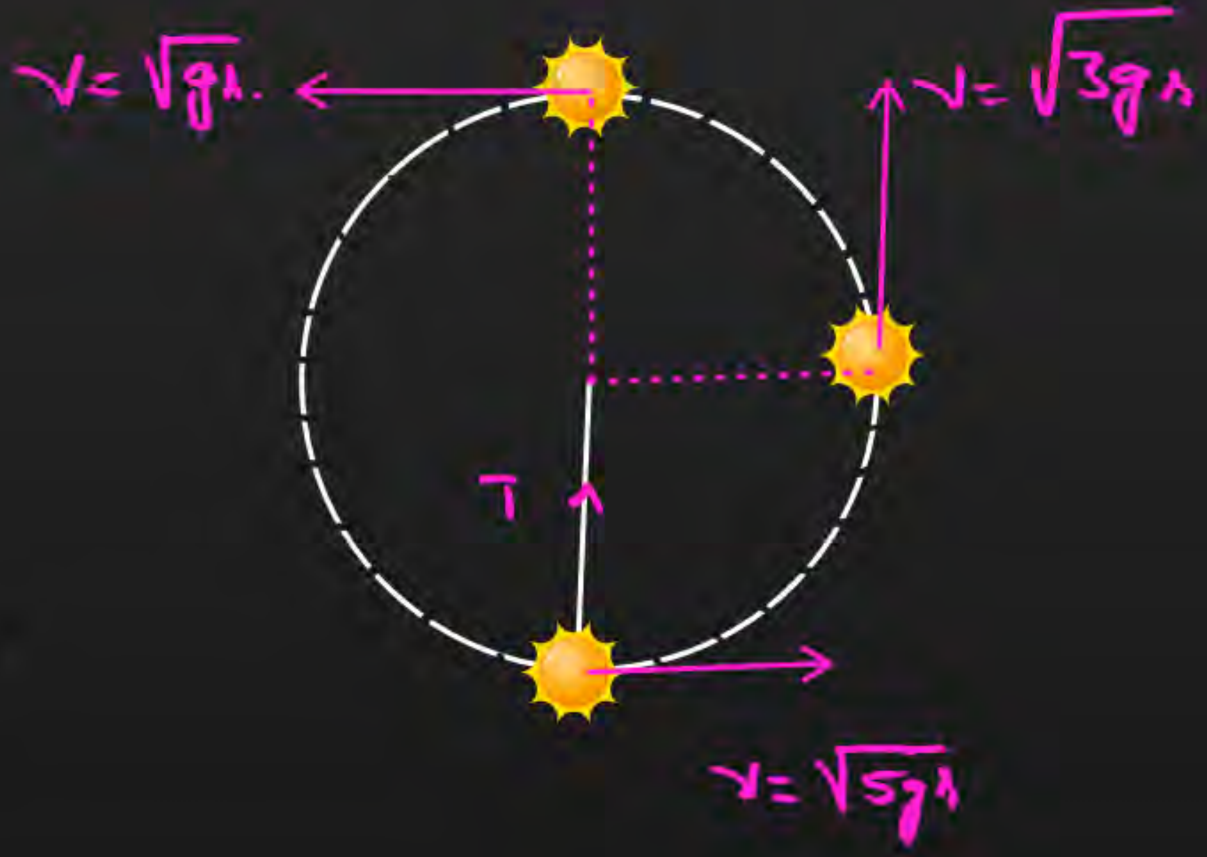
$$\boxed{v = \sqrt{gr}}$$

- Minimum speed at the lowest point for looping the loop,

$$\boxed{v = \sqrt{5gr}}$$

- When the string is horizontal, $\theta = 90°$,minimum velocity,

$$\boxed{v = \sqrt{3gr}}$$



QUESTION

What is the minimum velocity with which a body of mass m must enter a vertical loop of radius R so that it can complete the loop?

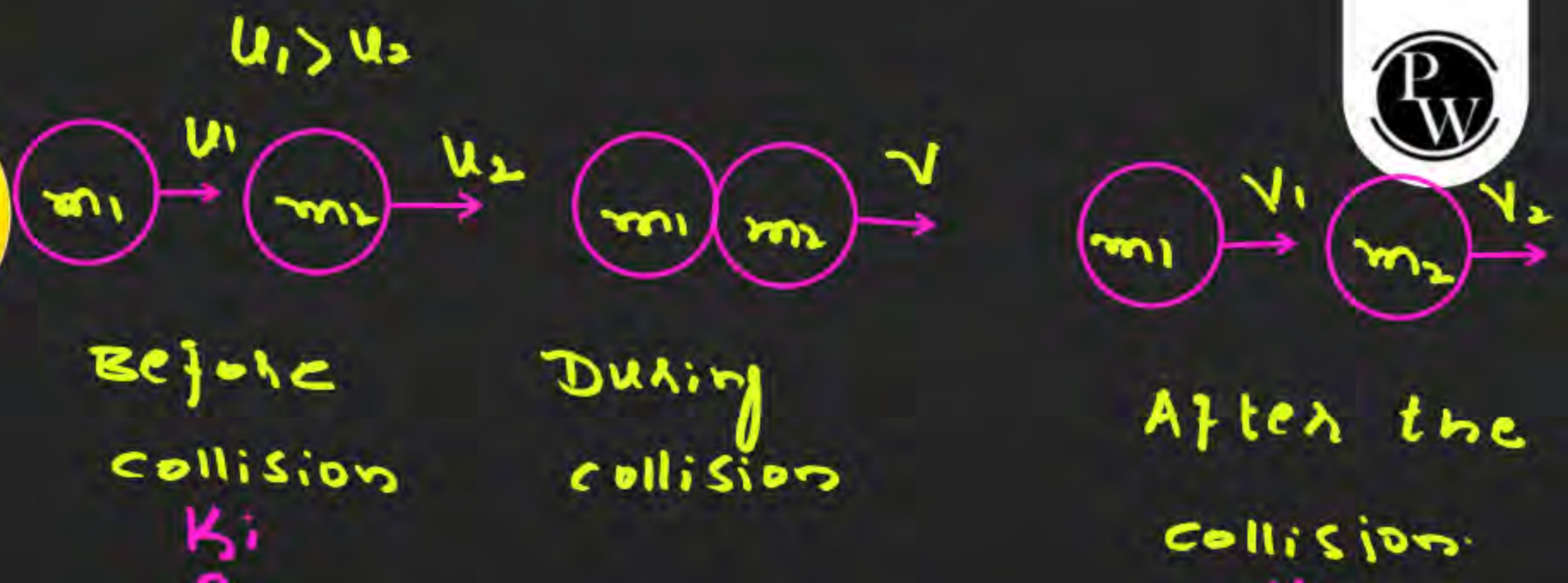
A) $\sqrt{2gR}$

B) $\sqrt{3gR}$

C) $\boxed{\sqrt{5gR}}$

D) $\sqrt{gR}$

Collision of bodies



- Elastic collision in one dimension:
- Before collision: Masses - m_1, m_2 Speeds - u_1, u_2
- After collision: Masses - m_1, m_2 Speeds - v_1, v_2
- Velocities after collision are given by: Both Energy & momentum are conserved

$$* \quad \boxed{v_1 = \frac{(m_1 - m_2)u_1 + 2m_2u_2}{m_1 + m_2}} \qquad * \quad \boxed{v_2 = \frac{(m_2 - m_1)u_2 + 2m_1u_1}{m_1 + m_2}}$$

Collision of bodies

- Perfectly inelastic collision in one dimension:
- Before collision: Masses - m_1 & m_2 Speeds- u_1 & u_2
- After Collision : Masses - m_1 & m_2 Speeds - $V_1 = V_2 = V$
- After collision they stick together moving with velocity, Momentum is conserved

Energy (K.E) is not conserved

$$P_i = P_f$$

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2) V$$

$$* \boxed{V = \frac{m_1 u_1 + m_2 u_2}{m_1 + m_2}}$$

Collision of bodies

- Kinetic energy lost in inelastic collision is,

$K = \frac{1}{2} m v^2$

* $$\boxed{\Delta K = \frac{1}{2}\left[\frac{m_1 m_2}{m_1 + m_2}\right](u_1 - u_2)^2 (1 - e^2)}$$

Collision of bodies

- Coefficient of restitution,

$$* \quad e = \frac{\text{Velocity of separation}}{\text{Velocity of approach}} = \frac{v_2 - v_1}{u_1 - u_2}$$

For perfectly elastic collision, $e = 1$.

For perfectly inelastic collision, $e = 0$.

QUESTION

Two bodies A and B of the $\boxed{\text{same mass}}$ undergo completely $\boxed{\text{inelastic}}$ one-dimensional collision. The body A moves with velocity $\boxed{v_1}$ while the body B is at $\boxed{\text{rest}}$ before collision. The velocity of the system after collision is v_2. The ratio of $v_1 : v_2$ is:

u_1 $u_2 = 0$

(A) $\boxed{2 : 1}$

(B) $4 : 1$

(C) $1 : 4$

(D) $1 : 2$

$$v = \frac{m_1 u_1 + m_2 u_2}{m_1 + m_2}$$

$$v_2 = \frac{m v_1 + m(0)}{m + m} = \frac{\cancel{m} v_1}{2\cancel{m}} = \frac{v_1}{2}$$

$$\boxed{\frac{v_1}{v_2} = \frac{2}{1}}$$

QUESTION

When masses = same
velocity = Exchange

$v_1 = -0.3$ m/s $v_2 = 0.5$ m/s

u_1 u_2

Two identical balls A and B having velocities of 0.5 m/s and −0.3 m/s respectively collide elastically in one dimension. The velocities of B and A after the collision respectively will be:

Body - A

$$v_1 = \frac{(m_1 - m_2)u_1 + 2m_2u_2}{m_1 + m_2}$$

$$v_1 = \frac{(m - m)0.5 + 2m(-0.3)}{m + m}$$

$$v_1 = -\frac{\cancel{2m} \times 0.3}{\cancel{2m}}$$

$$\boxed{v_1 = -0.3 \text{ m/s}}$$

Body - B

$$v_2 = \frac{(m_2 - m_1)u_2 + 2m_1u_1}{m_1 + m_2}$$

$$v_2 = \frac{0(-0.3) + 2m \times 0.5}{2m}$$

$$v_2 = \frac{2m \times 0.5}{2m}$$

$$\boxed{v_2 = 0.5 \text{ m/s}}$$

(A) −0.5 m/ sand 0.3 m/s

(B) 0.5 m/ sand −0.3 m/s

(C) −0.3 m/ sand 0.5 m/s

(D) 0.3 m/ sand 0.5 m/s

QUESTION

Two equal masses m, and m, moving along the same straight line with velocities +3 m/s and –5 m/s respectively collide elastically. Their velocities after the collision will be respectively :

A +4 m/s for both

B – 3 m/s and +5 m/s

C – 4 m/s and +4 m/s

D $\boxed{\text{–5 m/s and +3 m/s}}$

When $\boxed{\begin{array}{l}\text{masses = same} \\ \text{velocities = exchange}\end{array}}$ * VIP

QUESTION

Two perfectly elastic particles P and Q of $\boxed{\text{equal mass}}$ travelling along the line joining them with velocities 15 m/sec and 10 m/sec. $\boxed{\text{After collision}}$, their velocities respectively (in m/sec) will be

A. 0, 25

B. 5, 20

C. $\boxed{10, 15}$

D. 20, 5

QUESTION

A ball strikes the floor and after collision rebounds back. In this state –

(A) Momentum of the ball is conserved ✗

(B) Mechanical energy of the ball is conserved ✗

(C) Momentum of ball earth system is conserved

(D) The kinetic energy of ball earth system is conserved

QUESTION

In an inelastic collision between two bodies, the physical quantity that is conserved :

A. Kinetic energy

B. Momentum

C. Potential energy

D. Kinetic energy and momentum

QUESTION

A collision is said to be perfectly inelastic when :

A. Coefficient of restitution = 0

B. Coefficient of restitution = 1

C. Coefficient of restitution = ∞

D. Coefficient of restitution < 1

QUESTION

Which of the following is $\boxed{\text{true :}}$

A) Momentum is conserved in all collisions but kinetic energy is conserved only in inelastic collision

B) Neither momentum nor kinetic energy is conserved in inelastic collisions.

C) Momentum is conserved in all collisions but not kinetic energy

D) Both momentum and kinetic energy are conserved in all collisions

QUESTION

m_1 $\quad u_1 = 36 \times \frac{5}{18} = 2 \times 5 = 10\,m/s$

A metal ball of mass 2 kg moving with a velocity of $\boxed{36\text{ km/h}}$ has a head on collision with a stationary ball of mass 3 kg (m_2, $u_2 = 0$). If after the collision, the two balls move together ($e = 0$), the loss in kinetic energy due to collision is :

(A) 140 J

(B) 100 J

(C) $\boxed{60\text{ J}}$

(D) 40 J

$u_1 = 36\,km/h$

$= \frac{36\,km}{1\,h}$

$= \frac{\cancel{36} \times 1000\,m}{3600\,s}$

$\boxed{u_1 = 10\,m/s}$

$\Delta K = \frac{1}{2}\left(\frac{m_1 m_2}{m_1 + m_2}\right)(u_1 - u_2)^2(1 - e^2)$

$\Delta K = \frac{1}{2}\left(\frac{2 \times 3}{2+3}\right)(10 - 0)^2(1 - 0)$

$\Delta K = \frac{1}{\cancel{2}} \times \frac{\cancel{6}^{3}}{5} \times \cancel{100}^{20}$

$\Delta K = 3 \times 20$

$\boxed{\Delta K = 60\,J}$

Centre of mass of discrete particle system

$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

The coordinates of **centre of mass** are given by

$$\vec{r}_{cm} = \frac{\sum_{i=1}^{n} m_i r_i}{\sum_{i=1}^{n} m_i = M}$$

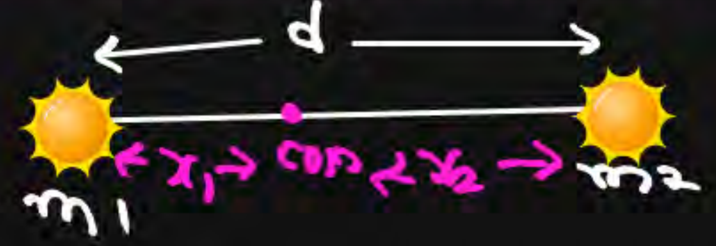
$$\boxed{\vec{r}_{cm} = \frac{1}{M}\sum_{i=1}^{n} m_i r_i}$$

$$x_{cm} = \frac{1}{M}\sum_{i=1}^{n} m_i x_i \;,\quad x_{cm} = \frac{m_1x_1 + m_2x_2 + \cdots}{M}.$$

$$y_{cm} = \frac{1}{M}\sum_{i=1}^{n} m_i y_i \;,\quad y_{cm} = \frac{m_1y_1 + m_2y_2 + \cdots}{M}$$

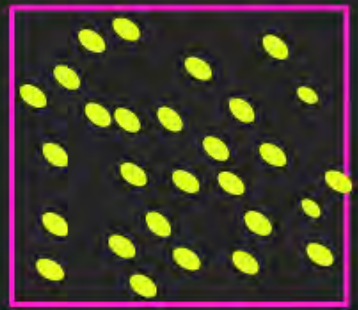
$$z_{cm} = \frac{1}{M}\sum_{i=1}^{n} m_i z_i \;,\quad z_{cm} = \frac{m_1z_1 + m_2z_2 + \cdots}{M}$$

The distance of the COM from the mass -



$$x_1 = \left(\frac{m_2}{m_1+m_2}\right)d \qquad x_2 = \left(\frac{m_1}{m_1+m_2}\right)d$$

Centre of mass of discrete particle system



For a continuous distribution of mass, the coordinates of centre of mass are given by

$$x_{cm} = \frac{1}{M}\sum_{i}^{n} m_i x_i \qquad X_{cm} = \frac{1}{M}\int x \cdot dm$$

$$y_{cm} = \frac{1}{M}\sum_{i=1}^{n} m_i y_i \qquad Y_{cm} = \frac{1}{M}\int y \cdot dm$$

$$z_{cm} = \frac{1}{M}\sum_{i=1}^{n} m_i z_i \qquad z_{cm} = \frac{1}{M}\int z \cdot dm$$

Centre of mass of discrete particle system

$$x_{cm} = \frac{1}{m}\sum_{i=1}^{n} m_i x_i$$

Velocity of centre of mass is given by

$$\boxed{v_{cm} = \frac{1}{m}\sum_{i=1}^{n} m_i v_i}$$

$$v = \frac{dx_{cm}}{dt} = \frac{1}{m}\sum_{i=1}^{n} m_i \frac{dx_i}{dt}$$

Acceleration of centre of mass is given by

$$\boxed{a_{cm} = \frac{1}{m}\sum_{i=1}^{n} m_i a_i}$$

Rotational Motion

Torque

$$\boxed{\begin{aligned} &\vec{\tau} = \vec{r} \times \vec{F} \\ &\tau = rF\sin\theta \end{aligned}}$$

Moment of inertia:

$$I = \sum_{i=1}^{n} m_i r_i^2$$

↳ particle

Theorem of perpendicular axes: X

Theorem of parallel axes: X

Linear		Rotation
m	$\longrightarrow$	I
S	$\longrightarrow$	θ
v	$\longrightarrow$	ω
a	$\longrightarrow$	α
F	$\longrightarrow$	τ
P	$\longrightarrow$	L
K_T	$\longrightarrow$	K_R

Rotational Motion

$F \quad m \qquad F = ma$

$\tau \qquad I$

Relation between torque and moment of inertia: $\tau = I\alpha$

Angular velocity, ω $\quad v = \frac{dx}{dt}, \quad \boxed{\omega = \frac{d\theta}{dt}}$

Angular acceleration, $a = \frac{dv}{dt} \qquad \boxed{\alpha = \frac{d\omega}{dt}}$

Equations of rotational motion Already done

Rotational Motion

Angular momentum

$L = I\omega$

↳ Rigid body

$\vec{L} = \vec{r} \times \vec{p}$

$L = rp\sin\theta$

↳ particles

$P = mv$

Relationship between torque and angular momentum

τ L

F P

$F = \frac{dP}{dt}$

$\tau = \frac{dL}{dt}$

Relation between angular momentum and moment of inertia.

L I

P m

$P = mv$

$L = I\omega$

Kinetic energy of rotational motion,

$K_T = \frac{1}{2}mv^2$

$v = \omega r$

$K = \frac{1}{2}m(\omega r)^2$

$K_R = \frac{1}{2}m\omega^2 r^2$

Rotational Motion

Kinetic energy of a rolling body = Translational kinetic energy (TK) + rotational kinetic energy (RK)

$$K.E = K_T + K_R = \frac{1}{2}mv^2 + \frac{1}{2}m\omega^2 r^2$$

* $$\boxed{K.E = \frac{1}{2}mv^2\left[1 + \frac{K^2}{r^2}\right]}$$

Where K - Radius of Gyration

$$\boxed{I = mK^2}$$

$$K = \frac{1}{2}mv^2$$

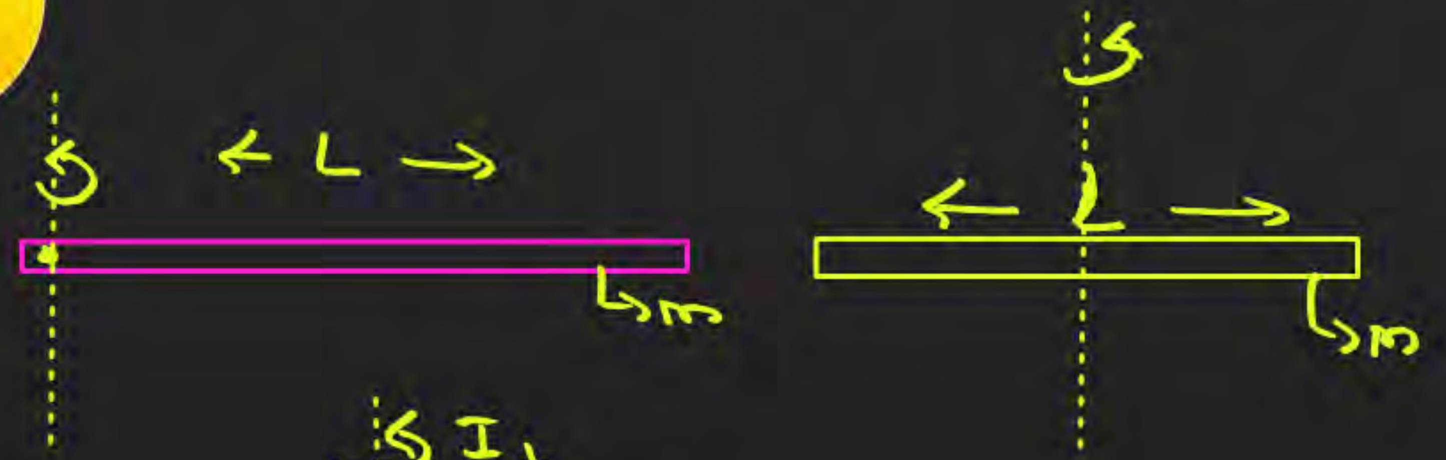
$$K = \frac{1}{2}I\omega^2$$

Moment of inertia of bodies

1. Rod

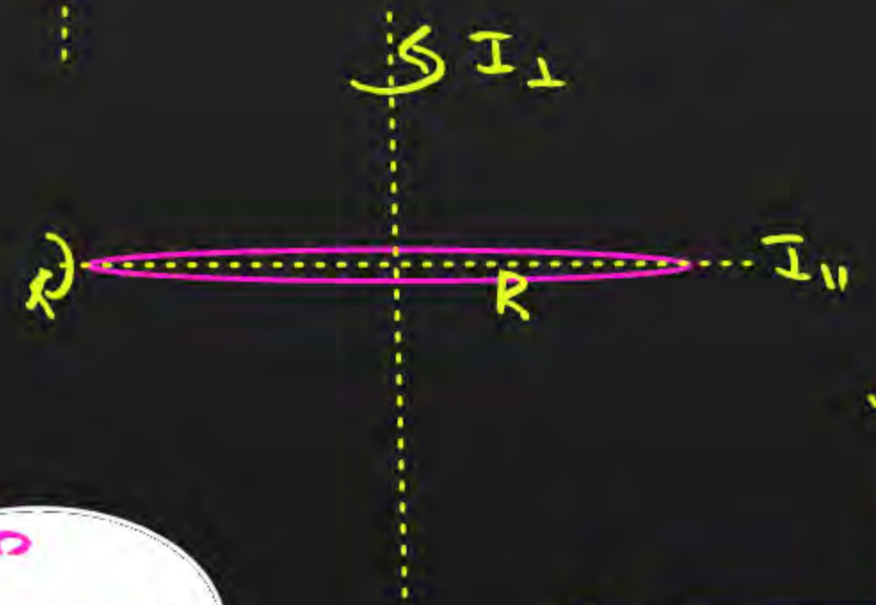
$I_{End} = \frac{ML^2}{2}$

$I_{mid} = \frac{ML^2}{12}$



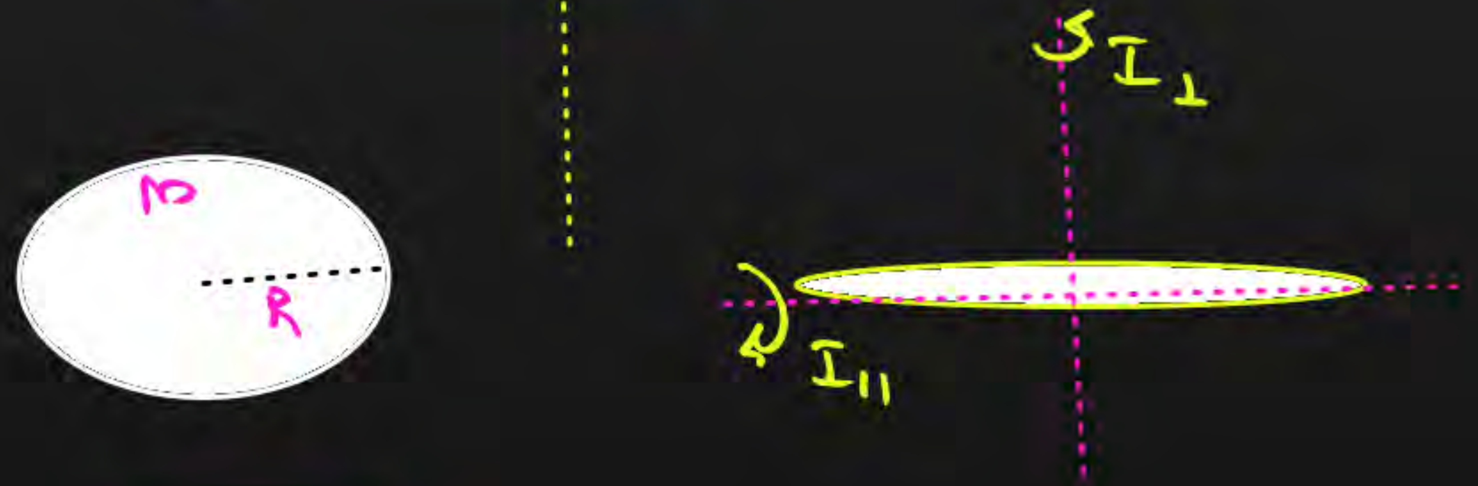
2. Ring and Hollow Cylinder

$I_{\perp} = MR^2 \quad I_{\parallel} = \frac{MR^2}{2}$



3. Disc and Solid Cylinder

$I_{\perp} = \frac{MR^2}{2} \quad I_{\parallel} = \frac{MR^2}{4}$



4. Solid Sphere $I = \frac{2}{5}MR^2$

5. Hollow Sphere $I = \frac{2}{3}MR^2$

QUESTION

The centre of mass of a body

$$x_{cm} = \frac{1}{M}\sum_{i=1}^{n} m_i x_i$$

$$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$$

A. $\boxed{\text{Depends on the choice of co-ordinate system}}$

B. is independent of the choice of co-ordinate system

C. May or may not depend on the choice of co-ordinate system

D. None of the above

QUESTION

The centre of mass of a system of particles does not depend on:

A Masses of the particles

$$x_{cm} = \frac{1}{M}\sum_{i=1}^{n} m_i x_i$$

B Forces acting on the particles

C Position of particles

D Relative distances between the particles

QUESTION

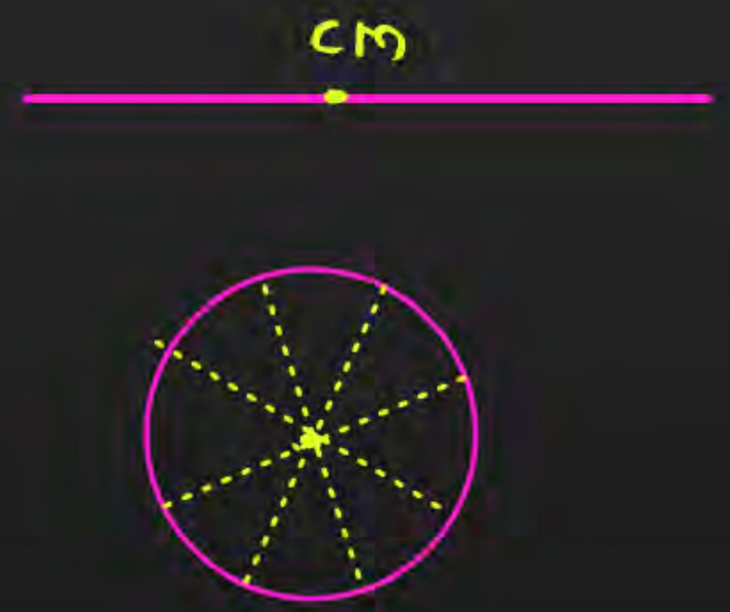
The centre of mass of a body:

A. Lies always at the geometrical centre

B. Lies always inside the body

C. Lies always outside the body

D. May lie within or outside the body



QUESTION

Three identical spheres, each of mass M, are placed at the corners of a right angle tringle with the mutually perpendicular sides equal to 2m (see figure). Taking the point of intersection of the two mutually perpendicular sides as the origin, find the position vector of centre of mass.

$\vec{r}_{cm} = x_{cm}\hat{i} + y_{cm}\hat{j}$

(A) $2(\hat{\imath}+\hat{\jmath})$

(B) $(\hat{\imath}+\hat{\jmath})$

(C) $\boxed{\frac{2}{3}(\hat{\imath}+\hat{\jmath})}$

(D) $\frac{4}{3}(\hat{\imath}+\hat{\jmath})$

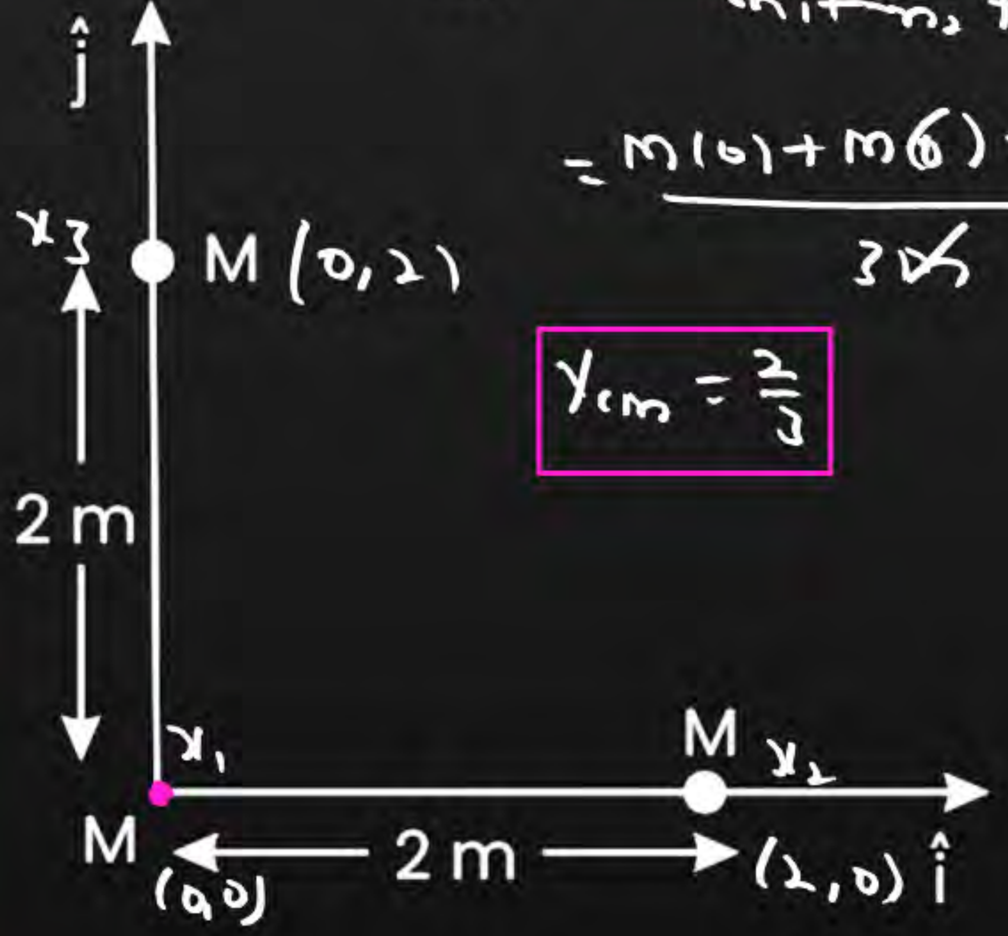
$$x_{cm} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1+m_2+m_3}$$

$$x_{cm} = \frac{M(0) + M(2) + M(0)}{3\cancel{M}}$$

$$\boxed{x_{cm} = \frac{2}{3}}$$

*

$$\boxed{\begin{aligned} \vec{r} &= \frac{2}{3}\hat{i} + \frac{2}{3}\hat{j} \\ \vec{r} &= \frac{2}{3}(\hat{i}+\hat{j}) \end{aligned}}$$



$$y_{cm} = \frac{m_1y_1 + m_2y_2 + m_3y_3}{m_1+m_2+m_3}$$

$$= \frac{M(0) + M(0) + M(2)}{3\cancel{M}}$$

$$\boxed{y_{cm} = \frac{2}{3}}$$

QUESTION

Two bodies of masses 1 kg and 3 kg have position vectors $(\hat{\imath} + 2\hat{\jmath} + \hat{k})$ and $(-3\hat{\imath} - 2\hat{\jmath} + \hat{k})$, respectively. The centre of mass of this system has a position vector

A $-2\hat{\imath} + 2\hat{k}$

B $\boxed{-2\hat{\imath} - \hat{\jmath} + \hat{k}}$

C $2\hat{\imath} - \hat{\jmath} + \hat{k}$

D $-\hat{\imath} + \hat{\jmath} + \hat{k}$

$$\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2}$$

$$\vec{r}_{cm} = \frac{1(\hat{i} + 2\hat{j} + \hat{k}) + 3(-3\hat{i} - 2\hat{j} + \hat{k})}{1+3}$$

$$\vec{r}_{cm} = \frac{\hat{i} + 2\hat{j} + \hat{k} - 9\hat{i} - 6\hat{j} + 3\hat{k}}{4}$$

$$= \frac{-8\hat{i} - 4\hat{j} + 4\hat{k}}{4}$$

$$\boxed{\vec{r}_{cm} = -2\hat{i} - \hat{j} + \hat{k}}$$

QUESTION

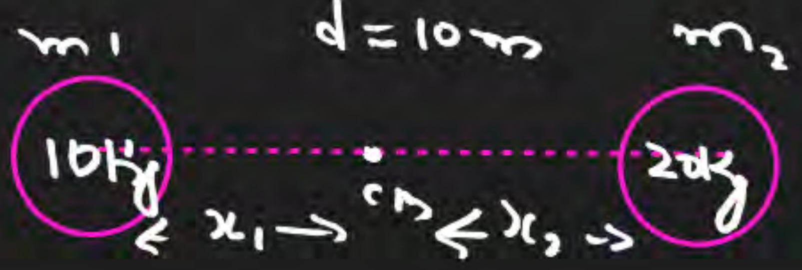
Two objects of mass 10 kg and 20 kg respectively are connected to the two ends of a rigid rod of length 10 m with negligible mass. The distance of the centre of mass of the system from the 10 kg mass is

(A) 10/3 m

(B) 20 /3 m

(C) 10 m

(D) 5 m



$$x_1 = \left(\frac{m_2}{m_1+m_2}\right)d$$

$$x_1 = \left(\frac{20}{10+20}\right)\times 10 = \frac{20}{3\cancel{0}}\times 1\cancel{0}$$

$$\boxed{x_1 = \frac{20}{3}\,m}$$

QUESTION

H.W

Two particles of mass 5 kg and 10 kg respectively are attached to the two ends of a rigid rod of length 1 m with negligible mass. The centre of mass of the system from the 5 kg particle is nearly at a distance of

(A) 50 cm

(B) $\boxed{67 \text{ cm}}$

(C) 80 cm

(D) 33 cm

QUESTION

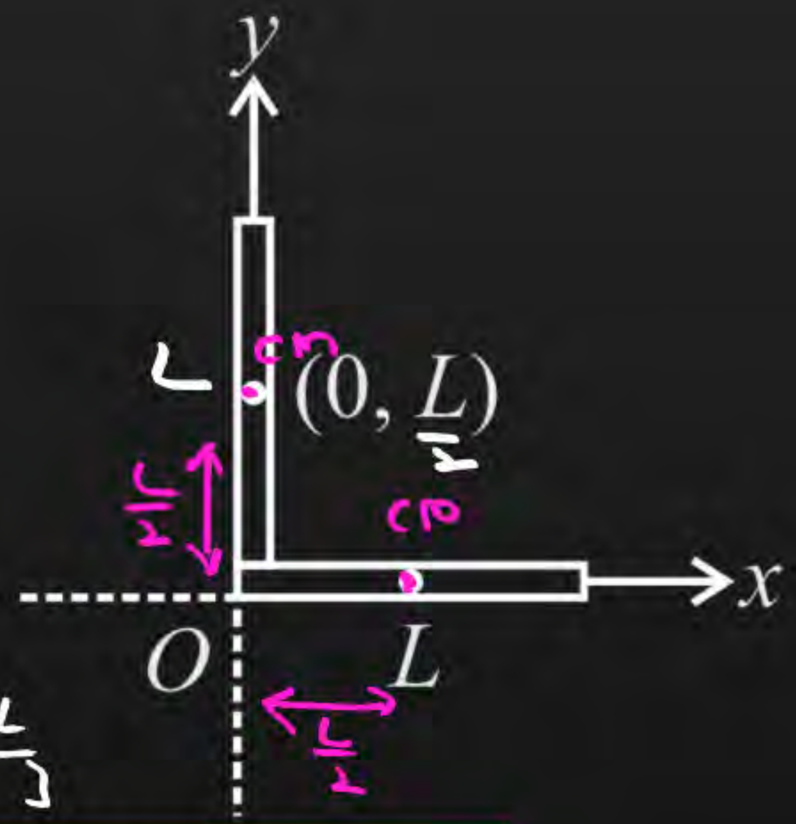
Figure shows a composite system of two uniform rod of mass M and 2M & lengths as indicated. Then the coordinates of the centre of mass of the system of rods are

(A) $\left(\frac{L}{2}, \frac{2L}{3}\right)$

(B) $\left(\frac{L}{4}, \frac{2L}{3}\right)$

(C) $\left(\frac{L}{6}, \frac{2L}{3}\right)$

(D) $\boxed{\left(\frac{L}{6}, \frac{L}{3}\right)}$



$m_1 = m \qquad m_2 = 2m$

$x_1 = \frac{L}{2} \qquad y_1 = 0$

$x_2 = 0 \qquad y_2 = \frac{L}{2}$

$x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2} \qquad y_{cm} = \frac{m_1 y_1 + m_2 y_2}{m_1 + m_2}$

$x_{cm} = \frac{m\frac{L}{2} + 2m(0)}{m + 2m} \qquad y_{cm} = \frac{m(0) + 2m\frac{L}{2}}{3m} = \frac{L}{3}$

$\boxed{x_{cm} = \frac{mL}{2 \times 3m} = \frac{L}{6}} \qquad \boxed{y_{cm} = \frac{L}{3}} \qquad \boxed{(x_{cm}, y_{cm}) = \left(\frac{L}{6}, \frac{L}{3}\right)}$

QUESTION

Two particle which are initially rest, move towards each other under the action of their internal attraction. If their speeds are v and $2v$ at any instant, then the speed of centre of mass off the system will be:-

A v

B $2v$

C zero

D $1.5\ v$

QUESTION

If the system is released, then the acceleration of the centre of mass of the system:-

(A) $\boxed{g/4}$

(B) g/2

(C) g

(D) 2g

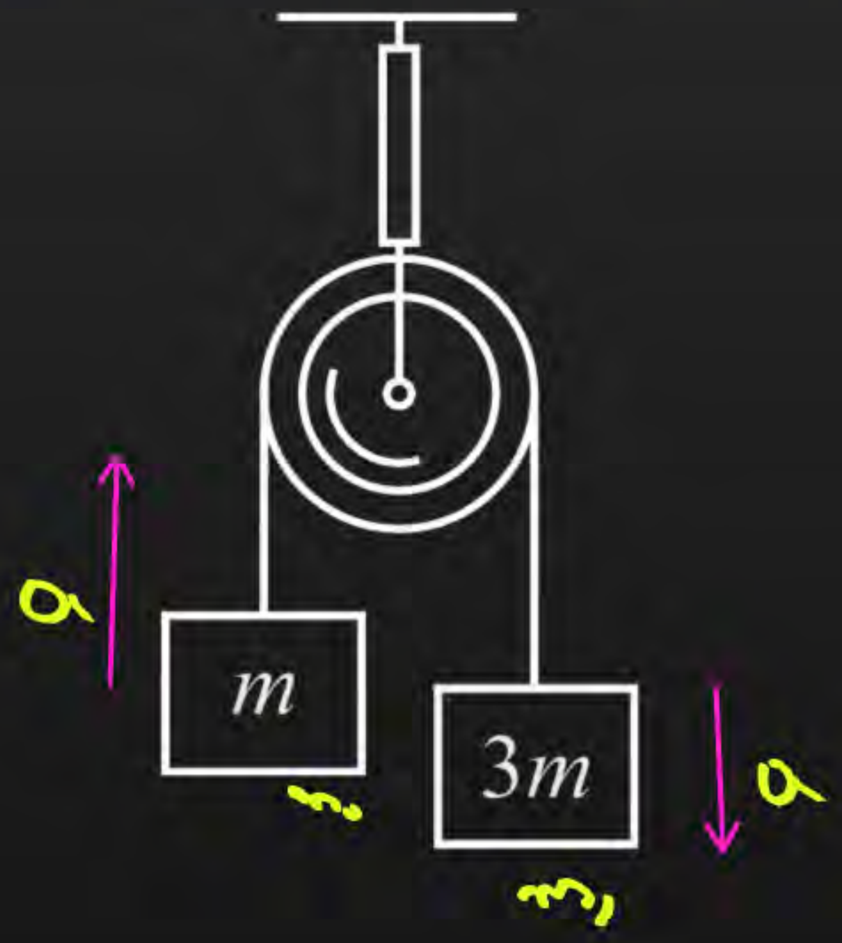
Acceleration of the system.

$$a = \frac{(3m - m)}{3m + m} \times g = \frac{2m}{4m} \times g$$

$$\boxed{a = \frac{g}{2}}$$

$$a_{cm} = \frac{m_1 a_1 + m_2 a_2}{m_1 + m_2} = \frac{3m \times \frac{g}{2} - \frac{mg}{2}}{3m + m}$$

$$a_{cm} = \frac{\frac{2mg}{2}}{4m} = \frac{1}{4} g = \boxed{\frac{g}{4}}$$



QUESTION

A 2 kg body and a 3 kg body are moving along the *x*-axis. At a particular instant the 2 kg body has a velocity of 3m/s and the 3 kg body has the velocity of 2m/s. The velocity of the centre of mass at that instant is :-

A) 5 m/s

B) 1 m/s

C) 0

D) $\boxed{\frac{12}{5}\,\text{m/s}}$

$$v_{cm} = \frac{m_1v_1 + m_2v_2}{m_1 + m_2}$$

$$= \frac{(2\times3) + (3\times2)}{2+3} = \frac{6+6}{5} = \frac{12}{5}$$

$$\boxed{v_{cm} = \frac{12}{5}}$$

QUESTION

$0.2\,\text{K}\hat{j}$

Two objects of masses 200 gram and 500 gram possess velocities $10\hat{\imath}$ m/s and $3\hat{\imath}+5\hat{\jmath}$ m/s respectively. The velocity of their centre of mass in m/s is:

(A) $5\hat{\imath}-25\hat{\jmath}$

(B) $\frac{5}{7}\hat{\imath}-25\hat{\jmath}$

(C) $\boxed{5\hat{\imath}+\frac{25}{7}\hat{\jmath}}$

(D) $25\hat{\imath}-\frac{5}{7}\hat{\jmath}$

$$\vec{v}_{cm}=\frac{m_1\vec{v}_1+m_2\vec{v}_2}{m_1+m_2}=\frac{0.2(10\hat{i})+0.5(3\hat{i}+5\hat{j})}{0.2+0.5}$$

$$\vec{v}_{cm}=\frac{2\hat{i}+1.5\hat{i}+2.5\hat{j}}{0.7}=\frac{3.5\hat{i}+2.5\hat{j}}{0.7}$$

$$\vec{v}_{cm}=\frac{3.5}{0.7}\hat{i}+\frac{2.5}{0.7}\hat{j}=\frac{\cancel{35}^{5}}{\cancel{7}}\hat{i}+\frac{25}{7}\hat{j}$$

$$\boxed{\vec{v}_{cm}=5\hat{i}+\frac{25}{7}\hat{j}}$$

QUESTION

A bullet of mass m is fired from a rifle of mass M. if $\vec{v}$ be the velocity of the bullet, velocity acquired by the rifle is:

A $\vec{V} = -\frac{M}{m}\vec{v}$

B $\boxed{\vec{V} = -\frac{m}{M}\vec{v}}$

C $\vec{V} = -\vec{v}$

D $\vec{V} = +\vec{v}$

$P_i = P_f$

$0 = m\vec{v} + M\vec{V}$

$M\vec{V} = -m\vec{v}$

$\boxed{\vec{V} = -\frac{m\vec{v}}{M}}$

QUESTION

A bullet weighing 50 gm leaves the gun with a velocity of 30 m/s. if the recoil speed imparted to the gun is 1 m/s, the mass of the gun is:

A) 15 kg

B) 30 kg

C) $\boxed{1.5 \text{ kg}}$

D) 20 kg

$P_i = P_f$

$0 = mv + MV$

$0 = (50\times10^{-3} \times 30) + M(-1)$

$M = 1500\times10^{-3}$

$\boxed{M = 1.5 \text{ kg}}$

QUESTION

A shell explodes and many pieces fly off in different direction. Which of the following in conserved?

A Kinetic energy

B $\boxed{\text{Momentum}}$

C Neither momentum nor KE

D Momentum and KE

$F_{ext} = \frac{dp}{dt}$ $P = const$

QUESTION

$u=0$

A bomb initially at rest explodes by it self into three equal mass fragments. The velocities of two fragments are $(3\hat{\imath}+2\hat{\jmath})$ m/s and $(-\hat{\imath}-4\hat{\jmath})$ m/s . The velocity of the third fragment is (in m/s)-

A) $2\hat{\imath}+2\hat{\jmath}$

B) $2\hat{\imath}-2\hat{\jmath}$

C) $\boxed{-2\hat{\imath}+2\hat{\jmath}}$

D) $-2\hat{\imath}-2\hat{\jmath}$

$P_i = P_f$

$0 = P_f$

$m_1\vec{v}_1 + m_2\vec{v}_2 + m_3\vec{v}_3 = 0$

$\cancel{m}(3\hat{i}+2\hat{j}) + \cancel{m}(-\hat{i}-4\hat{j}) + \cancel{m}\vec{v}_3 = 0$

$3\hat{i}+2\hat{j}-\hat{i}-4\hat{j}+\vec{v}_3 = 0$

$2\hat{i}-2\hat{j}+\vec{v}_3 = 0$

$\boxed{\vec{v}_3 = -2\hat{i}+2\hat{j}}$

QUESTION

The moment of inertia of a body about a given axis of rotation depends upon:-

(A) The distribution of mass ✓

(B) Distance of particle of body from the axis of rotation ✓

(C) Shape of the body ✓

(D) $\boxed{\text{All of the above}}$

QUESTION

The $\boxed{\text{moment of inertia}}$ in rotational motion is $\boxed{\text{equivalent}}$ to:

A. Angular velocity of linear motion

B. $\boxed{\text{Mass of linear motion}}$

C. Frequency of linear motion

D. Current

QUESTION

Three-point masses (each of mass m) are arranged in the X-Y plane the moment of inertia of this array of masses about Y-axis is

(A) ma^2

(B) $2\,ma^2$

(C) $4\,ma^2$

(D) $\boxed{6\,ma^2}$

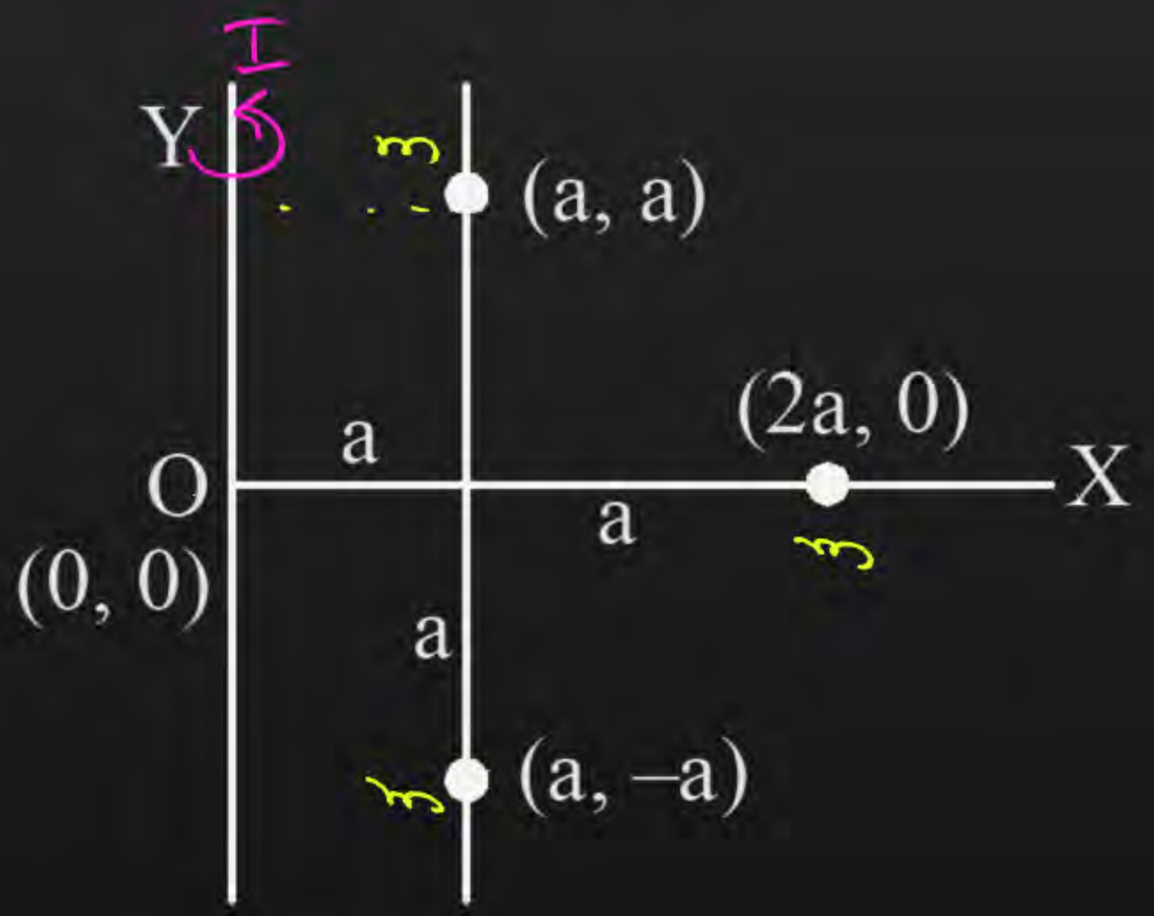
$I = mr^2$

$I = I_1 + I_2 + I_3$

$I = ma^2 + m(2a)^2 + ma^2$

$I = ma^2 + 4ma^2 + ma^2$

$\boxed{I = 6ma^2}$

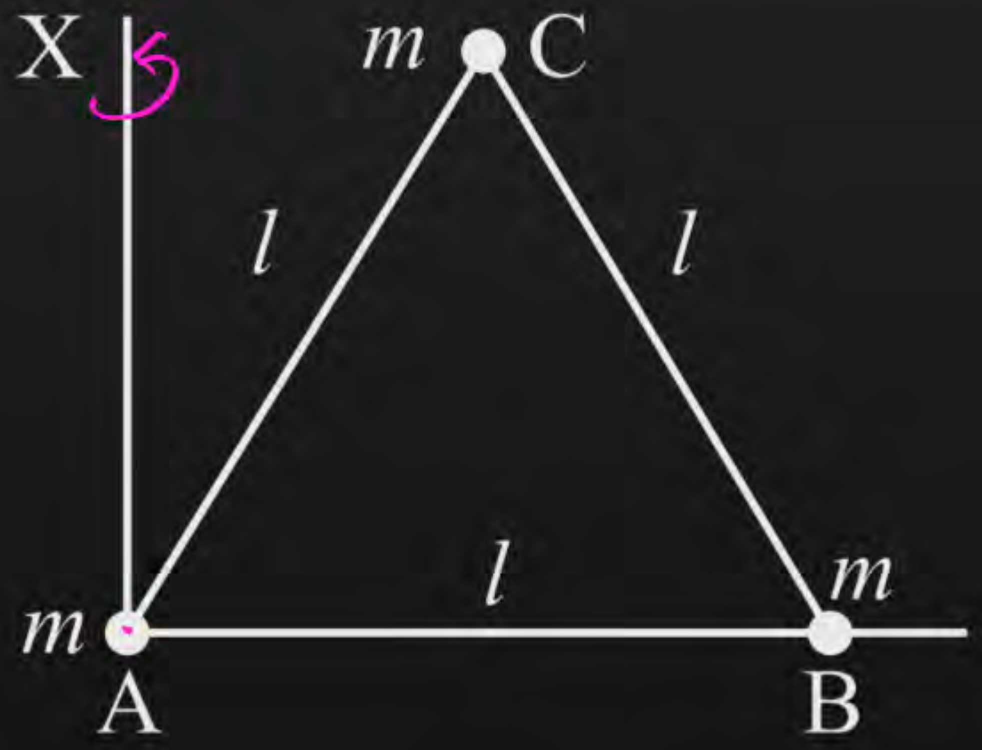


QUESTION

H.W

Three particles, each of mass m are situated at the vertices of an equilateral triangle ABC of side l (as shown in the figure).

The moment of inertia of the system about a line AX perpendicular to AB and in the plane of ABC, will be:



(A) $2\,ml^2$

(B) $5/4\,ml^2$

(C) $3/2\,ml^2$

(D) $3/4\,ml^2$

QUESTION

The ratio of radius of gyration of a solid sphere of mass M and radius R about its own axis to the radius of gyration of the thin hollow sphere of same mass and radius about its axis is:

(A) $\sqrt{\frac{5}{2}}$

(B) $\boxed{\sqrt{\frac{3}{5}}}$

(C) $\sqrt{\frac{5}{3}}$

(D) $\sqrt{\frac{2}{5}}$

$I_{SS} = \frac{2}{5} mR^2$

$I_{HS} = \frac{2}{3} mR^2$

$\boxed{\frac{K_1}{K_2} = \sqrt{\frac{3}{5}}}$

$I = mK^2$

$\frac{I_{SS}}{I_{HS}} = \frac{\cancel{m} K_1^2}{\cancel{m} K_2^2}$

$\frac{\frac{2}{5} m\cancel{R^2}}{\frac{2}{3} m\cancel{R^2}} = \left(\frac{K_1}{K_2}\right)^2$

$\frac{\cancel{2}}{5} \times \frac{3}{\cancel{2}} = \left(\frac{K_1}{K_2}\right)^2$

QUESTION

H.W

The ratio of the radius of gyration of a thin uniform disc about an axis passing through its centre and normal to its plane to the radius of gyration of the disc about its diameter is

$I_\perp = \frac{mR^2}{2}$ $\qquad$ $I_{\parallel} = \frac{mR^2}{4}$

(A) $2:1$

(B) $\sqrt{2}:1$

(C) $4:1$

(D) $1:\sqrt{2}$

QUESTION

Find the torque of a force $F = -3\hat{\imath} + \hat{\jmath} + 5\hat{k}$ acting at the point $\mathbf{r} = 7\hat{\imath} + 3\hat{\jmath} + \hat{k}$

(A) $-21\hat{\imath} + 3\hat{\jmath} + 5\hat{k}$

(B) $-14\hat{\imath} + 3\hat{\jmath} - 16\hat{k}$

(C) $4\hat{\imath} + 4\hat{\jmath} + 6\hat{k}$

(D) $\boxed{14\hat{\imath} - 38\hat{\jmath} + 16\hat{k}}$

$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$\vec{\tau} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 7 & 3 & 1 \\ -3 & 1 & 5 \end{vmatrix}$$

$$\vec{\tau} = \hat{i}(15-1) - \hat{j}(35+3) + \hat{k}(7+9)$$

$$\boxed{\vec{\tau} = 14\hat{i} - 38\hat{j} + 16\hat{k}}$$

QUESTION

H.W

Find the torque about the origin when a force of $F = 3\hat{j}\text{N}$ acting at on the particle whose position vector $\mathbf{r} = 2\hat{k}$ m

A) $6\hat{j}$ Nm

B) $\boxed{-6\hat{i}\ \text{Nm}}$

C) $6\hat{k}$ Nm

D) $6\hat{i}$ Nm

QUESTION

A rope is wound around a hollow cylinder of mass 3kg and radius 40cm. what is the angular acceleration of the cylinder, if the rope is pulled with a force of 30 N?

$I = MR^2 = 3 \times (40 \times 10^{-2})^2$

$I = 3 \times 1600 \times 10^{-4}$

$\boxed{I = 0.48}$

$\tau = rF$

$\tau = 40 \times 10^{-2} \times 30$

$\boxed{\tau = 12 \text{ N-m}}$

$F = ma$

$\tau = I\alpha$

$\alpha = \frac{\tau}{I}$

$\boxed{\alpha = \frac{12}{0.48} = 25}$

(A) 25 m/s^2

(B) 0.25 rad/s^2

(C) $\boxed{25 \text{ rad/s}^2}$

(D) 5 m/s^2

QUESTION

The moment of inertia of a disc of radius 0.5 m about its geometric axis is 2kg-m^2. If a string is tied to its circumference and a force of 10 Newton is applied, if the disc executes rotatory motion, its angular acceleration will be: [H.W]

A) 2.5 rad/sec^2

B) 5 rad/sec^2

C) 10 rad/sec^2

D) 20 rad/sec^2

QUESTION

A flywheel rotating about a fixed axis has a kinetic energy of 360 J when its angular speed is 30 rad/s. The moment of inertia of the wheel about the axis of rotation is

K

ω

I

(A) 0.6 kg-m^2

(B) 0.15 kg-m^2

(C) $\boxed{0.8 \text{ kg-m}^2}$

(D) 0.75 kg-m^2

$K = \frac{1}{2} I \omega^2$

$360 = \frac{1}{2} \times I \times (30)^2$

$\frac{360 \times 2}{900} = I$

$I = 0.8$

QUESTION

A ring of mass m and radius r rotates about an axis passing through its centre and perpendicular to its plane with angular velocity o. Its kinetic energy is

(A) $\boxed{\frac{1}{2}mr^2\omega^2}$

(B) $mr\omega^2$

(C) $mr^2\omega^2$

(D) $\frac{1}{3}mr^2\omega^2$

$K = \frac{1}{2}mv^2 = \frac{1}{2}m(\omega r)^2$

$\boxed{K = \frac{1}{2}m\omega^2 r^2}$

QUESTION

Two bodies have their moments of inertia I and 2I respectively about their axis of rotation. If their kinetic energies of rotation are equal, their angular momenta will be in the ratio

$K = \frac{P^2}{2m}$

(A) 1 : 2

$K_1 = K_2$

$K = \frac{L^2}{2I}$

(B) $\sqrt{2}$: 1

$\frac{L_1^2}{\cancel{2}I_1} = \frac{L_2^2}{\cancel{2}I_2}$

(C) 2 : 1

$\frac{L_1^2}{\cancel{I}} = \frac{L_2^2}{2\cancel{I}} \Rightarrow \left(\frac{L_1}{L_2}\right)^2 = \frac{1}{2} \Rightarrow \boxed{\frac{L_1}{L_2} = \frac{1}{\sqrt{2}}}$

(D) $\boxed{1 : \sqrt{2}}$

QUESTION

Two rotating bodies A and B of masses m and $2\,m$ with moments of inertia I_A and I_B ($I_B > I_A$) have equal kinetic energy of rotation. If L_A and L_B be their angular momenta respectively, then

(A) $L_A = \frac{L_R}{2}$

(B) $L_A = 2L_B$

(C) $\boxed{L_B > L_A}$

(D) $L_A > L_B$

$I_B > I_A$

$\frac{L_1}{L_2} = \sqrt{\frac{I_1}{I_2}} \Rightarrow \frac{L_A}{L_B} = \sqrt{\frac{I_A}{I_B}}$

$= \sqrt{\frac{5}{10}} = \sqrt{\frac{1}{2}}$

$\frac{L_A}{L_B} < 1$

$\boxed{\begin{array}{c} L_A < L_B \\ L_B > L_A \end{array}}$

Thank

You