DPP – 5

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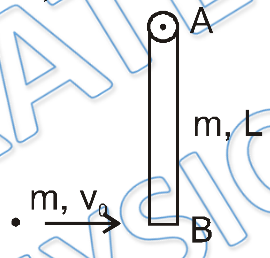
Q 1. A man sitting on a rotating stool with his arms stretched out, suddenly lowers his hands
(a) his angular velocity increases
(b) his moment of inertia decreases
(c) He does positive work
(d) his kinetic energy increases

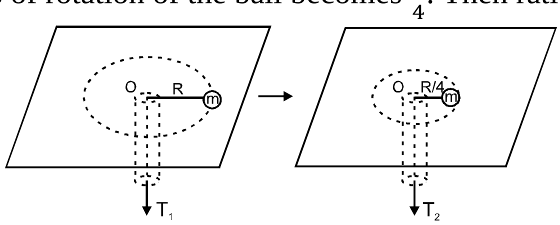
Q 2. If the radius of the earth is suddenly contracts to half of its present value, then the duration of day will be of
(a) 6 hours (b) 12 hours (c) 18 hours (d) 24 hours

Q 3. A thin uniform rod is free to rotate about a fixed smooth horizontal axis as shown. A point mass hits horizontally with velocity v_0 to the one end B of the rod. When it hits, it sticks to the rod, then:



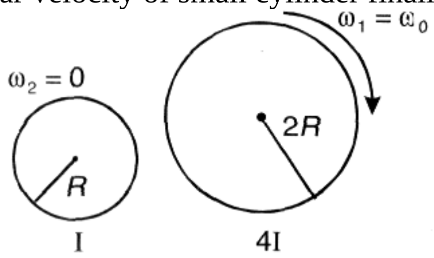
(a) Minimum value of v_0 for the rod to rotate by an angle $\frac{\pi}{2}$ is $2\sqrt{gL}$.
(b) Angular acceleration of the rod when the rod is horizontal is $\frac{9g}{8L}$.
(c) Force applied by the axis on the rod in the horizontal state is 5 mg/16
(d) None of these

Q 4. A ball of mass m is connected by a light inextensible cord and is rotated in a circle of radius R on a smooth fixed horizontal table. Initially the angular velocity of the ball was w_0 and pulling force applied was T_1. Now the pulling force is increased to T_2, until the radius of rotation of the ball becomes $\frac{R}{4}$. Then ratio $\frac{T_2}{T_1}$is:



(a) 8 (b) 18 (c) 32 (d) 64

Q 5. Two cylinders in completely rotational motion rotate about their centres as shown in figure (initial conditions), now it they are touched with each other surfaces are rough then find angular velocity of small cylinder finally



(a) $\frac{\omega_0}{4}$ (b) ω_0 (c) $\frac{\omega_0}{2}$ (d) $\frac{\omega_0}{8}$

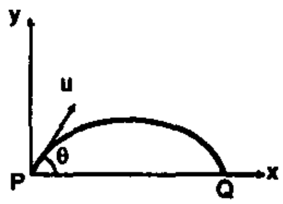
Q 6. A rigid spherical body is spinning around an axis without any external torque. Due to temperature its volume increases by 3%. Then percentage change in its angular speed is

(a) – 2% (b) – 1% (c) – 3% (d) 1 %

Q 7. A circular platform is mounted on a vertical frictionless axle. Its radius is r = 2m and its moment of Inertia is I = 200 kg-m^2. It is initially at rest. A 70kg man stands on the edge of the platform and begins to walk along the edge at speed v_0 = 1.0 m/s relative to the ground. when the man has walked once around the platform, so that he is at his original position on it, what is his angular displacement relative to ground?

(a) $\frac{6}{5}\pi$ (b) $\frac{5}{6}\pi$ (c) $\frac{4}{5}\pi$ (d) $\frac{5}{4}\pi$

Q 8. Average torque on a projectile of mass m, Initial speed u and angle of projection θ between Initial and final positions P and Q as shown in figure about the point of projection is:

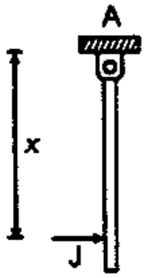


(a) $\frac{mu^2 \sin 2\theta}{2}$ (b) $mu^2 \cos\theta$ (c) $mu^2 \sin\theta$ (d) $\frac{mu^2 \cos\theta}{2}$

Q 9. A uniform rod AB of mass m and length 2a is falling freely without rotation under gravity with AB horizontal. Suddenly the end A is fixed when the speed of the rod is v. The angular speed with which the rod begins to rotate is:

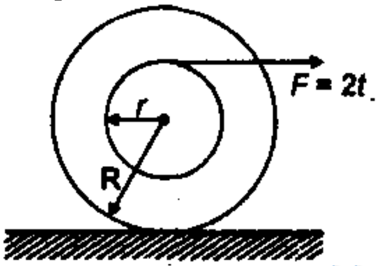
(a) $\frac{v}{2a}$ (b) $\frac{4v}{3a}$ (c) $\frac{v}{3a}$ (d) $\frac{3v}{4a}$

Q 10. A uniform rod of length 1 is pivoted at point A. It is struck by a horizontal force which delivers an impulse J at a distance x from point A as shown in figure, impulse delivered by pivot is zero, if x is equal to



(a) $\frac{l}{2}$ (b) $\frac{l}{3}$ (c) $\frac{2l}{3}$ (d) $\frac{3l}{4}$

Q 11. A time varying force F = 2t is applied on a spool as shown in figure. The angular momentum of the spool at time t about bottommost point is:

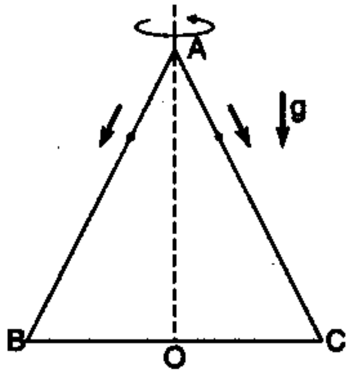


(a) $\frac{r^2t^2}{R}$
(b) $\frac{(R+r^2)}{r}t^2$
(c) (R + r) t^2
(c) data is insufficient

Q 12. A cubical block of side a moving with velocity v on a horizontal smooth plane as shown. It hits a ridge at point O. The angular speed of the block after it hits O is

(a) 3v/4a (b) 3v/2a (c) $\sqrt{3}/\sqrt{2}a$ (d) zero

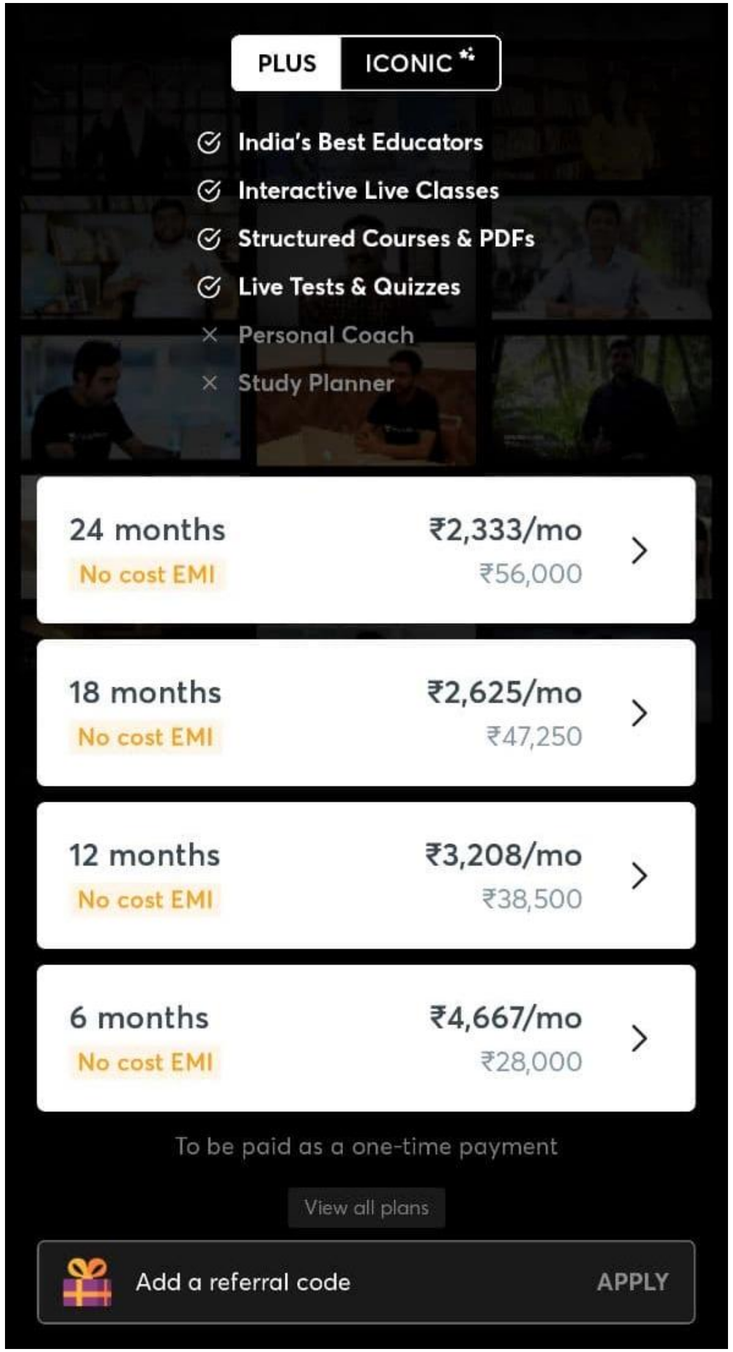
Q 13. An equilateral triangle ABC formed from a uniform wire has two small identical beads initially located at A. The triangle is set rotating about the vertical axis AO. Then the beads are released from rest simultaneously and allowed to slide down, one along AB and other along AC as shown. Neglecting frictional effects, the quantities that are conserved as beads slides down are:



(a) angular velocity and total energy (kinetic and potential)
(b) total angular momentum and total energy
(c) angular velocity and moment of inertia about the axis of rotation
(d) total angular momentum and moment of inertia about the axis of rotation

Answer Key

Q.1 a, b, c, d	Q.2 a	Q.3 a, b, c	Q.4 d	Q.5 b
Q.6 a	Q.7 b	Q.8 a	Q.9 d	Q.10 c
Q.11 c	Q.12 a	Q.13 b		



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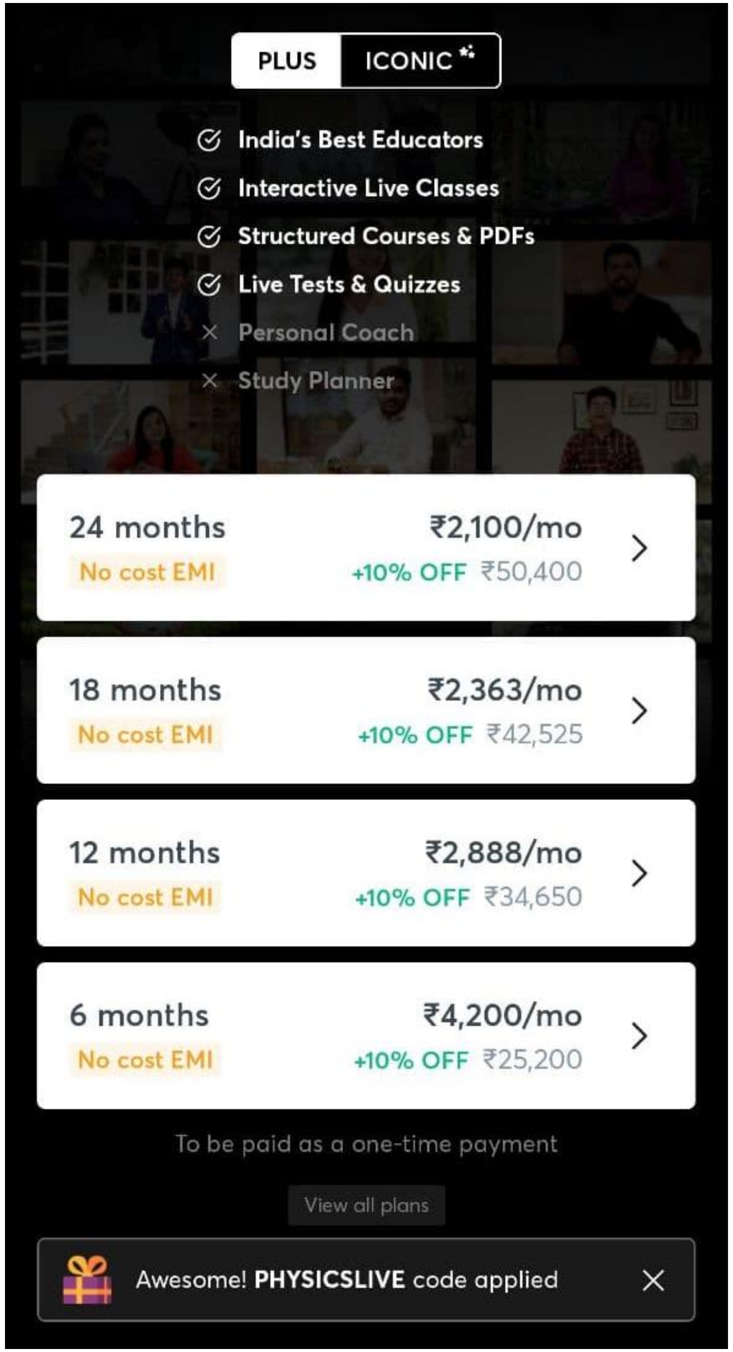

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Written Solution

JEE Main & Advanced, NSEP, INPhO, IPhO

Physics DPP

DPP- 5 Rotation: Conservation of Angular Momentum, Angular Impulse

By Physicsaholics Team

Q1) A man sitting on a rotating stool with his arms stretched out, suddenly lowers his hands

(a) his angular velocity increases

(b) his moment of inertia decreases

(c) He does positive work

(d) his kinetic energy increases

On lowering hands

$I \downarrow$ but $L =$ Constant as $\tau_{ext} = 0$

$\Rightarrow I\omega =$ Constant

$\Rightarrow \omega \uparrow$

$KE = \frac{L^2}{2I} \Rightarrow KE \uparrow$

Work done by man $= \Delta K = +ve$.

Q2) If the radius of the earth is suddenly contracts to half of its present value, then the duration of day will be of

$R \longrightarrow R/2$

$I = \frac{2}{5} m R^2$

$I \longrightarrow I/4$

(a) 6 hours (b) 12 hours (c) 18 hours (d) 24 hours

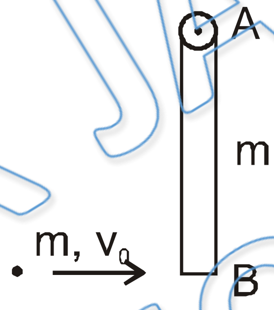
$L = \text{Constant} \Rightarrow I\omega = \text{Constant}$

$\Rightarrow \omega \longrightarrow 4\omega$

$\Rightarrow T \longrightarrow T/4$

(24 hr) (6 hr)

Q3) A thin uniform rod is free to rotate about a fixed smooth horizontal axis as shown. A point mass hits horizontally with velocity v_0 to the one end B of the rod. When it hits, it sticks to the rod, then :



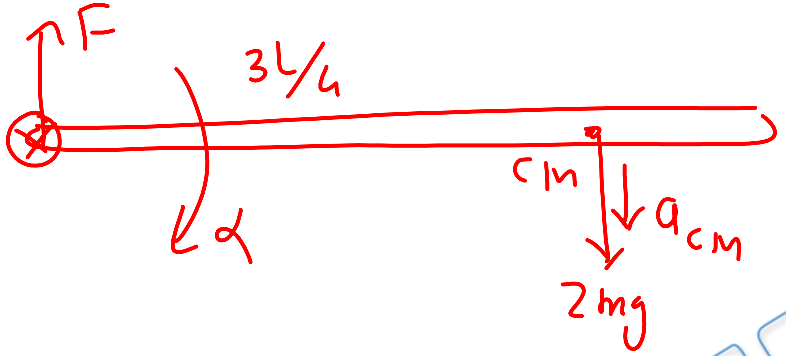
(a) Minimum value of v_0 for the rod to rotate by an angle $\frac{\pi}{2}$ is $2\sqrt{gL}$.

(b) Angular acceleration of the rod when the rod is horizontal is $\frac{9g}{8L}$.

(c) Force applied by the axis on the rod in the horizontal state is 5 mg/16

(d) None of these

Ans. a, b, c



$$\tau = I\alpha$$

$$2mg \times \frac{3L}{4} = \frac{4}{3}mL^2\alpha$$

$$\alpha = \frac{9g}{8L}$$

$$a_{cm} = \alpha\frac{3L}{4} = \frac{9g}{8L} \times \frac{3L}{4}$$

$$= \frac{27g}{32}$$

$$2mg - F = 2m \times \frac{27g}{32}$$

$$F = 2mg\left[1 - \frac{27}{32}\right]$$

$$= \frac{10mg}{32} = \frac{5mg}{16}$$

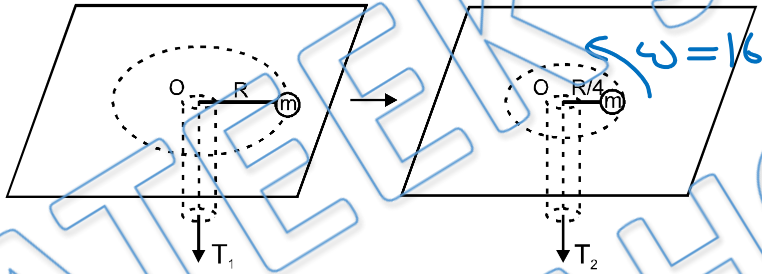
Q4) A ball of mass m is connected by a light inextensible cord and is rotated in a circle of radius R on a smooth fixed horizontal table. Initially the angular velocity of the ball was w_0 and pulling force applied was T_1. Now the pulling force is increased to T_2, until the radius of rotation of the ball becomes $\frac{R}{4}$. Then ratio $\frac{T_2}{T_1}$ is:

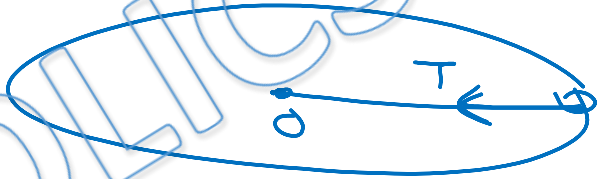
$T_1 = mR\omega_0^2$

by COAM

$mR^2\omega_0 = m\frac{R^2}{16}\omega$

$\omega = 16\omega_0$



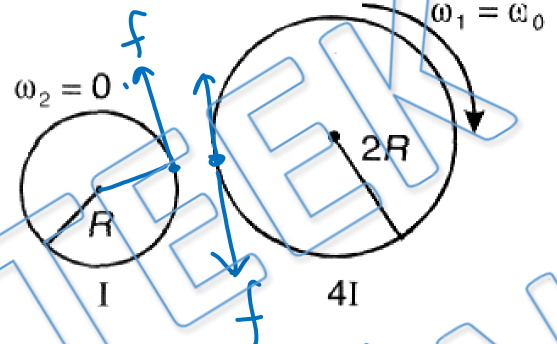


(a) 8 (b) 18 (c) 32 (d) 64 ✓

$T_2 = m\left(\frac{R}{4}\right)(16\omega_0)^2 = 64mR\omega_0^2$

$\frac{T_2}{T_1} = 64$

Q5) Two cylinders in completely rotational motion rotate about their centres as shown in figure (initial conditions), now it they are touched with each other surfaces are rough then find angular velocity of small cylinder finally

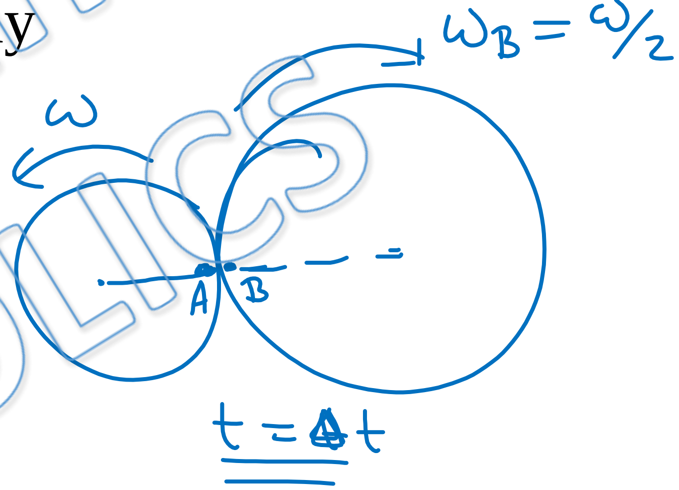


$V_A = V_B$ (for no Slipping)

$\Rightarrow \omega R = \omega_B \times 2R$

$\omega_B = \omega/2$ --- (1)

$\Rightarrow$



by Angular impulse - angular momentum theorem →

$f R \Delta t = I\omega$ —— (11) $\quad -f\,2R\Delta t = 4I\,\omega/2 - 4I\omega_0$

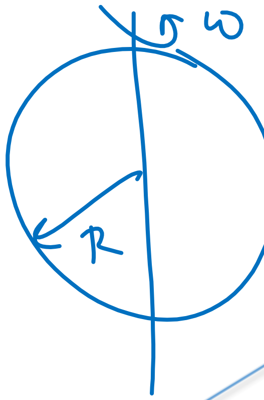
(a) $\frac{\omega_0}{4}$ (b) ω_0 (c) $\frac{\omega_0}{2}$ (d) $\frac{\omega_0}{8}$

$-2I\omega = 4I(\omega/2 - \omega_0)$

$-\omega = \omega - 2\omega_0$

$2\omega_0 = 2\omega \Rightarrow \omega = \omega_0$

Q6) A rigid spherical body is spinning around an axis without any external torque. Due to temperature its volume increases by 3%. Then percentage change in its angular speed is



$V = \frac{4}{3}\pi R^3$

% change in $V = 3 \times$ % change in R

% change in R = 1

(a) – 2%   (b) – 1%   (c) – 3%   (d) 1 %

$\frac{2}{5} m R^2 \omega = \text{Constant}$

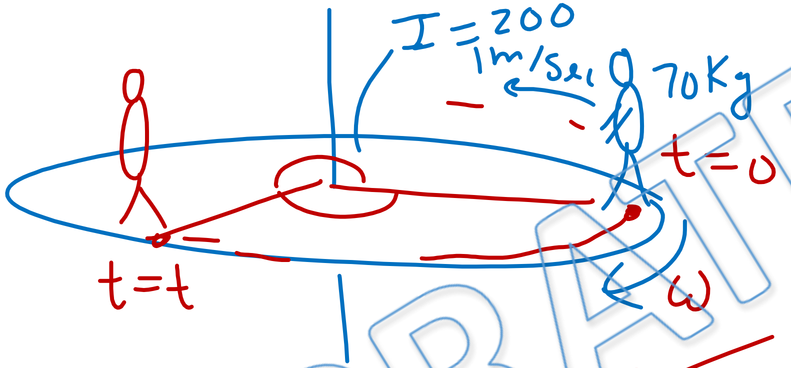
$\omega = C R^{-2}$

$\left(\frac{\Delta\omega}{\omega} \times 100\right) = -2\left(\frac{\Delta R}{R} \times 100\right)$

$= -2 \times 1$

$= -2\%$

Q7) A circular platform is mounted on a vertical frictionless axle. Its radius is r = 2m and its moment of Inertia is I = 200 kg-m^2. It is initially at rest. A 70kg man stands on the edge of the platform and begins to walk along the edge at speed v_0 = 1.0 m/s relative to the ground. when the man has walked once around the platform, so that he is at his original position on it, what is his angular displacement relative to ground?



by COAM

$70 \times 1 \times 2 = 200\,\omega$

$\omega = .7$ rad/sec

$\omega_{man} = \frac{v}{R} = .5$ rad/sec

$\omega t + \omega_{man} t = 2\pi$

(a) $\frac{6}{5}\pi$ (b) $\frac{5}{6}\pi$ (c) $\frac{4}{5}\pi$ (d) $\frac{5}{4}\pi$

$1.2t = 2\pi$

$t = \frac{2\pi}{1.2}$

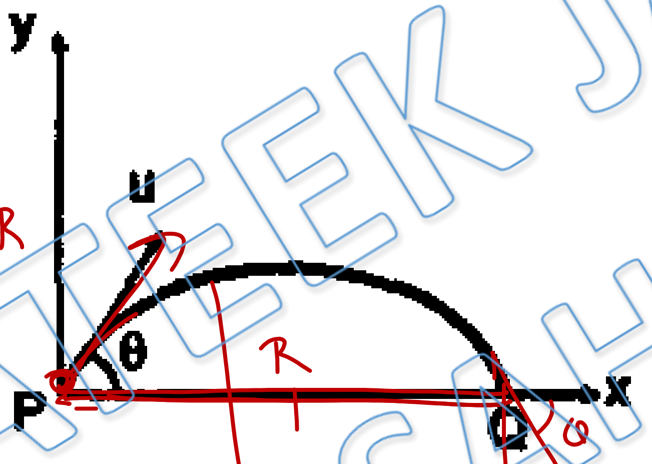
$\theta_{man} = \omega_{man} t = \frac{.5 \times 2\pi}{1.2} = \frac{5\pi}{6}$

Q8) Average torque on a projectile of mass m, Initial speed u and angle of projection θ between Initial and final positions P and Q as shown in figure about the point of projection is:

$\vec{\tau}_{av} = \frac{\Delta \vec{L}}{\Delta t}$

$L_i = 0$, $L_f = mu\sin\theta\, R$

$\tau_{av} = \frac{muR\sin\theta}{T}$



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

τ = force (⊥ Distance)

τ_{av} = force (av ⊥ Distance)

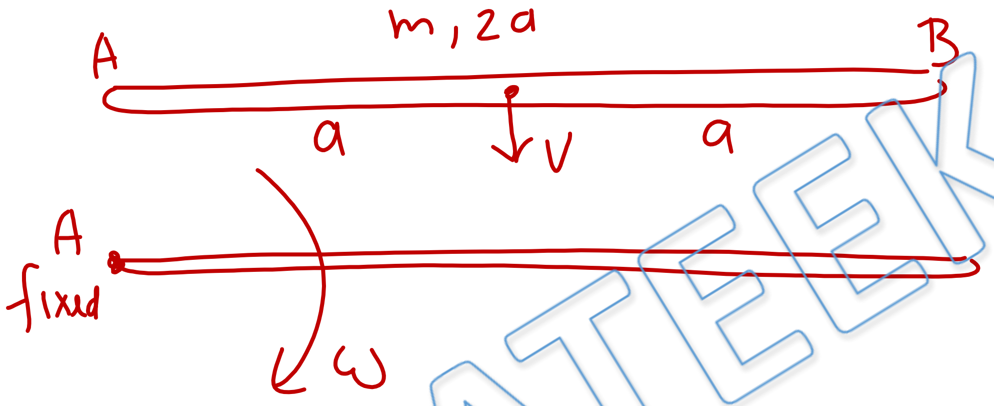
$= mg\, R/2 = mg \frac{u^2 \sin 2\theta}{2g}$

(a) $\frac{mu^2 \sin 2\theta}{2}$ (b) $mu^2 \cos\theta$ (c) $mu^2 \sin\theta$ (d) $\frac{mu^2 \cos\theta}{2}$

$\tau_{av} = mu\, u_x \sin\theta$

$= mu^2 \cos\theta \sin\theta = \frac{mu^2 \sin 2\theta}{2}$

Q9) A uniform rod AB of mass m and length 2a is falling freely without rotation under gravity with AB horizontal. Suddenly the end A is fixed when the speed of the rod is v. The angular speed with which the rod begins to rotate is:



by COAM

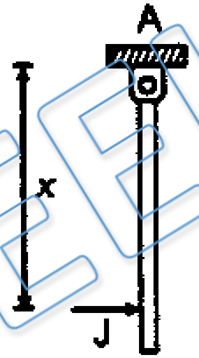
$$mva = \frac{m(2a)^2}{3}\omega$$

$$\omega = \frac{3v}{4a}$$

(a) $\frac{v}{2a}$ (b) $\frac{4v}{3a}$ (c) $\frac{v}{3a}$ (d) $\frac{3v}{4a}$

Q10) A uniform rod of length 1 is pivoted at point A. It is struck by a horizontal force which delivers an impulse J at a distance x from point A as shown in figure, impulse delivered by pivot is zero, if x is equal to

$$J = mv_{cm} = \frac{m\omega l}{2} \quad \text{---(1)}$$



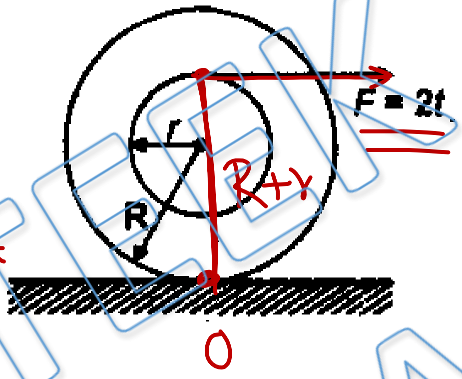
$$Jx = \frac{ml^2}{3}\omega$$

$$\frac{m\omega l}{2}x = \frac{ml^2}{3}\omega$$

(a) $\frac{l}{2}$ (b) $\frac{l}{3}$ (c) $\frac{2l}{3}$ (d) $\frac{3l}{4}$

$$x = \frac{2l}{3}$$

Q11) A time varying force F = 2t is applied on a spool as shown in figure. The angular momentum of the spool at time t about bottommost point is:



$\tau = 2t(R+r)$

$L = \int \tau \, dt = \int (R+r) 2t \, dt$

$= (R+r) t^2$

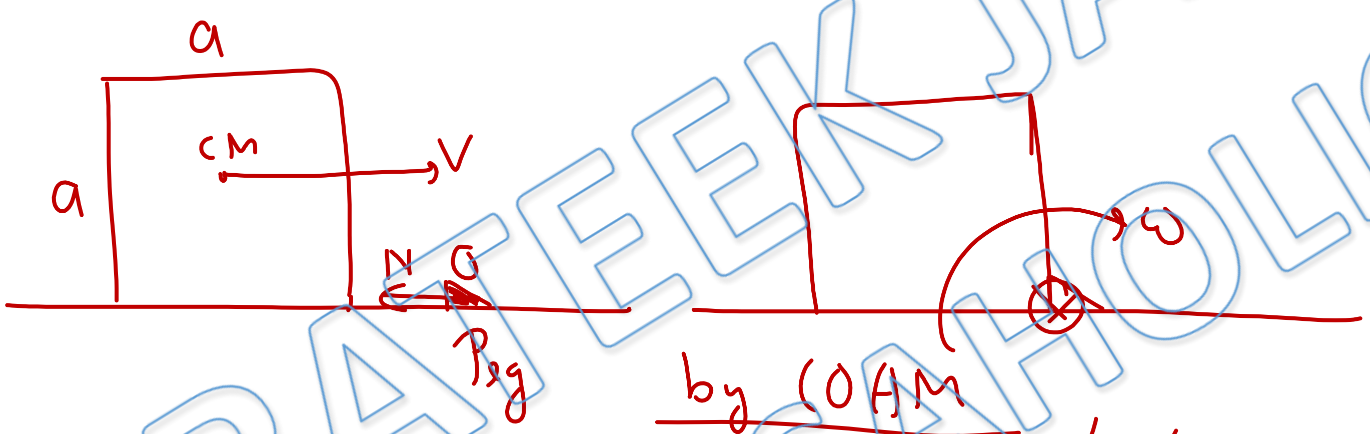
(a) $\frac{r^2 t^2}{R}$

(b) $\frac{(R+r^2)}{r} t^2$

(c) $(R + r) t^2$

(c) data is insufficient

Q12) A cubical block of side a moving with velocity v on a horizontal smooth plane as shown. It hits a ridge at point O. The angular speed of the block after it hits O is



by COAM

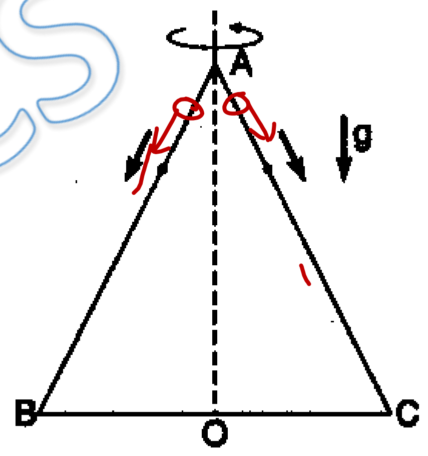
$mv\frac{a}{2} = \frac{2ma^2}{3}\omega$

(a) 3v/4a (b) 3v/2a (c) $\sqrt{3}/\sqrt{2}a$ (d) zero

$\omega = \frac{3v}{4a}$

Q13) An equilateral triangle ABC formed from a uniform wire has two small identical beads initially located at A. The triangle is set rotating about the vertical axis AO. Then the beads are released from rest simultaneously and allowed to slide down, one along AB and other along AC as shown. Neglecting frictional effects, the quantities that are conserved as beads slides down are:

$L =$ Constant & $I \uparrow \Rightarrow \omega \downarrow$



(a) angular velocity and total energy (kinetic and potential)

(b) total angular momentum and total energy

(c) angular velocity and moment of inertia about the axis of rotation

(d) total angular momentum and moment of inertia about the axis of rotation

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