Physicsaholics

DPP – 2

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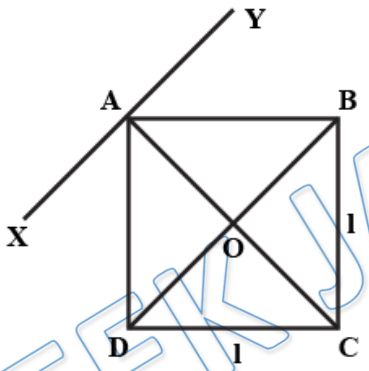
Q 1. Four point masses, each of value m, are placed at the corners of a square ABCD of side l. The moment of inertia of this system about an axis passing through A and parallel to BD is:



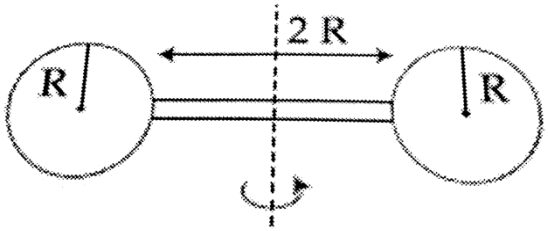
(a) $\sqrt{3}ml^2$ (b) $3ml^2$
(c) ml^2 (d) $2ml^2$

Q 2. In an arrangement of four particles, each of mass 2 gm are situated at the coordinate points (3, 2, 0), (1, -1, 0), (0, 0, 0) and (-1, 1, 0). The moment of inertia of this arrangement about the Z-axis will be:
(a) 8 unit (b) 19 unit
(c) 43 unit (d) 34 unit

Q 3. Three identical thin rods, each of mass m and length ℓ, are joined to form an equilateral triangular frame. The moment of inertia of the frame about an axis parallel to its one side and passing through the opposite vertex is
(a) $\frac{5}{2}ml^2$ (b) $\frac{5}{4}ml^2$
(c) $\frac{3}{2}ml^2$ (d) $\frac{5}{3}ml^2$

Q 4. Which of the following is not true about moment of inertia (I) ?
(a) If I about an axis is minimum, then it must pass through center of mass
(b) All axis passing through center of mass have same moment of inertia
(c) Perpendicular axis theorem can't be applied for 3 dimensional body
(d) Parallel axis theorem can be applied for 3 dimensional body

Q 5. Two identical solid spheres each of mass M and radius R are joined at the two ends of a light rod of length 2R as shown in the figure. The moment of inertia of the system about an axis perpendicular to the length of rod and passing through center of mass of the two spheres is:



(a) $\frac{22MR^2}{5}$ (b) $\frac{44MR^2}{5}$
(c) $\frac{11MR^2}{5}$ (d) $\frac{33MR^2}{5}$

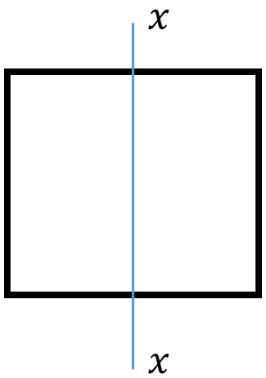
Q 6. The moment of inertia of a square plate about a diagonal is I_d and that about a side in its plane is I_s then
(a) $I_s = I_d$ (b) $I_s < I_d$
(c) $I_s > I_d$ (d) None of these

Q 7. The ratio of moments of inertia of a solid sphere about axes passing through its center and tangent respectively, is:
(a) 2 : 5 (b) 2 : 7
(c) 5 : 2 (d) 7 : 2

Q 8. Two point size bodies of masses 2 kg, 3 kg are fixed at two ends of a light rod of length 1 m. The moment of inertia of two bodies about an axis perpendicular to the length of rod and passing through center of mass of two bodies is:
(a) 0.6 kg m^2 (b) 0.8 kg m^2
(c) 1 kg m^2 (d) 1.2 kg m^2

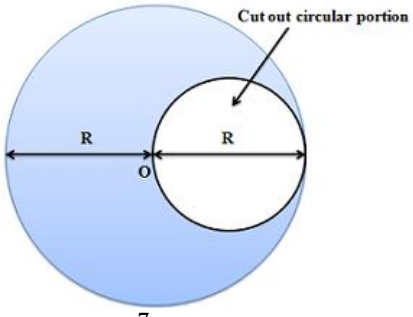
Q 9. The moment of inertia of a circular disc about its own axis is 4 kg$-m^2$. Its moment of inertia about the diameter will be
(a) 4 kg$-m^2$ (b) 2 kg$-m^2$
(c) Zero (d) 8 kg$-m^2$

Q 10. Four identical rods are joined end to end to form a square. The mass of each rod is M. The moment of inertia of the square about the median line is



(a) $\frac{Ml^2}{3}$ (b) $\frac{Ml^2}{4}$
(c) $\frac{Ml^2}{6}$ (d) None of these

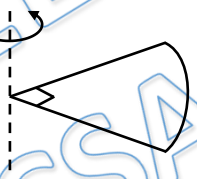
Q 11. A circular portion of diameter R is cut out from a uniform circular disc of mass M and radius R as shown in figure. The moment of inertia of the remaining (shaded) portion of the disc about an axis passing through the center O of the disc and perpendicular to its plane is:



(a) $\frac{15}{32}MR^2$ (b) $\frac{7}{16}MR^2$

(c) $\frac{13}{32}MR^2$ (d) $\frac{3}{8}MR^2$

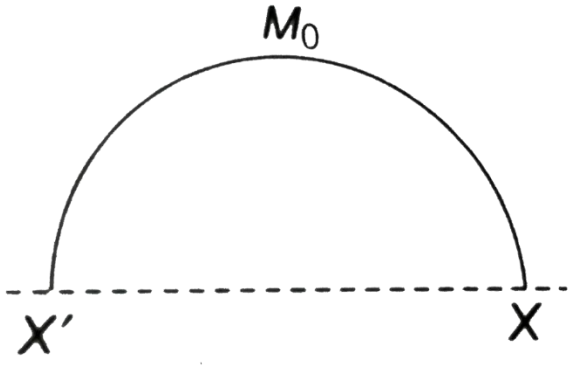
Q 12. One quarter sector is cut from a uniform disc of radius R. This sector has mass M. It is made to rotate about a line perpendicular to its plane and passing through the center of the original disc. Its moment of inertia about the axis of rotation is



(a) $\frac{1}{2}MR^2$ (b) $\frac{1}{4}MR^2$

(c) $\frac{1}{8}MR^2$ (d) $\sqrt{2}MR^2$

Q 13. A rod of length L and mass M_0 is bent to from a semi-circular ring as shown in figure. The moment of inertia about XX' is:



(a) $\frac{M_0L^2}{2\pi^2}$ (b) $\frac{M_0L^2}{\pi^2}$

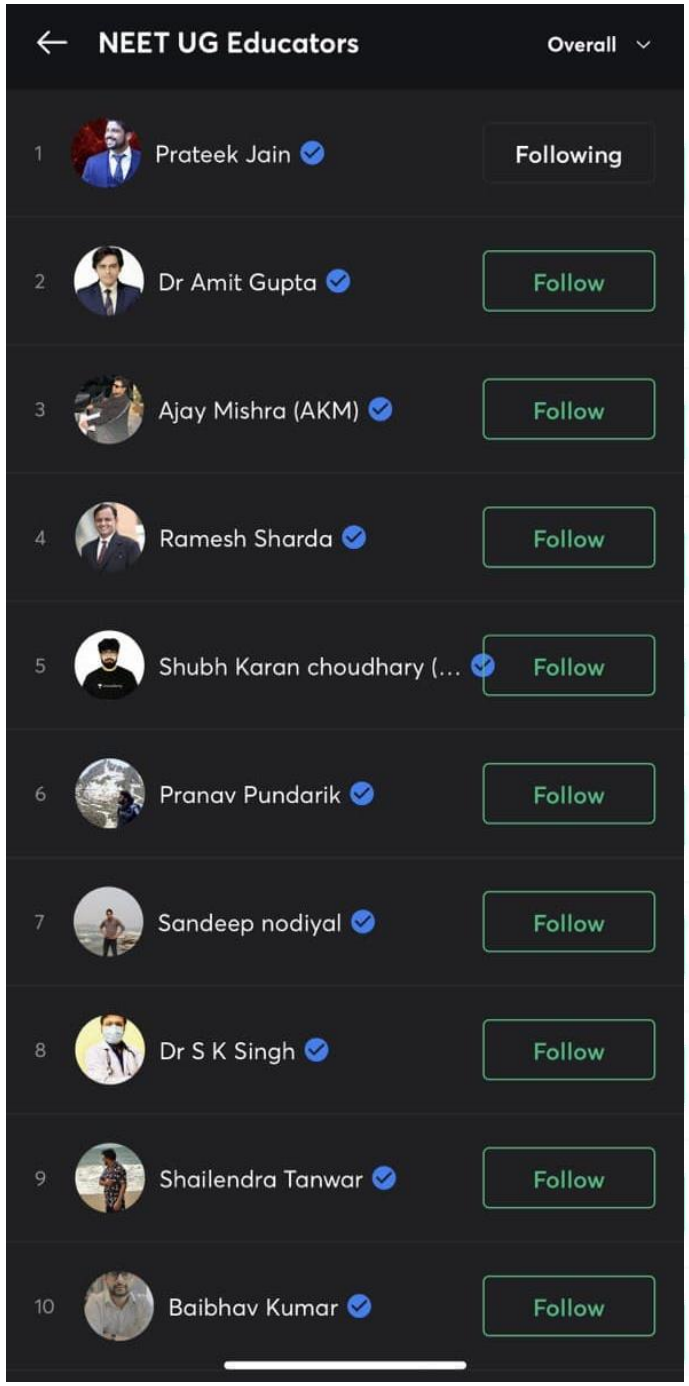
(c) $\frac{M_0 L^2}{4\pi^2}$ (d) $\frac{2M_0 L^2}{\pi^2}$

Q 14. A solid cylinder of 500 g and radius 10 cm has moment of inertia (about its natural axis)
(a) 2.5×10^{-3} kg-m^2 (b) 2×10^{-3} kg-m^2
(c) 5×10^{-3} kg-m^2 (d) 3.5×10^{-3} kg-m^2

Q 15. The moment of inertia of a uniform solid cone relative to its symmetry axis, if the mass of the cone is equal to m and the radius of its base to R is I = $\frac{3mR^2}{y}$. Find the value of y.
(a) 2 (b) 7
(c) 10 (d) 13 cm

Answer Key

Q.1 b	**Q.2 d**	**Q.3 b**	**Q.4 b**	**Q.5 b**
Q.6 c	**Q.7 b**	**Q.8 d**	**Q.9 b**	**Q.10 d**
Q.11 c	**Q.12 a**	**Q.13 a**	**Q.14 a**	**Q.15 c**



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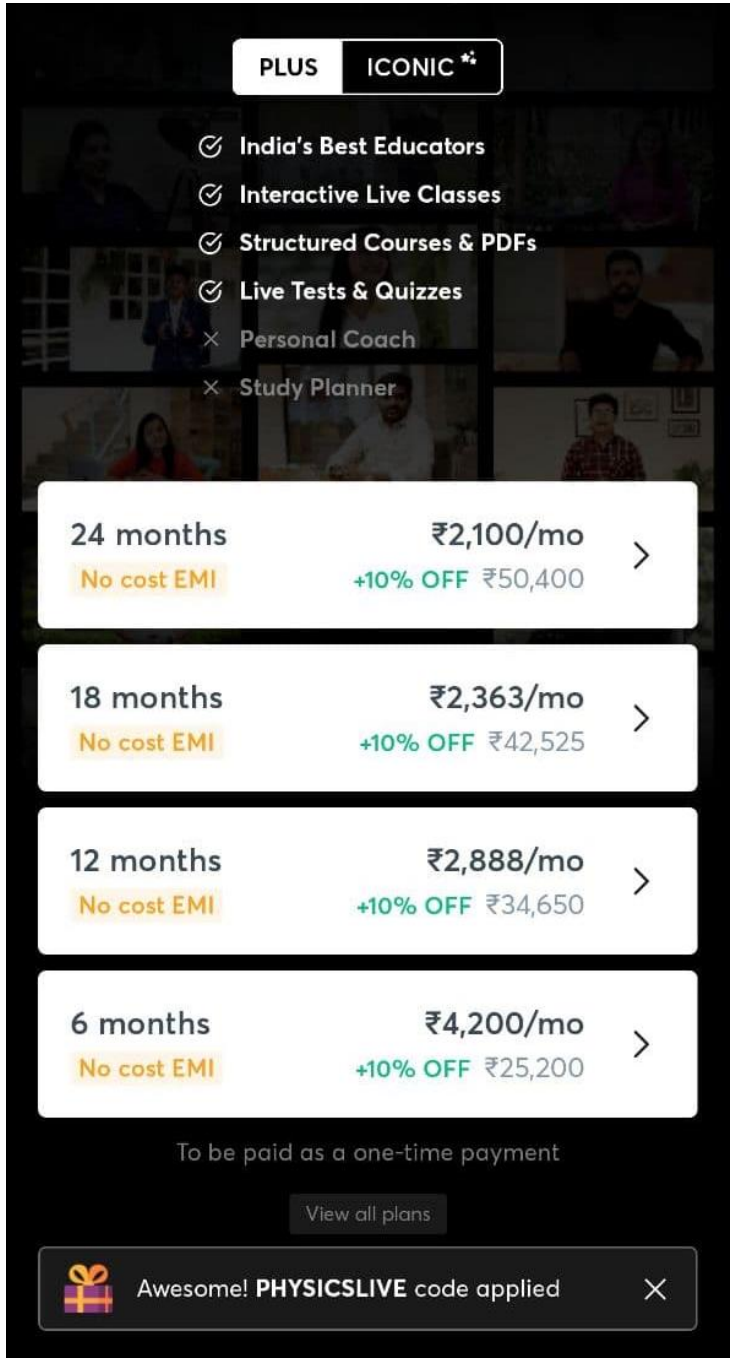
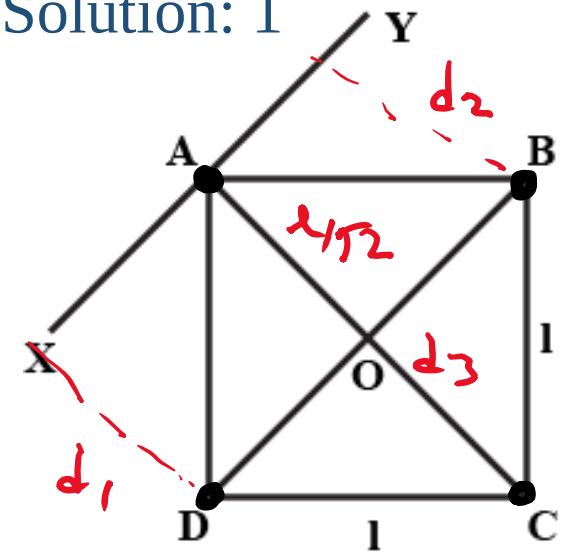


Written Solution

DPP- 2 Rotation: Moment of Inertia

By Physicsaholics Team

Solution: 1



$$d_1 = d_2 = \frac{l}{\sqrt{2}}$$

$$d_3 = \sqrt{2}\, l$$

$$I = m(0) + m d_1^2 + m d_2^2 + m d_3^2$$

$$I = 0 + m\left(\frac{l}{\sqrt{2}}\right)^2 + m\left(\frac{l}{\sqrt{2}}\right)^2 + m(\sqrt{2}l)^2$$

$$I = 0 + \frac{ml^2}{2} + \frac{ml^2}{2} + 2ml^2$$

$$\boxed{I = 3ml^2}$$ Ans.

Ans (b)

Solution: 2

distance from z-axis $= \sqrt{x^2+y^2}$

$I = m_1 d_1^2 + m_2 d_2^2 + m_3 d_3^2$

$m_1 = m_2 = m_3 = 2\,gm$

$I = 2 \times (d_1^2 + d_2^2 + d_3^2)$

$= 2 \times [13 + 2 + 2]$

$I = 34$ Unit

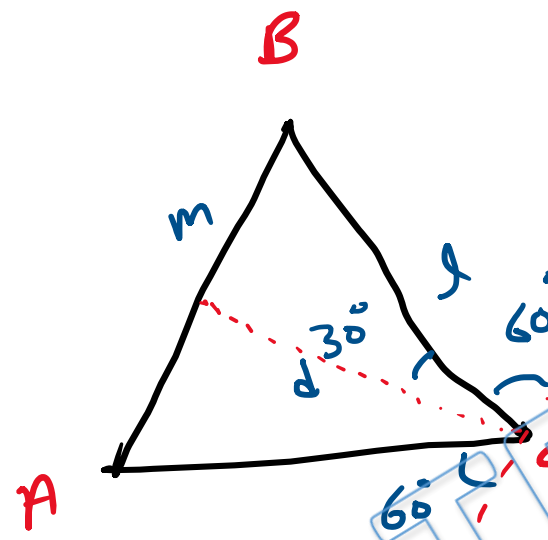
$d_1 = \sqrt{3^2+2^2} = \sqrt{13}$

$d_2 = \sqrt{1^2+(-1)^2} = \sqrt{2}$

$d_3 = \sqrt{(-1)^2+(1)^2} = \sqrt{2}$

Ans (d)

Solution: 3



$$I = I_{BC} + I_{AC} + I_{AB}$$

$$I = \frac{m(l\sin 60^\circ)^2}{} + \frac{m(l\sin 60^\circ)^2}{} + md^2$$

$$d = l\cos 30^\circ = \frac{\sqrt{3}l}{2}$$

$$= \frac{ml^2(\sqrt{3}/2)^2}{3} + \frac{ml^2(\sqrt{3}/2)^2}{3} + m\left(\frac{\sqrt{3}}{2}l\right)^2$$

$$= \frac{ml^2}{4} + \frac{ml^2}{4} + \frac{3ml^2}{4}$$

$$\boxed{I = \frac{5ml^2}{4}}$$

Ans (b)

Solution: 4

(A) If I about an axis is minimum, then I about any other axis parallel to the axis passing through the center of mass is more which can verified from the parallel axis theorem. Hence, it must pass through center of mass.

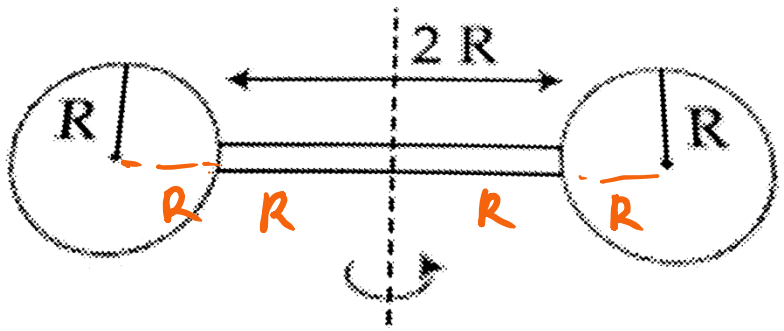
(B) Moment of Inertia about all axis passing through center of mass have same I is not correct.

(C) Perpendicular axis theorem can be applied to laminar bodies only

(D) Parallel axis theorem can be applied to 3D bodies, it is an general expression

Ans (b)

Solution: 5



$$I = 2\left[I_{cm} + md^2\right]$$

$$I = 2\left[\frac{2}{5}mR^2 + m(2R)^2\right]$$

$$I = 2\left[\frac{2}{5}mR^2 + 4mR^2\right]$$

$$I = 2\left[\frac{22mR^2}{5}\right]$$

$$\boxed{I = \frac{44mR^2}{5}} \quad \text{Ans.}$$

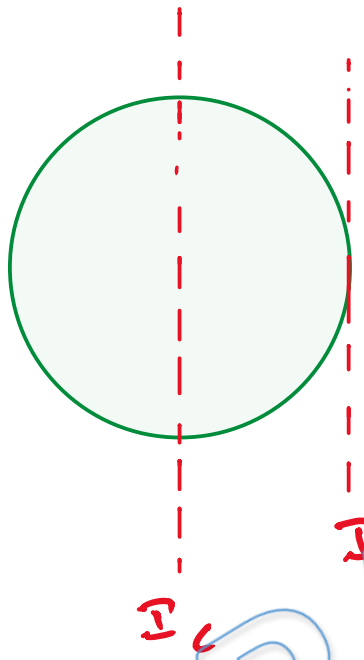
Ans (b)

Solution: 6

The moment of inertia is higher for a body if more mass is distributed away from the rotational axis. For a square rotating about a diagonal equal mass is distributed about its rotational axis, thus its moment of inertia will be lower.

Ans (C)

Solution: 7



$$\frac{I_C}{I_T} = \frac{\frac{2}{5}MR^2}{\frac{7}{5}MR^2}$$

$$\frac{I_C}{I_T} = \frac{2}{7}$$ Ans.

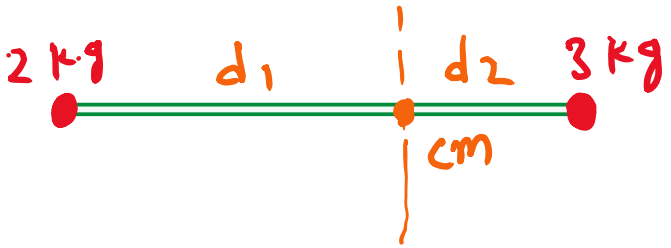
$$I_C = \frac{2}{5}mR^2$$

$$I_T = \frac{2}{5}mR^2 + mR^2$$

$$I_T = \frac{7}{5}mR^2$$

Ans (b)

Solution: 8



$2d_1 = 3d_2$

$d_1 + d_2 = 1$

$2d_1 + 2d_2 = 2$

$3d_2 + 2d_2 = 2$

$d_2 = \frac{2}{5}$ m

$d_1 = \frac{3}{5}$ m

$I_{cm} = 2 \times \left(\frac{3}{5}\right)^2 + 3 \times \left(\frac{2}{5}\right)^2$

$I_{cm} = \frac{18}{25} + \frac{12}{25}$

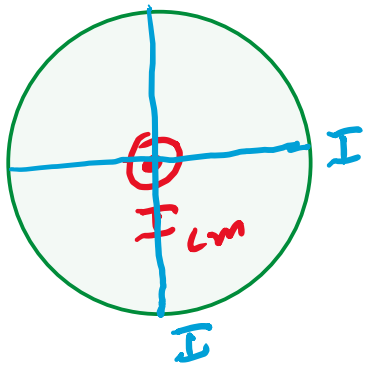
$I_{cm} = \frac{30}{25}$

$I_{cm} = \frac{6}{5}$

$I_{cm} = 1.2$ kg-m^2 Ans.

Ans (d)

Solution: 9



MOI about diameter = I

from perpendicular axis theorem

$I + I = I_{cm}$

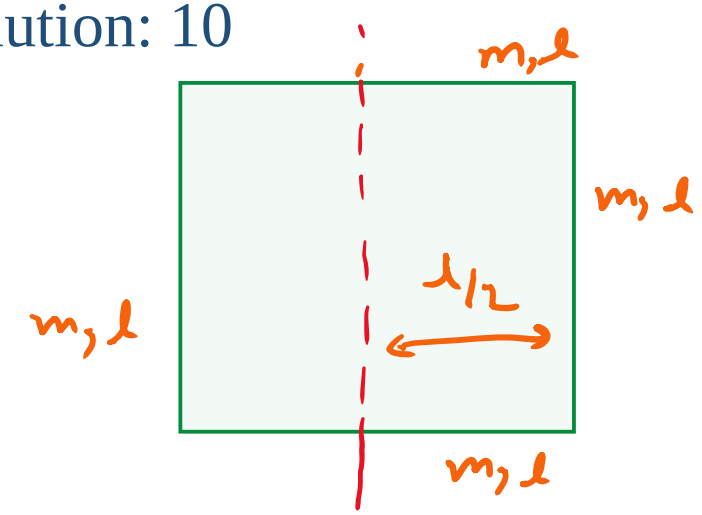
$2I = I_{cm}$

$2I = 4$

$I = 2\ kg\text{-}m^2$ Ans.

Ans (b)

Solution: 10



$$I = 2\left(\frac{ml^2}{12}\right) + 2\left(m\left(\frac{l}{2}\right)^2\right)$$

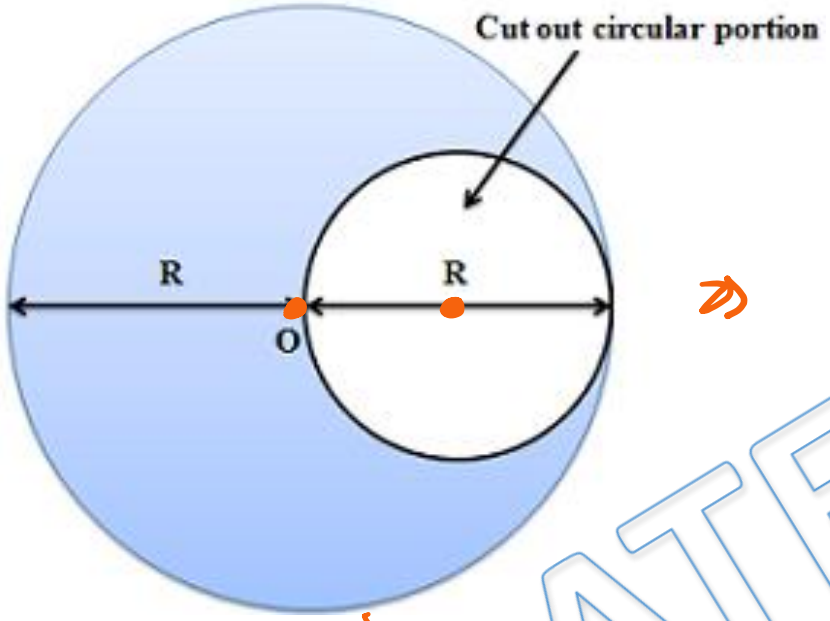
$$I = \frac{ml^2}{6} + \frac{ml^2}{2}$$

$$I = \frac{4ml^2}{6}$$

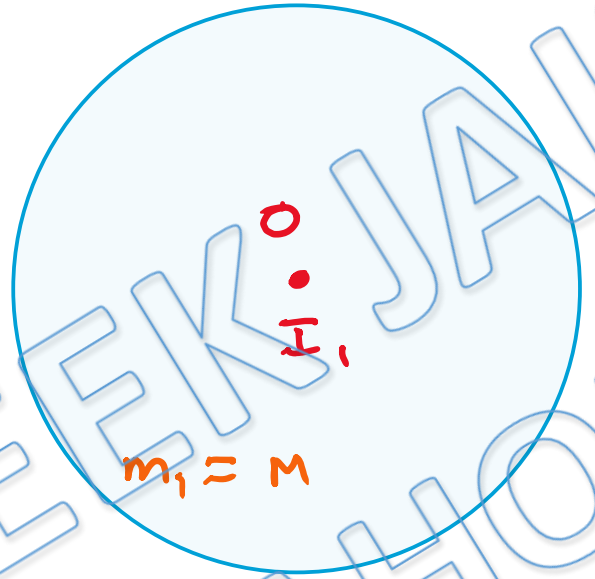
$$\boxed{I = \frac{2ml^2}{3}}$$ Ans.

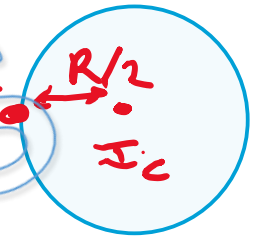
Ans (d)

Solution: 11



$\Rightarrow$





mass per unit area $= \frac{M}{\pi R^2}$

$I_1 = \frac{MR^2}{2}$

$m_2 = \frac{M}{\pi R^2}\left(\pi\left(\frac{R}{2}\right)^2\right) = \frac{M}{4}$

$I_2 = \frac{\left(\frac{M}{4}\right)\left(\frac{R}{2}\right)^2}{2} + \left(\frac{M}{4}\right)\left(\frac{R}{2}\right)^2$

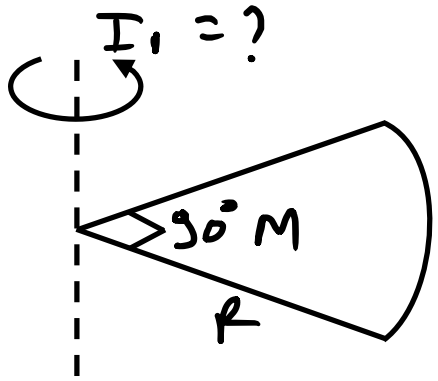
$I_2 = \frac{MR^2}{32} + \frac{MR^2}{16} = \frac{3MR^2}{32}$

$I = I_1 - I_2 = \frac{MR^2}{2} - \frac{3MR^2}{32}$

$\boxed{I = \frac{13MR^2}{32}}$ Ans.

Ans (C)

Solution: 12



$$I = 4 I_1$$

$$\frac{M_0 R^2}{2} = 4 (I_1)$$

$$\frac{4 M R^2}{2} = 4 I_1$$

$$\boxed{I_1 = \frac{M R^2}{2}}$$

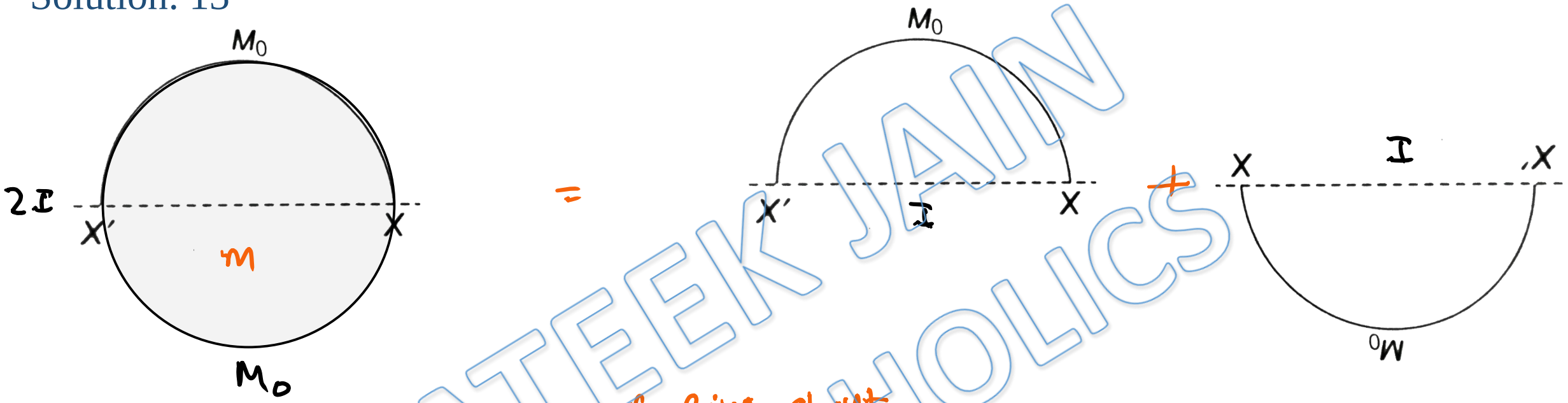
let

$$M_0 = 4M$$

$$I = \frac{MR^2}{2}$$

Ans (a)

Solution: 13



$L = \pi R$

$R = \frac{L}{\pi}$

$m = M_0 + M_0 = 2M_0$

MOI of Ring about diameter $= \frac{mR^2}{2}$

$I' = 2I = \frac{mR^2}{2}$

$I' = 2I = \frac{2M_0\left(\frac{L}{\pi}\right)^2}{2}$

$I = \frac{1}{2}\left[\frac{M_0 L^2}{(\pi^2)}\right]$

$\boxed{I = \frac{M_0 L^2}{2\pi^2}}$ Ans.

Ans (a)

Solution: 14

$I = \frac{MR^2}{2}$

$m = 500\,gm = 0.5\,kg$

$r = 10\,cm = 0.1\,m$

$I = \frac{0.5\,(0.1)^2}{2}$

$I = \frac{5 \times 10^{-3}}{2}$

$\boxed{I = 2.5 \times 10^{-3}\ kg\text{-}m^2}$ Ans.

Ans (a)

Solution: 15

MOI of solid cone

$$I = \frac{3}{10} M R^2$$

compare with

$$I = \frac{\gamma M R^2}{\gamma}$$

$$\Rightarrow \boxed{\gamma = 10} \text{ Ans.}$$

Ans (C)

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