Rotational Motion JEE Main PYQ - 2

Total Time: 25 Minute **Total Marks:** 40

Instructions

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1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Rotational Motion

1. The moment of inertia of a uniform cylinder of length l and radius R about its perpendicular bisector is l. What is the ratio $\frac{l}{R}$ such that the moment of inertia is minimum ? **(+4, -1)**

[8-Apr-2023 shift 1]

a. $\sqrt{\frac{3}{2}}$

b. $\frac{\sqrt{3}}{2}$

c. 1

d. $\frac{3}{\sqrt{2}}$

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2. A circular disc D_1 of mass M and radius R has two identical discs D_2 and D_3 of the same mass M and radius R attached rigidly at its opposite ends (see figure). The moment of inertia of the system about the axis OO', passing through the centre of D_1, as shown in the figure, will be : **(+4, -1)**

[11 Jan. 2019 II]

a. $3MR^2$

b. $\frac{2}{3}MR^2$

c. MR^2

d. $\frac{4}{5}MR^2$

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3. A long cylindrical vessel is half filled with a liquid. When the vessel is rotated about its own vertical axis, the liquid rises up near the wall. If the radius of vessel is $5\,cm$ and its rotational speed is 2 rotations per second, then the difference in the heights between the centre and the sides, in cm, will be **(+4, -1)**

[12 Jan. 2019 II]

a. 1.2

b. 0.1

c. 2

d. 0.4

4. A metal coin of mass $5\,g$ and radius $1\,cm$ is fixed to a thin stick AB of negligible mass as shown in the figure. The system is initially at rest. The constant torque, that will make the system rotate about AB at 25 rotations per second in $5\,s$, is close to : **(+4, -1)**

[10 Apr. 2019 II]

a. 4.0×10^{-6} Nm

b. 2.0×10^{-5} Nm

c. 1.6×10^{-5} Nm

d. 7.9×10^{-6} Nm

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5. A particle of mass m is fixed to one end of a light spring having force constant k and unstretched length l. The other end is fixed. The system is given an angular speed ω about the fixed end of the spring such that it rotates in a circle in gravity free space. Then the stretch in the spring is : **(+4, -1)**

[8 Jan. 2020 I]

a. $\frac{ml\omega^2}{k-\omega m}$

b. $\frac{ml\omega^2}{k-m\omega^2}$

c. $\frac{ml\omega^2}{k+m\omega^2}$

d. $\frac{ml\omega^2}{k+m\omega}$

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6. A rectangular solid box of length $0.3\,m$ is held horizontally, with one of its sides on the edge of a platform of height $5\,m$. When released, it slips off the table in a very short time $\tau = 0.01\,s$, remaining essentially horizontal. The angle by which it would rotate when it hits the ground will be (in radians) close to : **(+4, -1)**

[8 Apr. 2019 II]

a. 0.02

b. 0.28

c. 0.5

d. 0.3

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7. A rigid massless rod of length $3l$ has two masses attached at each end as shown in the figure. The rod is pivoted at point P on the horizontal axis (see figure). When released from initial horizontal position, its instantaneous angular acceleration will be : **(+4, -1)**

[10 Jan. 2019 II]

a. $\frac{g}{2l}$

b. $\frac{7g}{3l}$

c. $\frac{g}{13l}$

d. $\frac{g}{3l}$

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8. A roller is made by joining together two cones at their vertices O. It is kept on two rails AB and CD which are placed asymmetrically (see figure), with its axis perpendicular to CD and its centre O at the centre of line joining AB and CD (see figure). It is given a light push so that it starts rolling with its centre O moving parallel to CD in the direction shown. As it moves, the roller will tend to : **(+4, -1)**

[2016]

a. turn left.

b. turn right.

c. go straight.

d. turn left and right alternately.

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9. Two discs of same mass and different radii are made of different materials such that their thicknesses are 1 cm and 0.5 cm respectively. The densities of materials are in the ratio 3:5. The moment of inertia of these discs respectively about their diameters will be in the ratio of $\frac{x}{6}$. The value of x is ____. **(+4, -1)**

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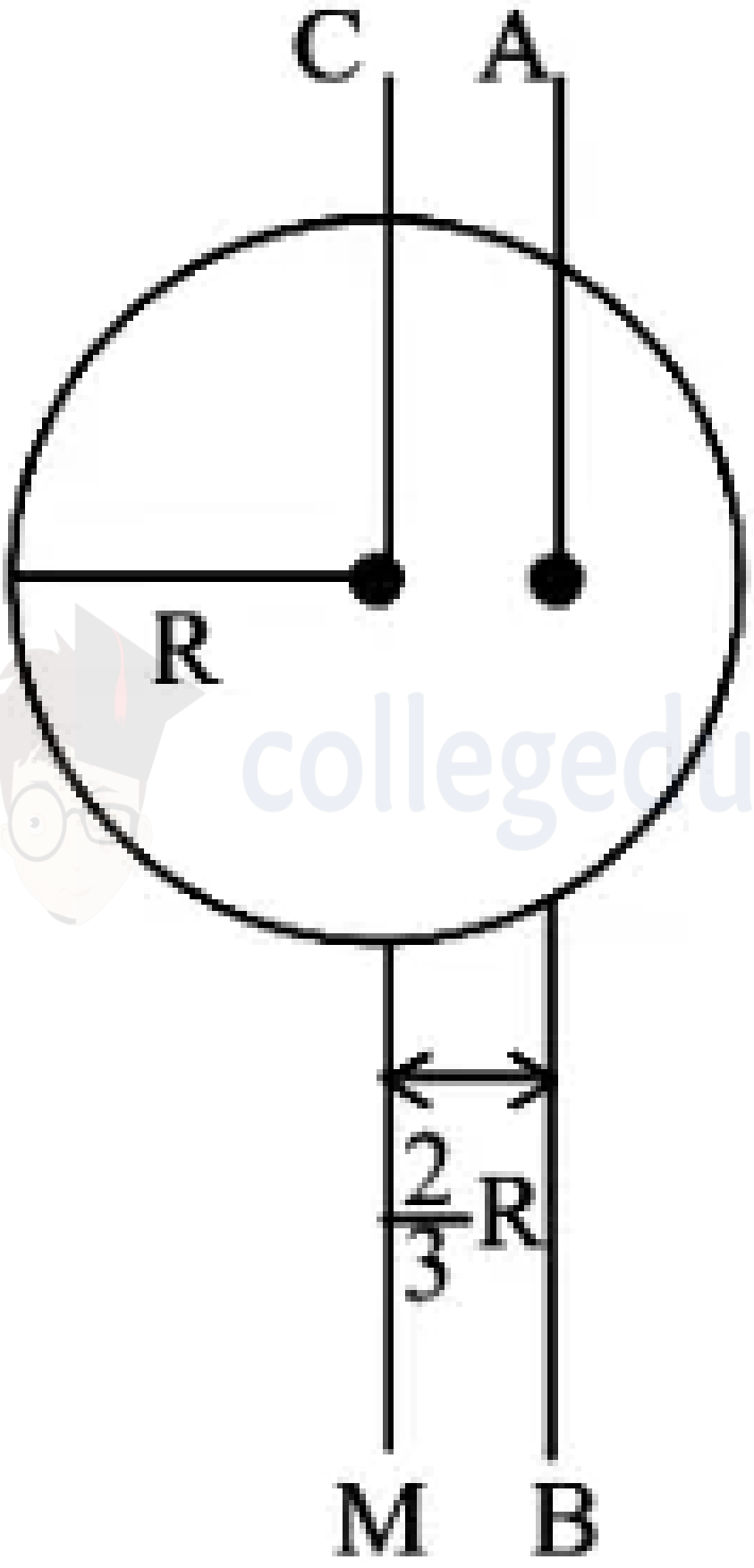
10. I_{CM} is the moment of inertia of a circular disc about an axis (CM) passing through its center and perpendicular to the plane of disc I_{AB} is it's moment of inertia about an axis AB perpendicular to plane and parallel to axis CM at a distance $\frac{2}{3}R$ from center Where R is the radius of the dise The ratio of I_{AB} and I_{CM} is $x : 9$ The value of x is_____ **(+4, -1)**

[31-Jan-2023 Shift 2]


C
A
R
$\frac{2}{3}R$
M
B

Answers

1. Answer: a

Explanation:

$I = \frac{mR^2}{4} + \frac{ml^2}{12}$
$I = \frac{m}{4}\left[R^2 + \frac{l^2}{3}\right]$
$= \frac{m}{4}\left[\frac{v}{\pi l} + \frac{l^2}{3}\right]$
$\frac{dl}{dl} = \frac{m}{4}\left[\frac{-v}{\pi l^2} + \frac{2l}{3}\right] = 0$
$\frac{v}{\pi l^2} = \frac{2l}{3}$
$v = \frac{2\pi l^3}{3}$
$\pi R^2 l = \frac{2\pi l^3}{3}$
$\frac{l^2}{R^2} = \frac{3}{2}$
$\frac{l}{R} = \sqrt{\frac{3}{2}}$

Concepts:

1. System of Particles and Rotational Motion:

1. The system of particles refers to the extended body which is considered a rigid body most of the time for simple or easy understanding. A rigid body is a body with a perfectly definite and unchangeable shape.
2. The distance between the pair of particles in such a body does not replace or alter. Rotational motion can be described as the motion of a rigid body originates in such a manner that all of its particles move in a circle about an axis with a common angular velocity.
3. The few common examples of rotational motion are the motion of the blade of a windmill and periodic motion.

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2. Answer: a

Explanation:

$I = \frac{MR^2}{2} + 2\left(\frac{MR^2}{4} + MR^2\right)$
$= \frac{MR^2}{2} + \frac{MR^2}{2} + 2MR^2$

$= 3\,MR^2$

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3. Answer: c

Explanation:

$y = \frac{\omega^2 x^2}{2g} = \frac{(2\times 2\pi)^2 \times (0.05)^2}{20}] \simeq 2\,cm$

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4. **Answer: b**

Explanation:

$\alpha = \frac{\Delta\omega}{\Delta t} = \frac{25\times 2\pi}{5} = 10\pi \text{rad}/\sec^2$
$\tau = \left(\frac{5}{4}MR^2\right)\alpha$
$= \frac{5}{4} \times 5 \times 10^{-3} \times \left(10^{-2}\right)^2 \times 10\pi$
$= 1.9625 \times 10^{-5} Nm$
$\simeq 2.0 \times 10^{-5} Nm$

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5. **Answer: b**

Explanation:

$kx = m\ell\omega^2 + mx\omega^2$
$x - \frac{m\ell\omega^2}{k - m\omega^2}$

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6. Answer: c

Explanation:

Angular impulse = change in angular momentum

$\tau \Delta t = \Delta L$

$mg\frac{\ell}{2} \times 0.1 = \frac{m\ell^2}{3}\omega$

$\omega = \frac{3g \times 0.01}{2\ell}$

$= \frac{3 \times 10 \times .01}{2 \times 0.3}$

$= \frac{1}{2} = 0.5\ rad/s$

time taken by rod to hit the ground

$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 5}{10}} = 1$ sec

in this time angle rotate by rod

$\theta = \omega t = 0.5 \times 1 = 0.5$ radian

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7. **Answer: c**

Explanation:

Applying torque equation about point P.

$2M_0\,(2l) - 5M_0gl = I\alpha$

$I = 2M_0\,(2l)^2 + 5M_0l^2 = 13M_0l^2d$

$\therefore \alpha = -\frac{M_0g\ell}{13M_0\ell^2} \Rightarrow \alpha = -\frac{g}{13\ell}$

$\therefore \alpha = \frac{g}{13\ell}$ anticlockwise

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8. **Answer: c**

Explanation:

If central line is at a distance r from instantaneous axis of rotation, the r is at lesser distance from point on left than on right. Since $v = r\omega$, the roller will turn to left.

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9. **Answer: 5 - 5**

Explanation:

The correct answer is 5.

Concepts:

1. Rotational Motion:

Rotational motion can be defined as the motion of an object around a circular path, in a fixed orbit.

Rotational Motion Examples:

The wheel or rotor of a motor, which appears in rotation motion problems, is a common example of the rotational motion of a rigid body.

Other examples:

- Moving by Bus
- Sailing of Boat
- Dog walking
- A person shaking the plant.
- A stone falls straight at the surface of the earth.
- Movement of a coin over a carrom board

Types of Motion involving Rotation:

1. Rotation about a fixed axis (Pure rotation)

2. Rotation about an axis of rotation (Combined translational and rotational motion)
3. Rotation about an axis in the rotation (rotating axis)

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10. Answer: 17 - 17

Explanation:

The correct answer is 17.

$I_{cm} = \frac{mR^2}{2}$

$I_{AB} = \frac{mR^2}{2} + m\left(\frac{2R}{3}\right)^2 = \frac{17}{18}mR^2$

$\frac{I_{AB}}{I_{cm}} = \frac{17}{9} \Rightarrow x = 17$

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