Rotational Motion

SET Self Evaluation Test - 7

1. A wheel of moment of inertia $5 \times 10^{-3}\ kg - m^2$ is making 20 revolutions per second. It is stopped in 20 seconds, then the angular retardation is

(a) $\pi\ radian/\sec^2$ (b) $2\pi\ radian/\sec^2$

(c) $4\pi\ radian/\sec^2$ (d) $8\pi\ radian/\sec^2$

2. A disc starting from rest acquires in 10 *sec* an angular velocity of 240 revolutions/minute. Its angular acceleration (assuming constant) is

(a) 1.52 *rad/sec* (b) 2.51 *rad/sec*

(c) 3.11 *rad/sec* (d) 3.76 *rad/sec*

3. The flywheel is so constructed that the entire mass of it is concentrated at its rim, because

(a) It increases the power

(b) It increases the speed

(c) It increases the moment of inertia

(d) It save the flywheel fan breakage

4. A wheel (rim) of mass 6 *kg* and radius 40 *cm* is revolving at the rate of 300 revolutions per minute. Its moment of inertia will be

(a) $0.092\ kg \times m^2$ (b) $0.96\ kg \times m^2$

(c) $2.4\ kg \times m^2$ (d) $2.98\ kg \times m^2$

5. In the above question the kinetic energy of rotation of the wheel should be

(a) $48\pi^2$ *joule* (b) 48 *joule*

(c) 48π *joule* (d) $\frac{48}{\pi}$ *joule*

6. Four spheres of diameter 2*a* and mass *M* are placed with their centres on the four corners of a square of side *b*. Then the moment of inertia of the system about an axis along one of the sides of the square is

(a) $\frac{4}{5}Ma^2 + 2Mb^2$ (b) $\frac{8}{5}Ma^2 + 2Mb^2$

(c) $\frac{8}{5}Ma^2$ (d) $\frac{4}{5}Ma^2 + 4Mb^2$

7. A rigid body of mass *m* rotates with the angular velocity ω about an axis at a distance '*a*' from the centre of mass *G*. The radius of gyration about *G* is *K*. Then kinetic energy of rotation of the body about new parallel axis is

(a) $\frac{1}{2}mK^2\omega^2$ (b) $\frac{1}{2}ma^2\omega^2$

(c) $\frac{1}{2}m(a^2 + K^2)\omega^2$ (d) $\frac{1}{2}m(a + K^2)\omega^2$

8. Two discs have same mass and thickness. Their materials are of densities ρ_1 and ρ_2. The ratio of their moment of inertia about central axis will be

(a) $\rho_1 : \rho_2$ (b) $\rho_1\rho_2 : 1$

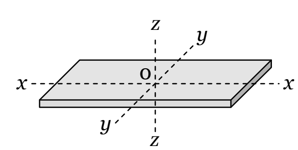
(c) $1 : \rho_1\rho_2$ (d) $\rho_2 : \rho_1$

9. A uniform cylinder has a radius *R* and length *L*. If the moment of inertia of this cylinder about an axis passing through its centre and normal to its circular face is equal to the moment of inertia of the same cylinder about an axis passing through its centre and perpendicular to its length, then

(a) $L = R$ (b) $L = \sqrt{3}R$

(c) $L = \frac{R}{\sqrt{3}}$ (d) $L = \sqrt{\frac{3}{2}}R$

10. The rectangular block shown in the figure is rotated in turn about $x - x, y - y$ and $z - z$ axes passing through its centre of mass *O*. Its moment of inertia is



(a) Same about all the three axes

(b) Maximum about $z - z$ axis

(c) Equal about $x - x$ and $y - y$ axes

(d) Maximum about $y - y$ axis

11. We have two spheres, one of which is hollow and the other solid. They have identical masses and moment of inertia about their respective diameters. The ratio of their radius is given by

(a) 5 : 7 (b) 3 : 5

(c) $\sqrt{3} : \sqrt{5}$ (d) $\sqrt{3} : 7$

12. A wheel of moment of inertia $5 \times 10^{-3}\ kg - m^2$ is making 20 revolutions/sec. The torque required to stop it in 10 *sec* is

(a) $2\pi \times 10^{-2}\ N - m$ (b) $2\pi \times 10^{2}\ N - m$

(c) $4\pi \times 10^{-2}\ N - m$ (d) $4\pi \times 10^{2}\ N - m$

13. If all of a sudden the radius of the earth decreases, then

(a) The angular momentum of the earth will become greater than that of the sun

(b) The angular speed of the earth will increase

(c) The periodic time of the earth will increase

(d) The energy and angular momentum will remain constant

14. A particle of mass m = 5 *units* is moving with a uniform speed $v = 3\sqrt{2}$ *units* in the *XOY* plane along the straight line $Y = X + 4$. The magnitude of the angular momentum about origin is

(a) Zero (b) 60 *units*

(c) 75 *units* (d) $40\sqrt{2}$ *units*

15. A thin uniform rod mass m and length l is hinged at the lower end to a level floor and stands vertically. It is now allowed to fall, then its upper end will strike the floor with a velocity given by

(a) $\sqrt{2gl}$ (b) $\sqrt{3gl}$

(c) $\sqrt{5gl}$ (d) $\sqrt{mgl}$

16. A sphere of mass 50 *gm* and diameter 20 *cm* rolls without slipping with a velocity of 5*cm/sec*. Its total kinetic energy is

(a) 625 *erg* (b) 250 *erg*

(c) 875 *erg* (d) 875 *joule*

17. From an inclined plane a sphere, a disc, a ring and a spherical shell are rolled without slipping. The order of their reaching at the base will be

(a) Ring, shell, disc, sphere

(b) Shell, sphere, disc, ring

(c) Sphere, disc, shell, ring

(d) Ring, sphere, disc, shell

18. When a uniform solid sphere and a disc of the same mass and of the same radius rolls down an inclined smooth plane from rest to the same distance, then the ratio of the time taken by them is

(a) 15 : 14 (b) $15^2 : 14^2$

(c) $\sqrt{14} : \sqrt{15}$ (d) 14 : 15

19. A reel of thread unrolls itself falling down under gravity. Neglecting mass of the thread, the acceleration of the reel is

(a) g (b) $g/2$

(c) $2g/3$ (d) $4g/3$

Answers and Solutions

(SET -7)

1. (b) $n_1 = 20\ rev/s$, $n_2 = 0$, $t = 20s$

$$\alpha = \frac{2\pi(n_2 - n_1)}{t} = -\frac{2\pi\times 20}{20} = -2\pi\, rad/\sec^2$$

2. (b) $\alpha = \frac{\omega_2 - \omega_1}{t} = \frac{2\pi(n_2 - n_1)}{t} = \frac{2\pi \times \left[\frac{240}{60} - 0\right]}{10}$

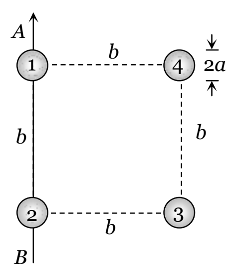
$\therefore \alpha = 2.51\ rad/s$

3. (c)

4. (b) $I = mr^2 = 6 \times (0.4)^2 = 0.96 kg \times m^2$

5. (a) $K_R = \frac{1}{2} I\omega^2 = \frac{1}{2}(0.96) \times \left(2\pi \times \frac{300}{60}\right) = 48\pi^2 J$

6. (b)



$I_1 = \frac{2}{5} Ma^2$ = M.I. of sphere 1 about AB axis

$I_2 = \frac{2}{5} Ma^2$ = M.I. of sphere 2 about AB axis

$I_3 = \frac{2}{5} Ma^2 + Mb^2$ = M.I. of sphere 3 about AB axis

$I_4 = \frac{2}{5} Ma^2 + Mb^2$ = M.I. of sphere 4 about AB axis

M.I. of system about axis AB

$$I_{\text{system}} = I_1 + I_2 + I_3 + I_4$$

$$= 2\left(\frac{2}{5} Ma^2\right) + 2\left(\frac{2}{5} Ma^2 + Mb^2\right)$$

$$= \frac{8}{5} Ma^2 + 2Mb^2$$

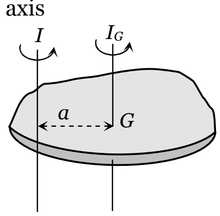
7. (c) M.I. of body about centre of mass $= I_{cm} = mK^2$

M.I. of a body about new parallel axis

$I_{new} = I_{cm} + ma^2 = mK^2 + ma^2$

$I_{new} = m(K^2 + a^2)$

$K_R = \frac{1}{2} I_{new}\omega^2 = \frac{1}{2} m(K^2 + a^2)\omega^2$



8. (d) M.I. of disc $I = \frac{1}{2} MR^2 = \frac{1}{2} M\left(\frac{M}{\pi\rho t}\right) = \frac{1}{2}\frac{M^2}{\pi\rho t}$

$\left(\text{As } \rho = \frac{\text{Mass}}{\text{Volume}} = \frac{M}{\pi R^2 t} \text{ therefore } R^2 = \frac{M}{\pi\rho t}\right)$

$\therefore I \propto \frac{1}{\rho}$ [If M and t are constant] $\Rightarrow \frac{I_1}{I_2} = \frac{\rho_2}{\rho_1}$

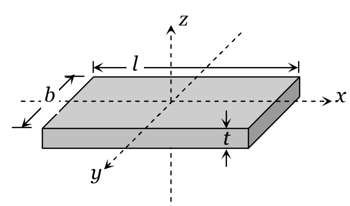
9. (b) M.I. of a cylinder about its centre and parallel to its length $= \frac{MR^2}{2}$

M.I. about its centre and perpendicular to its length $= M\left(\frac{L^2}{12} + \frac{R^2}{4}\right)$

According to problem, $\frac{ML^2}{12} + \frac{MR^2}{4} = \frac{MR^2}{2}$

By solving we get $L = \sqrt{3} R$

10. (b)



M.I. of block about x axis, $I_x = \frac{m}{12}(b^2 + t^2)$

M.I. of block about y axis, $I_y = \frac{m}{12}(l^2 + t^2)$

M.I. of block about z axis, $I_z = \frac{m}{12}(l^2 + b^2)$

As $l > b > t$ $\therefore$ $I_z > I_y > I_x$

11. (c) $I_{Hollow} = I_{Solid} \Rightarrow \frac{2}{3} M(R_H)^2 = \frac{2}{5} M(R_S)^2$

$\therefore \left(\frac{R_H}{R_S}\right)^2 = \frac{3}{5}$ or $\frac{R_H}{R_S} = \sqrt{\frac{3}{5}}$

12. (a) $\alpha = \frac{2\pi(n_2 - n_1)}{t} = \frac{2\pi(0 - 20)}{10} = -4\pi\ rad/s^2$

Negative sign means retardation

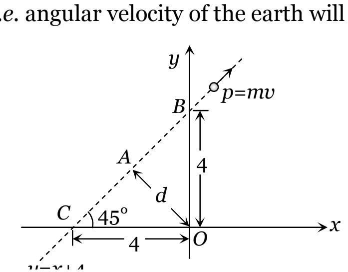
Now $\tau = I\alpha = 5 \times 10^{-3} \times 4\pi = 2\pi \times 10^{-2}\ N\text{-}m$

13. (b) If radius of earth decreases then its M.I. decreases.

As $L = I\omega$ $\therefore$ $\omega \propto \frac{1}{I}$ [L =constant]

i.e. angular velocity of the earth will increase.

14. (b)



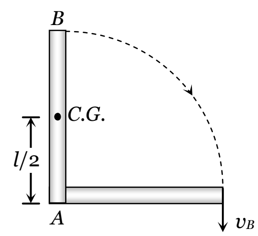
Form the triangle OAC

$$d = OC \sin 45° = 4 \times \frac{1}{\sqrt{2}} = 2\sqrt{2}$$

Angular momentum = Linear momentum × Perpendicular distance of line of action of linear momentum from the point of rotation

$$L = p \times d = mvd = 5 \times 3\sqrt{2} \times 2\sqrt{2} = 60 \text{ units}.$$

15. (b) Initially rod stand vertically its potential energy $= mg\frac{l}{2}$



When it strikes the floor, its potential energy will convert into rotational kinetic energy.

$$mg\left(\frac{l}{2}\right) = \frac{1}{2}I\omega^2$$

[Where, $I = \frac{ml^2}{3}$ = M.I. of rod about point A]

$$\therefore\ mg\left(\frac{l}{2}\right) = \frac{1}{2}\left(\frac{ml^2}{3}\right)\left(\frac{v_B}{l}\right)^2 \Rightarrow v_B = \sqrt{3gl}$$

16. (c) $K_N = \frac{1}{2}mv^2\left(1 + \frac{K^2}{R^2}\right) = \frac{1}{2} \times 50 \times (5)^2 \times \left(1 + \frac{2}{5}\right)$

$= 875 erg$

17. (c) $I_{Sphere} < I_{Disc} < I_{Shell} < I_{Ring}$

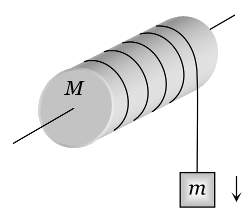
We know that body possess minimum moment of inertia will reach the bottom first and body possess maximum moment of inertia will reach the bottom at last.

18. (c) $t = \frac{1}{\sin\theta}\sqrt{\frac{2h}{g}\left(1 + \frac{K^2}{R^2}\right)}$

$$\Rightarrow \frac{t_S}{t_D} = \sqrt{\frac{1 + \left(\frac{K^2}{R^2}\right)_S}{1 + \left(\frac{K^2}{R^2}\right)_D}}$$

$$= \sqrt{\frac{1 + \frac{2}{5}}{1 + \frac{1}{2}}} = \sqrt{\frac{14}{15}}$$

19. (c)



$a = \frac{g}{1 + \frac{K^2}{R^2}}$ [For solid cylinder $\frac{K^2}{R^2} = \frac{1}{2}$]

$$\therefore\ a = \frac{g}{1 + \frac{1}{2}} = \frac{2}{3}g$$

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