DPP - Daily Practice Problems

Name : ____________________ **Date :** __________

Start Time : __________ **End Time :** __________

PHYSICS 17

SYLLABUS : Rotational Motion - 3 : Rolling Motion, Parallel and perpendicular theorems and their applications, Rigid body rotation, equations of rotational motion

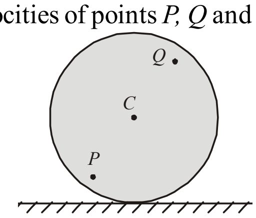
Max. Marks : 116 **Time : 60 min.**

GENERAL INSTRUCTIONS

- The Daily Practice Problem Sheet contains 30 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solution booklet.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus. Refer syllabus sheet in the starting of the book for the syllabus of all the DPP sheets.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

DIRECTIONS (Q.1-Q.20) : There are 20 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

Q.1 A disc is rolling (without slipping) on a horizontal surface. C is its centre and Q and P are two points equidistant from C. Let v_P, v_Q and v_C be the magnitude of velocities of points P, Q and C respectively, then



(a) $v_Q > v_C > v_P$

(b) $v_Q < v_C < v_P$

(c) $v_Q = v_P, v_C = \frac{v_P}{2}$

(d) $v_Q < v_C > v_P$

Q.2 A uniform rod of length $2L$ is placed with one end in contact with the horizontal and is then inclined at an angle α to the horizontal and allowed to fall without slipping at contact point. When it becomes horizontal, its angular velocity will be

(a) $\omega = \sqrt{\frac{3g\sin\alpha}{2L}}$

(b) $\omega = \sqrt{\frac{2L}{3g\sin\alpha}}$

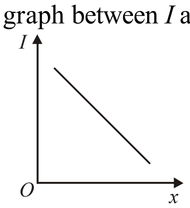
(c) $\omega = \sqrt{\frac{6g\sin\alpha}{L}}$

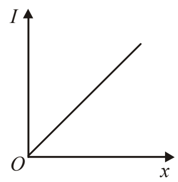
(d) $\omega = \sqrt{\frac{L}{g\sin\alpha}}$

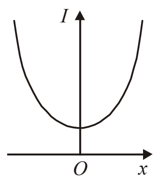
RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ

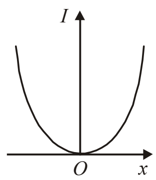
Space for Rough Work

Q.3 According to the theorem of parallel axes $I = I_{cm} + Mx^2$, the graph between I and x will be

(a) 

(b) 

(c) 

(d) 

Q.4 A solid cylinder of mass M and radius R rolls without slipping down an inclined plane of length L and height h. What is the speed of its centre of mass when the cylinder reaches its bottom

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

Q.5 An inclined plane makes an angle 30° with the horizontal. A solid sphere rolling down this inclined plane from rest without slipping has a linear acceleration equal to

(a) $\frac{g}{3}$ (b) $\frac{2g}{3}$ (c) $\frac{5g}{7}$ (d) $\frac{5g}{14}$

Q.6 A cord is wound round the circumference of wheel of radius r. The axis of the wheel is horizontal and moment of inertia about it is I. A weight mg is attached to the end of the cord and falls from the rest. After falling through a distance h, the angular velocity of the wheel will be

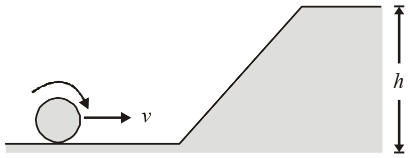
(a) $\sqrt{\frac{2gh}{I + mr}}$ (b) $\left[\frac{2mgh}{I + mr^2}\right]^{1/2}$

(c) $\left[\frac{2mgh}{I + 2mr^2}\right]^{1/2}$ (d) $\sqrt{2gh}$

Q.7 A solid sphere, disc and solid cylinder all of the same mass and made up of same material are allowed to roll down (from rest) on an inclined plane, then

(a) Solid sphere reaches the bottom first
(b) Solid sphere reaches the bottom late
(c) Disc will reach the bottom first
(d) All of them reach the bottom at the same time

Q.8 A solid sphere is rolling on a frictionless surface, shown in figure with a transnational velocity v m/s. If sphere climbs up to height h then value of v should be

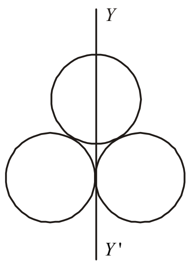


(a) $\geq \sqrt{\frac{10}{7}gh}$ (b) $\geq \sqrt{2gh}$ (c) $2gh$ (d) $\frac{10}{7}gh$

Q.9 Moment of inertia of a disc about its own axis is I. Its moment of inertia about a tangential axis in its plane is

(a) $\frac{5}{2}I$ (b) $3I$ (c) $\frac{3}{2}I$ (d) $2I$

Q.10 Three rings each of mass M and radius R are arranged as shown in the figure. The moment of inertia of the system about YY' will be



(a) $3MR^2$
(b) $\frac{3}{2}MR^2$
(c) $5MR^2$
(d) $\frac{7}{2}MR^2$

Q.11 One circular ring and one circular disc, both are having the same mass and radius. The ratio of their moments of inertia about the axes passing through their centres and perpendicular to their planes, will be

(a) 1 : 1 (b) 2 : 1
(c) 1 : 2 (d) 4 : 1

Q.12 From a disc of radius R, a concentric circular portion of radius r is cut out so as to leave an annular disc of mass M. The moment of inertia of this annular disc about the axis perpendicular to its plane and passing through its centre of gravity is

(a) $\frac{1}{2}M(R^2 + r^2)$ (b) $\frac{1}{2}M(R^2 - r^2)$

(c) $\frac{1}{2}M(R^4 + r^4)$ (d) $\frac{1}{2}M(R^4 - r^4)$

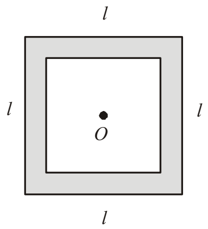
RESPONSE GRID					
	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ
	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ

Space for Rough Work

Q.13 The moment of inertia of a straight thin rod of mass M and length l about an axis perpendicular to its length and passing through its one end, is

(a) $\frac{M\ell^2}{12}$ (b) $\frac{M\ell^2}{3}$ (c) $\frac{M\ell^2}{2}$ (d) $M\ell^2$

Q.14 Four thin rods of same mass M and same length l, form a square as shown in figure. Moment of inertia of this system about an axis through centre O and perpendicular to its plane is



(a) $\frac{4}{3}Ml^2$

(b) $\frac{Ml^2}{3}$

(c) $\frac{Ml^2}{6}$

(d) $\frac{2}{3}Ml^2$

Q.15 The moment of inertia of a uniform circular ring, having a mass M and a radius R, about an axis tangential to the ring and perpendicular to its plane, is

(a) $2MR^2$ (b) $\frac{3}{2}MR^2$ (c) $\frac{1}{2}MR^2$ (d) MR^2

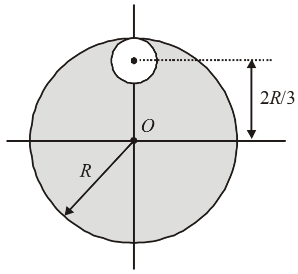
Q.16 The moment of inertia of uniform rectangular plate about an axis passing through its mid-point and parallel to its length l is (b = breadth of rectangular plate)

(a) $\frac{Mb^2}{4}$ (b) $\frac{Mb^3}{6}$ (c) $\frac{Mb^3}{12}$ (d) $\frac{Mb^2}{12}$

Q.17 The moment of inertia of a circular ring about an axis passing through its centre and normal to its plane is 200 gm × cm^2. Then moment of inertia about its diameter is

(a) 400 gm × cm^2 (b) 300 gm × cm^2
(c) 200 gm × cm^2 (d) 100 gm × cm^2

Q.18 From a circular disc of radius R and mass 9 M, a small disc of radius $R/3$ is removed from the disc. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through O is



(a) $4MR^2$

(b) $\frac{40}{9}MR^2$

(c) $10MR^2$

(d) $\frac{37}{9}MR^2$

Q.19 The moment of inertia of a thin rod of mass M and length L about an axis perpendicular to the rod at a distance $L/4$ from one end is

(a) $\frac{ML^2}{6}$ (b) $\frac{ML^2}{12}$ (c) $\frac{7ML^2}{24}$ (d) $\frac{7ML^2}{48}$

Q.20 A wheel has a speed of 1200 revolutions per minute and is made to slow down at a rate of 4 radians /s^2. The number of revolutions it makes before coming to rest is

(a) 143 (b) 272 (c) 314 (d) 722

DIRECTIONS (Q.21-Q.23) : In the following questions, more than one of the answers given are correct. Select the correct answers and mark it according to the following codes:

Codes:
(a) 1, 2 and 3 are correct **(b)** 1 and 2 are correct
(c) 2 and 4 are correct **(d)** 1 and 3 are correct

Q.21 In pure rolling fraction of its total energy associated with rotation is α for a ring and β for a solid sphere. Then

(1) $\alpha = 1/2$ (2) $\beta = 2/7$ (3) $\beta = 2/5$ (4) $\alpha = 1/4$

Q.22 One solid sphere and a disc of same radius are falling along an inclined plane without slip. One reaches earlier than the other due to

(1) different size
(2) different radius of gyration
(3) different moment of inertia
(4) different friction

Q.23 A body is rolling down an inclined plane. Its translational and rotational kinetic energies are equal. The body is not a

(1) solid sphere (2) hollow sphere
(3) solid cylinder (4) hollow cylinder

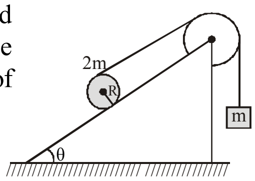
RESPONSE GRID					
	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ
	18. ⓐⓑⓒⓓ	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ
	23. ⓐⓑⓒⓓ				

Space for Rough Work

DIRECTIONS (Q.24-Q.26) : Read the passage given below and answer the questions that follows :

A uniform solid cylinder of mass 2m and radius R rolls on a rough inclined plane with its axis perpendicular to the line of the greatest slope.

System is released from rest and as the cylinder rolls it winds up a light string which passes over a light pulley.



Q.24 The acceleration of block of mass m is -

(a) $\frac{2}{7}g\,(1-\cos\theta)$ (b) $\frac{4}{7}g\,(1-\sin\theta)$

(c) $\frac{2}{7}g\,(1-\sin\theta)$ (d) $\frac{2}{14}g\,(1+\sin\theta)$

Q.25 The tension in the string is –

(a) $\left(\frac{4+3\sin\theta}{7}\right)$ mg (b) $\left(\frac{3-4\sin\theta}{7}\right)$ mg

(c) $\left(\frac{3+4\sin\theta}{7}\right)$ mg (d) $\frac{2}{7}(1-\sin\theta)$ mg

Q.26 The frictional force acting on the cylinder is-

(a) $\frac{2}{7}(1-\sin\theta)$ mg (b) $\left(\frac{6-\sin\theta}{7}\right)$ mg

(c) $\left(\frac{1+6\cos\theta}{7}\right)$ mg (d) $\left(\frac{1+6\sin\theta}{7}\right)$ mg

DIRECTIONS (Q. 27-Q.29) : Each of these questions contains two statements: Statement-1 (Assertion) and Statement-2 (Reason). Each of these questions has four alternative choices, only one of which is the correct answer. You have to select the correct choice.

(a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.

(c) Statement -1 is False, Statement-2 is True.

(d) Statement -1 is True, Statement-2 is False.

Q.27 **Statement-1 :** Two cylinders, one hollow (metal) and the other solid (wood) with the same mass and identical dimensions are simultaneously allowed to roll without slipping down an inclined plane from the same height. The hollow cylinder will reach the bottom of the inclined plane first.

Statement-2 : By the principle of conservation of energy, the total kinetic energies of both the cylinders are identical when they reach the bottom of the incline.

Q.28 **Statement-1:** The force of frction in the case of a disc rolling without slipping down an inclined plane is 1/3 g sin α.

Statement-2: When the disc rolls without slipping, friction is required because for rolling condition velocity of point of contact is zero.

Q.29 **Statement-1:** If two different axes are at same distance from the centre of mass of a rigid body, then moment of inertia of the given rigid body about both the axes will always be the same.

Statement-2: From parallel axis theorem, $I = I_{cm} + md^2$, where all terms have usual meaning.

RESPONSE GRID	
	24. ⓐⓑⓒⓓ 25. ⓐⓑⓒⓓ 26. ⓐⓑⓒⓓ 27. ⓐⓑⓒⓓ 28. ⓐⓑⓒⓓ
	29. ⓐⓑⓒⓓ

DAILY PRACTICE PROBLEM SHEET 17 - PHYSICS			
Total Questions	29	Total Marks	116
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	28	Qualifying Score	44
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

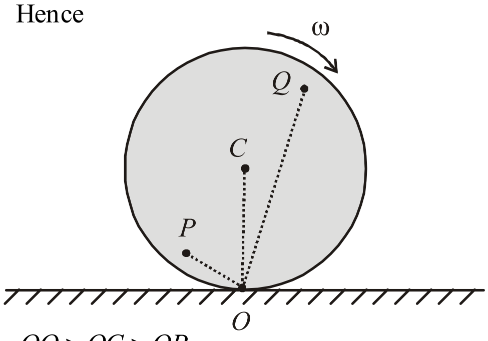
Space for Rough Work

DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS

17

1. **(a)** Since disc is rolling (without slipping) about point O. Hence



$OQ > OC > OP$ $\because v = r\omega$

$\therefore v_Q > v_C > v_P$

2. **(d)** Applying the theorem of perpendicular axis,

$I = I_1 + I_2 = I_3 + I_4$

Because of symmetry, we have

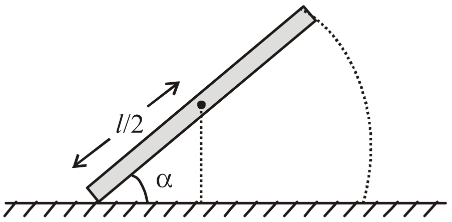
$I_1 = I_2$ and $I_3 = I_4$

Hence $I = 2I_1 = 2I_2 = 2I_3 = 2I_4$

or $I_1 = I_2 = I_3 = I_4$

i.e. sum of two moment of inertia of square plate about any axis in a plane (Passing through centre) should be equal to moment of inertia about the axis passing through the centre and perpendicular to the plane of the plate.

3. **(a)** By the conservation of energy



P.E. of rod = Rotational K.E.

$$mg\frac{1}{2}\sin\alpha = \frac{1}{2}I\omega^2$$

$$\Rightarrow mg\frac{1}{2}\sin\alpha = \frac{1}{2}\frac{ml^2}{3}\omega^2 \Rightarrow \omega = \sqrt{\frac{3g\sin\alpha}{l}}$$

But in the problem length of the rod $2L$ is given

$$\therefore \omega = \sqrt{\frac{3g\sin\alpha}{2L}}$$

4. **(c)** Graph should be parabola symmetric to I- axis, but it should not pass from origin because there is a constant value I_{cm} is present for $x = 0$.

5. **(b)** $v = \sqrt{\dfrac{2gh}{1+\dfrac{K^2}{R^2}}} = \sqrt{\dfrac{2gh}{1+\dfrac{1}{2}}} = \sqrt{\dfrac{4}{3}gh}$

6. **(d)** $a = \dfrac{g\sin\theta}{1+\dfrac{K^2}{R^2}} = \dfrac{g\sin\theta}{1+\dfrac{2}{5}} = \dfrac{g/2}{7/5} = \dfrac{5g}{14}$

As $\theta = 30^\circ$ and $\dfrac{K^2}{R^2} = \dfrac{2}{5}$

7. **(b)** We know $v = \sqrt{\dfrac{2gh}{1+\dfrac{k^2}{r^2}}}$

$$\therefore \omega = \frac{v}{r} = \sqrt{\frac{2gh}{r^2+k^2}}$$

$$\Rightarrow \omega = \sqrt{\frac{2mgh}{mr^2+mk^2}} = \sqrt{\frac{2mgh}{mr^2+I}} = \sqrt{\frac{2mgh}{I+mr^2}}$$

8. **(a)** Because its M.I. (or value of $\dfrac{K^2}{R^2}$) is minimum for sphere.

9. **(b)** As body is moving on a frictionless surface. Its mechanical energy is conserved. When body climbes up the inclined plane it keeps on rotating with same angular speed, as no friction force is present to provide retarding torque so

$$\frac{1}{2}I\omega^2 + \frac{1}{2}mv^2 \ge \frac{1}{2}I\omega^2 + mgh \Rightarrow v \ge \sqrt{2gh}$$

10. **(a)** $\dfrac{1}{2}MR^2 = I \Rightarrow MR^2 = 2I$

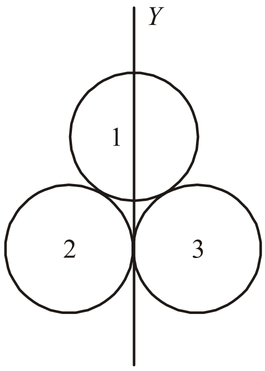
Moment of inertia of disc about a tangent in a plane

$$= \frac{5}{4}MR^2 = \frac{5}{4}(2I) = \frac{5}{2}I$$

11. **(d)** Moment of inertia of system about YY'

$I = I_1 + I_2 + I_3$

$$= \frac{1}{2}MR^2 + \frac{3}{2}MR^2 + \frac{3}{2}MR^2 = \frac{7}{2}MR^2$$

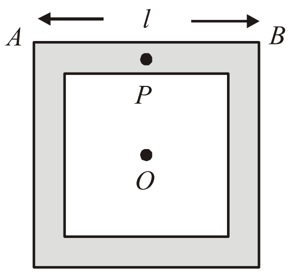


12. (b) $\frac{I_{Ring}}{I_{Disc}} = \frac{MR^2}{\frac{1}{2}MR^2} = 2:1$

13. (a)

14. (b) It follows from the theorem of parallel axes.

15. (a)



Moment of inertia of Rod AB about point P and perpendicular to the plane $= \frac{\mathrm{Ml}^2}{12}$

M.I. of rod AB about point 'O'

$$= \frac{\mathrm{Ml}^2}{12} + \mathrm{M}\left(\frac{\mathrm{l}}{2}\right)^2 = \frac{\mathrm{Ml}^2}{3}$$

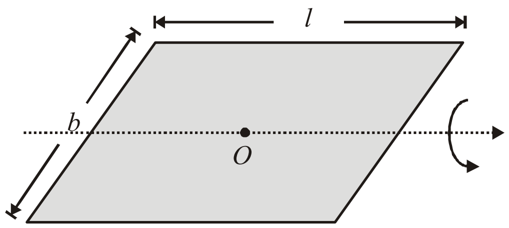
(By using parallel axis theorem)

but the system consists of four rods of similar type so by the symmetry

$$\mathrm{I}_{\text{system}} = 4\left(\frac{\mathrm{Ml}^2}{3}\right)$$

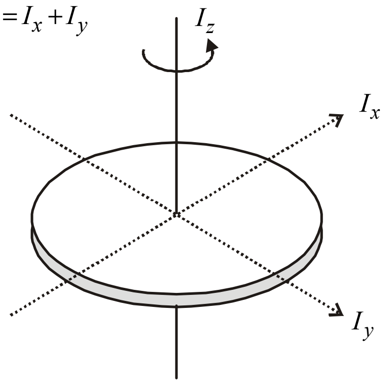
16. (a)

17. (d)



M.I. of plate about O and parallel to length $= \frac{Mb^2}{12}$

18. (d) $I_z = I_x + I_y$

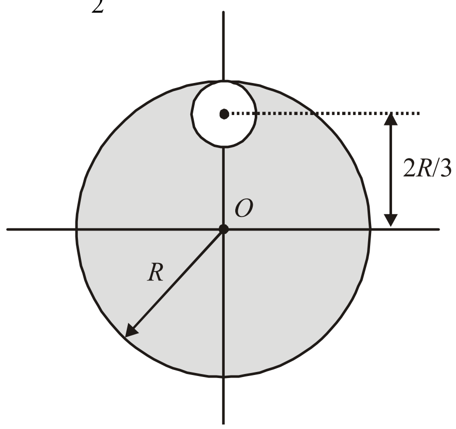


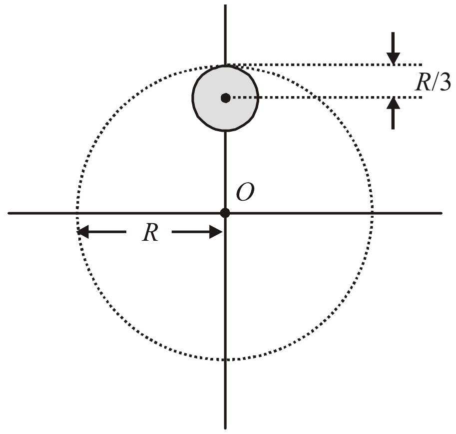
$200 = I_D + I_D = 2I_d$

$\therefore I_D = 100 \ gm \times cm^2$

19. (a) M.I. of complete disc about 'O' point

$I_{Total} - \frac{1}{2}(9M)R^2$





Radius of removed disc $= \frac{R}{3}$

$\therefore$ Mass of removed disc $= \frac{9M}{9} = M$

[As $M = \pi R^2 t \therefore M \propto R^2$]

M.I. of removed disc about its own axis

$$= \frac{1}{2}M\left(\frac{R}{3}\right)^2 = \frac{MR^2}{18}$$

Moment of inertia of removed disc about 'O'

$$I_{removed\ disc} = I_{cm} + mx^2 = \frac{MR^2}{18} + M\left(\frac{2R}{3}\right)^2 = \frac{MR^2}{2}$$

M. I. of complete disc can also be written as

$$I_{Total} = I_{Removed\ disc} + I_{Remaining\ disc}$$

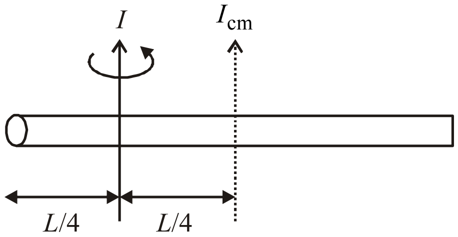
$$I_{Total} = \frac{MR^2}{2} + I_{Remaining\ disc} \qquad \text{..... (ii)}$$

Equating (i) and (ii) we get

$$\frac{MR^2}{2} + I_{Remaining\ disc} = \frac{9MR^2}{2}$$

$$\therefore I_{Remaining\ disc} = \frac{9MR^2}{2} - \frac{MR^2}{2} = \frac{8MR^2}{2} = 4MR^2$$

20. (d) $I = I_{cm} + Mx^2 = \frac{ML^2}{12} + M\left(\frac{L}{4}\right)^2$



$= \frac{ML^2}{12} + \frac{ML^2}{16} = \frac{7ML^2}{48}$

21. (c) $\omega^2 = \omega_0^2 - 2\alpha\theta \Rightarrow 0 = 4\pi^2 n^2 - 2\alpha\theta$

$$\theta = \frac{4\pi^2\left(\frac{1200}{60}\right)^2}{2\times4} = 200\pi^2 rad$$

$\therefore 2\pi n - 200\pi^2 \Rightarrow n = 100\pi = 314$ revolution

22. (b) Rotational K.E. $= \frac{1}{2}I\omega^2$ &

$$T.E. = \frac{1}{2}I\omega^2 + \frac{1}{2}MV^2$$

$$= \frac{1}{2}I\omega^2 + \frac{1}{2}MR^2\omega^2 = \frac{1}{2}\omega^2(I + MR^2)$$

For ring $I = MR^2$

$$\therefore\ T.E. = \frac{1}{2}\omega^2(MR^2 + MR^2) = \frac{1}{2}\omega^2 \times 2MR^2$$

Rotational K.E. $= \frac{1}{2}MR^2\omega^2$

$$\therefore \alpha = \frac{\frac{1}{2}MR^2\omega^2}{\frac{1}{2}\omega^2 \times 2MR^2} = \frac{1}{2}$$

For a solid sphere $I = \frac{2}{5}MR^2$

$$\therefore\ T.E. = \frac{1}{2}\omega^2\left(\frac{2}{5}MR^2 + MR^2\right) = \frac{1}{2}\omega^2 MR^2 \times \frac{7}{5}$$

Rotational K.E. $= \frac{1}{2}\times\frac{2}{5}MR^2\omega^2$

$$\beta = \frac{\frac{1}{2}\times\frac{2}{5}MR^2\omega^2}{\frac{1}{2}\omega^2 MR^2 \times \frac{7}{5}} = \frac{2}{7}$$

23. (a) Time of descent $\propto \frac{K^2}{R^2}$. Time of descent depends upon the value of radius of gyration (K) or moment of inertia (I). Actually radius of gyration is a measure of moment of inertia of the body.

24. (a) $K_T = K_R \Rightarrow \frac{1}{2}mv^2 = \frac{1}{2}mv^2\left(\frac{K^2}{R^2}\right) \Rightarrow \therefore \frac{K^2}{R^2} = 1$

This value of K^2/R^2 match with hollow cylinder.

25. (b) 26. (c) 27. (d)

(i) Let acceleration of centre of mass of cylinder be a then acceleration of block will be 2a.

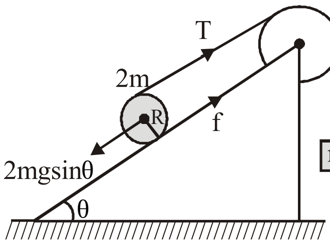
For linear motion of cylinder $T + f - 2mg\sin\theta = 2m(a)$

For rolling motion of cylinder

$$(T - f)R = I\alpha = \left(\frac{2mR^2}{2}\right)\left(\frac{a}{R}\right) \Rightarrow T - f = ma$$

For linear motion of block

$$mg - T = m(2a) \Rightarrow a = \frac{2}{7}(1 - \sin\theta)g$$



(ii) $T = mg - 2m\left(\frac{2}{7}g(1 - \sin\theta)\right) = \left(\frac{3 + 4\sin\theta}{7}\right)mg$

(iii) $F = T - ma = \left(\frac{1 + 6\sin\theta}{7}\right)mg$

28. (c) The acceleration of a body rolling down an inclined plane is given by $a = \frac{g\sin\theta}{1 + \frac{I}{MR^2}}$

For hollow cylinder $\frac{I}{MR^2} = \frac{MR^2}{MR^2} = 1$

For solid cylinder $\frac{I}{MR^2} = \frac{\frac{1}{2}MR^2}{MR^2} = \frac{1}{2}$

$\Rightarrow$ Acceleration of solid cylinder is more than hollow cylinder and therefore solid cylinder will reach the bottom of the inclined plane first.

$\therefore$ Statement -1 is false

• Statement - 2

In the case of rolling there will be no heat losses. Therefore total mechanical energy remains conserved. The potential energy therefore gets converted into kinetic energy. In both the cases since the initial potential energy is same, the final kinetic energy will also be same. Therefore statement -2 is correct.

29. (b) Frictional force on an inclined plane

$= \frac{1}{3}g\sin\alpha$ (for a disc).

30. (c) The moment of inertia about both the given axes shall be same if they are parallel. Hence statement–1 is false.