PHYSICS

DPP

DAILY PRACTICE PROBLEMS

DPP No. 66

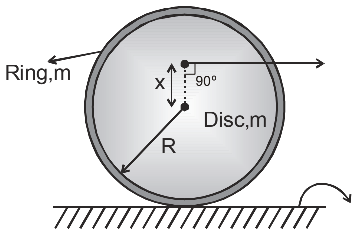
Total Marks : 23

Max. Time : 24 min.

Topics : Rigid Body Dynamics, Center of Mass

Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1 Q.2	(3 marks, 3 min.)	[6, 6]
Multiple choice objective ('–1' negative marking) Q.3	(4 marks, 4 min.)	[4, 4]
Subjective Questions ('–1' negative marking) Q.4	(4 marks, 5 min.)	[4, 5]
Comprehension ('–1' negative marking) Q.5 to Q.7	(3 marks, 3 min.)	[9, 9]

1. A ring and a disc of same mass m and same radius R are joined concentrically. This system is placed on a smooth plane with the common axis parallel to the plane as shown in figure. A horizontal force F is applied on the system at a point which is at a distance x from the centre. The value of x so that it starts pure rolling is

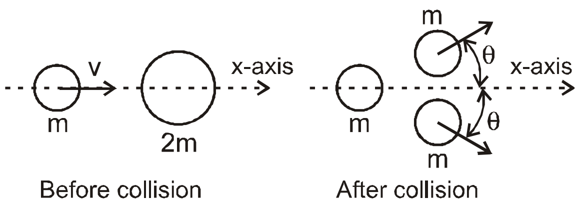


(A) $\frac{R}{2}$ (B) $\frac{3R}{4}$

(C) R (D) Pure rolling is not possible as the floor is smooth.

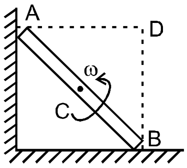
2. A particle of mass m is moving along the x-axis with speed v when it collides with a particle of mass 2m initially at rest. After the collision, the first particle has come to rest, and the second particle has split into two equal-mass pieces that are shown in the figure. Which of the following statements correctly describes the speeds of the two pieces

? ($\theta > 0$)



(A) Each piece moves with speed v.
(B) Each piece moves with speed v/2.
(C) One of the pieces moves with speed v/2, the other moves with speed greater than v/2
(D) Each piece moves with speed greater than v/2.

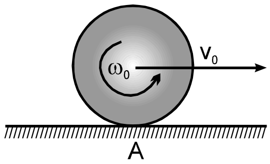
3. A thin uniform rod AB is sliding between two fixed right angled surfaces. At some instant its angular velocity is ω. If I_x represent moment of inertia of the rod about an axis perpendicular to the plane and passing through the point X (A, B, C or D), the kinetic enegy of the rod is



(A) $\frac{1}{2}I_A\omega^2$ (B) $\frac{1}{2}I_B\omega^2$

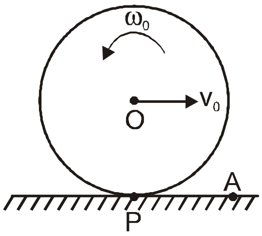
(C) $\frac{1}{2}I_C\omega^2$ (D) $\frac{1}{2}I_D\omega^2$

4. A solid sphere of mass m and radius r is given an initial angular velocity ω_0 and a linear velocity $v_0 = \lambda r \omega_0$ from a point A on a rough horizontal surface. It is observed that the ball turns back and returns to the point A after some time if λ is less than a certain maximum value λ_0. Find λ_0.



COMPREHENSION

A wheel is released on a rough horizontal floor after imparting it an initial horizontal velocity v_0 and angular velocity ω_0 as shown in the figure below. Point O is the centre of mass of the wheel and point P is its instantaneous point of contact with the ground. The radius of wheel is r and its radius of gyration about O is k. Coefficient of friction between wheel and ground is μ. A is a fixed point on the ground.



5. Which of the following is conserved ?
(A) linear momentum of wheel
(B) Angular momentum of wheel about O
(C) Angular momentum of wheel about A
(D) none of these

6. If the wheel comes to permanent rest after sometime, then :

(A) $v_0 = \omega_0 r$ (B) $v_0 = \frac{\omega_0 k^2}{r}$ (C) $v_0 = \frac{\omega_0 r^2}{R}$ (D) $V_0 = \omega_0\left(r + \frac{k^2}{r}\right)$

7. In above question, distance travelled by centre of mass of the wheel before it stops is -

(A) $\frac{v_0^2}{2\mu g}\left(1+\frac{r^2}{k^2}\right)$ (B) $\frac{v_0^2}{2\mu g}$ (C) $\frac{v_0^2}{2\mu g}\left(1+\frac{k^2}{r^2}\right)$ (D) None of these

Answers Key

DPP NO. - 66

1. (B) **2.** (D) **3.** (A)(B)(D) **4.** $\lambda_0 = 2/5$
5. (C) **6.** (B) **7.** (B)

Hint & Solutions

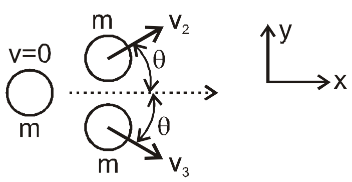
DPP NO. - 66

1. $a_{cm} = \frac{F}{2m}$ $\alpha = \frac{F.x}{\frac{mR^2}{2} + mR^2} = \frac{2F.x}{3mR^2}$

$a_{cm} = \alpha R$

$\frac{F}{2m} = \frac{2Fx}{3mR^2}.R$ $x = \frac{3R}{4}$.

2. After collision by momentum conservation
Along y-axis



$0 = 0 + mv_2 \sin\theta - mv_3 \sin\theta$

$\Rightarrow v_2 = v_3$

Along x-axis

$mv = 0 + mv_2 \cos\theta + mv_3 \cos\theta$

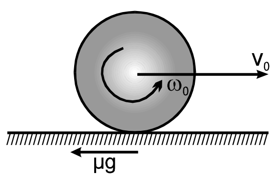
$mv = 2\,m\,v_2 \cos\theta$

$v_2 = \frac{v}{2}\frac{1}{\cos\theta}$ so $v_2 = v_3 > \frac{v}{2}$ $\because \cos\theta < 1$

3. **(Tough)** The point D is the instanteneous centre of rotation.

$K.E. = \frac{1}{2}I_D\omega^2 = \frac{1}{2}I_A\omega^2 = \frac{1}{2}I_B\omega^2$

4. Ball will comes back to the initial position if its angular velocity is greater than zero is the same direction (in which it was released) at the moment its' linear velocity becomes zero. In this condition ball would return back

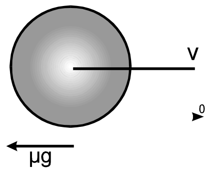


For linear motion

$0 = v_0 + (\mu g)\, t$

$t = \dfrac{v_0}{\mu g}$ (time when ball stops)

For rotation motion



$\tau = I\alpha$

$\Rightarrow \quad \alpha = \dfrac{\tau}{I} = \dfrac{\mu mg \times R}{\frac{2}{5}MR^2} = \dfrac{5\mu g}{2R^2}$

using $\quad \omega_f = \omega_0 - \alpha t$

$\omega_f > 0$

$\Rightarrow \quad \omega_0 > \alpha t$

$\Rightarrow \quad \dfrac{v_0}{\alpha R} > \dfrac{5\mu g}{2R} \cdot \dfrac{v_0}{\mu g}$ for limiting condition.

$\Rightarrow \quad \lambda_0 = \dfrac{2}{5}$

5. to 7 Torque of friction about A is zero.

6. Angular momentum conservation about point A.

$L_{in} = mv_0 r - mk^2\omega$

$L_{fin} = 0$

$L_{fin} = L_{in}$

$\Rightarrow \quad v_0 = \omega k^2/r.$

7. $a_{cm} = -\mu g$

$0^2 = v_0^2 - 2\mu gs \quad \Rightarrow S = \dfrac{v_0^2}{2\mu g}$