YASHWANT CLASSES

Head Office: Govind Vihar Tower, Behind Vaishali Cinema, Badlapur (W)

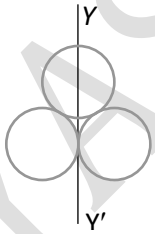
Date : 28-06-2022
Time : 00:15:00
Marks : 60

TEST ID: 115
PHYSICS

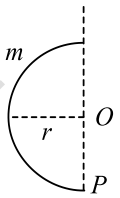
1.ROTATIONAL DYNAMICS ,7.SYSTEM OF PARTICLES AND ROTATIONAL MOTION

Single Correct Answer Type

1. A body is rolling without slipping on a horizontal surface and its rotational kinetic energy is equal to the translational kinetic energy. The body is
   a) Disc b) Sphere c) Cylinder d) Ring
2. In the above question, find the angular speed at the bottom
   a) 68 rad/sec b) 8.5 rad/sec
   c) 17 rad/sec d) 34 rad/sec
3. If the torque is zero, what will be the value of angular momentum?
   a) Constant in magnitude but changing is direction
   b) Changing in magnitude but constant in direction
   c) Constant on both magnitude and direction
   d) Zero
4. A wheel is rolling along the ground with a speed of 2 ms^{-1}. The magnitude of the velocity of the points at the extremities of the horizontal diameter of the wheel is equal to
   a) $2\sqrt{10}\ ms^{-1}$ b) $2\sqrt{3}\ ms^{-1}$
   c) $2\sqrt{2}\ ms^{-1}$ d) $2\ ms^{-1}$
5. 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) $3\ MR^2$ b) $\frac{3}{2}\ MR^2$ c) $5\ MR^2$ d) $\frac{7}{2}\ MR^2$
6. A homogeneous disc of mass 2 kg and radius 15 cm is rotating about its axis (which is fixed) with an angular velocity of 4 $radian/s$. The linear momentum of the disc is
   a) 1.2 $kg\text{-}m/s$ b) 1.0 $kg\text{-}m/s$
   c) 0.6 $kg\text{-}m/s$ d) None of the above
7. If the external forces acting on a system have zero resultant, the center of mass
   a) May move but not accelerate
   b) May Accelerate
   c) Must not move
   d) None of the above
8. A straight rod of length L has one of its ends at the origin and the other at $x = L$. If the mass per unit length of the rod is given by Ax where A is constant, where is its mass centre?
   a) $L/3$ b) $L/2$ c) $2L/3$ d) $3L/4$
9. A thin wire of length l and mass m is bent in the form of semicircle. Its moment of inertia about an axis joining its free ends will be



   a) $m\ l^2$ b) Zero
   c) $m\ l^2/\pi^2$ d) None of these
10. A ballet dancer, dancing on a smooth floor is spinning about a vertical axis with her arms folded with an angular velocity of 20 rad/s. When she stretches her arms fully, the spinning speed decrease in 10 rad/s. If I is the initial moment of inertia of the dancer, the new moment of inertia is
    a) $2\ I$ b) $3\ I$ c) $I/2$ d) $I/3$
11. A disc of moment of inertia 5 kg- m^2 is acted upon by a constant torque of 40 Nm. Starting from rest the time taken by it to acquire an angular velocity of 24 $rads^{-1}$ is
    a) 3 s b) 4 s c) 2.5 s d) 120 s
12. Consider a system of two particles having masses m_1 and m_2. If the particle of mass m_1 is pushed towards the centre of mass of particles through a distance d, by what distance would be particle of mass m_2 move so as to keep the centre of mass of particles at the original position

a) $\frac{m_1}{m_1+m_2}d$ b) $\frac{m_1}{m_2}d$

c) d d) $\frac{m_2}{m_1}d$

13. A solid cylinder 30 cm in diameter at the top of an inclined plane 2.0 m high is released and rolls down the incline without loss of energy due to friction. Its linear speed at the bottom is
    a) 5.29 m/sec b) 4.1×10^3 m/sec
    c) 51 m/sec d) 51 cm/sec
14. The radius of a rotating disc is suddenly reduced to half without any change in its mass. Then its angular velocity will be
    a) Four times b) Double
    c) Half d) Unchanged
15. The centre of mass of a body
    a) Lies always outside the body
    b) May lie within, outside on the surface of the body
    c) Lies always inside the body
    d) Lies always on the surface of the body

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: ANSWER KEY :

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

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: HINTS AND SOLUTIONS :

Single Correct Answer Type

1 **(d)**

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

$i.e.$ the body is ring

2 **(d)**

Angular speed $\omega = \frac{v}{R} = \frac{5.29}{0.15} = 34\ rad/s$

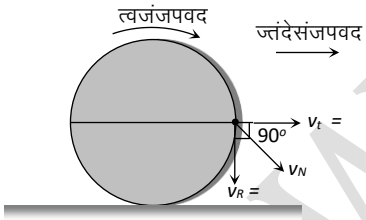
3 **(c)**

From law of conservation of angular momentum we have, if no external torque is acting on a body ($\tau = 0$), then the angula momentum ($J = I\omega$) or in other words the moment of momentum of a body remains constant.

4 **(c)**

v_t = velocity due to translator motion

v_R = velocity due to rotational motion



$v_N = \sqrt{v_t^2 + v_R^2} = \sqrt{v^2 + v^2} = \sqrt{2v} = 2\sqrt{2}m/s$

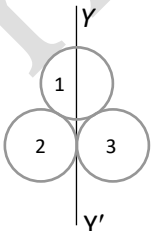
5 **(d)**

Moment of inertia of system about YY'

$I = I_1 + I_2 + I_3$

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

$= \frac{7}{2}MR^2$



6 **(d)**

Since $v_{C.M.} = 0$ so it's linear momentum $= 0$

7 **(a)**

According to the equation of motion of the centre of mass

$M\,\mathbf{a}_{CM} = \mathbf{F}_{ext}$

If $\mathbf{F}_{ext} = 0, \mathbf{a}_{CM} = 0$

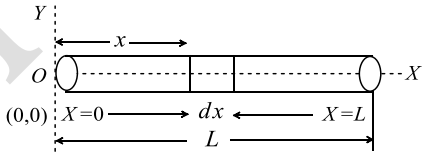
$\therefore\ \mathbf{v}_{CM}$ = constant

ie, if no external force acts on a system the velocity of its centre of mass remains constant. Thus, the centre of mass may move but not accelerate.

8 **(c)**

Let the mass of an element of length dx of the rod located at a distance x away from left end is $\frac{M}{L}dx$.

The x- coordinate of the centre of mass is given by



Total mass of rod $= \int_0^L Ax\,dx = \frac{AL^2}{2}$

$X_{cm} = \frac{1}{M}\int x\,dm = \frac{1}{\left(\frac{AL^2}{2}\right)}\int_0^L x\,(Ax\,dx)$

$= \frac{2A}{AL^2}\left[\frac{x^3}{3}\right]_0^L = \left[\frac{2}{L^2}\right]\left[\frac{L^3}{3}\right] = \frac{2L}{3}$

Hence, the centre of mass is at $\left(\frac{2L}{3}, 0, 0\right)$

9 **(d)**

$\pi r = l \quad \therefore r = l/\pi$

Moment of inertia of a ring about its diameter $= \frac{1}{2}Mr^2$

$\therefore$ Moment of inertia of semicircle $= \frac{1}{2}\left[m\left(\frac{l}{\pi}\right)^2\right] = \frac{ml^2}{2\pi^2}$

10 **(a)**

Angular momentum of system remains constant

$I \propto \frac{1}{\omega} \Rightarrow \frac{I_2}{I_1} = \frac{\omega_1}{\omega_2} = \frac{20}{10} \Rightarrow I_2 = 2I_1 = 2I$

11 **(a)**

Torque is defined as rate of change of angular momentum

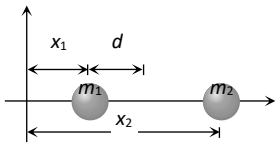
$\therefore \quad \tau = \frac{dJ}{dt} = \frac{d(I\omega)}{dt}$

Given, $\tau = 40$ Nm, $I = 5$ kgm^2, $\omega = 24$ rads^{-1}

$$dt = \frac{d(I\omega)}{\tau} = \frac{5\times24}{40} = 3 \text{ s}$$

12 **(b)**

Initial position of centre of mass $r_{cm} = \frac{m_1x_1+m_2x_2}{m_1+m_2}$ ...(i)



If the particles of mass m_1 is pushed towards the centre of mass of the system through distance d and to keep the centre of mass at the original position let second particle be displaced through distance d' away from the centre of mass

Now $r_{cm} = \frac{m_1(x_1+d)+m_2(x_2+d')}{m_1+m_2}$ ...(ii)

Equating (i) and (ii)

$$\frac{m_1x_1 + m_2x_2}{m_1 + m_2} = \frac{m_1(x_1 + d) + m_2(x_2 + d')}{m_1 + m_2}$$

By solving $d' = -\frac{m_1}{m_2}d$

Negative sign shows that particle m_2 should be displaced towards the centre of mass of the system

13 **(a)**

$$v = \sqrt{\frac{2gh}{1+\frac{K^2}{R^2}}} = \sqrt{\frac{2\times10\times2}{1+\frac{1}{2}}} = \sqrt{26.66}$$

$= 5.29 m/\text{s}$ approx

14 **(a)**

$L = \frac{1}{2}MR^2\omega = \text{constant} \therefore \omega \propto \frac{1}{R^2}$ [If $m =$ constant]

If radius is reduced to half then angular velocity will be four times

15 **(b)**

Depends on the distribution of mass in the body