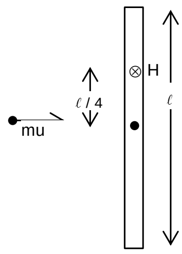
Single Correct Answer Type

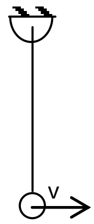
1. A thin uniform rod of mass 2m and length ℓ is pivoted at H as shown in figure. Rod is free to rotate in vertical plane. A particle of mass m strikes elastically at cm of rod. The angular velocity of rod just after collision



(A) $\frac{13u}{17\ell}$ (B) $\frac{15u}{17\ell}$

(C) $\frac{24u}{17\ell}$ (D) $\frac{12u}{17\ell}$

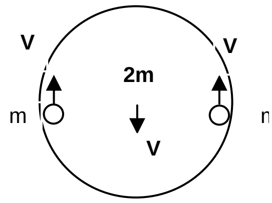
2. A body of mass m, tied at lower end of a vertical string of length l, is projected with velocity $\sqrt{3.5gl}$ as shown in the figure .At what height from its lowest position will it leave the circular path



(A) $\frac{5}{3}l$ (B) $\frac{5}{4}l$

(C) $\frac{3}{2}l$ (D) $\frac{4}{3}l$

3. A smooth uniform dish plate of mass 2m is placed on a smooth horizontal table. Two particles each of mass m are placed at diametrically opposite positions. Dish and both particles are given speed v simultaneously as shown. The speed of the particles when they collide is.



(A) v (B) $2v$

(C) $\frac{v}{\sqrt{2}}$ (D) $\sqrt{2}v$

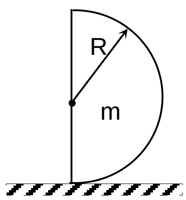
4. A uniform rod of length 2ℓ and mass m is rotating about a vertical axis passing through centre and placed over smooth horizontal surface. The angular velocity of rod is ω_0 rad/sec. At t = 0, an insect of mass m falls at the centre of the rod and then moves towards its one of the end of rod. The kinetic energy of system (insect and rod) at instant when insect reaches the end.

(A) $\frac{1}{2}m\ell^2\omega_0^2$ (B) $\frac{1}{15}m\ell^2\omega_0^2$ (C) $\frac{2}{15}m\ell^2\omega_0^2$ (D) none of these

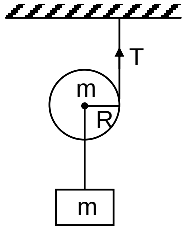
5. A uniform hollow hemispherical bowl of mass m and radius R is released from rest from a vertical position as shown in the figure. Assuming the hemispherical bowl does not slip, the initial magnitude of angular acceleration of the hemispherical bowl will be

(A) $\frac{4g}{3\pi R}$ (B) $\frac{3g}{10R}$

(C) $\frac{9g}{34R}$ (D) $\frac{6g}{17R}$



6. System shown in the figure lies in the vertical plane, is released from rest. Assume no slipping between the pulley and the string wound over it and the pulley to be a uniform disc, then tension T is



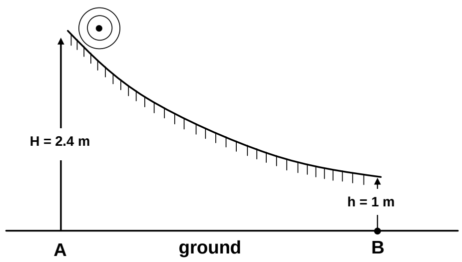
(A) $\frac{mg}{5}$ (B) $\frac{3mg}{5}$

(C) $\frac{2mg}{5}$ (D) $\frac{7mg}{10}$

7 A small meteorite of mass $'m'$ traveling towards the centre of earth strikes the earth at equator. The earth is a uniform sphere of mass M and R. The length of the day is T before the meteorite strikes. When the meteorite strikes, the length of day will be increased by (in sec).

(A) $\frac{5mT}{2M}$ (B) $\frac{m}{M}T$ (C) $\frac{4mT}{5M}$ (D) $\frac{M}{3mT}$

8 A small sphere rolls down without slipping from the top of a track in a vertical plane, shown in figure. The distance on the ground with respect the point ‘B”where the sphere lands is



(A) 1 m (B) 2 m
(C) 3 m (D) 4 m

9 A uniform disc of radius R is spinned to the angular velocity ω and then carefully placed on a horizontal surface. How long will disc be rotating on the surface if the friction coefficient is equal to $'\mu'$

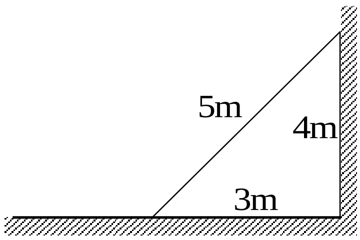
(Assume pressure exerted by the disc on the surface uniform)

(A) $\frac{\omega R}{2\mu g}$ (B) $\frac{4\omega R}{\mu g}$ (C) $\frac{4\mu R}{\mu g}$ (D) l $\frac{3\omega R}{4\mu R}$

10 Two rods each of mass ‘M’, and length ‘L’ are joined to form ‘L’ shaped object. The moment of inertia of the system about an axis passing through free end of one of the rods and perpendicular to the plane is.

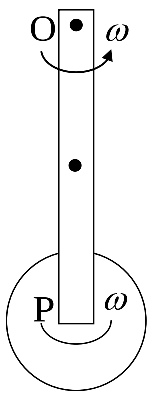
(A) $\frac{23ML^2}{12}$ (B) $\frac{21ML^2}{12}$ (C) $\frac{5ML^2}{3}$ (D) $\frac{19ML^2}{12}$

11. A uniform ladder of length 5 m is placed against the wall as shown in the figure. If coefficient of friction μ is the same for both the walls, the minimum value of μ for it not to slip?



(A) $\mu = 1/2$ (B) $\mu = 1/4$
(C) $\mu = 1/3$ (D) $\mu = 1/5$

12. A rod of mass m and length $2R$ can rotate about an axis passing through O in vertical plane. A disc is hinged to the other end P of the rod and can freely rotate about P. When disc is at lowest point both rod and disc has angular velocity ω. If rod rotates by maximum angle $\theta = 60^0$ with downward vertical, the ω in term of R and g will be (all hinges are smooth)



(A) $\sqrt{\frac{9g}{16R}}$ (B) $\sqrt{\frac{3g}{23R}}$

(C) $\frac{1}{3}\sqrt{\frac{g}{R}}$ (D) none of these

13. A uniform disc of radius R is spinned to the angular velocity ω and then carefully placed on a horizontal surface. How long will disc be rotating on the surface if the friction coefficient is equal to $'\mu'$

(Assume pressure exerted by the disc on the surface uniform)

(A) $\dfrac{\omega R}{2\mu g}$ (B) $\dfrac{4\omega R}{\mu g}$ (C) $\dfrac{4\mu R}{\mu g}$ (D) $\dfrac{3\omega R}{4\mu R}$

14. A disc is given an angular velocity ω_0 and a linear velocity v_0 as shown in the figure. It is released on a rough horizontal surface. Mark the correct statement.

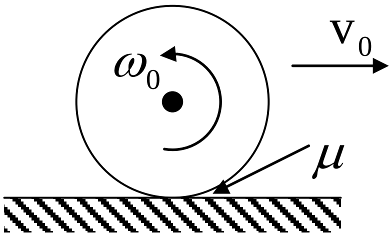
($\omega_0 = 3v_0/R$)

(A) The frictional force will be μmg during the entire motion

(B) After some time the disc will start rolling without sliding in along positive x-axis

(C) After some time the disc will start rolling without sliding in along negative x-axis

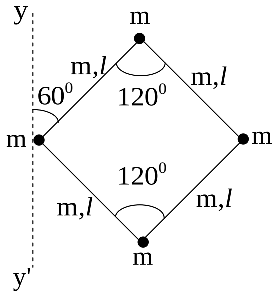
(D) The mechanical energy of disc will remain conserved.



15. Moment of inertia of the given system about YY' axis is parallel to the plane of rhombus)

(A) $\dfrac{5}{2}ml^2$ (B) $6ml^2$

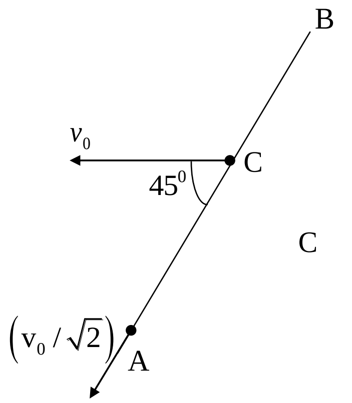
(C) $\dfrac{17}{2}ml^2$ (D) none of these



16. A rigid rod AB moves on horizontal plane such that at the instant shown velocity of centre C of rod is v_0 at an angle of 45^0 with the rod. While velocity of end A is $v_0/\sqrt{2}$ and has direction along the rod. Velocity of end B of the rod at the given instant is

(A) $v_0/\sqrt{2}$ (B) $2v_0$

(C) $\sqrt{\dfrac{5}{2}}v_0$ (D) $\sqrt{2}v_0$



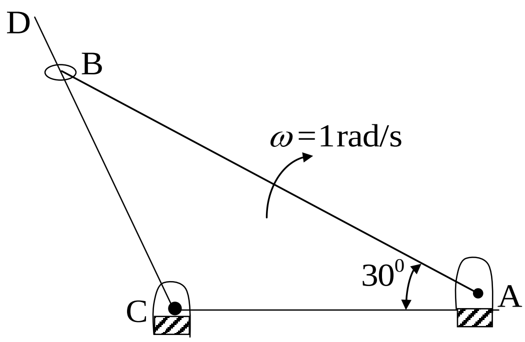
17. In the figure shown a smooth ring is connected to rod AB, while rod CD passes through ring. At the given instant angular velocity of rod AB about hinge A is 1 rad/s and AC = CB. Instantaneous angular velocity of rod CD about hinge C is

(A) 1 rad/s

(B) 1/2 rad/s

(C) $\sqrt{3}/2$ rad/s

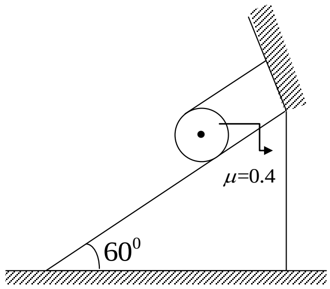
(D) $3/2$ rad/s



18. A solid cylinder is wrapped with a string and placed on an inclined plane as shown in the figure. Then the frictional force acting between cylinder and plane is

(A) zero (B) 5 mg

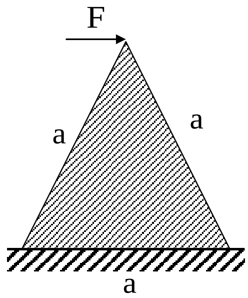
(C) $\frac{7mg}{2}$ (D) $\frac{mg}{5}$



19. An equilateral prism of mass m rests on a rough horizontal surface with coefficient of friction μ. A horizontal force F is applied on the prism as shown in the figure. If the coefficient of friction is sufficiently high so that the prism does not slide before toppling, then the minimum force required to topple the prism is:

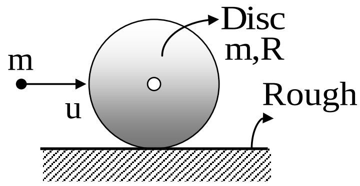
(A) $\frac{mg}{\sqrt{3}}$ (B) $\frac{mg}{4}$

(C) $\frac{\mu mg}{\sqrt{3}}$ (D) $\frac{\mu mg}{4}$



20. A point mass m collides with a disc of mass m and radius R resting on a rough horizontal surface as shown. Its collision is perfectly in elastic. Find angular velocity of system after collision.

(A) $\left(\frac{2u}{7R}\right)$ (B) $\left(\frac{7u}{2R}\right)$ (C) $\left(\frac{5u}{2R}\right)$ (D) $\left(\frac{2u}{5R}\right)$



Numerical Based

21. A body is uniformly rotating about an axis fixed in an inertial frame of reference. Let $\vec{A}$ be a unit vector along the axis of rotation and $\vec{B}$ be the unit vector along the resultant force on a particle P of the body away from the axis. The value of $\vec{A}\cdot\vec{B}$ is …..

22 A solid sphere of mass m rolls without slipping on a plane surface. its kinetic energy at an instant when its centre moves with speed v is $\frac{\alpha}{10}$ mv^2.Find the value of α .

23. The angular velocity of the engine (and hence of the wheel) of a scooter is proportional to the petrol input per second. The scooter is moving on a frictionless road with uniform velocity. If the petrol input is increased by 10%, Find the percentage increase in the linear velocity of the scoter ?

24. A particle moving in a circular path of radius R = 1 m decelerates according to $\alpha = -K\sqrt{\omega}$ where α and ω are the angular acceleration and angular velocity and K = 2.5 units. If the initial angular speed of the particle is ω_0 = 27 rad/sec. Find the average angular speed (in rad/s) over the entire time of motion of the particle.

25. Three thin metal rods, each of mass M and length ℓ are welded to form on equilateral triangle. The moment of inertia of the composite structure about an axis passing through the center of mass of the structure and perpendicular its plane is $\frac{M\ell^2}{K}$. Find the value of K.

KEY

1.	**C**	**2.**	**C**	**3.**	**D**	**4.**	**B**	**5.**	**B**
6.	**C**	**7.**	**A**	**8.**	**B**	**9**	**D**	**10.**	**C**
11.	**C**	**12.**	**A**	**13.**	**D**	**14.**	**C**	**15.**	**D**
16.	**C**	**17.**	**D**	**18.**	**D**	**19.**	**A**	**20.**	**A**
21	**0**	**22**	**7**	**23**	**0**	**24.**	**9**	**25**	**2**

SOLUTIONS

1. **C**

2. **C**

3. **D**

4. **B**

5. **B**

6. **C**

7. A

conserving the angular momentum before and after

$\left(\frac{2}{5}MR^2\right)w = \left(\frac{2}{5}MR^2 + mR^2\right)w^1$ but $\left(w = \frac{2\pi}{T}\right)$

$$\Rightarrow \quad \frac{T^1}{T} = \frac{w^1}{w} = \frac{\left(M + \frac{5}{2}m\right)}{M} = 1 + \frac{5m}{2M}$$

$$T - T^1 = \frac{5mT}{2M}$$

8. B

$KE_{gain} = \frac{7}{10}mv^2 = mg\left(H-h\right)$ and Range = $v\sqrt{\frac{2h}{g}} = 2\,m$

9 D

Consider an elementary disc of thickness $'dr'$ at a distance r from the centre

Mass of elementary strip = $\frac{M}{\pi R^2}.2\pi r\,dr$

$\therefore$ Frictional force on the strip = μ(weight of strip)

$\therefore$ Torque due to friction

$d\tau$ = (friction) x r

$= \left[\mu.\frac{M}{\pi R^2}.2\pi r\,dr.g\right]r$ ______________(1)

$\therefore$ Total Torque = $\int_0^R d\tau = \frac{1}{2}MR^2 \times \frac{4\mu g}{3R} = I.\alpha$

$\therefore \alpha = \frac{4\mu g}{3R}$ ______________(2)

Now time (t) $=\frac{\omega}{\alpha}=\frac{3\omega R}{4\mu g}$

10. C

11. C

12. A

13. D

Consider an elementary disc of thickness $'dr'$ at a distance r from the centre

Mass of elementary strip = $\frac{M}{\pi R^2}.2\pi r\,dr$

$\therefore$Frictional force on the strip = μ(weight of strip)

$\therefore$Torque due to friction

$d\tau$ = (friction) x r

$$=\left[\mu.\frac{M}{\pi R^2}.2\pi r\,dr.g\right]r \quad \text{\_\_\_\_\_\_\_\_\_\_(1)}$$

$\therefore$ Total Torque = $\int_0^R d\tau=\frac{1}{2}MR^2\times\frac{4\mu g}{3R}=I.\alpha$

$$\therefore \alpha=\frac{4\mu g}{3R} \quad \text{\_\_\_\_\_\_\_\_\_\_(2)}$$

Now time (t) $=\frac{\omega}{\alpha}=\frac{3\omega R}{4\mu g}$

14. C

$v=v_0-\frac{ft}{m},\ \omega=\omega_0-\frac{2f}{mR}t$

15. D

16. C

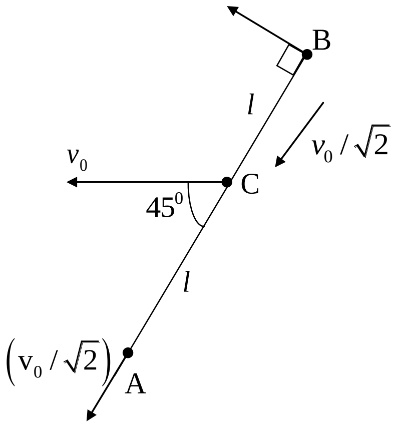
Sol: C

Angular velocity of rod is

$\omega=\frac{v_0\sin 45}{l}$

From figure

$v_B=\sqrt{\left(\frac{v_0}{\sqrt{2}}\right)^2+(2l\omega)^2}=\left(\sqrt{\frac{5}{2}}\right)v_0$



17. D

Velocity of constant point on rod CD ring should have same component of velocity along normal to rod CD.

$\therefore$ CD (ω)' = 2(BC cosθ) ω cosθ

$\Rightarrow$ω' = 2ω cos^{2}θ = 3/2 rad/s.

18. D

Sol:- $\frac{\sqrt{3}}{4}mg+f=\frac{\sqrt{3}}{2}mg\Rightarrow f=\frac{\sqrt{3}}{4}mg$

$$f_l = \frac{\mu mg}{2} = \frac{mg}{5} < f$$

So $f = \frac{mg}{5}$

19. A

20. A

21 **0**

22 **7**

K.E = $\frac{1}{2}mV_{cm}^2 + \frac{1}{2}I_{cm}\,\omega^2$; since it rolls without slipping; $\omega = \frac{V_{cm}}{R}$ and $I_{cm} = \frac{2}{5}mR^2$

23 **0**

24. **9**

25 **2**