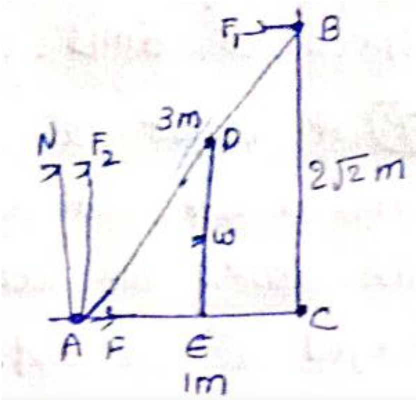
SRIGAYATRI EDUCATIONAL INSTITUTIONS
INDIA

System of particles (UT-05 QB)

1. **A 3m long ladder weighing lokg leans on a frictiontess wall. Its feet rest on the floor 1M from the wall as shown in fig find the reaction force of the wall and the fllor**



2. **The angular speed of a motor wheel is increased from 1200rpm to 3120 rpm in 20 seconds. What is its angular acceleration Assuming the acceleration to be uniform ?**

3. In the HCl molecule the separation between the nuclei of the two atoms is about $1.27A^0$ $\left(1A^0 = 10^{-10}m\right)$ Find the approximate location of the CM of the molecule, given that a chlorine atom is about 25.5 times as massive as a hyfrogen atom and nearly all the mass of an atom is concentrated in its nucleus ?

4. A Solid cylinder of mass 10 kg rotates about its Axis with angular speed 100 rad s^{-1} The radius of the cylinder is 0.25 m what is the kinetic energy associated with the ratation of the cylinder ? what is the magnitude of angular momentum of the cylinder about its axis ?

5. A rope of negligible mass is wound round a bellow cylinder of mass 2 kg and radius 40cm. what is the angular acceleration of the cylinder if the rope is pulled with a force of 30 N / what is the linear acceleration of the rope ? Assume that there is no slipping

6. A solid cylinder rolls up an inclined plane of angle of inclination 30^0 At the bottom of the inclined plane the centre of mass of the cylinder has a speed of 6m/s How far will the cylinder go up the planer ?

7. A bullet of mass 20 g and speed 500 m/s is fired into a door and gets embedded exactly at the centre of the door the door is 2.0 m wide and weights 12 kg it is hinged at one end and rotates about a vertical axis practically with out friction Find the angular speed of the door Just after the bullet embeds into it

8. A solid disc and a ring both of radius 10 cm are paced on a horizontal table simulate ously, with initial angular speed equal to $20\pi rads^{-1}$. Which of the two will start to roll earlier? The co-efficient of kinetic friction is $\mu_k = 0.2$

9. A cylinder of mass 10 kg and radius 10 cm is rolling perfectly on a plane of inclination 30^0 the co – efficient of static friction $\mu_s = 0.25$ what is the work done against friction during rolling ?

10. A hoop of radius 4m weights 100 kg. It rolls along a horizontal floor so that its centre of mass has a speed of 20m/s how much work has to be done to stop it ?

11. A child is standing at one end of a long trolley moving with a speed v on a smooth horizontal floor. If the child starts running towards the other end of the trolley with a speed u, the centre of mass of the system (trolley + child) will move with a speed

a) Zero b) (v + u) c) (v – u) d) v

12. If F^{-} is the force acting on a particle having position vector $\bar{r}$ *and* $\bar{\tau}$ be the torque of this force about the origin, then

a) $\vec{r}\cdot\vec{\tau} > 0 \text{and} \vec{F}\cdot\vec{\tau} < 0$

b) $\vec{r}\cdot\vec{\tau} = 0 \text{and} \vec{F}\cdot\vec{\tau} = 0$

c) $\vec{r}\cdot\vec{\tau} = 0 \text{and} \vec{F}\cdot\vec{\tau} \neq 0$

d) $\vec{r}\cdot\vec{\tau} \neq 0 \text{and} \vec{F}\cdot\vec{\tau} = 0$

13. A disc is rotating with angular velocity $\vec{\omega}$ about its axis A force $\vec{F}$ acts at a point whose position vector with respect to the axis of rotation is $\vec{r}$. The power associated with the torque due to the force is given by

a) $(\vec{r}\times\vec{F})\cdot\vec{\omega}$

b) $(\vec{r}\times\vec{F})\times\vec{\omega}$

c) $\vec{r}\cdot(\vec{F}\times\vec{\omega})$

d) $\vec{r}\times(\vec{F}\cdot\vec{\omega})$

14. A uniform ladder 3 m long weighing 20 kg leans against a frictionless wall. Its foot rest on a rough floor 1 m from the wall. The reaction forces of the wall and floor are

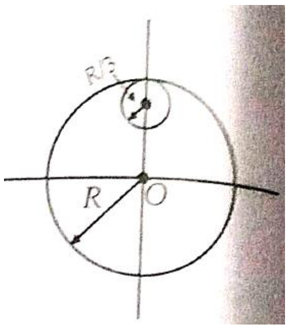
a) $25\sqrt{2}\text{N}, 203\text{N}$

b) $50\sqrt{2}\text{N}, 230\text{N}$

c) $203\text{N}, 25\sqrt{2}\text{N}$

d) $230\text{N}, 50\sqrt{2}\text{N}$

15. From a circular disc of radius R and mass 9M a small disc of radius $\frac{R}{3}$ is removed as shown in figure 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) $40MR^2$

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

16. A grindstone has a moment of inertia $6 kgm^2$ of A constant torque is applied and the grindstone is found to have a speed of 150 rpm, 10 seconds after starting from rest. The torque is

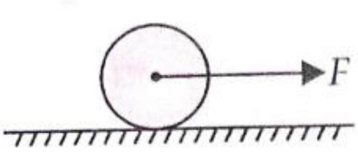
a) $3\pi Nm$(b)

b) 3 N M

c) $\frac{\pi}{3} Nm$

d) $4\pi Nm$

17. A uniform disc of mass M and radius R, is resting on a table on its rim. The coefficient of friction between disc and table is μ Now the disc is pulled with a force F as shown in the figure. What is the maximum value of F for which the disc rolls without slipping?



a) μMg

b) $2\mu Mg$

c) $3\mu Mg$

d) $4\mu Mg$

18. A circular platform is mounted on a vertical frictionless axle. Its radius is r = 2 m and its moment of inertia I = 200 kg m^2 . It is initially at rest . A 70 kg man stands on the edge of the platform and begins to walk along the edge at speed $v_0 = 1 ms^{-1}$ relative to the ground. The angular velocity of the platform is

a) $1.2 rads^{-1}$

b) $0.4 rads^{-1}$

c) $0.7 rads^{-1}$

d) $2 rads^{-1}$

19. Angular momentum L and rotational kinetic energy K_R of a rigid body are related to each other by the relation. (I= moment of inertia)

a) $K_R = 2IL$

b) $K_R = \frac{L^2}{2I}$

c) $K_R = \frac{2I}{L}$

d) $K_R = \frac{L^2}{I}$

20. A solid sphere of mass m and radius R is rotating about its diameter. A solid cylinder of the same mass and same radius is also rotating about its geometrical axis with an angular speed twice that of the sphere. The ratio of their kinetic energies of rotation $\left(E_{sphere} / E_{cylinder}\right)$ will be

1) 2 : 3

2) 1 : 5

3) 1 : 4

4) 3 : 1

21. A solid cylinder rolls up an inclined plane of inclination θ with an initial velocity v. How far does the cylinder go up the plane?

a) $\frac{3v^2}{2g\sin\theta}$

b) $\frac{v^2}{4g\sin\theta}$

c) $\frac{3v^2}{g\sin\theta}$

d) $-\frac{3v^2}{4g\sin\theta}$

22. When a solid sphere rolls without slipping down an inclined plane making an angle θ with the horizontal, the acceleration of its centre of mass is a. If the same sphere slides without friction, its acceleration a' will be

a) $\frac{7}{2}a$

b) $\frac{5}{7}a$

c) $\frac{7}{5}a$

d) $\frac{5}{2}a$

23. A wheel of mass 5 kg and radius 0.40 is rolling on a road without sliding with angular velocity $10\text{rad}s^{-1}$. The moment of inertia of the wheel about the axis of rotation is 0.65kgm^2 . The percentage of kinetic energy of rotation in the total kinetic energy of the wheel is

a) 22.4 %
b) 11. 2 %
c) 88.8 %
d) 44. 8 %

24. Thedencityofanon-uniform rod of length 1 m is given by $\rho(x) = a\left(1+bx^2\right)$ where a and b are constants and $0 \le x \le 1$. The centre of mass of the rod will be at

1) $\frac{3(2+b)}{4(3+b)}$ 2) $\frac{4(2+b)}{3(3+b)}$ 3) $\frac{3(3+b)}{4(2+b)}$ 4) $\frac{4(3+b)}{3(2+b)}$

25. A particle is projected at time t=0 from point P on the ground with a speed v_0, at an angle of 45^O to the horizontal. The magnitude of an angular momentum of the particle about P at time t=v^0 / g is

1) $\frac{mv_0^3}{2\sqrt{2}g}$

2) $\frac{mv_0^3}{\sqrt{2}g}$

3) $\frac{3mv_0^3}{\sqrt{2}g}$

4) $\frac{\sqrt{2}mv_0^3}{g}$

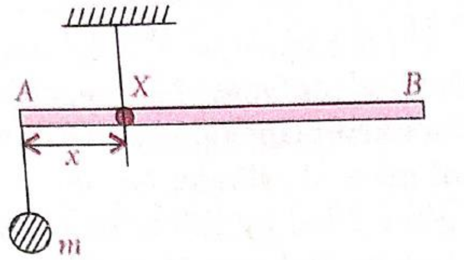
26. A circular disc of radius R and thickness $\frac{R}{6}$ moment of inertia I about an axis passing through its centre and perpendicular to its plane. It is melted and recasted into a solid sphere. The moment of inertia of the sphere about its diameter as axis of rotation is

1) I
2) $\frac{2I}{3}$
3) $\frac{I}{5}$
4) $\frac{I}{10}$

27. A disc of radius 2 m and mass 100 kg rolls on a horizontal floor. Its centre of mass has speed of 20 cm/s How much work is needed to stop it?
1) 1 J
2) 3 J
3) 30 KJ
4) 2 J

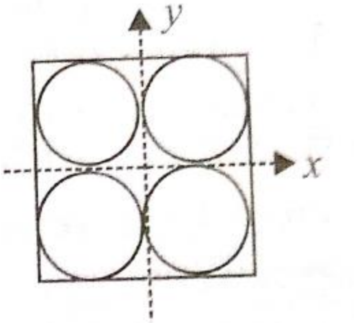
28. The moment of inertia of two spheres of equal masses about their diameters are equal. If one of them is solid and other is hollow. the ratio of their radii is
1) $\sqrt{3}:\sqrt{5}$
2) 3 : 5
3) $-\sqrt{5}:\sqrt{3}$
4) 5 : 3

29. A uniform rod AB is suspended from a point X, at a variable distance x from A, as shown. To make the rod horizontal, a mass m is suspended from it end A. A set of (m, x) value is recorded. The appropriate variables that give a straight line, when plotted, are



1) $m, \frac{1}{x^2}$
2) m, x^2
3) M , x
4) $m, \frac{1}{x}$

30. Four holes of radius R are cut from a thin square plate of side AR and mass M. The moment of inertia of the remaining portion about z -axis is



1) $\frac{\pi}{12}MR^2$

2) $\left(\frac{4}{3}-\frac{\pi}{4}\right)MR^2$

3) $\left(\frac{4}{3}-\frac{\pi}{6}\right)MR^2$

4) $\left(\frac{8}{3}-\frac{10\pi}{16}\right)MR^2$

.

KEY

1) 600 $\sqrt{2}$	**2) 115**	**3)1.26**	**4) 1.56**	**5) 10**	**6) 5.4m**	**7) w=0.3125**	**8) 0.538**	**9) 0**	**10) 40**
11) **4**	12) **2**	13) **1**	14) **1**	15) **1**	16) **1**	17) **3**	18) **3**	19) **2**	20) **2**
21) **4**	22) **3**	23) **4**	24) **1**	25) **1**	26) **3**	27) **2**	28) **3**	29) **4**	30) **4**

SOLUTIONS

1) N cosθ=mg
   F_s=F
   $N=\frac{mg}{\cos\theta}$
   N=300N
   F= $600\sqrt{2}N$

2) $\alpha=\frac{w_2-w_1}{t}=115rad/s$

3) $X_{cm}=\frac{m_1x_1+m_2x_2}{m_1+m_2}$

$r_1=\frac{m_2d}{m_1+m_2}$

$r_1=1.26A^0$

4)K.E= $\frac{1}{2}Iw^2$

K.E=1562

=1.56 KJ

5) $\tau = FR$

$I\alpha = FR$

$\alpha = \frac{FR}{I}$

$a = R\alpha$

$a = 10m/s^2$

6) $\frac{1}{2}mv^2 + \frac{1}{2}(\frac{1}{2}mv^2)w^2 = mgh$

$\frac{3}{4}mv^2 = mgh$

$h = \frac{3v^2}{4g}$

$\sin\theta = \frac{h}{s}$

$s = \frac{h}{\sin\theta}$

S=5.4m

7) L=mvr

$I = \frac{ML^2}{3}$

L=Iw

$w = \frac{L}{I}$

W=0.3125 rad/s

8.

$f = M_k$ mg

τ = f.R = $M_k mg\ R = -i\alpha$

$a = M_k g$

$v = M_k gt$

$\alpha - \frac{-M_k mgR}{I}$

$t^2 = \frac{Rw_0}{M_k g\left[1 + \frac{R^2}{k^2}\right]}$

$k^2 = \frac{R^2}{2}$; t = $\frac{w_0 R}{3M_k g}$

$k^2 = R^2$; t=$\frac{w_0 R}{2M_k g}$

t = 0.538 s

9) W = 0, Ans = 0

$T.E$ of hoop = $\frac{1}{2}MV^2+\frac{1}{2}Iw^2$

10) $T.E = MV^2$

$w = MV^2 = 100\times 20^2$

$w = 40$ KJ

11) The speed of the c.m of the system remains unchanged. Because no internal force acts on the system. The forces involved in running on the trolley are internal to this systems.

12) Torque due to central force zero.

$\vec{r}.\vec{\tau}=0$ as well as $\vec{F}.\vec{\tau}=0$

13. $\vec{\tau}=\vec{r}\times\vec{F}$

$p=\vec{\tau}.\vec{w}=\left(\vec{r}\times\vec{F}\right).\vec{w}$

14. AB = 3

AC = 1

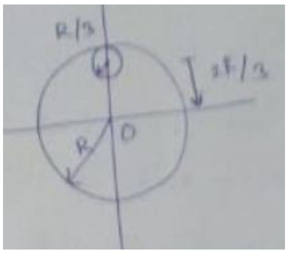
$BC=\sqrt{(AB)^2-(AC)^2}=2\sqrt{2}$

$R_1=\frac{w}{4\sqrt{2}}=\frac{200}{4\sqrt{2}}=25\sqrt{2}$

$f=R_1=25\sqrt{2}N$

$R_2=\sqrt{N^2+f^2}=203N$

15.



Mass per uunit area of disc= $\frac{9M}{\pi R^2}$ mass removed portion of disc = $\frac{9M}{\pi R^2}\times\left(\frac{R}{3}\right)^2=M$

$I_1=\frac{M}{2}\left(\frac{R}{3}\right)^2+M\left(\frac{2R}{3}\right)^2=\frac{1}{2}MR^2$

$I_2=\frac{9}{2}MR^2$

$I=I_2-I_1=4MR^2$

16. $u=\frac{5}{2}$ rps

$w=2\pi u=5\pi$ rad/s

$\alpha=\frac{w-w_0}{t}=\frac{\pi}{2}$ rad/s^2

$\tau=I\alpha$

$=3\pi Nm$

17. $ma = F-f \rightarrow (1)$

$\alpha=\frac{a}{R}\rightarrow(2)$

$\tau=I\alpha=Rf$

$\tau = \left(\frac{1}{2}mR^2\right)\alpha = Rf$

Ma=2f substituting this G'n (1) weset

$f = \frac{F}{3}$

$f \le \mu Mg \Rightarrow F \le 3\mu Mg$

$F_{max} = 3\mu Mg$

18. $mv_0 r = Iw$

19. $KR = \frac{L^2}{2I}$

20. $\frac{Esphere}{Ecylinder} = \frac{\frac{1}{2}I_s w_s^2}{\frac{1}{2}I_e w_e^2}$

$w_e = 2w_s$

21. $\frac{1}{2}Mv^2 + \frac{1}{2}Iw^2 = Mgh$

$\sin\theta = \frac{h}{s}$

22. $a = \frac{g\sin\theta}{1+\frac{I}{mR^2}}$

Solid sphere $I = \frac{2}{5}MR^2$

$a^1 = g\sin\theta$

23. V = RW

$K.E_T = \frac{1}{2}mV^2$

$K.E_R = \frac{1}{2}Iw^2$

Total K.E = $K.E_T + K.E_R$

% of rotational

$K.E = \frac{K.ER}{Total\ \ K.E} \times 100$

24. $x_{cm} = \frac{\int_0^1 x\,dm}{\int_0^1 dm}$

25. L = $xp_y - yp_x$

$L = m[xv_y - yv_x]\hat{k}$

26. $I = \frac{1}{2}MR^2$

$\frac{4}{3}\pi R_1^3 = \pi R^2 \times \frac{R}{6}$

27. $-(k_f - k_i) = 0 + k_i$

$$\frac{1}{2}Fw^2 + \frac{1}{2}mv^2 = \frac{1}{2}\left(\frac{1}{2}mR^2\right)w^2 + \frac{1}{2}mv^2$$

28. $\frac{2}{5}MR^2s = \frac{2}{3}MR^2H$

29. $mgx = Mg\left(\frac{\ell}{2} - x\right)$

$$m = \left(M\frac{\ell}{2}\right)\frac{1}{x} - M$$

30. $m = \frac{M}{16R^2} \times \pi R^2$

$$= \frac{M\pi}{16}$$

$I = I_{Square}\text{-}4I_{hole}$