Rotational Motion Assignment

1. Two particles *A* and *B* initially at rest move towards each other under a mutual force of attraction. At the instant when the speed of *A* is *v* and the speed of *B* is 2*v*, the speed of centre of mass of the system is

(a) Zero (b) *v* (c) 1.5*v* (d) 3*v*

2. A circular plate of uniform thickness has diameter 56 *cm*. A circular part of diameter 42 *cm* is removed from one edge. What is the position of the centre of mass of the remaining part

(a) 3 *cm* (b) 6 *cm* (c) 9 *cm* (d) 12 *cm*

3. Two point masses *m* and *M* are separated by a distance *L*. The distance of the centre of mass of the system from *m* is

(a) $L(m/M)$ (b) $L(M/m)$ (c) $L\left(\frac{M}{m+M}\right)$ (d) $L\left(\frac{m}{m+M}\right)$

4. Three identical spheres, each of mass 1 *kg* are placed touching each other with their centres on a straight line. Their centres are marked *K, L* and *M* respectively. The distance of centre of mass of the system from *K* is

(a) $\frac{KL+KM+LM}{3}$ (b) $\frac{KL+KM}{3}$ (c) $\frac{KL+LM}{3}$ (d) $\frac{KM+LM}{3}$

5. Two particles of masses 1 *kg* and 3 *kg* move towards each other under their mutual force of attraction. No other force acts on them. When the relative velocity of approach of the two particles is 2*m/s,* their centre of mass has a velocity of 0.5 *m/s.* When the relative velocity of approach becomes 3 *m/s,* the velocity of the centre of mass is

(a) 0.5 *m/s* (b) 0.75 *m/s* (c) 1.25 *m/s* (d) Zero

6. A particle *B* is moving in a circle of radius *a* with a uniform speed *u*. *C* is the centre of the circle and *AB* is diameter. The angular velocity of *B* about *A* and *C* are in the ratio

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

7. Two particles having mass '*M*' and '*m*' are moving in circular paths having radii *R* and *r*. If their time periods are same then the ratio of their angular velocities will be

(a) $\frac{r}{R}$ (b) $\frac{R}{r}$ (c) 1 (d) $\sqrt{\frac{R}{r}}$

8. A body is in pure rotation. The linear speed *v* of a particle, the distance *r* of the particle from the axis and angular velocity ω of the body are related as $\omega = \frac{v}{r}$, thus

(a) $\omega \propto \frac{1}{r}$ (b) $\omega \propto r$ (c) $\omega = 0$ (d) ω is independent of *r*

9. A strap is passing over a wheel of radius 30 *cm*. During the time the wheel moving with initial constant velocity of 2 rev/sec. comes to rest the strap covers a distance of 25 *m*. The deceleration of the wheel in *rad/s*^{2} is

(a) 0.94 (b) 1.2 (c) 2.0 (d) 2.5

10. A particle starts rotating from rest. Its angular displacement is expressed by the following equation $\theta = 0.025t^2 - 0.1t$ where θ is in radian and *t* is in seconds. The angular acceleration of the particle is

(a) 0.5 *rad/sec*^{2} at the end of 10 *sec* (b) 0.3 rad/sec^2 at the end of 2 *sec*

(c) 0.05 *rad/sec*^{2} at the end of 1 *sec* (d) Constant 0.05 *rad/sec*^{2}

11. The planes of two rigid discs are perpendicular to each other. They are rotating about their axes. If their angular velocities are 3 *rad/sec* and 4 *rad/sec* respectively, then the resultant angular velocity of the system would be

(a) 1 *rad/sec* (b) 7 *rad/sec* (c) 5 *rad/sec* (d) $\sqrt{12}$ *rad/sec*

12. A sphere is rotating about a diameter

(a) The particles on the surface of the sphere do not have any linear acceleration

(b) The particles on the diameter mentioned above do not have any linear acceleration

(c) Different particles on the surface have different angular speeds

(d) All the particles on the surface have same linear speed

13. A rigid body is rotating with variable angular velocity $(a - bt)$ at any instant of time *t*. The total angle subtended by it before coming to rest will be (*a* and *b* are constants)

(a) $\frac{(a-b)a}{2}$ (b) $\frac{a^2}{2b}$ (c) $\frac{a^2-b^2}{2b}$ (d) $\frac{a^2-b^2}{2a}$

14. When a ceiling fan is switched on, it makes 10 rotations in the first 3 seconds. How many rotations will it make in the next 3 seconds (Assume uniform angular acceleration)

(a) 10 (b) 20 (c) 30 (d) 40

15. When a ceiling fan is switched off, its angular velocity falls to half while it makes 36 rotations. How many more rotations will it make before coming to rest (Assume uniform angular retardation)

(a) 36 (b) 24 (c) 18 (d) 12

16. Let $\vec{A}$ be a unit vector along the axis of rotation of a purely rotating body and $\vec{B}$ be a unit vector along the velocity of a particle *P* of the body away from the axis. The value of $\vec{A}.\vec{B}$ is

(a) 1 (b) – 1 (c) 0 (d) None of these

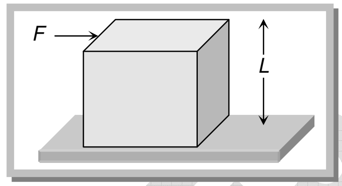
17. A cubical block of side *L* rests on a rough horizontal surface with coefficient of friction μ. A horizontal force *F* is applied on the block as shown. If the coefficient of friction is sufficiently high so that the block does not slide before toppling, the minimum force required to topple the block is

(a) Infinitesimal

(b) *mg*/4

(c) *mg*/2

(d) $mg(1-\mu)$



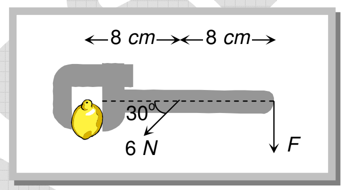
18. When a force of 6.0 *N* is exerted at 30^o to a wrench at a distance of 8 *cm* from the nut, it is just able to loosen the nut. What force *F* would be sufficient to loosen it, if it acts perpendicularly to the wrench at 16 *cm* from the nut

(a) 3 *N*

(b) 6 *N*

(c) 4 *N*

(d) 1.5 *N*



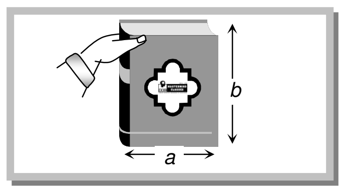
19. A person supports a book between his finger and thumb as shown (the point of grip is assumed to be at the corner of the book). If the book has a weight of *W* then the person is producing a torque on the book of

(a) $W\frac{a}{2}$ anticlockwise

(b) $W\frac{b}{2}$ anticlockwise

(c) Wa anticlockwise

(d) Wa clockwise



20. Weights of $1g, 2g, ..., 100\,g$ are suspended from the 1 *cm*, 2 *cm*, ... 100 *cm*, marks respectively of a light *metre* scale. Where should it be supported for the system to be in equilibrium

(a) 55 *cm* mark (b) 60 *cm* mark (c) 66 *cm* mark (d) 72 *cm* mark

21. A uniform cube of side *a* and mass *m* rests on a rough horizontal table. A horizontal force *F* is applied normal to one of the faces at a point that is directly above the centre of the face, at a height $\frac{3a}{4}$ above the base. The minimum value of *F* for which the cube begins to tilt about the edge is (assume that the cube does not slide)

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

22. From a uniform wire, two circular loops are made (i) *P* of radius *r* and (ii) *Q* of radius *nr*. If the moment of inertia of *Q* about an axis passing through its centre and perpendicular to its plane is 8 times that of *P* about a similar axis, the value of *n* is (diameter of the wire is very much smaller than *r* or *nr*)

(a) 8 (b) 6 (c) 4 (d) 2

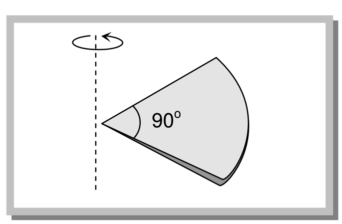
23. One quarter sector is cut from a uniform circular disc of radius *R*. This sector has mass *M*. It is made to rotate about a line perpendicular to its plane and passing through the centre of the original disc. Its moment of inertia about the axis of rotation is

(a) $\frac{1}{2}MR^2$

(b) $\frac{1}{4}MR^2$

(c) $\frac{1}{8}MR^2$

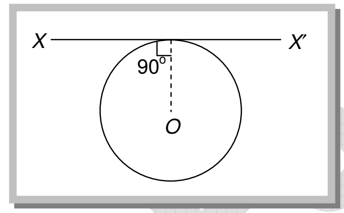
(d) $\sqrt{2}\,MR^2$



24. Two discs of same thickness but of different radii are made of two different materials such that their masses are same. The densities of the materials are in the ratio 1 : 3. The moments of inertia of these discs about the respective axes passing through their centres and perpendicular to their planes will be in the ratio

(a) 1 : 3 (b) 3 : 1 (c) 1 : 9 (d) 9 : 1

25. A thin wire of length L and uniform linear mass density ρ is bent into a circular loop with centre at O as shown. The moment of inertia of the loop about the axis XX' is



(a) $\frac{\rho L^3}{8\pi^2}$

(b) $\frac{\rho L^3}{16\pi^2}$

(c) $\frac{5\rho L^3}{16\pi^2}$

(d) $\frac{3\rho L^3}{8\pi^2}$

26. If solid sphere and solid cylinder of same radius and density rotate about their own axis, the moment of inertia will be greater for ($L = R$)

(a) Solid sphere (b) Solid cylinder (c) Both (d) Equal both

27. Two point masses of 0.3 *kg* and 0.7 *kg* are fixed at the ends of a rod of length 1.4 *m* and of negligible mass. The rod is set rotating about an axis perpendicular to its length with a uniform angular speed. The point on the rod through which the axis should pass in order that the work required for rotation of the rod is minimum is located at a distance of

(a) 0.4 *m* from mass of 0.3 *kg*
(b) 0.98 from mass of 0.3 *kg*
(c) 0.70 *m* from mass of 0.7 *kg*
(d) 0.98 *m* from mass of 0.7 *kg*

28. A circular disc A of radius r is made from an iron plate of thickness t and another circular disc B of radius $4r$ is made from an iron plate of thickness $t/4$. The relation between the moments of inertia I_A and I_B is

(a) $I_A > I_B$
(b) $I_A = I_B$
(c) $I_A < I_B$
(d) Depends on the actual values of t and r

29. A thin wire of length l and mass M is bent in the form of a semi-circle. What is its moment of inertia about an axis passing through the ends of the wire

(a) $\frac{Ml^2}{2}$ (b) $\frac{Ml^2}{\pi^2}$ (c) $\frac{2Ml^2}{\pi^2}$ (d) $\frac{Ml^2}{2\pi^2}$

30. If I_1 is the moment of inertia of a thin rod about an axis perpendicular to its length and passing through its centre of mass, and I_2 is the moment of inertia of the ring formed by bending the rod, then

(a) $I_1 : I_2 = 1 : 1$ (b) $I_1 : I_2 = \pi^2 : 3$ (c) $I_1 : I_2 = \pi : 4$ (d) $I_1 : I_2 = 3 : 5$

31. A particle undergoes uniform circular motion. About which point on the plane of the circle, will the angular momentum of the particle remain conserved

(a) Centre of the circle
(b) On the circumference of the circle
(c) Inside the circle
(d) Outside the circle

32. A thin uniform circular disc of mass M and radius R is rotating in a horizontal plane about an axis passing through its centre and perpendicular to its plane with an angular velocity ω. Another disc of same dimension but of mass $M/4$ is placed gently on the first disc coaxially. The angular velocity of the system now is

(a) $2\omega/5$ (b) $2\omega/\sqrt{5}$ (c) $4\omega/5$ (d) $4\omega/\sqrt{5}$

33. A smooth sphere A is moving on a frictionless horizontal plane with angular speed ω and center of mass with velocity υ. It collides elastically and head-on with an identical sphere B at rest. Neglect friction everywhere. After the collision, their angular speeds are ω_A and ω_B respectively. Then

(a) $\omega_A < \omega_B$ (b) $\omega_A = \omega_B$ (c) $\omega_A = \omega$ (d) $\omega = \omega_B$

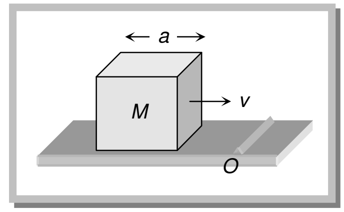
34. A cubical block of side *a* is moving with velocity *v* on a horizontal smooth plane as shown. It hits a ridge at point *O*. The angular speed of the block after it hits *O* is

(a) $3v/4a$

(b) $3v/2a$

(c) $\frac{\sqrt{3}v}{\sqrt{2}a}$

(d) Zero



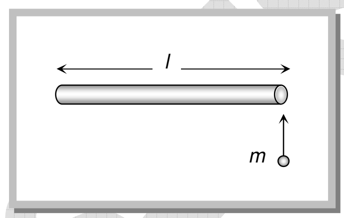
35. A stick of length *l* and mass *M* lies on a frictionless horizontal surface on which it is free to move in any way. A ball of mass *m* moving with speed *v* collides elastically with the stick as shown in the figure. If after the collision ball comes to rest, then what should be the mass of the ball

(a) $m = 2M$

(b) $m = M$

(c) $m = M/2$

(d) $m = M/4$



36. In a playground there is a merry-go-round of mass 120 *kg* and radius 4 *m*. The radius of gyration is 3*m*. A child of mass 30 *kg* runs at a speed of 5 *m*/*sec* tangent to the rim of the merry-go-round when it is at rest and then jumps on it. Neglect friction and find the angular velocity of the merry-go-round and child

(a) 0.2 *rad*/*sec* (b) 0.1 *rad*/*sec* (c) 0.4 *rad*/*sec* (d) 0.8 *rad*/*sec*

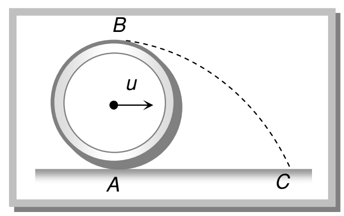
37. A wheel of radius *r* rolls without slipping with a speed *v* on a horizontal road. When it is at a point *A* on the road, a small jump of mud separates from the wheel at its highest point *B* and drops at point *C* on the road. The distance *AC* will be

(a) $v\sqrt{\frac{r}{g}}$

(b) $2v\sqrt{\frac{r}{g}}$

(c) $4v\sqrt{\frac{r}{g}}$

(d) $\sqrt{\frac{3r}{g}}$



38. A fly wheel of moment of inertia *I* is rotating at *n* revolutions per sec. The work needed to double the frequency would be

(a) $2\pi^2 In^2$ (b) $4\pi^2 In^2$ (c) $6\pi^2 In^2$ (d) $8\pi^2 In^2$

39. If *L*, *M* and *P* are the angular momentum, mass and linear momentum of a particle respectively which of the following represents the kinetic energy of the particle when the particle rotates in a circle of radius *R*

(a) $\frac{L^2}{2M}$ (b) $\frac{P^2}{2MR}$ (c) $\frac{L^2}{2MR^2}$ (d) $\frac{MP}{2}$

40. A uniform thin rod of length *l* is suspended from one of its ends and is rotated at *f* rotations per second. The rotational kinetic energy of the rod will be

(a) $\frac{2}{3}\pi^2 f^2 ml^2$ (b) $\frac{4}{3}f^2 ml^2$ (c) $4\pi^2 f^2 ml^2$ (d) Zero

41. A body rotating at 20 *rad*/*sec* is acted upon by a constant torque providing it a deceleration of 2 rad/sec^2. At what time will the body have kinetic energy same as the initial value if the torque continues to act

(a) 20 *secs* (b) 40 *secs* (c) 5 *secs* (d) 10 *secs*

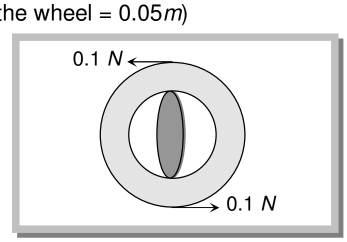
42. Part of the tuning arrangement of a radio consists of a wheel which is acted on by two parallel constant forces as shown in the fig. If the wheel rotates just once, the work done will be about (diameter of the wheel = 0.05*m*)

(a) 0.062 *J*

(b) 0.031 *J*

(c) 0.015 *J*

(d) 0.057 *J*



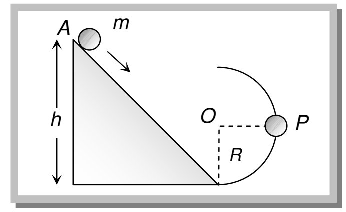
43. A solid ball of mass m and radius r rolls without slipping along the track shown in the fig. The radius of the circular part of the track is R. The ball starts rolling down the track from rest from a height of $8R$ from the ground level. When the ball reaches the point P then its velocity will be

(a) $\sqrt{gR}$

(b) $\sqrt{5gR}$

(c) $\sqrt{10gR}$

(d) $\sqrt{3gR}$



44. A ring takes time t_1 in slipping down an inclined plane of length L and takes time t_2 in rolling down the same plane. The ratio $\frac{t_1}{t_2}$ is

(a) $\sqrt{2}:1$ (b) $1:\sqrt{2}$ (c) 1 : 2 (d) 2 : 1

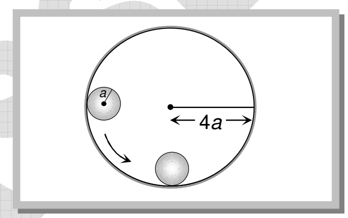
45. A ring of radius $4a$ is rigidly fixed in vertical position on a table. A small disc of mass m and radius a is released as shown in the fig. When the disc rolls down, without slipping, to the lowest point of the ring, then its speed will be

(a) $\sqrt{ga}$

(b) $\sqrt{2ga}$

(c) $\sqrt{3ga}$

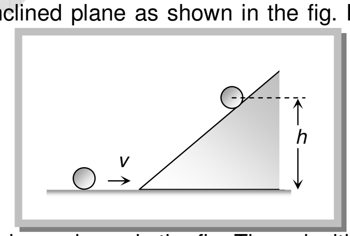
(d) $\sqrt{4ga}$



46. A disc of mass M and radius R rolls in a horizontal surface and then rolls up an inclined plane as shown in the fig. If the velocity of the disc is v, the height to which the disc will rise will be

(a) $\frac{3v^2}{2g}$ (b) $\frac{3v^2}{4g}$

(c) $\frac{v^2}{4g}$ (d) $\frac{v^2}{2g}$



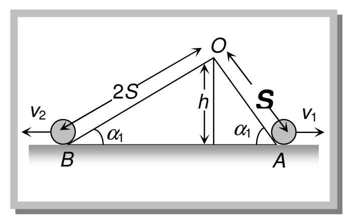
47. Two uniform similar discs roll down two inclined planes of length S and $2S$ respectively as shown is the fig. The velocities of two discs at the points A and B of the inclined planes are related as

(a) $v_1 = v_2$

(b) $v_1 = 2v_2$

(c) $v_1 = v_1 \frac{v_2}{4}$

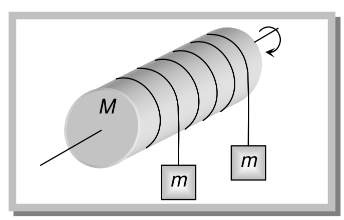
(d) $v_1 = \frac{3}{4}v_2$



48. A uniform solid cylinder of mass M and radius R rotates about a frictionless horizontal axle. Two similar masses suspended with the help two ropes wrapped around the cylinder. If the system is released from rest then the acceleration of each mass will be

(a) $\frac{4mg}{M+2m}$ (b) $\frac{4mg}{M+4m}$

(c) $\frac{2mg}{M+m}$ (d) $\frac{2mg}{M+2m}$



49. In the above problem the angular velocity of the cylinder, after the masses fall down through distance h, will be

(a) $\frac{1}{R}\sqrt{8mgh/(M+4m)}$ (b) $\frac{1}{R}\sqrt{8mgh/(M+m)}$ (c) $\frac{1}{R}\sqrt{mgh/(M+m)}$ (d) $\frac{1}{R}\sqrt{8mgh/(M+2m)}$

50. The string of a simple pendulum is replaced by a uniform rod of length L and mass M. If the mass of the bob of the pendulum is m, then for small oscillations its time period would be (assume radius of bob $r << L$)

(a) $2\pi\sqrt{\frac{2(M+3m)L}{3(M+2m)g}}$ (b) $2\pi\sqrt{\frac{(M+2m)L}{3(M+3m)g}}$ (c) $2\pi\sqrt{\left(\frac{2M}{3m}\right)\frac{L}{g}}$ (d) $2\pi\sqrt{\left(\frac{M+m}{M+3m}\right)\frac{L}{g}}$