विध्न विचारत भीरु जन, नहीं आरम्भे काम, विपति देख छोड़े तुरंत मध्यम मन कर श्याम।
पुरुष सिंह संकल्प कर, सहते विपति अनेक, 'बना' न छोड़े ध्येय को, रघुबर राखे टेक।।

रचितः मानव धर्म प्रणेता
सद्गुरु श्री रणछोड़दासजी महाराज

STUDY PACKAGE

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Topic : ROTATIONAL DYNAMICS

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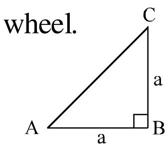
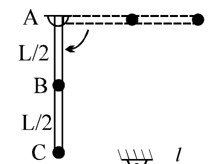
EXERCISE–I

Q.1 A wheel, of radius 1 m, is rolling purely on a flat, horizontal surface. It's centre is moving with a constant horizontal acceleration = 3 m/s^2. At a moment when the centre of the wheel has a velocity 3 m/s, then find the acceleration of a point 1/3 m vertically above the centre of the wheel.

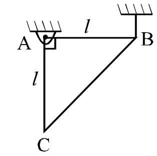
Q.2 A rigid body in shape of a triangle has $v_A = 5$ m/s $\downarrow$, $v_B = 10$ m/s $\downarrow$. Find velocity of point C.



Q.3 Two masses each of m are attached at mid point B & end point C of massless rod AC which is hinged at A. It is released from horizontal position as shown. Find the force at hinge A when rod becomes vertical

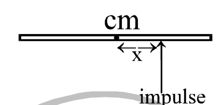


Q.4 An isosceles right triangular plate ABC of mass m is free to rotate in vertical plane about a fixed horizontal axis through A. It is supported by a string such that the side AB is horizontal. Find the reaction at the support A.



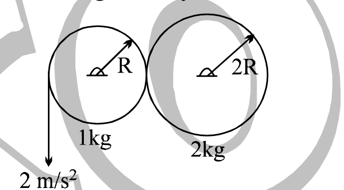
Q.5 A particle of mass m is projected with a velocity u at an angle of θ with horizontal. Find the intial angular momentum of the particle about the highest point of its trajectory.

Q.6 A uniform rod of length l is given an impulse at right angles to its length as shown. Find the distance of instantaneous centre of rotation from the centre of the rod.

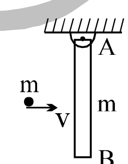


Q.7 A particle of mass 1 kg is moving with constant velocity of 10 m/s along the straight line y = 7x + 4. Find the angular momentum of the particle with respect to the point (3,4).

Q.8 Two discs A and B touch each other as in figure. A rope tightly wound on A is pulled down at 2 m/s^2. Find the friction force between A and B if slipping is absent



Q.9 A uniform rod AB of length L and mass m is suspended freely at A and hangs vertically at rest when a particle of same mass m is fired horizontally with speed v to strike the rod at its mid point. If the particle is brought to rest after the impact. Then find the impulsive reaction at A.



Q.10 A solid cylinder is released from rest from the top of an inclined plane of inclination 60° where friction coefficient varies with distance x as $\mu = \dfrac{2-3x}{\sqrt{3}}$. Find the distance travelled by the cylinder on incline before it starts slipping.

Q.11 Two men, each of mass 75 kg , stand on the rim of a horizontal large disc, diametrically opposite to each other. The disc has a mass 450 kg and is free to rotate about its axis. Each man simultaneously start along the rim clockwise with the same speed and reaches their original starting points on the disc. Find the angle turned through by the disc with respect to the ground.

Q.12 A solid sphere of radius 3R, a solid disc of radius 2R and a ring of radius R (all are of mass m) roll down a rough inclined plane. Their acclerations are *a,b* and *c* respectively. Find the ratio of a/b and b/c .

Q.13 A uniform disc of radius 1m and mass 2kg is mounted on an axle supported on fixed frictionless bearings. A light cord is wrapped around the rim of the disc and a mass of 1kg is tied to the free end. If it is released from rest, then find the tension in the cord.

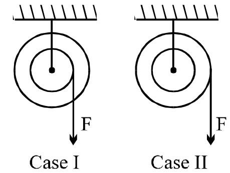
Q.14 A uniform disc of mass m and radius R rotates about a fixed vertical axis passing through its centre with angular velocity ω. A particle of same mass m and having velocity 2ωR towards centre of the disc collides with the disc moving horizontally and sticks to its rim. Find

(a) the angular velocity of the disc.

(b) the impulse on the particle due to disc.

(c) the impulse on the disc due to hinge.

Q.15 A person pulls along a rope wound up around a pulley with a constant force F for a time interval of t seconds. If a and b are the radii of the inner and the outer circumference (a < b), then find the ratio of work done by the person in the two cases shown in the figure is W_1/W_2.



Q.16 A solid sphere of mass m and radius R is placed on a smooth horizontal surface. A sudden blow is given horizontally to the sphere at a height h = 4R/5 above the centre line. If I is the impulse of the blow then find

(a) the minimum time after which the highest point B will touch the ground

(b) the displacement of the centre of mass during this internal.

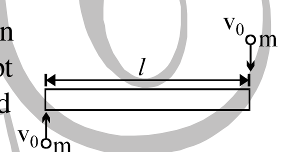
Q.17 A uniform ball of radius R rolls without slipping between two rails such that the horizontal distance is d between two contact points of the rail to the ball. If R=10cm, d=16cm and the angular velocity is 5rad/s then find the velocity of centre of mass of the ball.

Q.18 A cylinder of mass M and radius R is resting on a horizontal platform (which is parallel to the x-y plane) with its axis fixed along the y axis and free to rotate about its axis . The platform is given a motion in the x-direction given by $x = A\cos(\omega t)$. There is no slipping between the cylinder and platform. Find the maximum torque acting on the cylinder during its motion.

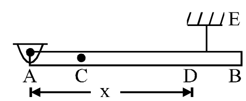
Q.19 The door of an automobile is open and perpendicular to the body. The automobile starts with an acceleration of 2 ft/sec^2, and the width of the door is 30 inches. Treat the door as a uniform rectangle, and neglect friction to find the speed of its outside edge as seen by the driver when the door closes.

Q.20 A bit of mud stuck to a bicycle's front wheel of radius r detaches and is flung horizontally forward when it is at the top of the wheel. The bicycle is moving forward at a speed v and it is rolling without slipping. Find the horizontal distance travelled by the mud after detaching from the wheel.

Q.21 On a smooth table two particles of mass m each, travelling with a velocity v_0 in opposite directions, strike the ends of a rigid massless rod of length l, kept perpendicular to their velocity. The particles stick to the rod after the collision. Find the tension in rod during subsequent motion.



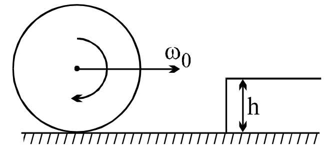
Q.22 A slender bar AB is supported in a horizontal position as in figure. At what distance x from the hinge A should the vertical string DE be attached to the bar in order that, when it is cut, there will be no immediate change in the reaction at A.



Q.23 A solid spherical ball which rests in equilibrium at the interior bottom of a fixed spherical globe is perfectly rough. the ball is struck a horizontal blow of such magnitude that the initial speed of its centre is v. Prove that, if v lies between $(10\,dg/7)^{1/2}$ and $(27\,dg/7)^{1/2}$, the ball will leave the globe, d being the difference between the radii of the ball and globe.

Q.24 A force of constant magnitude F starts acting on a uniform rod AB in gravity free space at the end A of the rod. The force always remains perpendicular to the rod, even as it moves. The mass of the rod is M and its length L. Then, find the value of the dot product $\vec{F}\cdot\vec{a}_A$ at any later time(where $\vec{a}_A$ is acceleration of point A.)

Q.25 A solid uniform sphere of radius R and mass M rolls without slipping with angular velocity ω_0 when it encounters a step of height 0.4 R. Find the angular velocity immediately after inelastic impact with the rough step.

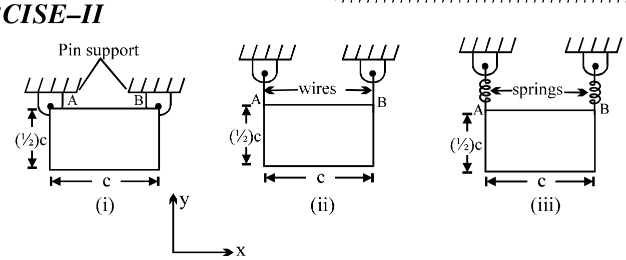


EXERCISE–II

Q.1 A uniform plate of mass m is suspended in each of the ways shown. For each case determine immediately after the connection at B has been released ;

(a) the angular acceleration of the plate.

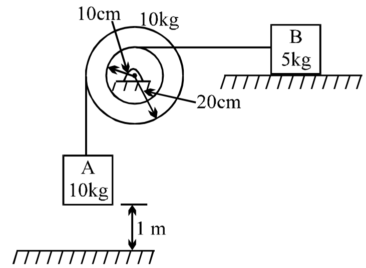
(b) the acceleration of its mass center.



Q.2 The disk shown has weight 10 kg. Cylinder A and block B are attached to cords that are wrapped on the pulley as shown. The coefficient of kinetic friction between block B and the surface is 0.25. Knowing that the system is released from rest in the position shown, determine

(a) the velocity of cylinder A as it strikes the ground.

(b) the total distance that block B moves before coming to rest.

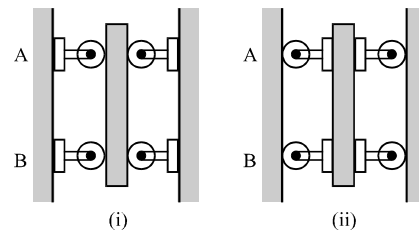


Q.3 A bar of mass m is held as shown between 4 disks, each of mass m′ & radius r = 75 mm Determine the acceleration of the bar immediately after it has been released from rest, knowing that the normal forces exerted on the disks are sufficient to prevent any slipping and assuming that ;

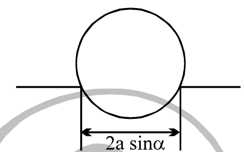
(a) m = 5 kg and m′ = 2 kg .

(b) the mass m′ of the disks is negligible.

(c) the mass m of the bar is negligible.

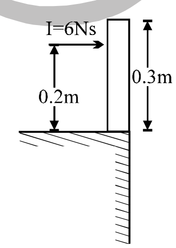


Q.4 Show that, if a uniform heavy right circular cylinder of radius a be rotated about its axis, and laid gently on two rough horizontal rails at the same level and distant 2a sinα apart so that the axis of the cylinder is parallel to the rails, the cylinder will remain in contact with both rails if the coefficient of friction $\mu < \tan\alpha$, but will initially rise on one rail if $\mu > \tan\alpha$.



Q.5 A diwali cracker known as **sudarashan chakra** works on the principle of thrust . Consider such a toy the centre of which is hinged.The initial mass of the toy is M_0 and radius is R . The toy is in the shape of a spiral the turns of which are very close (it can be assumed as a disc).The gases are ejected tangentially from the end of the toy with a constant velocity u relative to the toy. Find the angular velocity of the toy when mass remains half.

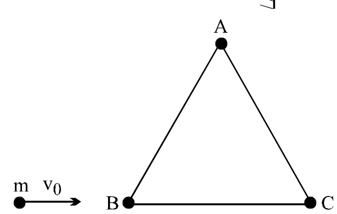
Q.6 A uniform thin rod with a mass M = 0.60 kg and a length of 0.30 m stands on the edge of a frictionless table as shown in the figure. The rod is struck , a horizontal impulse blow at a point 0.20 m above the table top, driving the rod directly off the table. Determine the orientation of the rod and the position of its C.M. 1 s after the blow is struck. ($g = 9.8\ m/s^2$)



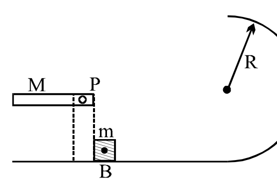
Q.7 Three particles A, B, C of mass m each are joined to each other by massless rigid rods to form an equilateral triangle of side a. Another particle of mass m hits B with a velocity v_0 directed along BC as shown. The colliding particle stops immediately after impact .

(i) Calculate the time required by the triangle ABC to complete half-revolution in its subsequent motion.

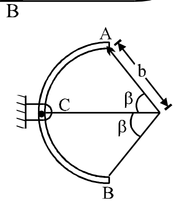
(ii) What is the net displacement of point B during this interval ?



Q.8 A rod of length R and mass M is free to rotate about a horizontal axis passing through hinge P as in figure . First it is taken aside such that it becomes horizontal and then released . At the lowest point the rod hits the block B of mass m and stops . Find the ratio of masses such that the block B completes the circle. Neglect any friction.



Q.9 A uniform rod AB is bent in the shape of an arc of circle. Determine the angular acceleration of the rod immediately after it is released from rest and show that it is independent of β.

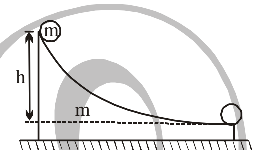


Q.10 Assume that the centre of mass of a girl crouching in a light swing has been raised to 1.2m. The girl has her centre of mass is 3.7m from the pivot of the swing while she is in the crouched position. The swing is released from rest and at the bottom of the arc the girl stands up instantaneously, thus raising her centre of mass 0.6m. Find the height of her centre of mass at the top of the arc.

Q.11 A uniform ball of radius R rolls without slipping between two rails such that the horizontal distance is d between the two contact points of the rail to the ball. (a) Show that at any instant, velocity of centre of mass is given as : $v_{cm} = \omega\sqrt{R^2 - \frac{d^2}{4}}$

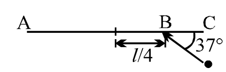
Discuss the above expression in the limits d=0 and d=2R. (b) For a uniform ball starting from rest and decending a vertical distance h while rolling without slipping down a ramp, $v_{cm} = \sqrt{\frac{10gh}{7}}$, if the ramp is replaced with two rails, show that : $v_{cm} = \sqrt{\frac{10gh}{5 + \frac{2}{1 - d^2/4R^2}}}$.

Q.12 A hollow sphere is released from the top of a movable wedge as shown in the figure. There is no friction between the wedge and the ground. There is sufficient friction between sphere and wedge to provide pure rolling of sphere. Find the velocity of centre of sphere w.r.t. ground just before it leaves the wedge horizontally.(Assume masses of the wedge and sphere are equal & h >> R the radius of sphere)



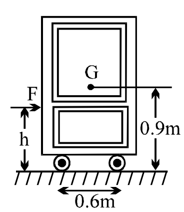
Q.13 A small ring of mass m is threaded on a horizontal smooth rod which is rotating about its end with constant angular velocity ω. The ring is initially located at the axis of rotation. When the distance of the ring from the axis becomes r, then find the power required to rotate the system with same angular velocity.

Q.14 A rod AC of length L and mass m is kept on a horizontal smooth plane. It is free to rotate and move. A particle of same mass m moving with velocity v strikes rod at point B which is at a distance L/4 from mid point making angle 37^0 with the rod. The collision is elastic. After collision find



(a) the angular velocity of the rod.
(b) the distance which centre of the rod will travel in the time in which it makes half rotation.
(c) the impulse of the impact force.

Q.15 A 20 kg cabinet is mounted on small casters that allow it to move freely ($\mu = 0$) on the floor. If a 100 N force is applied as shown, determine
(a) the acceleration of the cabinet,
(b) the range of values of h for which the cabinet will not tip.



List of recommended questions from I.E. Irodov.

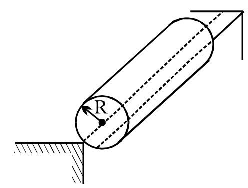
1.51 to 1.54, 1.58, 1.187, 1.188, 1.190, 1.192, 1.193, 1.199, 1.234, 1.237, 1.241, 1.245, 1.248, 1.249, 1.251, 1.255 to 1.264, 1.266, 1.270 to 1.279

EXERCISE–III

Q.1 Two point masses of 0.3kg and 0.7kg are fixed at the ends of a rod which is of length 1.4m 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 [JEE' 95]

(A) 0.42 from the mass of 0.3kg (B) 0.70 m from the mass of 0.7kg
(C) 0.98m from the mass of 0.3kg (D) 0.98m from the mass of 0.7kg

Q.2 A rectangular rigid fixed block has a long horizontal edge. A solid homogeneous cylinder of radius R is placed horizontally at rest with its length parallel to the edge such that the axis of the cylinder and the edge of the block are in the same vertical plane as shwon in figure. there is sufficient friction present at the edge so that a very small displacement cause the cylinder to roll of the edge without slipping. Determine



(a) the angle θ_C through which the cylinder rotates before it leaves contact with the edge,
(b) the speed of the centre of mass of the cylinder before leaving contact with the edge, and
(c) the ratio of the translational to rotational kinetic energies of the cylinder when its centre of mass is in horizontal line with the edge. [JEE' 95]

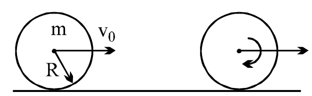
Q.3 A mass m moving with a constant velocity along a line parallel to the x axis, away from the origin. Its angular momentum with respect to the origin. [JEE' 97]

(A) is zero (B) remains constant
(C) goes on increasing (D) goes on decreasing

Q.4 A uniform disk of mass m and radius R is rolling up a rough inclined plane which makes an angle of 30° with the horizontal. If the coefficient of static and kinetic friction are each equal to μ and the only forces acting are gravitational and frictional, then the magnitude of the frictional force acting on the disk is ____ and its direction is ____ (write up or down) the inclined plane. [JEE' 97]

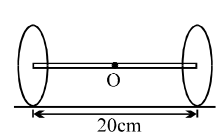
Q.5 A uniform disk of mass m and radius R is projected horizontally with velocity v_0 on a rough horizontal floor so that it starts off with a purely sliding motion at t=0. After t_0 seconds it acquires a purely rolling motion as shown in figure.

(i) Calculate the velocity of the centre of mass of the disk at t_0.
(ii) Assuming the coefficient of friction to be μ calculate t_0. Also calculate the work done by the frictional force as a function of time and the total work done by it over a time t much longer than t_0. [JEE' 97]



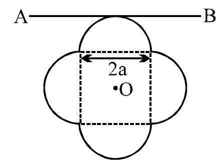
Q.6 Two thin circular disks of mass 2kg and radius 10cm each are joined by a rigid massless rod of length 20cm. The axis of the rod is along the perpendicular to the planes of the disks through their centre. The object is kept on a truck in such a way that the axis of the object is horizontal and perpendicular to the direction of motion of the truck. Its friction with the floor of the truck is large enough so that the object can roll on the truck without slipping. Take x-axis as the direction of motion of the truck and z-axis as the vertically upwards direction. If the truck has an acceleration of $9 m/s^2$ calculate :

(a) the force of friction on each disk
(b) The magnitude and the direction of the frictional torque acting on each disk about the centre of mass O of the object. Express the torque in the vector form of unit vectors in the x-y and z directions. [JEE' 97]



Q.7 A rod of weight w is supported by two parallel knife edges A and B is in equilibrium in a horizontal position. The knives are at a distance d from each other. The centre of mass of the rod is at a distance x from A. The normal reaction on A is ___ and on B is ____ [JEE' 97]

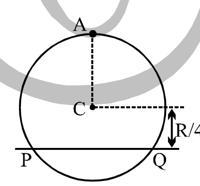
Q.8 A symmetric lamina of mass M consists of a square shape with a semicircular section over each of the edge of the square as in fig. The side of the square is 2a. The moment of inertia of the lamina about an axis through its centre of mass and perpendicular to the plane is 1.6 M a^2. The moment of inertia of the lamina about the tangent AB in the plane of lamina is ______ [JEE' 97]



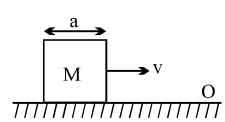
Q.9 Let I be the moment of inertia of a uniform square plate about an axis AB that passes through its centre and is parallel to two of its sides. CD is a line in the plane of the plate that passes through the centre of the plate and makes an angle θ with AB. The moment of inertia of the plate about the axis CD is then equal to
(A) I (B) $I\sin^2\theta$ (C) $I\cos^2\theta$ (D) $I\cos^2(\theta/2)$ [JEE' 98]

Q.10 The torque $\vec{\tau}$ on a body about a given point is found to be equal to $\vec{A}\times\vec{L}$ where $\vec{A}$ is a constant vector and $\vec{L}$ is the angular momentum of the body about that point. From this it follows that [JEE' 98]
(A) $d\vec{L}/dt$ is perpendicular to $\vec{L}$ at all instants of time
(B) the components of $\vec{L}$ in the direction of $\vec{A}$ does not change with time
(C) the magnitude of $\vec{L}$ does not change with time
(D) $\vec{L}$ does not change with time

Q.11 A uniform circular disc has radius R and mass m. A particle also of mass m is fixed at a point A on the wedge of the disc as in fig. The disc can rotate freely about a fixed horizontal chord PQ that is at a distance R/4 from the centre C of the disc. The line AC is perpendicular to PQ. Initially the disc is held vertical with the point A at its highest position. It is then allowed to fall so that it starts rotating about PQ. Find the linear speed of the particle at it reaches its lowest position. [JEE' 98]

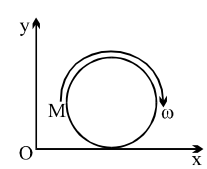


Q.12 A cubical block of side a is moving with velocity v on a horizontal smooth plane as shown. It hits a ridge at point O. The angular speed of the block after it hits O is:
(A) 3v/4a (B) 3v/2a
(C) $\sqrt{3v}/\sqrt{2a}$ (D) zero [JEE' 99]

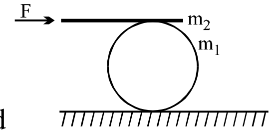


Q.13 A smooth sphere A is moving on a frictionless horizontal plane with angular speed ω and centre of mass velocity v. It collides elastically and head on with an identical sphere B at rest. Neglect friction everywhere. After the collision, their angularspeeds are ω_A and ω_B, respectively. Then [JEE' 99]
(A) $\omega_A < \omega_B$ (B) $\omega_A = \omega_B$ (C) $\omega_A = \omega$ (D) $\omega_B = \omega$

Q.14 A disc of mass M and radius R is rolling with angular speed w on a horizontal as shown. The magnitude of angular momentum of the disc about the origin O is: [JEE' 99]
(A) $(1/2)MR^2\omega$ (B) $MR^2\omega$
(C) $(3/2)MR^2\omega$ (D) $2MR^2\omega$



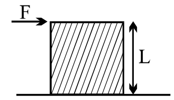
Q.15 A man pushes a cylinder of mass m_1 with the help of a plank of mass m_2 as shown. There is no slipping at any contact. The horizontal component of the force applied by the man is F. Find



(a) the accelerations of the plank and the center of mass of the cylinder, and

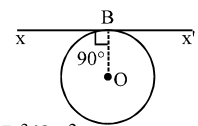
(b) the magnitudes and directions of frictional forces at contact points. [JEE' 99]

Q.16 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 frictionis sufficiently high so that the block does not slide before toppling, the minimum force required to topple the block is: [JEE'(Scr)'2000]



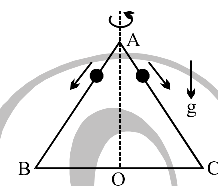
(A) infinitesimal (B) mg/4 (C) mg/2 (D) mg(1-μ)

Q.17 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: [JEE'(Scr)'2000]



(A) $\rho L^3/8\pi^2$ (B) $\rho L^3/16\pi^2$ (C) $5\rho L^3/16\pi^2$ (D) $3\rho L^3/8\pi^2$

Q.18 An equilateral triangle ABC formed from a uniform wire has two small identical beads initially located at AO. Then, the beads are released from rest simultaneously and allowed to slide down, one along AB and the other AC as shown. Neglecting frictional effects, the quantities that are conserved as the beads slide down, are: [JEE'(Scr)'2000]



(A) angula velocity and total energty (kinetic and potential)
(B) total angular momentum and total energy
(C) angular velocity and moment of inertia about the axis of rotaiton.
(D) total angular momentum and moment of inertia about the axis of rotation.

Q.19 A rod AB of mass M and length L is lying on a horizontal frictionless surface. A particle of mass m travelling along the surface hits the end 'A' of the rod with a velocity v_0 in the direction perpendicular to AB. The collision is completely elastic. After the collision the particle comes to rest.

(a) Find the ratio m/M .

(b) A point P on the rod is at rest immediately after the collision. Find the distance AP.

(c) Find the linear speed of the point P at a time $\pi L/(3v_0)$ after the collision. [JEE' 2000]

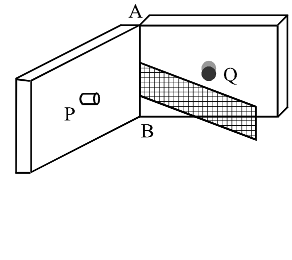
Q.20 Two heavy metallic plates are joined together at 90^0 to each other. A laminar sheet of mass 30 Kg is hinged at the line AB joining the two heavy metallic plates. The hinges are frictionless. The moment of inertia of the laminar sheet about an axis parallel to AB and passing through its centre of mass is 1.2 Kg-m^2. Two rubber obstacles P and Q are fixed, one on each metallic plate at a distance 0.5 m from the line AB. This distance is chosen so that the reaction due to the hinges on the laminar sheet is zero during the impact. Initially the laminar sheet hits one of the obstacles with an angular velocity 1 rad/s and turns back. If the impulse on the sheet due to each obstacle is 6 N–s.

(a) Find the location of the centre of mass of the laminar sheet from AB.

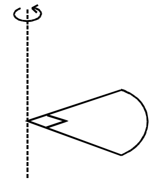
(b) At what angular velocity does the laminar sheet come back after the first impact ?

(c) After how many impacts, does the laminar sheet come to rest ?

[JEE' 2001]

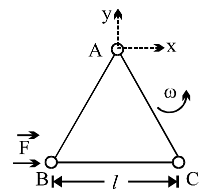


Q.21 One quarter sector is cut from a uniform circular disc of radius R. This sector has mass M. It is made to rotate about a line perpendicular to its plane and passing through the centre of the original disc. Its moment of inertia about the axis of rotation is [JEE'(Scr)2001]



(A) $\frac{1}{2}MR^2$ (B) $\frac{1}{4}MR^2$ (C) $\frac{1}{8}MR^2$ (D) $\sqrt{2}\,MR^2$

Q.22 Three particles A, B and C, each of mass m, are connected to each other by three massless rigid rods to form a rigid, equilateral triangular body of side l. This body is placed on a horizontal frictionless table (x-y plane) and is hinged to it at the point A so that it can move without friction about the vertical axis through A (see figure). The body is set into rotational motion on the table about A with a constant angular velocity ω.



(a) Find the magnitude of the horizontal force exerted by the hinge on the body.

(b) At time T, when the side BC is parallel to the x-axis, a force F is applied on B along BC (as shown). Obtain the x-component and the y-component of the force exterted by the hinge on the body, immediately after time T. [JEE' 2002]

Q.23 A particle is moving in a horizontal uniform circular motion. The angular momentum of the particle is conserved about the point : [JEE'(Scr)2003]

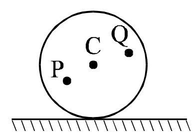
(A) Centre of the circle (B) Outside the circle

(C) Inside the circle (D) Point on circumference

Q.24 Two particles each of mass M are connected by a massless rod of length l. The rod is lying on the smooth sufrace. If one of the particle is given an impulse MV as shown in the figure then angular velocity of the rod would be : [JEE'(Scr)2003]

(A) v/l (B) $2v/l$ (C) $v/2l$ (D) None

Q.25 A disc is rolling (without slipping) on a horizontal surface. C is its center and Q and P are two points equidistant from C. Let V_P, V_Q and V_C be the magnitude of velocities of points P, Q and C respectively, then [JEE' 2004 (Scr)]



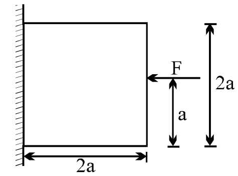
(A) $V_Q > V_C > V_P$ (B) $V_Q < V_C < V_P$

(C) $V_Q = V_P$, $V_C = \frac{1}{2}V_P$ (D) $V_Q < V_C > V_P$

Q.26 A child is standing with folded hands at the center of a platform rotating about its central axis. The kinetic energy of the system is K. The child now stretches his arms so that the moment of inertia of the system doubles. The kinetic energy of the system now is [JEE' 2004 (Scr)]

(A) 2K (B) $\frac{K}{2}$ (C) $\frac{K}{4}$ (D) 4K

Q.27 A block of mass m is held fixed against a wall by a applying a horizontal force F. Which of the following option is incorrect:

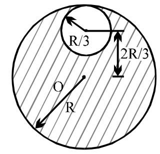


(A) friction force = mg (B) F will not produce torque

(C) normal will not produce torque (D) normal reaction = F

[JEE'2005 (Scr)]

Q.28 A disc has mass 9m. A hole of radius $\frac{R}{3}$ is cut from it as shown in the figure. The moment of inertia of remaining part about an axis passing through the centre 'O' of the disc and perpendicular to the plane of the disc is:



(A) 8 mR^2 (B) 4 mR^2 (C) $\frac{40}{9}$ mR^2 (D) $\frac{37}{9}$ mR^2

[JEE'2005 (Scr)]

Q.29 A particle moves in circular path with decreasing speed. Which of the following is correct

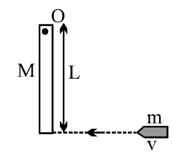
(A) $\vec{L}$ is constant (B) only direction of $\vec{L}$ is constant

(C) acceleration $\vec{a}$ is towards the centre (D) it will move in a spiral and finally reach the centre

[JEE'2005 (Scr)]

Q.30 A wooden log of mass M and length L is hinged by a frictionless nail at O. A bullet of mass m strikes with velocity v and sticks to it. Find angular velocity of the system immediately after the collision about O.

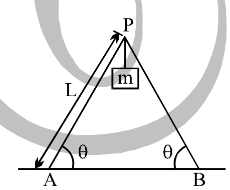
[JEE 2005]



Q.31 A cylinder of mass m and radius R rolls down an inclined plane of inclination θ. Calculate the linear acceleration of the axis of cylinder. [JEE 2005]

Q.32 Two identical ladders, each of mass M and length L are resting on the rough horizontal surface as shown in the figure. A block of mass m hangs from P. If the system is in equilibrium, find the magnitude and the direction of frictional force at A and B.

[JEE 2005]



Q.33 A solid sphere of mass M, radius R and having moment of inertia about an axis passing through the centre of mass as I, is recast into a disc of thickness t, whose moment of inertia about an axis passing through its edge and perpendicular to its plane remains I. Then, radius of the disc will be

(A) $\frac{2R}{\sqrt{15}}$ (B) $R\sqrt{\frac{2}{15}}$ (C) $\frac{4R}{\sqrt{15}}$ (D) $\frac{R}{4}$ [JEE 2006]

Q.34 A solid cylinder of mass m and radius r is rolling on a rough inclined plane of inclination θ. The coefficient of friction between the cylinder and incline is μ. Then

(A) frictional force is always μmg cos θ.

(B) friction is a dissipative force

(C) by decreasing θ, frictional force decreases

(D) friction opposes translation and supports rotation. [JEE 2006]

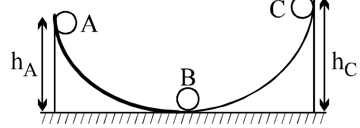
Q.35 A ball moves over a fixed track as shown in the figure. From A to B the ball rolls without slipping. Surface BC is frictionless. K_A, K_B and K_C are kinetic energies of the ball at A, B and C, respectively. Then

(A) $h_A > h_C$; $K_B > K_C$

(B) $h_A > h_C$; $K_C > K_A$

(C) $h_A = h_C$; $K_B = K_C$

(D) $h_A < h_C$; $K_B > K_C$



[JEE 2006]

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ANSWER KEY

EXERCISE–I

Q.1 $5\ m/s^2$

Q.2 $5\sqrt{5}$ m/s

Q.3 $\frac{28mg}{5}$

Q.4 2mg/3

Q.5 $\frac{mu^3 \sin^2\theta\cos\theta}{2g}$

Q.6 $\frac{l^2}{12x}$

Q.7 $21\sqrt{2}$ kg m^2/s, remains constant

Q.8 2 N

Q.9 $\frac{mv}{4}$

Q.10 $\frac{1}{3}$ m

Q.11 $\frac{4\pi}{5}$

Q.12 $\frac{a}{b}=\frac{15}{14}$ *and* $\frac{b}{c}=\frac{4}{3}$

Q.13 5 N

Q.14 (a) ω/3, (b) $\frac{\sqrt{37}}{3}m\omega R$, (c) $\frac{\sqrt{37}}{3}m\omega R$

Q.15 a^2/b^2

Q.16 (a) $t=\frac{\pi Rm}{2I}$; (b) $s=\frac{\pi R}{2}$

Q.17 0.3 m/s

Q.18 $(1/2)MRA\,\omega^2$

Q.19 $\sqrt{15}$ ft/sec

Q.20 $\sqrt{16rv^2/g}$

Q.21 $\frac{2mv_0^{\ 2}}{l}$

Q.22 $2l/3$

Q.24 $4F^2/M$

Q.25 $\frac{5\omega_0}{7}$

EXERCISE–II

Q.1 (i)(a) $\frac{1.2g}{c}$ (cw) (b) $-03.(\hat{i}+2\hat{j})g$ (ii) (a) 24g/17c (cw) (b) 12g/17 ↓ (iii) (a) 2.4 g/c(cw) (b) 0.5 g ↓

Q.2 (a) $\sqrt{\frac{150}{13}}$ m/s, (b) $\frac{44}{13}$ m

Q.3 (i) (a) 5g/9 ↓ (b) g ↓ (c) 0 (ii) (a) $\frac{13g}{17}$ ↓ (b) g ↓ (c) $\frac{2g}{3}$ ↓

Q.5 $w=\frac{4u}{R}\left(\sqrt{2}-1\right)$

Q.6 [10, –4.75 m] w.r.t. initial position of lower end of rod, $\frac{200}{3}$ rad with upward vertical

Q.7 (i) $t=\frac{6a\pi}{\sqrt{3}v_0}$; (ii) $s=\frac{a}{\sqrt{3}}\sqrt{1+\left(2\pi+\sqrt{3}\right)^2}$

Q.8 $\frac{M}{m}=\sqrt{15}$

Q.9 g/2b

Q.10 2.3 m

Q.12 $\sqrt{\frac{3}{7}gh}$

Q.13 $2mw^3r^2$

Q.14 (a) $\frac{72}{55}\frac{v}{\ell}$, (b) $\frac{\pi\ell}{3}$, (c) $\frac{24mV}{55}$

Q.15 (a) $5\ m/s^2$ →, (b) $0.3 < h < 1.5$ m

EXERCISE–III

Q.1 C

Q.2 (a) $\theta_C = \cos^{-1}(4/7)$, (b) $v = \sqrt{4/7\ gR}$, (c) $K_T/K_R = 6$

Q.3 B

Q.4 $Mg\sin\theta/3$, up

Q.5 (i) $2v_0/3$, (ii) $t = v_0/3\mu g$, $W = \frac{1}{2}[3\mu mg^2t^2 - 2\mu m g t v_0]$ $(t < t_0)$, $W = -\frac{1}{6}mv_0^2$ $(t > t_0)$

Q.6. $6N, -0.6\hat{j} \pm 0.6\hat{k}$

Q.7 $w(d-x)/d$, wx/d

Q.8 $4.8Ma^2$

Q.9 A

Q.10 A, B, C

Q.11 $v = \sqrt{5gR}$

Q.12 A

Q.13 C

Q.14 C

Q.15 $a_c = \frac{4F}{(3m_1 + 8m_2)}$, $a_p = \frac{8F}{(3m_1 + 8m_2)}$; $f_1 = \frac{3m_1F}{(3m_1 + 8m_2)}$, $f_2 = \frac{m_1F}{(3m_1 + 8m_2)}$

Q.16 C

Q.17 D

Q.18 B

Q.19 (a) $\frac{m}{M} = \frac{1}{4}$; (b) $x = \frac{2L}{3}$; (c) $\frac{v_0}{2\sqrt{2}}$

Q.20 (a) $l = 0.1m$; (b) $w' = 1rad/s$; (c) laminar sheet will never come to rest

Q.21 A

Q.22 (a) $\sqrt{3}\, m\,\omega^2 l$, (b) $F_x = F/4$, $F_y = \sqrt{3}\, m\,\omega^2 l$

Q.23 A

Q.24 A

Q.25 A

Q.26 B

Q.27 C

Q.28 B

Q.29 B

Q.30 $\omega = \frac{3mv}{(3m + M)L}$

Q.31 $a_{axis} = \frac{2g\sin\theta}{3}$

Q.32 $f = (M+m)\, g\frac{\cot\theta}{2}$

Q.33 A

Q.34 C,D

Q.35 A,B