Physics

Chapterwise Practise Problems (CPP) for JEE (Main & Advanced)

Chapter - System of Particles and Rotational Motion

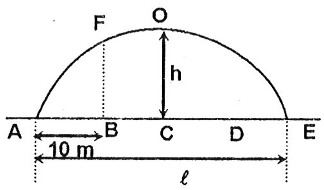
Level-1

SECTION - A

Straight Objective Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

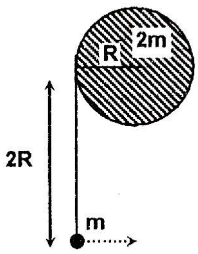
1. A car of mass m = 1000 kg is moving with constant speed v = 10 m/s on a parabolic shaped bridge AFOE of span ℓ = 40 m and height h = 20 m as shown in the figure. Then the net force applied by the bridge on the car when the car is at point F, is



(A) $5000\sqrt{\frac{5}{2}}$N (B) $\frac{5000}{\sqrt{2}}$N

(C) $\frac{10000}{\sqrt{2}}$N (D) $5000\sqrt{\frac{2}{5}}$N

2. A uniform circular disc of mass 2m and radius R placed freely on a horizontal smooth surface as shown in the figure. A particle of mass m is connected to the circumference of the disc with a massless string. Now an impulse J is applied on the particle in the directions shown by dotted line. The acceleration of centre of mass of the disc just after application of impulse is (if J = 10 N-sec., m = $\sqrt{10}$ kg and R = 25 cm.)

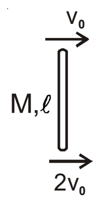


(A) 1 m/s² (B) 2 m/s²
(C) 3 m/s² (D) 4 m/s²

3. Two particles of masses m and 2m has initial velocity $\vec{u}_1 = 2\hat{i} + 3\hat{j}$ m/s and $\vec{u}_2 = -4\hat{i} + 3\hat{j}$ m/s respectively. These particles have constant acceleration $\vec{a}_1 = 4\hat{i} + 3\hat{j}$ (m/s²) and $\vec{a}_2 = -4\hat{i} - 2\hat{j}$ (m/s²) respectively. Path of the centre of mass of these two particle system will be:

(A) Straight line (B) Circular
(C) Parabolic (D) Helical

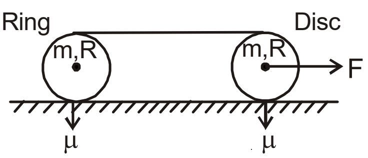
4. A uniform rod of mass M and length ℓ is moving on a smooth horizontal plane, such that its one end is moving with a velocity v_0 and other end is moving with a velocity $2v_0$ in the same direction as shown. Then the kinetic energy of the rod is



(A) $\frac{13}{24}Mv_0^2$ (B) $\frac{24}{31}Mv_0^2$

(C) $\frac{31}{24}Mv_0^2$ (D) $\frac{7}{6}Mv_0^2$

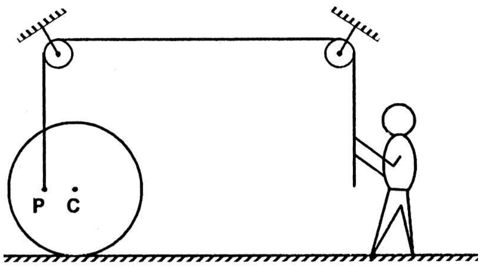
5. In the given situation disc and ring are connected with a string as shown in the figure. Both are placed on the rough surface of coefficient of friction μ. A force F is applied at the centre of disc horizontally. Then frictional force acting on the ring will be (assume pure rolling for both)



(A) $\frac{2F}{3}$ (B) $\frac{F}{3}$

(C) Zero (D) None of these

6. A solid cylinder lies on a rough horizontal surface sufficiently rough to prevent slipping. A string is attached to cylinder, which passes through two pulley and is pulled by a man as shown in the figure. Tension in the string is less than weight of cylinder when person pulls the string. Immediately after pulling the string which of the following is not true?



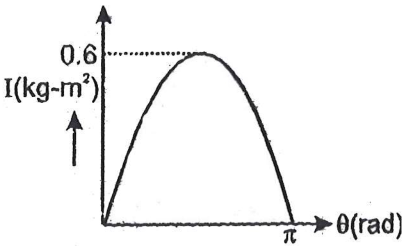
(A) Acceleration of centre C is towards right

(B) Acceleration of P is upward

(C) Friction by surface on cylinder is towards right

(D) Acceleration of P is inclined to horizontal.

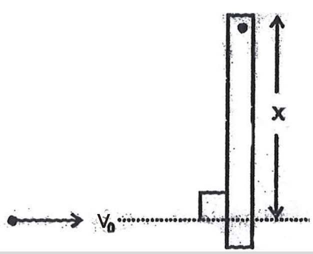
7. Figure shows the variation of the moment of inertia of a uniform rod, about an axis passing thorough its centre and inclined at an angle θ to the length. The moment of inertia of the rod about an axis passing through one of its ends and making an $\theta = \frac{\pi}{3}$ with the length will be



(A) 0.45 kgm^2 (B) 1.8 kgm^2

(C) 2.4 kgm^2 (D) 1.5 kgm^2

8. A uniform rod of length L and mass m is hinged at one end and free to rotate in horizontal plane. All the surfaces are smooth. A particle of mass m collides with the rod perpendicular to the length of rod with a speed v_0. If hinge reaction during the collision is zero then the value of x is



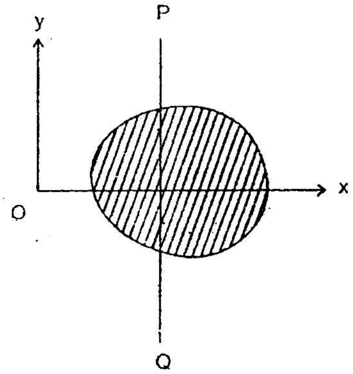
(A) No such value of x is possible

(B) $x = \frac{L}{2}$

(C) $x = \frac{2L}{3}$

(D) x = L

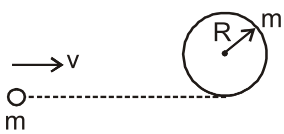
9. Line PQ is parallel to y-axis at a distance x from the y-axis and moment of inertia of a rigid body about PQ line is given by $I = 2x^2 - 12x + 27$, where x is in meter and I is in kg-m^2. The minimum value of I is (in Kg m^2)



(A) 27 (B) 17

(C) 11 (D) 9

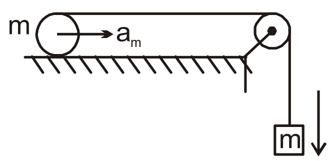
10. A circular wooden loop of mass m and radius R rests flat on a horizontal frictionless surface. A bullet, also of mass m, and moving with a velocity v, strikes the loop and gets embedded in it. The thickness of the loop is much smaller than R. The angular velocity with which the system rotates after the bullet strikes the loop is



(A) $\frac{v}{4R}$ (B) $\frac{v}{3R}$

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

11. In the given figure a ring of mass m is kept on a horizontal surface while a body of equal mass 'm' attached through a string which is wounded on the ring. When the system is released the ring rolls without slipping. Consider the following statements and choose the correct option (Pulley is ideal)



(a) Acceleration of the centre of mass of ring is $\frac{2g}{3}$

(b) Acceleration of the hanging particle is $\frac{4g}{3}$

(c) Frictional force (on the ring) acts along forward direction

(d) Frictional force (on the ring) acts along backward direction

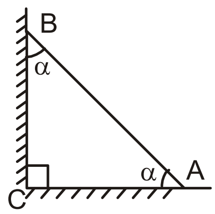
(A) Statement (a) and (b) only

(B) Statement (b) and (c) only

(C) Statement (a) and (d) only

(D) None of these

12. In the figure shown, the end A of the rod of length L is being pushed towards left parallel to the surface AC with a velocity = v and B moves up vertically. Let the velocity of end B = u and the angular velocity of the rod = ω. Then,



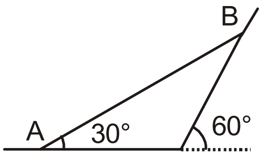
(A) $u = v\cot\alpha$, upwards

(B) $u = v$, downwards

(C) $\omega = \frac{v\sin\alpha}{2L}$

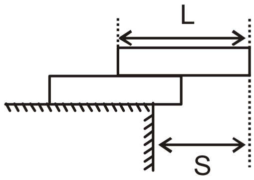
(D) $\omega = v\sin\alpha / L$

13. In the figure shown, the instantaneous speed of end A of the rod AB is v to the left. The angular velocity of the rod of length L, must be



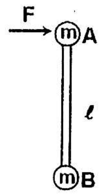
(A) v/2L
(B) v/L
(C) $v\sqrt{3}/2L$
(D) None

14. Two identical bricks of length L are piled on top of the other on a table as shown in the figure. The maximum distance S the top brick can overhang the table with the system still balanced is



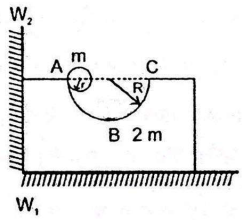
(A) $\frac{1}{2}L$
(B) $\frac{2}{3}L$
(C) $\frac{3}{4}L$
(D) $\frac{7}{8}L$

15. Figure shows the overhead view of two small identical balls connected with each other by a massless rigid rod. The balls and rod combination is kept on a smooth horizontal surface. A force F is applied horizontally on ball A in a direction perpendicular to the rod. The immediate acceleration of the ball A and B are respectively.



(A) F/m, F/m
(B) F/2m, F/2m
(C) F/m, 0
(D) F/2m, 0

16. A sphere of mass m and radius r is released from a block of mass 2m as shown. ABC is hemispherical position of radius R. Find the impulse imparted to the system consisting of wedge and sphere by the vertical wall w_1w_2 till the time sphere reaches at the bottom most position of spherical portion for the first time. Friction between wedge and horizontal surface is absent and between sphere and wedge friction is sufficient to avoid slipping between them.



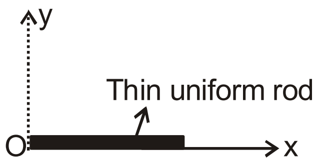
(A) $m\sqrt{\frac{2g(R-r)}{7}}$
(B) $m\sqrt{\frac{10g(R-r)}{7}}$
(C) $2m\sqrt{\frac{5g(R-r)}{7}}$
(D) $3m\sqrt{\frac{2g(R-r)}{7}}$

17. A ring of radius R is rolling without slipping on the outer surface of a pipe of radius 4R, with constant speed v. Then, the acceleration of the point on the ring which is in contact with the surface of the pipe is

(A) $\frac{4v^2}{5R}$ (B) $\frac{3v^2}{5R}$

(C) $\frac{v^2}{4R}$ (D) Zero

18. The locus of all the points on the x-y plane where the moment of inertia of the uniform rod shown in figure about an axis perpendicular to xy-plane and passing through that point is same as that about axis perpendicular to rod and passing through point 'O' is



(A) Circle (B) Parabola

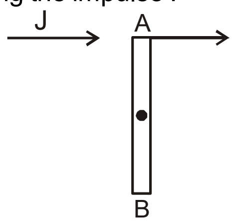
(C) Straight line (D) Ellipse

SECTION - B

Multiple Correct Answer Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

19. A uniform rod AB of mass M and length L lies on a smooth horizontal table. An impulse J is applied to end A as shown in the figure. Then immediately after imparting the impulse :



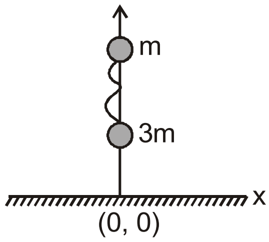
(A) the radius of curvature of trajectory of A as seen from the ground is $\frac{8}{9}L$

(B) the radius of curvature of trajectory of B as seen from the ground is $\frac{2}{9}L$

(C) the instantaneous axis of rotation is at a distance of L/6 from the mid point of the rod.

(D) the mid point of the rod will move along a straight line.

20. A coordinate axis system taking x-axis as horizontal smooth floor is shown in figure. Two small balls of masses m and 3m attached with a string are released from some heights on y-axis as shown in figure. The balls may collide head on or obliquely. After a certain time mass m is at (9 cm, 20 cm) while mass 3m is 25 cm above the x axis and the string is taut. The balls always remain in x-y plane. The length of string is



(A) 15 cm (B) 12 cm

(C) 13 cm (D) None of these

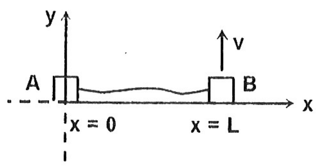
SECTION - C

Linked Comprehension Type

This section contains paragraphs. Based upon these paragraphs, some multiple choice questions have to be answered. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE OR MORE** is/ are correct.

Paragraph for Question Nos. 21 to 23

Two small identical blocks A and B are kept on smooth horizontal surface and tied with an inextensible string of length $\sqrt{2}$ L. At time t = 0, the block A is at rest at x = 0 and the block B is at x = L moving with speed v in +y direction.



21. The coordinates of centre of mass of the system at time $t = \frac{L}{v}$ is

(A) $\left(\frac{L}{2}, 0\right)$ (B) $\left(\frac{L}{2}, \frac{L}{2}\right)$

(C) $\left(\frac{L}{2}, L\right)$ (D) $\left(\frac{L}{2}, \frac{3L}{2}\right)$

22. Velocity of block B just after time $t=\frac{L}{v}$ is

(A) $-\frac{v}{4}\hat{i}-\frac{3v}{4}\hat{j}$

(B) $-\frac{v}{4}\hat{i}+\frac{3v}{4}\hat{j}$

(C) $\frac{v}{4}\hat{i}+\frac{3v}{4}\hat{j}$

(D) None of these

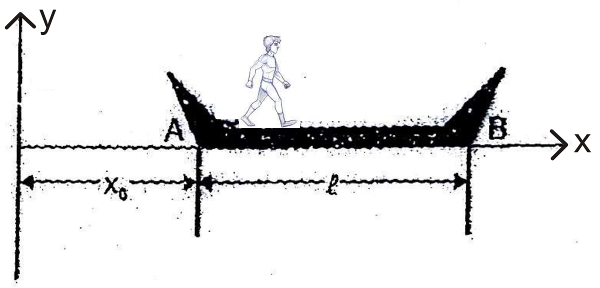
23. Velocity of block A just after time $t=\frac{L}{v}$ is

(A) $\frac{v}{4}\hat{i}+\frac{v}{4}\hat{j}$ (B) $-\frac{v}{4}\hat{i}+\frac{v}{4}\hat{j}$

(C) $-\frac{v}{4}\hat{i}-\frac{v}{4}\hat{j}$ (D) None of these

Paragraph for Question Nos. 24 to 26

A man of mass m walks from end A to the other end B of a boat of mass M and length ℓ. The coefficient of friction between man and boat is μ and the friction between boat and water is negligible.



24. The minimum time in which the man meets the other end is

(A) $\sqrt{\frac{2m\ell}{(M+m)\mu g}}$ (B) $\sqrt{\frac{2M\ell}{(M+m)\mu g}}$

(C) $\sqrt{\frac{2\ell}{\mu g}}$ (D) $\sqrt{\frac{2(M+m)\ell}{m\mu g}}$

25. The position of end A when the man reaches the end B is

(A) $x_0-\frac{m\ell}{M+m}$

(B) $x_0+\frac{m\ell}{M+m}$

(C) $x_0-\frac{M\ell}{M+m}$

(D) $x_0-\frac{m\ell}{M}$

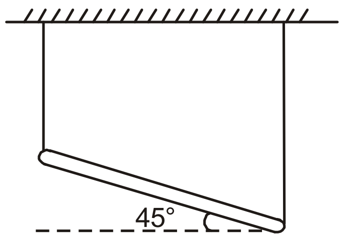
26. The displacement of man is

(A) $\frac{M\ell}{M+m}\hat{i}$ (B) $\frac{m\ell}{M+m}\hat{i}$

(C) $-\frac{m\ell}{M+m}\hat{i}$ (D) $-\frac{m\ell}{M}\hat{i}$

Paragraph for Question Nos. 27 to 29

A uniform rod of mass m and length ℓ, is supported at its ends by two vertical strings of unequal length as shown in diagram. Now the right string is burnt. Immediately after burning the string



27. The acceleration of centre of the rod is

(A) g/2 (B) g

(C) 2g/5 (D) 3g/5

28. The tension in the left string is

(A) $\frac{3}{5}mg$ (B) $\frac{2}{5}mg$

(C) mg (D) mg/2

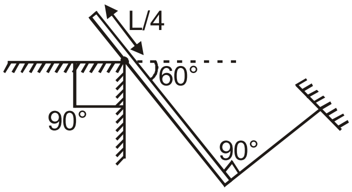
29. The acceleration of lowest point of left string is

(A) $\frac{2}{5}g$ (B) $\frac{3}{5}g$

(C) $\frac{g}{5}$ (D) $\frac{\sqrt{2}}{5}g$

Paragraph for Question Nos. 30 to 32

A uniform rod of mass m and length L lying in vertical plane is in equilibrium as shown in diagram. The rod is making an angle of 60° with the horizontal and the string is perpendicular to the length of the rod at equilibrium.



30. The tension in the string is

(A) $\frac{mg}{4}$ (B) $\frac{mg}{6}$

(C) $\frac{3mg}{4}$ (D) None of these

31. The friction force acting on the rod is

(A) $\frac{mg}{2}$ (B) $\frac{mg}{4}$

(C) $\frac{\sqrt{3}}{2}mg$ (D) Zero

32. Just after the string is cut, the normal reaction on the rod is (Assume that rod does not slip or leave contact with corner just when the string is cut)

(A) 2 mg (B) $\frac{3}{7}mg$

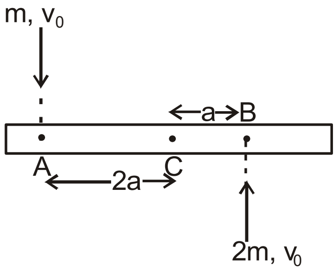
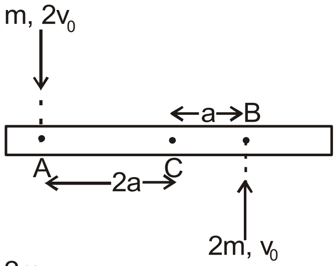
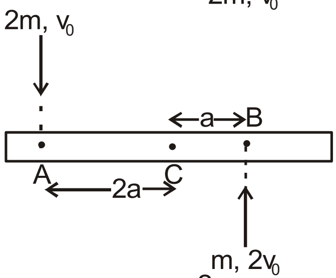
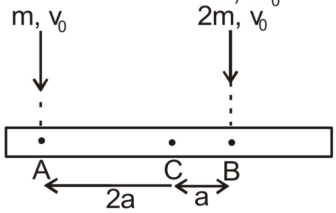
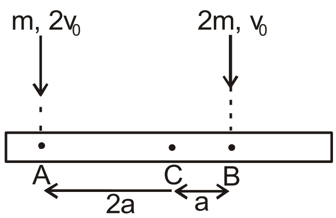
(C) $\frac{2mg}{7}$ (D) None of these

SECTION-D

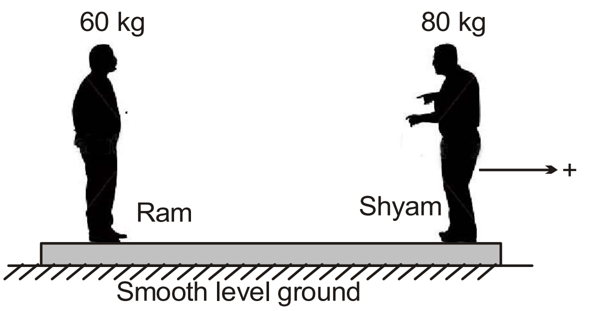
Matrix-Match Type

This **Section D** have "match the following" type question. Question contains two columns, **Col-I** and **Col-II**. Match the entries in **Col-I** with the entries in **Col-II**. One or more entries in **Col-I** may match with one or more entries in **Col-II**.

33. A rod of mass 6m and length 6a is kept at horizontal smooth surface. Two point masses of masses 2m and m respectively moving perpendicular to the rod, collide with the rod and stick to the rod after collision as shown in the column - II. Point C represent centre of mass of the rod. AC = 2a and CB = a. v is the linear speed of the centre of mass of the system just after collision and ω is the angular speed of the system just after collision

Column I	**Column II**
(A) $v = 0$	(p) 
(B) $\omega = 0$	(q) 
(C) $v \neq 0$	(r) 
(D) $\omega \neq 0$	(s) 
	(t) 

34. Two men of mass 60 kg and 80 kg stand on plank of mass 20 kg. Both of them can jump with a velocity of 1 m/s relative to the plank. In each event shown in **Column-I**, match the velocity of plank after the event, given in **Column II**



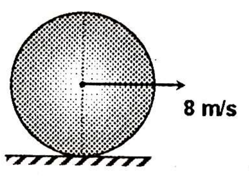
Column I	Column II
(A) Ram alone jumps to the left	(p) $\frac{-17}{40}$ m/s
(B) Shyam alone jumps to the right	(q) $-\frac{1}{2}$ m/s
(C) Ram jumps to left and shyam jumps to right simultaneously	(r) $\frac{3}{8}$ m/s
(D) Ram jumps to left and after that shyam jumps to right	(s) $-\frac{1}{8}$ m/s

SECTION-E

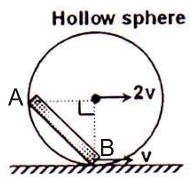
Integer Answer Type

This section contains Integer type questions. The answer to each of the questions is an integer.

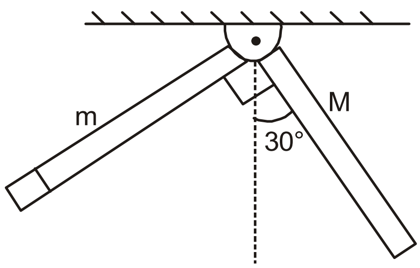
35. A 10 kg solid sphere of radius r = 0.8 m is rolling without slipping on a horizontal rough surface with 8 m/s. The force applied by the right half of the sphere on the left half is 30x Newton. Find the value of x.



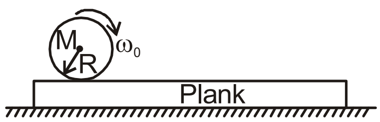
36. A uniform rod AB of mass M and length $\sqrt{2}$ R is moving in a vertical plane inside a hollow sphere of radius R. The sphere is rolling on a fixed horizontal surface without slipping with velocity of its centre of mass 2v. When the end B is at the lowest position, its speed is found to be v as shown in the figure. If the kinetic energy of the rod at this instant is $\frac{4}{K}Mv^2$. Find K.



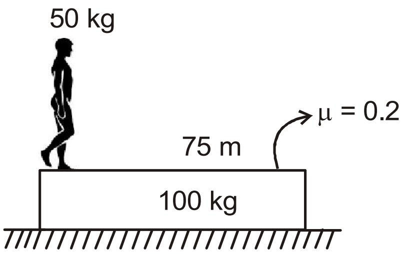
37. Two uniform rods of equal lengths but different masses are rigidly joined to form an L-shaped body, which is then pivoted as shown. In equilibrium, the body is in the shown configuration and $\frac{M}{m} = x^{1/4}$. Find x



38. A uniform solid spherical ball of mass M and radius R is given an angular velocity ω_0 in clockwise direction and placed gently on a thin plank of same mass M. The friction coefficient between plank and ground is zero and between plank and ball is sufficient for pure rolling in steady state . The kinetic energy of the ball in joule after long time is 13 K. Then find the value of K [Assume plank is sufficiently long and M = 4.05 kg, R=1m, ω_0 = 10 rad/s]



39. A man of mass 50 kg is standing on one end of a stationary wooden plank resting on a frictionless surface. The mass of the plank is 100 kg, its length is 75 m and the coefficient of friction between the man and the plank is 0.2. The least possible time (in sec) is 5x in which the man can reach the other end starting from rest and stopping at the other end. Find x



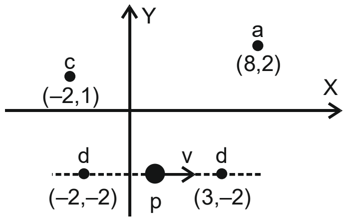
❑ ❑ ❑

SECTION - A

Straight Objective Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

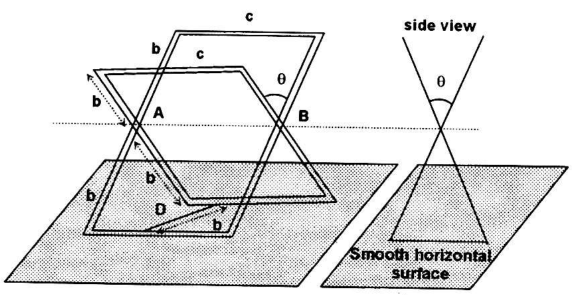
1. Figure shows a particle P moving with constant velocity v along the positive x axis and four points a, b, c and d with their x and y coordinates. If L_1, L_2, L_3 and L_4 are the magnitudes of angular momentum of the particle about the points a, b, c and d respectively, then which of the following is incorrect



(A) $L_1 > L_3$ (B) $L_2 = L_4$

(C) $L_1 = L_3$ (D) $L_1 > L_2$

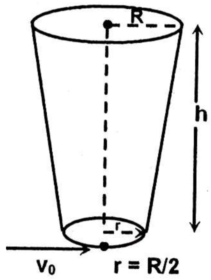
2. The two identical rectangular steel frames with the dimensions shown are fabricated from a bar of the same material and are hinged at the midpoints A and B of their sides (3m × 1m). If the frame is resting in the position shown on a horizontal surface with negligible friction, determine the velocity v with which each of the upper ends of the frame hits the horizontal surface if the cord D is cut. (Take the value of dimensions shown in figure c = 1 m, b = 3/2 m and θ = 74° i.e., $\sin\frac{\theta}{2} = \frac{3}{5}$ and $\cos\frac{\theta}{2} = \frac{4}{5}$ and g = 10 m/s^2)



(A) 5 m/s (B) 8 m/s

(C) 3 m/s (D) 4 m/s

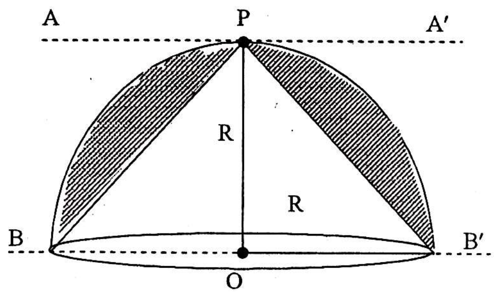
3. A smooth glass tumbler lies on rough ground. A small particle of mass m lies on the bottom surface touching circumference as shown in the figure. Find the minimum value of V_0 (along the circumference) such that particle just reaches at the top of glass. Assume no sliding between tumbler and ground.



(A) $\sqrt{2gh}$ (B) $\frac{2}{3}\sqrt{2gh}$

(C) $\sqrt{gh}$ (D) $2\sqrt{\frac{2gh}{3}}$

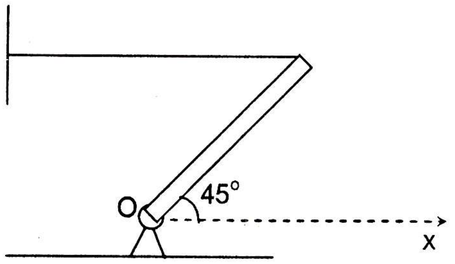
4. From a solid hemisphere of radius 'R' a cone of base radius 'R' and height 'R' is removed as shown in the figure. The moment of inertia of the remaining body about an axis BB′ in the plane of the base and passing through the centre 'O' is I_0. I_1 is the moment of inertia about AA′ which is parallel to BB′ and I_2 is moment of inertia about an axis perpendicular to BB′ passing through O, then



(A) $I_1 = I_0$ (B) $I_2 = 2I_0$

(C) $I_1 = I_0/2$ (D) $I_2 = 3I_0$

5. A uniform rod of mass M is hinged about hinge O and its other end is tied with a string. The string is horizontal and whole system is in equilibrium. The rod makes an angle of 45° with horizontal.



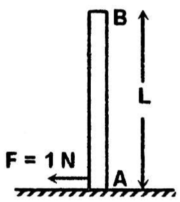
(A) The horizontal and the vertical component of the hinge reaction are equal to $N_x = Mg/2$; $N_Y = Mg/2$

(B) The horizontal and the vertical component of the hinge reaction are equal to $N_x = Mg$; $N_Y = Mg$

(C) If the string is cut, then the value of N_X and N_Y immediately after cutting the string is equal to $N_X = 3Mg/8$; $N_Y = 5Mg/8$

(D) If the string is cut, then the value of N_X and N_Y immediately after cutting the string is equal to $N_X = 3Mg/8$; $N_Y = Mg$

6. A uniform smooth rod of mass m = 1 kg and length L is balanced in the vertical position when a horizontal force F is applied at end A. Then the acceleration of top point B is



(A) 2 m/s^2 to right (B) 1 m/s^2 to left
(C) 1 m/s^2 to right (D) 0.5 m/s^2 to left

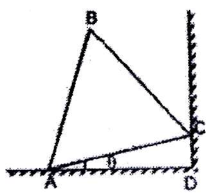
7. A thin uniform equilateral triangular plate rests in a vertical plane with one of its ends (A) on a rough horizontal floor and the other end (C) on a smooth vertical wall. The least angle its base (AC) can make with horizontal will be

(A) $\theta = \cot^{-1}\left(2\mu + \frac{1}{\sqrt{3}}\right)$

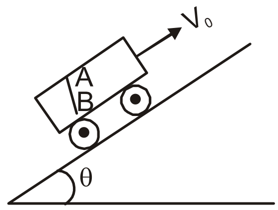
(B) $\theta = \tan^{-1}\left(2\mu + \frac{1}{\sqrt{3}}\right)$

(C) $\theta = \tan^{-1}\left(2\mu + \frac{1}{2\sqrt{3}}\right)$

(D) $\theta = \cot^{-1}\left(2\mu + \frac{1}{2\sqrt{3}}\right)$



8. A uniform rod AB of length l and mass m hangs from point a in a car moving with velocity v_0 on an inclined plane as shown in Figure. The rod can rotate in vertical plane about the axis at point A. If the car suddenly stops, the angular speed with which the rod starts rotating is



(A) $\frac{3}{2}\frac{v_0}{l}\cos\theta$

(B) $\frac{v_0}{2}\frac{\cos\theta}{l}$

(C) $\frac{3}{2}\frac{v_0}{l}\sin\theta$

(D) $\frac{5}{2}\frac{v_0}{l}\sin\theta$

9. Two particles approach each other with different velocities. After collision, one of them is found to have momentum $\bar{p}$ in their centre of mass frame. In the same reference frame, the other particle must have momentum

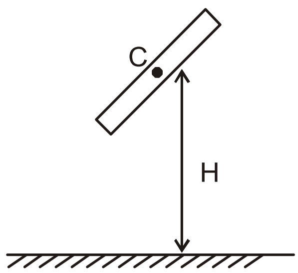
(A) Zero

(B) $\frac{\bar{p}}{2}$

(C) $-\bar{p}$

(D) $-2\bar{p}$

10. A rod of mass M is dropped on a horizontal smooth surface from the position shown (the centre of mass C is at height H above the surface). It collides elastically with surface. After collision with the surface the centre of mass of rod rises to a maximum height H_0. Then:



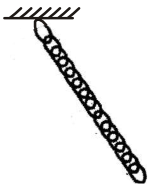
(A) $H_0 = H$

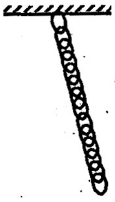
(B) $H_0 > H$

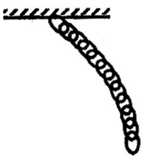
(C) $H_0 < H$

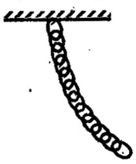
(D) None of these

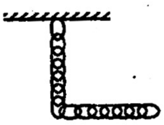
11. One end of a chain attached to ceiling and released from rest from the position given in the figure. In subsequent motion the shape of chain can be best represented by (assume no friction anywhere)



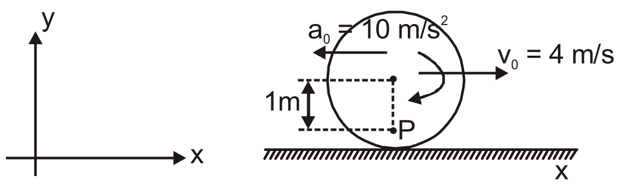
(A) 

(B) 

(C) 

(D) 

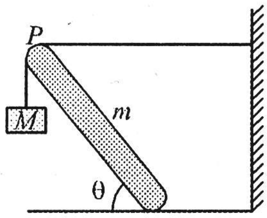
12. A solid sphere of radius 2m rolls without slipping on horizontal surface under the action of some external force. Centre of mass has velocity v_0 = 4 m/s and acceleration 10 m/s^2 as shown in figure. Then acceleration of point P is



(A) $5\hat{i}-4\hat{j}$ (B) $-5\hat{i}+4\hat{j}$

(C) $10\hat{i}+4\hat{j}$ (D) $10\hat{i}-4\hat{j}$

13. A uniform beam of mass m is inclined at angle θ to the horizontal. Its upper end produces a ninety degree bend in a very rough massless rope tied to a wall and its lower end rests on a rough floor. If coefficient of static friction between beam and floor is μ_s, determine the maximum value of M that can be suspended from the top before the beam slips



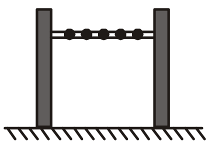
(A) $\frac{m}{2}\frac{(\mu_s \sin\theta)}{(\cos\theta-\mu_s\sin\theta)}$

(B) $\frac{m}{2}\frac{(2\mu_s \sin\theta-\cos\theta)}{(\cos\theta-\mu_s\sin\theta)}$

(C) $\frac{m}{4}\frac{(\mu_s \sin\theta)}{(2\cos\theta-\mu_s\sin\theta)}$

(D) $\frac{m}{2}\frac{(\mu_s \sin\theta)}{(2\cos\theta-\mu_s\cos\theta)}$

14. Five identical balls each of mass m and radius r are placed like beads at random and at rest along a smooth, rigid, horizontal, thin rod of length L, mounted between immovable supports. Assume 10r < L and that the collision between balls or between balls and supports are elastic. If one ball is struck horizontally so as to acquire a speed v, the average force felt by the support is



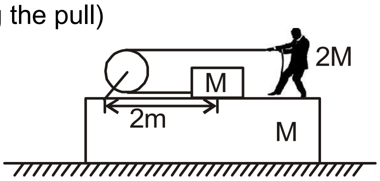
(A) $\frac{5mv^2}{L-5r}$

(B) $\frac{mv^2}{L-10r}$

(C) $\frac{5mv^2}{L-10r}$

(D) $\frac{mv^2}{L-5r}$

15. A block of mass M is tied to one end of a massless rope. The other end of the rope is in the hands of a man of mass 2M as shown in the figure. The block and the man are resting on a rough plank of mass M as shown in the figure. The whole system is resting on a smooth horizontal surface. The man pulls the rope. Pulley is massless and frictionless. What is the displacement of the plank when the block meets the pulley? (Man does not leave his position on plank during the pull)



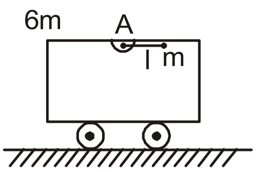
(A) 0.5 m

(B) 1 m

(C) Zero

(D) $\frac{2m}{3}$

16. In the figure shown the cart of mass 6 m is initially at rest. A particle of mass m is attached to the end of the light rod of length l which can rotate freely about A. If the rod is released from rest in a horizontal position shown, determine the velocity v_{rel} of the particle with respect to the cart when the rod is vertical. Assume frictionless surface.



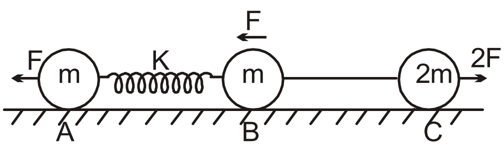
(A) $\sqrt{\frac{7}{3}gl}$

(B) $\sqrt{\frac{7}{6}gl}$

(C) $\sqrt{\frac{14}{3}gl}$

(D) $\sqrt{\frac{8}{3}gl}$

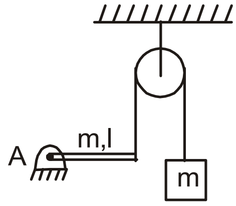
17. Three masses are connected with a spring and a string (both ideal) as shown. They are initially at rest, with spring at its natural length and string with zero slack and zero tension. Find the maximum extension in the spring after the forces start acting as shown (friction is absent)



(A) F/K (B) 2F/K

(C) F/2K (D) 4F/K

18. Uniform rod AB is hinged at end A in horizontal position as shown in the figure. The other end is connected to a block through a massless string m as shown. The pulley is smooth and massless. Masses of block and rod is same and is equal to m. Then acceleration of block just after release from this position is



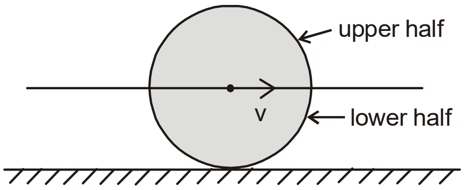
(A) $\frac{6g}{13}$

(B) $\frac{g}{4}$

(C) $\frac{3g}{8}$

(D) $\frac{5g}{8}$

19. Consider a uniform disc of mass 'm' performing pure rolling with velocity 'v' on a fixed rough surface



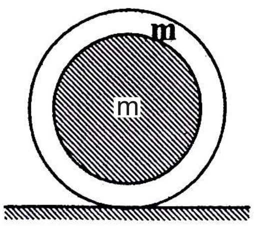
(A) Kinetic energy of upper half will be $\frac{3}{8}mv^2$

(B) Kinetic energy of upper half will be less than $\frac{3}{8}mv^2$

(C) Kinetic energy of upper half will be more than $\frac{3}{8}mv^2$ but not more than $\frac{3}{4}mv^2$

(D) Kinetic energy of upper half will be more than $\frac{3}{4}mv^2$

20. A thin uniform hollow sphere of mass m is completely filled with an ideal non viscous liquid of mass m. When the sphere rolls without slipping with a velocity v, then kinetic energy of the system is equal to



(A) $\frac{1}{2}mv^2$

(B) mv^2

(C) $\frac{4}{3}mv^2$

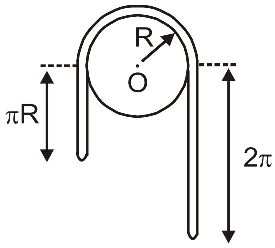
(D) $\frac{4}{5}mv^2$

SECTION - B

Multiple Correct Answer Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

21. Consider a rope of mass 4m and length $4\pi R$ on a fixed rough pulley of radius R as shown in the figure. The rope is in equilibrium as the pulley is held at rest. Length of vertical hanging parts is shown in the figure



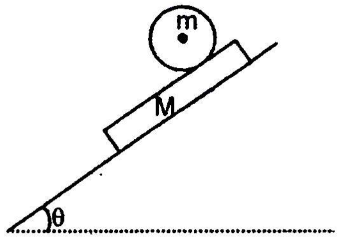
(A) Torque of normal force between rope and pulley on pulley about O is zero

(B) Torque of tension force about O on pulley is 4mgR

(C) Torque of friction force between rope and pulley on pulley about O is mgR

(D) Torque of friction force between rope and pulley on pulley about O is zero

22. A solid sphere of mass m is released on the plank of mass M which lies on an inclined plane of inclination θ as shown in figure. There is sufficient frictional force between sphere and plank and let the minimum value of co-efficient of friction between plank and surfaces be μ to keep the plank at rest. Then



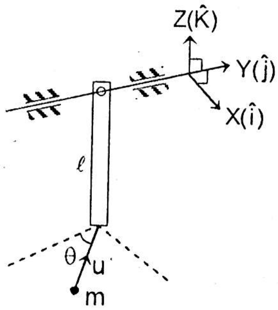
(A) Frictional force between sphere and plank is $\frac{2}{7}$ mg sin θ, when plank is at rest

(B) The value of μ is $\frac{7M+2m}{7(M+m)}$ tan θ

(C) If there is no friction between the plank and inclined plane, then acceleration of plank is less than g sin θ

(D) If there is no friction between plank and inclined plane, then friction force on the sphere is zero

23. A particle of mass m moving in XY horizontal plane strikes the end of the vertical thin rod at an angle 37° with Y-axis. Rod has mass m and length ℓ and it is free to rotate about hinge along Y-axis. If particle strikes rod with speed u and sticks to it, find the correct choices



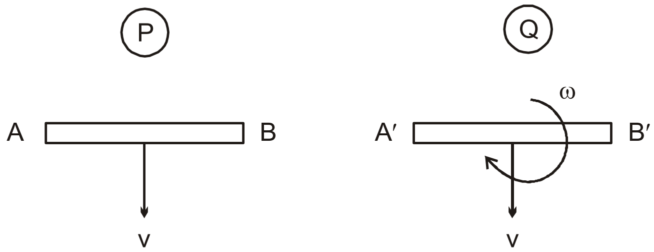
(A) Velocity of particle just after impact will be $-\frac{4u\hat{i}}{5}+\frac{9u\hat{j}}{5}$

(B) Velocity of particle just after impact will be $-\frac{9u\hat{i}}{20}$

(C) Minimum speed of particle so that rod completes full rotation about hinge is $\frac{5}{2}\sqrt{2gl}$

(D) Angular momentum of system during collision is conserved about Y-axis

24. Two identical uniform rods P and Q move with the same velocity v as shown in the figure. The second rod has an angular velocity ω (<6v/l) clockwise along with linear velocity v.



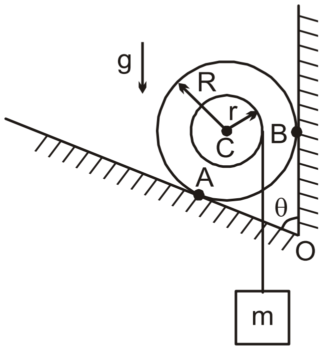
(A) If the ends A and A′ are suddenly brought to rest simultaneously, the rod Q will rotate with lesser angular velocity

(B) If the ends A and A′ are suddenly brought to rest simultaneously, the rod Q will rotate with greater angular velocity

(C) If the ends B and B′ are suddenly brought to rest simultaneously both rods will rotate with same angular velocity

(D) If the ends B and B′ are suddenly brought to rest simultaneously, the rod P will rotate with greater angular velocity

25. A massless spool of inner radius r, outer radius R is placed against vertical wall and tilted split floor as shown. A light inextensible thread is tightly wound around the spool through which a mass m is hanging. There exists no friction at point A, while the coefficient of friction between spool and point B is μ. The angle between two surfaces is θ.



The system is in equilibrium. Then

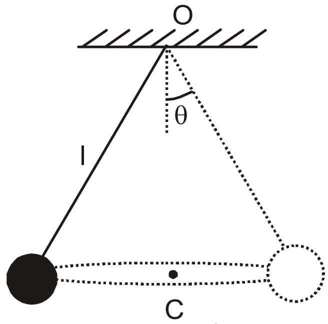
(A) The magnitude of force on the spool at B is $mg\sqrt{\left(\frac{r}{R}\right)^2+\left(1-\frac{r}{R}\right)^2\frac{1}{\tan^2\theta}}$

(B) The magnitude of force on the spool at B is $mg\left(1-\frac{r}{R}\right)\frac{1}{\tan\theta}$

(C) The minimum value of μ should be $\frac{\cot\theta}{(R/r)-1}$

(D) The minimum value of μ should be $\frac{\tan\theta}{(R/r)-1}$

26. A particle of mass m is suspended from point O which undergoes circular motion in horizontal plane as conical pendulum as shown in figure



(A) Angular momentum of particle about point of suspension does not remains constant

(B) Angular momentum of particle about centre of circle remains constant

(C) Average force on the particle during half rotation is $\frac{2mg\tan\theta}{\pi}$

(D) Average torque about axis OC during half rotation is zero

SECTION - C

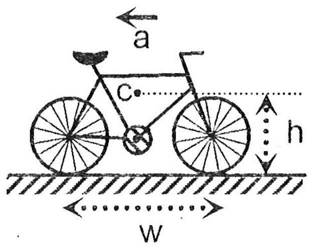
Linked Comprehension Type

This section contains paragraphs. Based upon these paragraphs, some multiple choice questions have to be answered. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE OR MORE** is/are correct.

Paragraph for Question Nos. 27 and 28

A simplified model of a bicycle of mass M has two tires such that each comes into contact with the ground at a point. The wheel base of this bicycle (the distance between the points of contact with the ground) is w, and the centre of mass C of the bicycle is located midway between the tires and a height h above the ground. The bicycle is moving to the right, but slowing down at a constant rate. The acceleration has a magnitude a. Air resistance may be ignored.

Assuming that the coefficient of sliding friction between each tire and the ground is μ and that both tires are skidding (sliding without rotating). Express your answer in terms of w, h, M and g.



27. What is the maximum value of a so that both tires remain in contact with the ground ?

(A) $\frac{wg}{h}$

(B) $\frac{wg}{2h}$

(C) $\frac{hg}{w}$

(D) $\frac{hg}{2w}$

28. What is the maximum value of μ so that both tires remain in contact with the ground ?

(A) w/2h

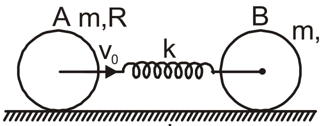
(B) h/2w

(C) 2h/w

(D) w/h

Paragraph for Question Nos. 29 and 30

Two identical discs A and B of mass m and radius R each are placed on the rough horizontal surface. Their centres are connected with a light spring of spring constant k. Initially spring is in its natural length and discs are at rest. Now centre of disc A is given velocity v_0 in the horizontal direction as shown in the figure. There is suffiicient friction between discs and ground to prevent the slipping at all instants.



29. Find the maximum compression of the spring.

(A) $\frac{v_0}{2}\sqrt{\frac{m}{k}}$ (B) $\frac{v_0}{2}\sqrt{\frac{m}{3k}}$

(C) $\frac{v_0}{2}\sqrt{\frac{3m}{k}}$ (D) $\frac{v_0}{2}\sqrt{\frac{3m}{2k}}$

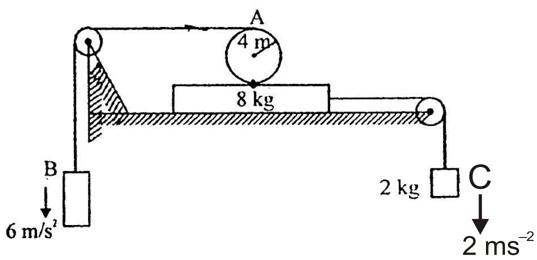
30. Find the angular velocity of disc A at the instant of maximum compression in the spring.

(A) $\frac{v_0}{2R}$ (B) $\frac{v_0}{R}$

(C) $\frac{2v_0}{R}$ (D) $\frac{v_0}{4R}$

Paragraph for Question Nos. 31 and 32

The figure shows a uniform solid cylinder A of radius 4 m rolling without slipping on the 8 kg smooth plank which in turn is supported by a fixed smooth surface. Block B, is known to accelerate down with 6 m/s^2 and block C is going down with 2 m/s^2.



31. What is the angular acceleration of the cylinder ?

(A) $\frac{4}{5}$rads^{-2} (B) $\frac{6}{5}$rads^{-2}

(C) 2 rad s^{-2} (D) 1 rad s^{-2}

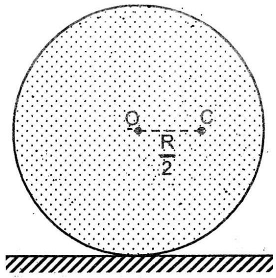
32. What is the ratio of the mass of the cylinder to the mass of block B ?

(A) 1 (B) 2

(C) 3 (D) 4

Paragraph for Question Nos. 33 to 35

A solid non uniform sphere of mass M and radius R is released on smooth horizontal surface from the situation shown in the figure. In given situation centre of mass (C) and geometric centre (O) are on same horizontal line. The distance OC is $\frac{R}{2}$. The moment of inertia about an axis passing through C and perpendicular to the plane of the paper is $I_0 = \frac{MR^2}{2}$. Acceleration of centre of mass is a and angular acceleration of the sphere is α



33. Just after release relation between a and α is

(A) $a = \alpha R$

(B) $a = 2\alpha R$

(C) $a = \sqrt{5}\,\frac{\alpha R}{2}$

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

34. At the moment of release, the acceleration of centre of mass is

(A) g/3 (B) 2g/3

(C) g/6 (D) 2g/4

35. At the moment when centre of mass is at the lowest point, angular velocity of the sphere is

(A) $\sqrt{\frac{g}{3R}}$

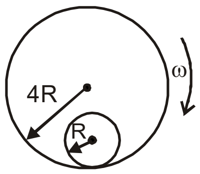
(B) $\sqrt{\frac{4g}{3R}}$

(C) $\sqrt{\frac{g}{2R}}$

(D) $\sqrt{\frac{2g}{R}}$

Paragraph for Question Nos. 36 to 38

In a gravity free space, a hollow cylinder of radius 4R and mass M is being rotated with a constant angular velocity ω clockwise with respect to an inertial frame of reference. Another hollow cylinder of radius R and mass m is rotating inside this cylinder, such that it touches the inner surface of larger cylinder without slipping and its centre of mass appears stationary from inertial frame Dynamic friction coefficient between cylinders is μ. If the normal reaction between cylinders is denoted by N, answer the following questions.



36. What is the angular velocity of smaller cylinder ?

(A) $\omega/3$ (B) 3ω

(C) 4ω (D) $3\omega/4$

37. What is the value of N ?

(A) $m(4R)\omega^2$ (B) $m(R)(4\omega)^2$

(C) $m(3R)\left(\frac{3}{4}\omega\right)^2$ (D) Zero

38. A small tangential velocity v is given to the smaller cylinder towards right. What will be N, once the steady state is achieved ?

(A) $m\frac{v^2}{16R}$

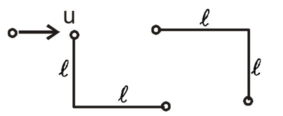
(B) $m\frac{v^2}{12R}$

(C) $m\frac{(3R.(3\omega/4)+v)^2}{3R}$

(D) Zero

Paragraph for Question Nos. 39 to 41

Read the paragraph carefully and answer the following questions :



fig(a) fig(b)

A spherical ball of mass M moving with initial velocity u collides elastically with another ball of mass M which is at an end of a L shaped rigid massless frame as shown in the figure. The L shaped frame contains another mass M connected at other end

39. The speed of striking mass after collision is

(A) u/7 backwards

(B) u/3 is same direction

(C) Zero

(D) u/2 backwards

40. The angular speed of L frame immediately after collision is

(A) $\frac{u}{7L}$ (B) $\frac{4u}{2L}$

(C) $\frac{u}{3L}$ (D) $\frac{4u}{7L}$

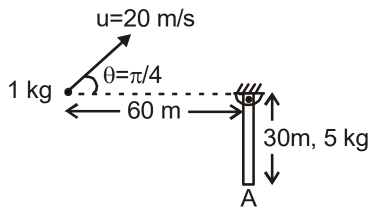
41. How soon will the frame come to the orientation shown in the figure(b) after collision ?

(A) $\frac{7\pi L}{4u}$ (B) $\frac{\pi L}{2u}$

(C) $\frac{7\pi L}{8u}$ (D) $\frac{\pi L}{u}$

Paragraph for Question Nos. 42 to 44

Read the paragraph carefully and answer the following questions :



A particle of mass 1 kg is projected at an angle of $\theta = \pi/4$ from horizontal with a muzzle velocity of 20 m/s. A long slender rod of mass 5 kg and length 30 m is suspended vertically from a point at the same horizontal level as that of point of projection and at a distance of 60 m from the projection point. The rod can rotate freely. When collision occurs, the particle sticks to the rod. ($g = 10\ m/s^2$)

42. Angular velocity of rod after collision is

(A) $\frac{1}{4\sqrt{2}}$ rad/sec (B) $\frac{4}{\sqrt{2}}$ rad/sec

(C) $4\sqrt{2}$ rad/sec (D) Zero

43. The particle strikes the rod at an angle α with the horizontal where α is

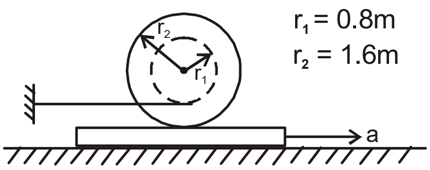
(A) $\tan^{-1}(2)$ (B) $\tan^{-1}(3)$

(C) $\tan^{-1}(4)$ (D) $\tan^{-1}(5)$

44. If the rod tilts to an angle θ after collision, then
(A) $\theta = 0°$ (B) $\theta = \cos^{-1}(40/42)$
(C) $\theta = \cos^{-1}(41/42)$ (D) $\theta = \cos^{-1}(27/28)$

Paragraph for Question Nos. 45 to 47

A spool of mass 500 kg has a radius of gyration 1.3 m. It rests on the surface of a horizontal plank with coefficient of static friction 0.5 and coefficient of kinetic friction 0.4 which is kept on a smooth floor. If the plank starts accelerating at a rate of 1 m/s^2, (No slipping between the string and spool.)



$r_1 = 0.8$m
$r_2 = 1.6$m

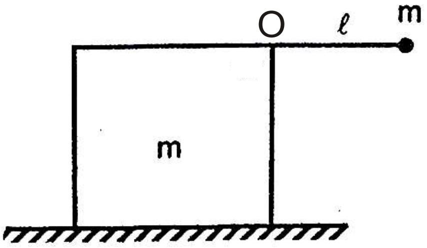
45. The initial tension in the string is
(A) 0.32 kN (B) 2.32 kN
(C) 3.32 kN (D) 0.66 kN

46. The angular acceleration of spool is
(A) 2.25 rad/sec^2 (B) 4.25 rad/sec^2
(C) 1.25 rad/sec^2 (D) 0.625 rad/sec^2

47. The frictional force between the plank and spool is
(A) 1.82 kN (B) 2.45 kN
(C) 0.82 kN (D) 0.66 kN

Paragraph for Question Nos 48 and 49

A particle of mass m is connected to a block of same mass by an ideal string of length l. The block is free to slide on the smooth horizontal surface. Size of the block is large enough so, that it doesn't topple and particle doesn't hit on the ground. Now the particle is released from the horizontal position of the string as shown in the figure. Answer the following two questions



48. Speed of the block as function of θ (where θ is the angle made by the string with downward vertical) will be

(A) $\sqrt{\dfrac{gl\cos\theta}{1+\tan^2\theta}}$ (B) $\sqrt{\dfrac{2gl\cos\theta}{1+\tan^2\theta}}$

(C) $\sqrt{\dfrac{gl\cos\theta}{1+2\tan^2\theta}}$ (D) $\sqrt{\dfrac{gl\cos\theta}{2+\tan^2\theta}}$

49. Normal reaction exerted by ground on the wedge as a function θ, (where θ is the angle made by the string with downward vertical) will be

(A) $mg\cos\theta\left(\dfrac{5+\sin^2\theta}{\left(1+\sin^2\theta\right)^2}\right)$

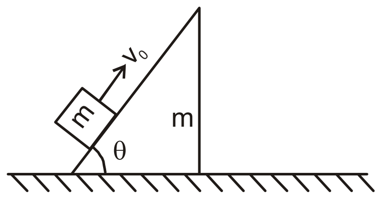
(B) $mg\left(1+\dfrac{\cos^2\theta\left(5+\sin^2\theta\right)}{(1+\sin^2\theta)^2}\right)$

(C) $mg\cos\theta\left(\dfrac{\left(5+\sin^2\theta\right)}{1+\sin^2\theta}\right)$

(D) $mg\cos\theta\left(1+\dfrac{\cos^2\theta\left(3+\sin^2\theta\right)}{\left(1+\sin^2\theta\right)^2}\right)$

Paragraph for Question Nos. 50 to 52

Ram is preparing for IIT JEE. He sets on to tackle a typical problem in mechanics. He sees that the wedge is kept on a smooth ground and it's inclined surface is also smooth. A block is projected on it as shown. Both the block and wedge have equal mass. Can you help him find the answer to following three questions?



50. He sets on to find the maximum height attained by the block, assuming the block does not fall off to the other side. Which of the following equations is correct?

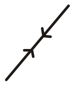
(A) $mgh = \frac{1}{2}mv_0^2$ (by conservation of energy) where h is maximum height of the block
(B) $0^2 = v^2 - 2g\sin\theta \times s$ where s is maximum displacement along the inclined surface
(C) $mv_0 = mv + mv$ (by conservation of momentum) and $\frac{1}{2}mv_0^2 = \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + mgh$
(D) None of these

51. How does the path of block look like as seen from ground ?

(A) 

(B) 

(C) 

(D) 

52. What is the radius of curvature of it's path at the highest point as observed from ground ?

(A) $\frac{v_0^2 \cos^2\theta}{2g}$

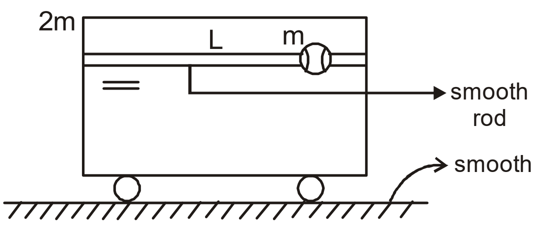
(B) $\frac{v_0^2 \cos^2\theta}{g\left(\sin\theta\cos\theta + \sin^2\theta\right)}$

(C) $\frac{v_0^2 \cos^2\theta}{2g\left(1+\sin^2\theta\right)}$

(D) $\frac{v_0^2 \cos^2\theta}{4g}$

Paragraph for Question Nos. 53 and 54

A horizontal frictionless rod is threaded through a bead of mass m. The rod is fixed between two opposite vertical sides of a cart of mass 2m. The length of the rod is L and the size of the bead is very small in comparison to L. Initially the bead is at the right end of the cart. The cart is given an impulse which imparts velocity V_0 to it. Consider all collisions between the bead and the cart walls as perfectly elastic



53. Find the velocity of the centre of mass of the cart and the bead system after first collision between them

(A) $\frac{v_0}{2}$

(B) $\frac{v_0}{3}$

(C) $\frac{2v_0}{3}$

(D) None of these

54. The duration between the first and second collision between the bead and the cart walls is

(A) $\frac{L}{2v_0}$

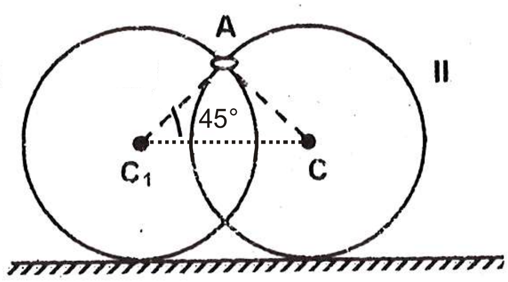
(B) $\frac{L}{v_0}$

(C) $\frac{L}{3v_0}$

(D) $\frac{4L}{3v_0}$

Paragraph for Question Nos. 55 to 57

A ring A of mass 100 gm connecting freely two identical thin loops of mass 200 gm each, starts sliding down from point A at t = 0. The loops move apart over a sufficiently rough horizontal surface so as to prevent slipping. [Neglect the friction between the ring and the loops and take g = 10 m/s^2]



55. The normal force acting on the each loop, exerted by horizontal surface at t = 0 is

(A) 20/9 N

(B) 22/9 N

(C) $\frac{\sqrt{2}}{9}$N

(D) $\frac{2\sqrt{2}}{9}$N

56. The friction force acting on the second loop at t = 0 is

(A) 10/9 N

(B) 22/9 N

(C) $\frac{\sqrt{2}}{9}$N

(D) $\frac{2}{9}$N

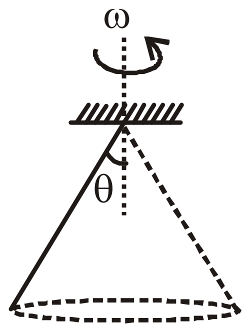
57. The acceleration of ring at t = 0 is

(A) 10/9 m/s^2 (B) 20/9 m/s^2

(C) 10/3 m/s^2 (D) 20/3 m/s^2

Paragraph for Question Nos. 58 to 60

A rod of mass m and length ℓ is rotating about a fixed point on the ceiling. Its angular velocity is ω with respect to vertical axis as shown in the figure. The rod maintains a constant angle θ with the vertical.



58. What will be the horizontal component of angular momemtum of the rod about the point of suspension in terms of m, ω, ℓ and θ ?

(A) $\frac{m\omega L^2}{3}\cos\theta$

(B) $\frac{m\omega L^2}{3}\sin\theta$

(C) $\frac{m\omega L^2}{6}\sin 2\theta$

(D) $\frac{m\omega L^2}{3}\sin\theta$

59. What is the rate of change of angular momentum of the rod with respect to the point of suspension ?

(A) $\frac{m\omega^2\ell^2\sin\theta}{6}$

(B) $\frac{m\omega^2\ell^2\sin 2\theta}{6}$

(C) $\frac{m\omega^2\ell^2\sin^2\theta}{6}$

(D) $\frac{m\omega^2\ell^2\cos^2\theta}{6}$

60. What angle will the rod make with the vertical ?

(A) $\cos^{-1}\left(\frac{g}{\omega^2\ell}\right)$

(B) $\cos^{-1}\left(\frac{2g}{3\omega^2\ell}\right)$

(C) $\cos^{-1}\left(\frac{3g}{2\omega^2\ell}\right)$

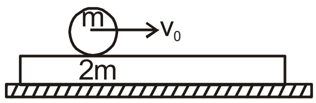
(D) $\cos^{-1}\left(\frac{3g}{4\omega^2\ell}\right)$

SECTION-D

Matrix-Match Type

This **Section D** have "match the following" type question. Question contains two columns, **Col-I** and **Col-II**. Match the entries in **Col-I** with the entries in **Col-II**. One or more entries in **Col-I** may match with one or more entries in **Col-II**.

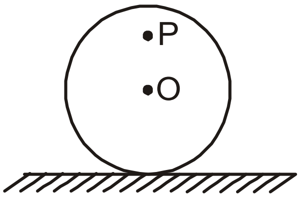
61. A thin but very long plank of mass 2m is placed on a horizontal smooth surface. A solid cylinder of mass m and radius r is given only translation velocity v_0 and gently placed on the plank as shown in the figure. The coefficient of kinetic friction between the plank and the cylinder is μ.



Match the statements from List I with those in List II and select the correct answer.

List-I	List-II
(A) Final kinetic energy of the plank	(p) $\frac{14mv_0^2}{98}$
(B) Final kinetic energy of the cylinder	(q) $\frac{mv_0^2}{49}$
(C) Magnitude of work done by kinetic friction till the cylinder starts rolling	(r) $\frac{24mv_0^2}{98}$
(D) Final kinetic energy of the cylinder with respect to plank	(s) $\frac{33mv_0^2}{98}$

62. A uniform disc rolls without slipping on a rough horizontal surface with uniform angular velocity. Point O is the centre of disc and P is a point on disc as shown. Match the statements in Column-I with the results in Column-II.



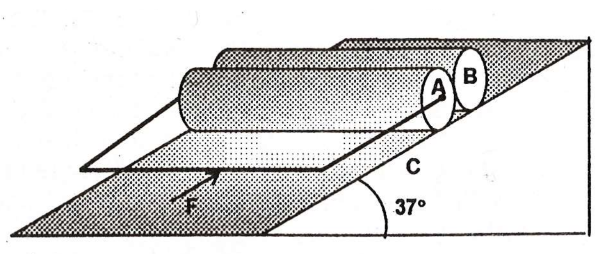
	Column I		**Column II**
(A)	The velocity of point P on disc	(P)	Changes in magnitude with time
(B)	The acceleration of point P on disc	(Q)	Is always directed from that point (the point on disc given in column-I) towards centre of disc
(C)	The tangential acceleration of point P	(R)	is always zero
(D)	The acceleration of point on disc which is in contact with rough horizontal surface	(S)	is non-zero and remains constant in magnitude

SECTION-E

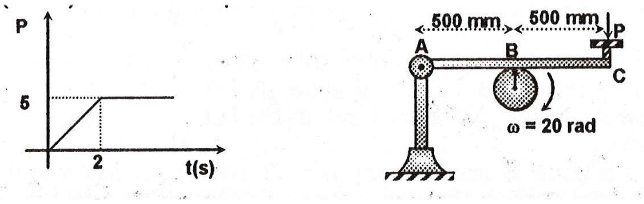
Integer Answer Type

This section contains Integer type questions. The answer to each of the questions is an integer.

63. A minimum force F needed to push the two 50 kg cylinders up the incline is 200x Newton. The force acts parallel to the plane and the coefficients of friction at contacting surfaces are as μ_A = 0.3 between cylinder A and ground, μ_B = 0.25 between cylinder B and ground and μ_C = 0, between two cylinders. The cylinder A can rotate about its axis without friction. Find the value of x.

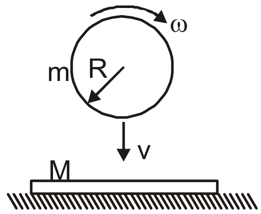


64. A 12 kg disc with fixed centre has an angular velocity of ω = 20 rad/s and radius 200 mm rotating in a frictionless horizontal plane. If the brake ABC is applied such that the magnitude of force P varies with time as shown, determine the time (in sec) needed to stop the disc. The coefficient of friction at B is μ = 0.4.

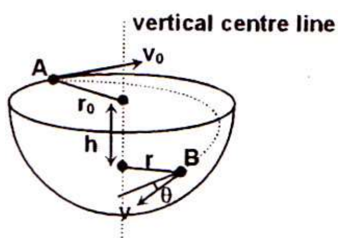


65. A uniform circular disc of radius R is placed on a frictionless horizontal plane. Another identical disc rotating with angular velocity ω is gently placed on top of the first disc. If the time in which both the disc acquire the same angular velocity is $\frac{3R\omega}{n\mu g}$ where coefficient of friction between the discs is μ. Find the value of n.

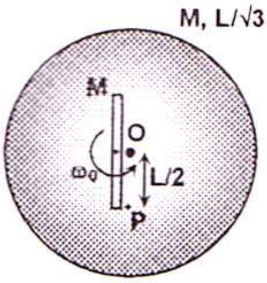
66. A solid ball of mass m and radius R spinning with angular velocity ω falls on horizontal slab of mass M with rough upper surface (coefficient of friction μ) and smooth lower surface. Immediately after collision normal component of velocity of the ball remains half of its value just before collision and it stops spinning. Find the velocity (in m/s) of the sphere in horizontal direction immediately after impact (Given: $R\omega$ = 5 m/s)



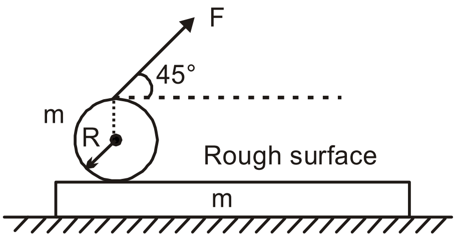
67. A small particle is given an initial velocity v_o = 10 m/s along the tangent to the brim of a fixed smooth hemispherical bowl of radius $r_o = 15\sqrt{2}$ m as shown in the figure. The particle slides on the inner surface and reaches point B, a vertical distance h = 15 m below A and a distance r from the vertical centerline, where its velocity v makes an angle θ with the horizontal tangent to the bowl through B. If $\theta°$ = (15° K) find the value of K (take g = 10 m/s^2)



68. A smooth disc of mass M and radius $\frac{L}{\sqrt{3}}$ is placed at rest horizontally on a smooth horizontal surface. A massless pin is fixed at point P at a distance L/2 from centre O of the disc as shown in the figure. Now a thin uniform rod of mass M and length L is placed horizontally on the surface of the disc parallel to the line OP such that its mid point and centre O of the disc just coincide as shown in figure. Now rod has given angular velocity ω_0 = 24 rad/sec in counter clockwise direction as shown. As a result, the end of the rod strikes the pin P and sticks to it rigidly. Calculate the angular velocity of disc in rad/sec just after collision.

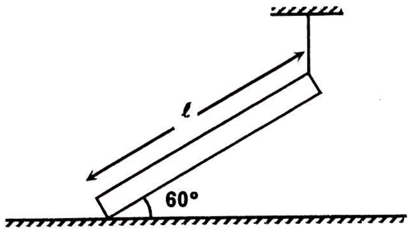


69. A plank of mass m is placed on a smooth surface. Now, a uniform solid sphere of equal mass m and radius R is placed on the plank as shown in the figure. A force F is applied at topmost point of the sphere at an angle of 45° to the horizontal. Surface between the plank and the sphere is extremely rough so that there is no slipping between the plank and the sphere. The force of friction acting between the plank and the sphere is $\frac{F}{k\sqrt{2}}$. Find the value of k.

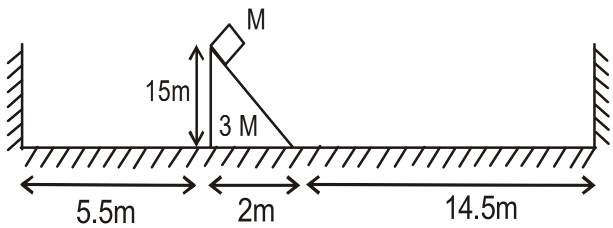


70. Two particles of different masses projected from a tower with same speed horizontally but in opposite direction. One particle of mass 3 kg follows a path $y = \frac{x^2}{20}$ and C.O.M. of the system also follows a path $y = \frac{5}{4}x^2$ in the same direction as 3 kg particle. Then find the mass of the others particle (in kg).

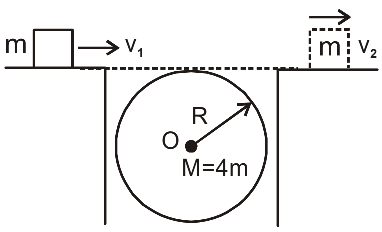
71. A uniform thin rod has mass m and length ℓ. One end of the rod lies over rough horizontal surface and other end is connected to a vertical string, as shown in the figure. When string is cut, there is no slipping between rod and surface. Calculate the friction on the rod immediately after the string is cut. $\left(\text{given } mg = \frac{16}{\sqrt{3}}\right)$



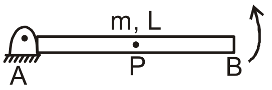
72. A block of mass M is placed on a smooth wedge of mass 3M. The wedge is placed on a smooth horizontal surface, and is free to move on that surface. This arrangement is between two rigid walls separated by 22m. The height of the wedge and other distances at time t = 0 are as mentioned in the figure. Assume that the transition of block at the bottom of the wedge is smooth, and all collisions are perfectly elastic. If the block M is released from the top of the wedge, find it's time period in seconds if block takes 2 seconds to slide down completely on the wedge.



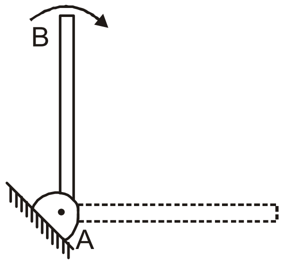
73. A uniform disc of mass 4m, and radius R, is free to rotate about a horizontal axis passing through O as shown in figure. A block of mass m initially moving with speed v_1 = 24 m/s on a frictionless surface, passes over the disc, making contact with the disc. At the instant the block makes contact with the disc, it slips. But, due to friction, the slipping stops, before the mass loses contact, with the disc. Find the velocity v_2 (in m/s) of the mass(m), in the dotted position. (The disc is initially at rest)



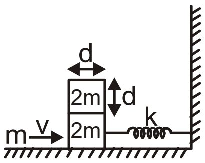
74. A uniform thin rod AB of length L and mass m is undergoing rotation about its fixed end A as shown in figure. The kinetic energy of section AP of rod is equal to kinetic energy to section BP of rod at an instant. Then the value of $\left(\frac{AB}{AP}\right)^3$ is (AB and AP are lengths of respective parts of rod)



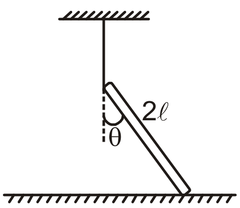
75. A uniform slender bar AB of mass m and length L supported by a frictionless pivot at A is released from rest at its vertical position as shown in the figure. If the reaction at the pivot acts at an angle $\alpha = \tan^{-1}\left(\frac{1}{x}\right)$ (with horizontal), when the rod just becomes horizontal, find x



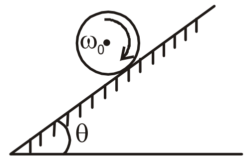
76. A block is placed over another identical block as shown. If a particle of mass m strikes the lower block along the line of their centre of mass elastically while moving horizontally then find minimum value of v(in m/s)such that upper block will topple over lower block. Initially spring is in its natural length and there is no friction anywhere. (d=0.8 meter, k=50N/meter, m=250 gm)



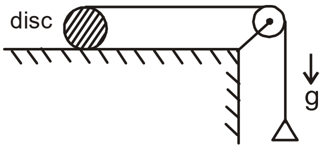
77. A uniform rod of length 2ℓ and mass m is suspended from one end by inextensible string and other end lies on a smooth ground. The angle made by rod with vertical is $\theta = \sin^{-1}\left(1/\sqrt{3}\right)$. If N_1 and N_2 represents the contact force from ground on rod just before and just after cutting string, then find the ratio of N_1/N_2.



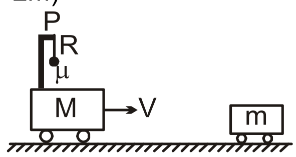
78. A solid sphere of mass m and radius R initially rotating about its centroidal axis with ω_0 is gently placed on rough inclined plane with its axis horizontal as shown in figure. The angle of inclination of plane is θ. The time after which sphere starts pure rolling is $t_0 = x\left(\frac{\omega_0 R}{g(7\mu\cos\theta - 2\sin\theta)}\right)$, find x. (Coefficient of friction = μ)]



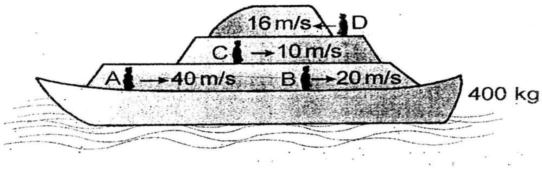
79. In the adjacent figure a light and thin string is wound on a uniform disc of mass m and radius r very tightly. The disc is kept at rest in vertical position on a rough horizontal surface and string passes over a fixed pulley. A light pan is attached to the free end of the string. The maximum mass that can be placed on the pan so that disc will not slip is equal to = mK/2. Find K. Coefficient of friction between the surface and the disc is 0.1 and there is no friction between string and pulley



80. A cart of mass M has a pole on it from which a ball of mass μ hangs from a thin string attached at point P. The cart and ball have initial velocity V. The cart crashes onto another cart of mass m and sticks to it. If the length of the string is R, the smallest initial velocity (in m/s) for which the ball can go in a full vertical circle around point P is 6x. Find x. (Neglect friction and assume M, m>>μ. Given m = 1kg, M=2kg, R=2m)



81. Figure shows a Yatch of mass 400 kg with three decks. When the engine of Yatch is off, four men A, B, C and D (m_A = 100 kg, m_B = 120 kg. m_C = 80 kg and m_D = 100 kg) started running on different decks with constant horizontal velocities relative to Yatch which are marked in figure. All the velocity vectors are collinear. Due to this, Yatch also started moving. What is the speed in m/s with which Yatch moves ?



❑ ❑ ❑

CPP-06
FS JEE(M) &
ADVANCED

ANSWERS

LEVEL-1

1. (A)	2. (D)	3. (A)	4. (D)	5. (C)	6. (B)
7. (B)	8. (C)	9. (D)	10. (B)	11. (D)	12. (D)
13.(B)	14. (C)	15. (C)	16. (B)	17. (A)	18. (A)
19.(A,B,C,D)	20. (C)	21. (B)	22. (B)	23. (A)	24. (B)
25.(A)	26. (A)	27. (D)	28. (B)	29. (B)	30. (B)
31.(C)	32. (C)	33. (A-q,r B-s C-p,s,t D-p,q,r,t)		34.(A-r, B-q ,C-s, D-p)	
35.(5)	36. (3)	37. (9)	38. (2)	39. (2)	

LEVEL-2

1. (C)	2. (B)	3. (D)	4. (A)	5. (C)	6. (A)
7. (A)	8. (A)	9. (C)	10. (C)	11. (C)	12. (B)
13. (B)	14. (B)	15. (A)	16. (A)	17. (B)	18. (C)
19. (C)	20. (C)	21. (A,C)	22. (A,B,D)	23. (B,D)	24. (B,D)
25. (A,D)	26.(A,B,C,D)	27. (B)	28. (A)	29. (C)	30. (A)
31. (D)	32. (B)	33. (D)	34. (A)	35. (D)	36. (C)
37. (D)	38. (B)	39. (A)	40. (D)	41. (A)	42. (A)
43. (A)	44. (D)	45. (B)	46. (C)	47. (A)	48. (C)
49. (B)	50. (D)	51. (A)	52. (D)	53. (C)	54. (B)
55. (B)	56. (D)	57 (A)	58. (C)	59. (B)	60. (C)
61. (A-q, B-s ,C-p, D-r)		62.(A-P B-Q,S C-P D-Q,S)		63. (3)	64. (7)
65. (8)	66. (2)	67. (3)	68. (8)	69. (3)	70. (2)
71. (3)	72. (6)	73. (8)	74. (2)	75. (6)	76. (6)
77. (1)	78 (2)	79. (3)	80. (5)	81. (7)	

❑ ❑ ❑