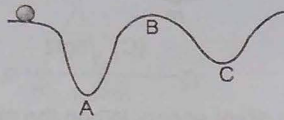


- 8.25 A uniform rod of mass  $m$  and length  $\ell$  is rotating with constant angular velocity  $\omega$  about an axis which passes through its one end and perpendicular to the length of rod. The area of cross section of the rod is  $A$  and its Young's modulus is  $Y$ . Neglect gravity. The strain at the mid point of the rod is :

(A)  $\frac{m\omega^2 \ell}{8AY}$       (B)  $\frac{3m\omega^2 \ell}{8AY}$       (C)  $\frac{3m\omega^2 \ell}{4AY}$       (D)  $\frac{m\omega^2 \ell}{4AY}$

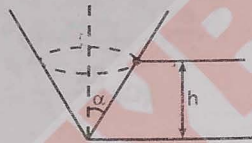
- 8.26 A body moves along an uneven surface with constant speed at all points. The normal reaction of the road on the body is:



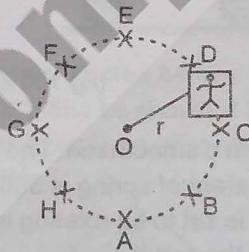
- (A) maximum at A      (B) maximum at B      (C) minimum at C      (D) the same at A, B & C

### SECTION - II : MULTIPLE CORRECT ANSWER TYPE

- 8.27 A particle is describing circular motion in a horizontal plane in contact with the smooth inside surface of a fixed right circular cone with its axis vertical and vertex down. The height of the plane of motion above the vertex is  $h$  and the semivertical angle of the cone is  $\alpha$ . The period of revolution of the particle:



- (A) increases as  $h$  increases      (B) decreases as  $h$  increases  
(C) increases as  $\alpha$  increases      (D) decreases as  $\alpha$  increases
- 8.28 A machine, in an amusement park, consists of a cage at the end of one arm, hinged at  $O$ . The cage revolves along a vertical circle of radius  $r$  (ABCDEFGH) about its hinge  $O$ , at constant linear speed  $v = \sqrt{gr}$ . The cage is so attached that the man of weight ' $w$ ' standing on a weighing machine, inside the cage, is always vertical. Then which of the following is/are correct



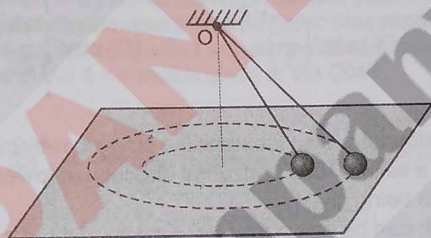
- (A) the weight reading at A is greater than the weight reading at E by  $2w$ .  
(B) the weight reading at G =  $w$   
(C) the ratio of the weight reading at E to that at A = 0  
(D) the ratio of the weight reading at A to that at C = 2.
- 8.29 A small sphere of mass  $m$  suspended by a thread is first taken aside so that the thread forms the right angle with the vertical and then released, then :
- (A) total acceleration of sphere as a function of  $\theta$  is  $g\sqrt{1+3\cos^2\theta}$   
(B) thread tension as a function of  $\theta$  is  $T = 3mg \cos \theta$   
(C) the angle  $\theta$  between the thread and the vertical at the moment when the total acceleration vector of the sphere is directed horizontally is  $\cos^{-1} 1/\sqrt{3}$   
(D) thread tension at the moment when the vertical component of the sphere's velocity is maximum will be  $mg$

- 8.30 On a circular table, A and B are moving on the circumference. Man A runs behind man B to catch him. A runs with constant angular speed  $\omega_1$  with respect to table and B runs at constant tangential speed  $v_2$  with respect to ground. If it is found that the table rotates  $30^\circ$  in the opposite direction in every one second and the initial angular separation between A and B is  $30^\circ$ , then A catches B after : (Radius of table is 3 m).

- (A) 0.5 sec, if  $\omega_1 = \frac{5\pi}{6}$  rad/s and  $v_2 = 3.14$  m/s  
 (B) 0.5 sec, if  $\omega_1 = \frac{4\pi}{3}$  rad/s and  $v_2 = 3.14$  m/s  
 (C) 0.5 sec, if  $\omega_1 = \frac{4\pi}{3}$  rad/s and  $v_2 = 6.28$  m/s  
 (D) A can not catch B within 0.5 s, if  $\omega_1 = \frac{\pi}{6}$  rad/s and  $v_2 = 6.28$  m/s

### SECTION - III : ASSERTION AND REASON TYPE

- 8.31 **Statement-1** : Two small spheres are suspended from same point O on roof with strings of different lengths. Both spheres move along horizontal circles as shown. Then both spheres may move along circles in same horizontal plane.



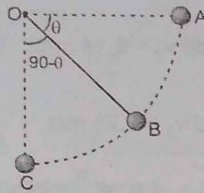
**Statement-2** : For both spheres in statement-1 to move in circular paths in same horizontal plane, their angular speeds must be same.

- (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.  
 (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1  
 (C) Statement-1 is True, Statement-2 is False  
 (D) Statement-1 is False, Statement-2 is True
- 8.32 **Statement-1** : A ball tied by thread is undergoing circular motion (of radius R) in a vertical plane. (Thread always remains in vertical plane). The difference of maximum and minimum tension in thread is independent of speed (u) of ball at the lowest position ( $u > \sqrt{5gR}$ )
- Statement-2** : For a ball of mass m tied by thread undergoing vertical circular motion (of radius R), difference in maximum and minimum magnitude of centripetal acceleration of the ball is independent of speed (u) of ball at the lowest position ( $u > \sqrt{5gR}$ ).
- (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.  
 (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1  
 (C) Statement-1 is True, Statement-2 is False  
 (D) Statement-1 is False, Statement-2 is True

**SECTION - IV : COMPREHENSION TYPE**

**Comprehension # 1**

One end of a light string of length  $L$  is connected to a ball and the other end is connected to a fixed point  $O$ . The ball is released from rest at  $t = 0$  with string horizontal and just taut. The ball then moves in vertical circular path as shown. The time taken by ball to go from position  $A$  to  $B$  is  $t_1$  and from  $B$  to lowest position  $C$  is  $t_2$ . Let the velocity of ball at  $B$  is  $\vec{v}_B$  and at  $C$  is  $\vec{v}_C$  respectively.



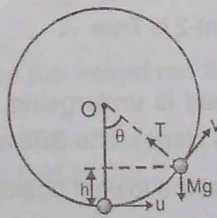
- 8.33 If  $|\vec{v}_C| = 2|\vec{v}_B|$  then the value of  $\theta$  as shown is  
 (A)  $\cos^{-1} \frac{1}{4}$  (B)  $\sin^{-1} \frac{1}{4}$  (C)  $\cos^{-1} \frac{1}{2}$  (D)  $\sin^{-1} \frac{1}{2}$
- 8.34 If  $|\vec{v}_C| = 2|\vec{v}_B|$  then :  
 (A)  $t_1 > t_2$  (B)  $t_1 < t_2$  (C)  $t_1 = t_2$  (D) Information insufficient
- 8.35 If  $|\vec{v}_C - \vec{v}_B| = |\vec{v}_B|$ , then the value of  $\theta$  as shown is :  
 (A)  $\cos^{-1} \left(\frac{1}{4}\right)^{1/3}$  (B)  $\sin^{-1} \left(\frac{1}{4}\right)^{1/3}$  (C)  $\cos^{-1} \left(\frac{1}{2}\right)^{1/3}$  (D)  $\sin^{-1} \left(\frac{1}{2}\right)^{1/3}$

**Comprehension # 2**

A particle of mass  $M$  attached to an inextensible string is moving in a vertical circle of radius  $R$  about fixed point  $O$ . It is imparted a velocity  $u$  in horizontal direction at lowest position as shown in figure.

Following information is being given :

- (i) Velocity at a height  $h$  can be calculated by using formula  $v^2 = u^2 - 2gh$ .
- (ii) Particle will complete the circle if  $u \geq \sqrt{5gR}$ ,
- (iii) Particle will oscillates in lower half ( $0^\circ < \theta \leq 90^\circ$ ) if  $0 < u \leq \sqrt{2gR}$
- (iv) The magnitude of tension at a height 'h' is calculated by using formula  $T = \frac{M}{R} \{u^2 + gR - 3gh\}$ .



- 8.36 If  $R = 2m$ ,  $M = 2$  kg and  $u = 12$  m/s. Then value of tension at lowest position is :  
 (A) 120 N (B) 164 N (C) 264 N (D) zero
- 8.37 Tension at highest point of its trajectory in above question will be :  
 (A) 100 N (B) 44 N (C) 144 N (D) 264 N
- 8.38 If  $M = 2$  kg,  $R = 2m$  and  $u = 10$  m/s the velocity of particle when  $\theta = 60^\circ$ ,  
 (A)  $2\sqrt{5}$  m/s (B)  $4\sqrt{5}$  m/s (C)  $5\sqrt{2}$  m/s (D) 5 m/s

**SECTION - V :**

- 8.39 In column describe Column  
 (A)  $\vec{u} \times \vec{F}$   
 (B)  $\vec{u} \cdot \vec{F}$   
 (C)  $\vec{v} \cdot \vec{F}$  and the  
 (D)  $\vec{u} =$
- 8.40 A parti given i Column  
 (A) M  
 (B) M  
 (C) M  
 wi  
 (D) V  
 ac  
 o
- 8.41 Each ang resu by d  
 (A)

## SECTION - V : MATRIX - MATCH TYPE

- 8.39 In column-I condition on velocity, force and acceleration of a particle is given. Resultant motion is described in column-II.  $\vec{u}$  = initial velocity,  $\vec{F}$  = resultant force and  $\vec{v}$  = instantaneous velocity.

Column-I

- (A)  $\vec{u} \times \vec{F} = 0$  and  $\vec{F} = \text{constant}$   
 (B)  $\vec{u} \cdot \vec{F} = 0$  and  $\vec{F} = \text{constant}$   
 (C)  $\vec{v} \cdot \vec{F} = 0$  all the time and  $|\vec{F}| = \text{constant}$  and the particle always remains in one plane.  
 (D)  $\vec{u} = 2\hat{i} - 3\hat{j}$  and acceleration at all time  $\vec{a} = 6\hat{i} - 9\hat{j}$

Column-II

- (p) path will be circular path  
 (q) speed will increase  
 (r) path will be straight line  
 (s) path will be parabolic  
 (t) Particle may retrace back

- 8.40 A particle is moving with speed  $v = 2t^2$  on the circumference of circle of radius R. Match the quantities given in column-I with corresponding results in column-II

Column-I

- (A) Magnitude of tangential acceleration of particle  
 (B) Magnitude of Centripetal acceleration of particle  
 (C) Magnitude of angular speed of particle with respect to centre of circle  
 (D) Value of  $\tan \theta$ , where  $\theta$  is angle between the total acceleration vector and centripetal acceleration vector of particle

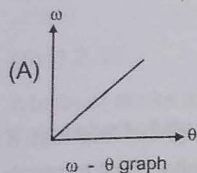
Column-II

- (p) decreases with time.  
 (q) increases with time  
 (r) remains constant

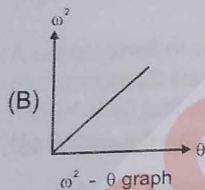
(s) proportional to R

(t) inversely proportional to R

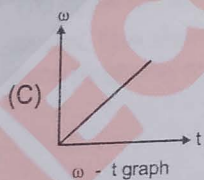
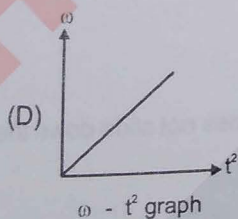
- 8.41 Each situation in column I gives graph of a particle moving in circular path. The variables  $\omega$ ,  $\theta$  and  $t$  represent angular speed (at any time  $t$ ), angular displacement (in time  $t$ ) and time respectively. Column II gives certain resulting interpretation. Match the graphs in column I with statements in column II and indicate your answer by darkening appropriate bubbles in the  $4 \times 4$  matrix given in the OMR.



(p) Angular acceleration of particle is uniform



(q) Angular acceleration of particle is non-uniform

(r) Angular acceleration of particle is directly proportional to  $t$ .(s) Angular acceleration of particle is directly proportional to  $\theta$ .

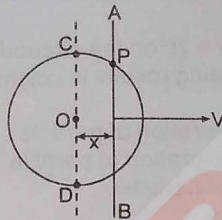
(t) Angular acceleration of particle is directly proportional to slope of the curve.

**SECTION - VI : INTEGER TYPE**

8.42 A ball is projected making an angle  $\theta$  with the vertical. Consider a small part of the trajectory near the highest position and take it approximately to be a circular arc. What is the radius of this circle? This radius is called the radius of curvature (ROC) of the curve at the point. if  $u = 20$  then ROC in m.

8.43 A rod AB is moving on a fixed circle of radius R with constant velocity 'v' as shown in figure. P is the point of intersection of the rod and the circle. At an instant the rod is at a distance  $x = \frac{3R}{5}$  from centre of the circle.

The velocity of the rod is perpendicular to the rod and the rod is always parallel to the diameter CD.



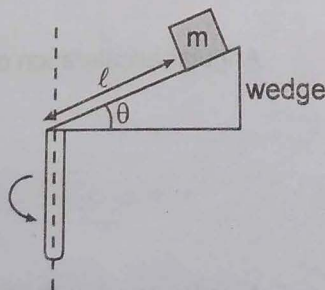
The speed of point of intersection P is  $\frac{xv}{4}$  m./sec. then x is

8.44 A toy car of mass m can travel at a fixed speed. It moves in a circle on a fixed horizontal table. A string is connected to car and attached to a block of mass  $M = 5m$  that hangs as shown in figure (the portion of string below the table is always vertical). The coefficient of friction between the surface of table and tyres of the toy car is  $\mu$ . The ratio of the maximum radius to the minimum radius for which the toy car

can move in a circular path with centre O on table is  $\frac{X}{4}$ , then X is :

8.45 A squirrel climbing up a cylindrical post spirally makes the circle in a vertical height of four feet. If the top of the post is sixteen feet high and three feet in circumference, the distance travelled by it to reach the top is x in feet. Find the value of  $\frac{x}{10}$ .

8.46 A small wedge whose base is horizontal is fixed to a vertical rod as shown in the figure.  $\theta = 45^\circ$ ,  $l = \frac{1}{5\sqrt{2}}$  m. The sloping side of the wedge is frictionless and the wedge is spun with a constant angular speed  $\omega$  about vertical axis as shown in the figure. Find



The value of angular speed  $\omega$  (rad/sec) for which the block of mass m just does not slide down the wedge?

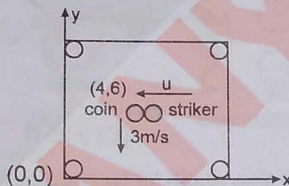
## TOPIC

## 9

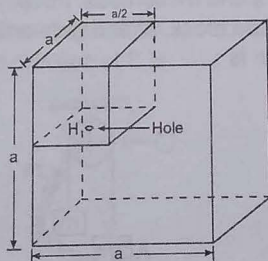
## CENTRE OF MASS

## SECTION - I : STRAIGHT OBJECTIVE TYPE

- 9.1 Two particles A and B start moving due to their mutual interaction only. If at any time 't',  $\vec{a}_A$  &  $\vec{a}_B$  are their respective accelerations,  $\vec{v}_A$  and  $\vec{v}_B$  are their respective velocities and upto that time  $W_A$  and  $W_B$  are the work done on A & B respectively by the mutual force,  $m_A$  and  $m_B$  are their masses respectively, then which of the following is always correct.
- (A)  $\vec{v}_A + \vec{v}_B = 0$       (B)  $m_A \vec{v}_A + m_B \vec{v}_B = 0$       (C)  $W_A + W_B = 0$       (D)  $\vec{a}_A + \vec{a}_B = 0$
- 9.2 On a smooth carom board, a coin moving in negative y-direction with a speed of 3 m/s is being hit at the point (4, 6) by a striker moving along negative x-axis. The line joining centres of the coin and the striker just before the collision is parallel to x-axis. After collision the coin goes into the hole located at the origin. Masses of the striker and the coin are equal. Considering the collision to be elastic, the initial and final speeds of the striker in m/s will be :



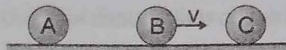
- (A) (1.2, 0)      (B) (2, 0)      (C) (3, 0)      (D) none of these
- 9.3 A train of mass  $M$  is moving on a circular track of radius ' $R$ ' with constant speed  $V$ . The length of the train is half of the perimeter of the track. The linear momentum of the train will be
- (A) 0      (B)  $\frac{2MV}{\pi}$       (C)  $MVR$       (D)  $MV$
- 9.4 A canon shell moving along a straight line bursts into two parts. Just after the burst one part moves with momentum 20 Ns making an angle  $30^\circ$  with the original line of motion. The minimum momentum of the other part of shell just after the burst is :
- (A) 0 Ns      (B) 5 Ns      (C) 10 Ns      (D) 17.32 Ns
- 9.5 The figure shows a hollow cube of side ' $a$ ' of volume  $V$ . There is a small chamber of volume  $\frac{V}{4}$  in the cube as shown. This chamber is completely filled by  $m$  kg of water. Water leaks through a hole  $H$ . Then the work done by gravity in this process assuming that the complete water finally lies at the bottom of the cube is :



- (A)  $\frac{1}{2} m g a$       (B)  $\frac{3}{8} m g a$       (C)  $\frac{5}{8} m g a$       (D)  $\frac{1}{8} m g a$

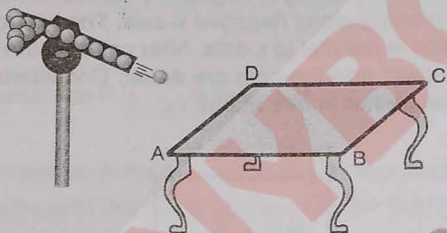
- 9.6 A balloon having mass 'm' is filled with gas and is held in hands of a boy. Then suddenly it get released and gas starts coming out of it with a constant rate. The velocities of the ejected gases is also constant 2 m/s with respect to the balloon. Find out the velocity of the balloon when the mass of gas is reduced to half. [Effect of atmosphere and gravity is neglected]  
 (A)  $\ln 2$  (B)  $2 \ln 4$  (C)  $2 \ln 2$  (D) none of these

- 9.7 Three balls A, B and C ( $m_A = m_C = 4 m_B$ ) are placed on a smooth horizontal surface. Ball B collides with ball C with an initial velocity  $v$  as shown in the figure. Total number of collisions between the balls will be : (All collisions are elastic)



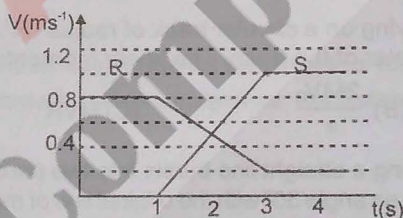
- (A) one (B) two (C) three (D) four

- 9.8 A gun is firing 20 balls per seconds of mass 20 gm each on the smooth horizontal table surface ABCD. If the collision is perfectly elastic and balls are striking at the centre of table with a speed 5 m/sec at an angle of  $60^\circ$  with the vertical just before collision, then force exerted by one of the leg on ground is (assume total weight of the table is 0.2 kg and  $g = 10 \text{ m/s}^2$ ) :



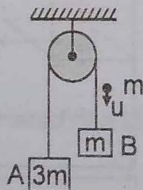
- (A) 0.5 N (B) 1 N (C) 0.25 N (D) 0.75 N

- 9.9 The diagram shows the velocity - time graph for two masses R and S that collided elastically. Which of the following statements is true?



- I. R and S moved in the same direction after the collision.  
 II. The velocities of R and S were equal at the mid time of the collision.  
 III. The mass of R was greater than mass of S.  
 (A) I only (B) II only (C) I and II only (D) I, II and III

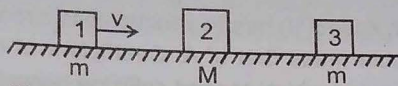
- 9.10 A system of two blocks A and B are connected by an inextensible massless string as shown in the figure . The pulley is massless and frictionless. Initially the system is at rest when, a bullet of mass 'm' moving with a velocity 'u' hits the block 'B' and gets embedded into it. The impulse imparted by tension force to the block of mass 3m is :



- (A)  $\frac{5mu}{4}$  (B)  $\frac{4mu}{5}$  (C)  $\frac{2mu}{5}$  (D)  $\frac{3mu}{5}$

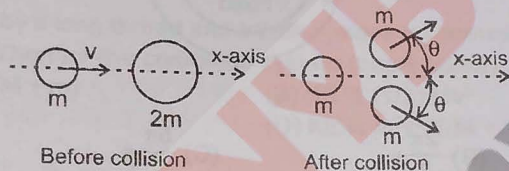
- 9.11 A stationary body explodes into four identical fragments such that three of them fly off mutually perpendicular to each other, each with same K.E.,  $E_0$ . The energy of explosion will be:  
 (A)  $6E_0$  (B)  $\frac{4E_0}{3}$  (C)  $4E_0$  (D)  $8E_0$

- 9.12 Three blocks are placed on smooth horizontal surface and lie on same horizontal straight line. Block 1 and block 3 have mass  $m$  each and block 2 has mass  $M$  ( $M > m$ ). Block 2 and block 3 are initially stationary, while block 1 is initially moving towards block 2 with speed  $v$  as shown. Assume that all collisions are head on and perfectly elastic. What value of  $\frac{M}{m}$  ensures that block 1 and block 3 have the same final speed?

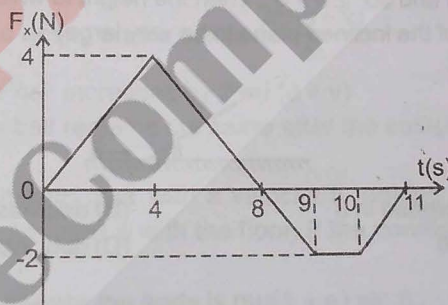


- (A)  $5 + \sqrt{2}$  (B)  $5 - \sqrt{2}$  (C)  $2 + \sqrt{5}$  (D)  $3 + \sqrt{5}$

- 9.13 A particle of mass  $m$  is moving along the  $x$ -axis with speed  $v$  when it collides with a particle of mass  $2m$  initially at rest. After the collision, the first particle has come to rest and the second particle has split into two equal-mass pieces that are shown in the figure. Which of the following statements correctly describes the speeds of the two pieces? ( $\theta > 0$ )

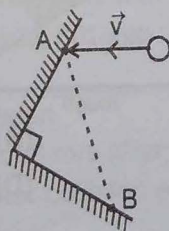


- (A) Each piece moves with speed  $v$ .  
 (B) Each piece moves with speed  $v/2$ .  
 (C) One of the pieces moves with speed  $v/2$ , the other moves with speed greater than  $v/2$ .  
 (D) Each piece moves with speed greater than  $v/2$ .



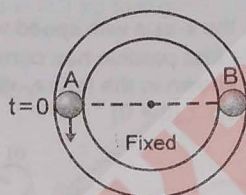
- (A)  $-i$  m/s (B)  $-1.5i$  m/s (C)  $6.5i$  m/s (D)  $13i$  m/s

- 9.15 AB is an L shaped obstacle fixed on a horizontal smooth table. A ball strikes it at A, gets deflected and strikes it at B. If the velocity vector before collision is  $\vec{v}$  and coefficient of restitution of each collision is 'e', then the velocity of ball after its second collision at B is



- (A)  $e^2\vec{v}$  (B)  $-e^2\vec{v}$  (C)  $-e\vec{v}$  (D) data insufficient

- 9.16 For a two-body system in absence of external forces, the kinetic energy as measured from ground frame is  $K_0$  and from center of mass frame is  $K_{cm}$ . Pick up the wrong statement
- (A) The kinetic energy as measured from center of mass frame is least
  - (B) Only the portion of energy  $K_{cm}$  can be transformed from one form to another due to internal changes in the system.
  - (C) The system always retains at least  $K_0 - K_{cm}$  amount of kinetic energy as measured from ground frame irrespective of any kind of internal changes in the system.
  - (D) The system always retains at least  $K_{cm}$  amount of kinetic energy as measured from ground frame irrespective of any kind of internal changes in the system
- 9.17 Particle 'A' moves with speed 10 m/s in a frictionless circular fixed horizontal pipe of radius 5 m and strikes with 'B' of double mass that of A. Coefficient of restitution is  $1/2$  and particle 'A' starts its journey at  $t = 0$ . The time at which second collision occurs is :



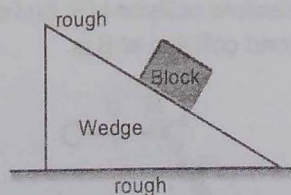
- (A)  $\frac{\pi}{2}$  s
- (B)  $\frac{2\pi}{3}$  s
- (C)  $\frac{5\pi}{2}$  s
- (D)  $4\pi$  s

- 9.18 A particle of mass  $m$  is given initial speed  $u$  as shown in the figure. It transfers to the fixed inclined plane without a jump, that is, its trajectory changes sharply from the horizontal line to the inclined line. All the surfaces are smooth and  $90^\circ \geq \theta > 0^\circ$ . Then the height to which the particle shall rise on the inclined plane (assume the length of the inclined plane to be very large)



- (A) increases with increase in  $\theta$
- (B) decreases with increase in  $\theta$
- (C) is independent of  $\theta$
- (D) data insufficient

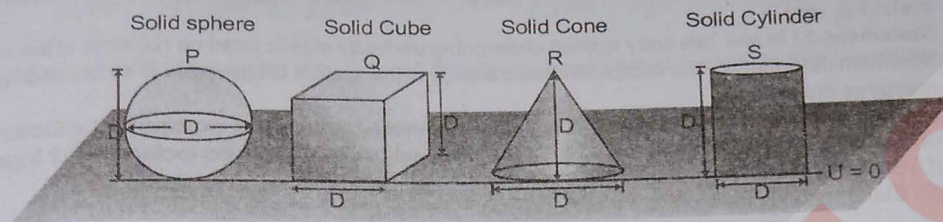
- 9.19 When a block is placed on a wedge as shown in the figure, the block starts sliding down and the wedge also start sliding on ground. All surfaces are rough. The centre of mass of (wedge + block) system will move



- (A) leftward and downward.
- (B) right ward and downward.
- (C) leftward and upwards.
- (D) only downward.

## SECTION - II : MULTIPLE CORRECT ANSWER TYPE

9.20 Assuming potential energy 'U' at ground level to be zero.



All objects are made up of same material.

$U_P$  = Potential energy of solid sphere

$U_Q$  = Potential energy of solid cube

$U_R$  = Potential energy of solid cone

$U_S$  = Potential energy of solid cylinder

(A)  $U_S > U_P$

(B)  $U_Q > U_S$

(C)  $U_P > U_Q$

(D)  $U_S > U_R$

9.21 A bag of mass  $M$  hangs by a long thread and a bullet (mass  $m$ ) comes horizontally with velocity  $v$  and gets caught in the bag. Then for the combined system (bag + bullet) :

(A) Momentum is  $mMv/(M+m)$

(B) KE is  $(1/2)Mv^2$

(C) Momentum is  $mv$

(D) KE is  $m^2v^2/2(M+m)$

9.22 A ball of mass  $m$  moving with a velocity  $v$  hits a massive wall of mass  $M$  ( $M \gg m$ ) moving towards the ball with a velocity  $u$ . An elastic impact lasts for a time  $\Delta t$ .

(A) The average elastic force acting on the ball is  $\frac{m(u+v)}{\Delta t}$

(B) The average elastic force acting on the ball is  $\frac{2m(u+v)}{\Delta t}$

(C) The kinetic energy of the ball increases by  $2mu(u+v)$

(D) The kinetic energy of the ball remains the same after the collision.

9.23 A particle strikes a horizontal smooth floor with a velocity  $u$  making an angle  $\theta$  with the floor and rebounds with velocity  $v$  making an angle  $\phi$  with the floor. If the coefficient of restitution between the particle and the floor is  $e$ , then :

(A) the impulse delivered by the floor to the body is  $mu(1+e)\sin\theta$ .

(B)  $\tan\phi = e\tan\theta$ .

(C)  $v = u\sqrt{1 - (1-e^2)\sin^2\theta}$ .

(D) the ratio of the final kinetic energy to the initial kinetic energy is  $(\cos^2\theta + e^2\sin^2\theta)$

9.24 A smooth sphere A of mass  $m$  collides elastically with an identical sphere B at rest. The velocity of A before collision is  $8\text{ m/s}$  in a direction making  $60^\circ$  with the line joining the centres at the time of impact. Which of the following is/are possible :

(A) the sphere A comes to rest after collision

(B) the sphere B will move with a speed of  $8\text{ m/s}$  after collision

(C) the directions of motion of A and B after collision are at right angles

(D) the speed of B after collision is  $4\text{ m/s}$ .

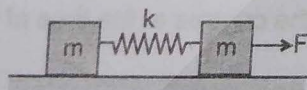
## SECTION - III : ASSERTION AND REASON TYPE

- 9.25 **Statement-1** : No external force acts on system of two spheres which undergo a perfectly elastic head on collision. The minimum kinetic energy of this system is zero if the net momentum of this system is zero.  
**Statement-2** : In any two body system undergoing perfectly elastic head on collision, at the instant of maximum deformation, the complete kinetic energy of the system is converted to deformation potential energy of the system.  
 (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1  
 (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1  
 (C) Statement-1 is True, Statement-2 is False  
 (D) Statement-1 is False, Statement-2 is True.
- 9.26 **Statement-1** : A sphere of mass  $m$  moving with speed  $u$  undergoes a perfectly elastic head on collision with another sphere of heavier mass  $M$  at rest ( $M > m$ ), then direction of velocity of sphere of mass  $m$  is reversed due to collision [no external force acts on system of two spheres]  
**Statement-2** : During a collision of spheres of unequal masses, the heavier exerts more force on lighter mass in comparison to the force which lighter mass exerts on heavier mass.  
 (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.  
 (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1  
 (C) Statement-1 is True, Statement-2 is False  
 (D) Statement-1 is False, Statement-2 is True
- 9.27 **Statement-1** : A rocket launched vertically upward explodes at the highest point it reaches. The explosion produces three fragments with non-zero initial velocity. Then the initial velocity vectors of all the three fragments are in one plane.  
**Statement-2** : For sum of momentum of three particles to be zero all the three momentum vectors must be coplanar.  
 (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.  
 (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1  
 (C) Statement-1 is True, Statement-2 is False  
 (D) Statement-1 is False, Statement-2 is True
- 9.28 **Statement-1** : Two spheres undergo a perfectly elastic collision. The kinetic energy of system of both spheres is always constant. [There is no external force on system of both spheres].  
**Statement-2** : If net external force on a system is zero, the velocity of centre of mass remains constant.  
 (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.  
 (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1  
 (C) Statement-1 is True, Statement-2 is False  
 (D) Statement-1 is False, Statement-2 is True

## SECTION - IV : COMPREHENSION TYPE

## Comprehension # 1

Two blocks of equal mass  $m$  are connected by an unstretched spring and the system is kept at rest on a frictionless horizontal surface. A constant force  $F$  is applied on the first block pulling it away from the other as shown in figure.



- 9.29 Then the displacement of the centre of mass at time  $t$  is :

- (A)  $\frac{Ft^2}{2m}$       (B)  $\frac{Ft^2}{3m}$       (C)  $\frac{Ft^2}{4m}$       (D)  $\frac{Ft^2}{m}$

9.30 If the extension of the spring is  $x_0$  at time  $t$ , then the displacement of the right block at this instant is :

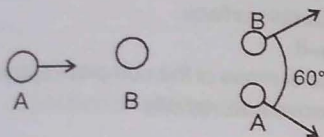
- (A)  $\frac{1}{2} \left( \frac{Ft^2}{2m} + x_0 \right)$  (B)  $-\frac{1}{2} \left( \frac{Ft^2}{2m} + x_0 \right)$  (C)  $\frac{1}{2} \left( \frac{Ft^2}{2m} - x_0 \right)$  (D)  $\left( \frac{Ft^2}{2m} + x_0 \right)$

9.31 If the extension of the spring is  $x_0$  at time  $t$ , then the displacement of the left block at this instant is :

- (A)  $\left( \frac{Ft^2}{2m} - x_0 \right)$  (B)  $\frac{1}{2} \left( \frac{Ft^2}{2m} + x_0 \right)$  (C)  $\frac{1}{2} \left( \frac{2Ft^2}{m} - x_0 \right)$  (D)  $\frac{1}{2} \left( \frac{Ft^2}{2m} - x_0 \right)$

### Comprehension # 2

A smooth ball 'A' moving with velocity 'V' collides with another smooth identical ball at rest. After collision both the balls move with same speed with angle between their velocities  $60^\circ$ . No external force acts on the system of balls.



9.32 The speed of each ball after the collision is

- (A)  $\frac{V}{2}$  (B)  $\frac{V}{3}$  (C)  $\frac{V}{\sqrt{3}}$  (D)  $\frac{2V}{\sqrt{3}}$

9.33 If the kinetic energy lost is fully converted to heat then heat produced is

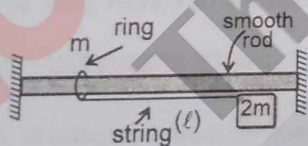
- (A)  $\frac{1}{3}mV^2$  (B)  $\frac{2}{3}mV^2$  (C) 0 (D)  $\frac{1}{6}mV^2$

9.34 The value of coefficient of restitution is

- (A) 1 (B)  $\frac{1}{3}$  (C)  $\frac{1}{\sqrt{3}}$  (D) 0

### Comprehension # 3

In given figure, the small block of mass  $2m$  is released from rest when the string is in horizontal position.



9.35 Displacement of the ring when string makes an angle  $\theta = 37^\circ$  with the vertical will be:

- (A)  $\frac{4l}{15}$  (B)  $\frac{l}{15}$  (C)  $\frac{2l}{15}$  (D) none of these

9.36 Maximum possible velocity of ring of mass 'm' is (Assuming zero friction):

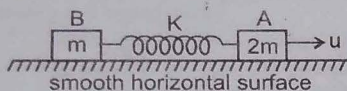
- (A)  $\sqrt{2gl}$  (B)  $\sqrt{\frac{4gl}{3}}$  (C)  $\sqrt{\frac{8gl}{3}}$  (D) none of these

9.37 Find the tension in the string when the block has maximum velocity.

- (A) 12 mg (B) 14 mg (C) 8 mg (D) 20 mg

**SECTION - V : MATRIX - MATCH TYPE**

**9.38** Two blocks A and B of mass  $m$  and  $2m$  respectively are connected by a massless spring of spring constant  $K$ . This system lies over a smooth horizontal surface. At  $t = 0$  the block A has velocity  $u$  towards right as shown while the speed of block B is zero, and the length of spring is equal to its natural length at that instant. In each situation of column I, certain statements are given and corresponding results are given in column II. Match the statements in column I with corresponding results in column II.



**Column I**

- (A) The velocity of block A
- (B) The velocity of block B
- (C) The kinetic energy of system of two blocks
- (D) The potential energy of spring

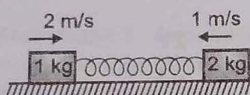
**Column II**

- (p) can never be zero
- (q) may be zero at certain instants of time
- (r) is minimum at maximum compression of spring
- (s) is maximum at maximum extension of spring

**9.39** In all cases in column-I, the blocks are placed on the smooth horizontal surface.

**Column-I**

- (A) The initial velocities given to the blocks when spring is relaxed are as shown (friction is absent)



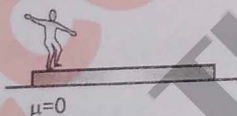
System (two blocks + spring)

- (B) A constant force is applied on 2 kg block. Springs are initially relaxed & friction is absent



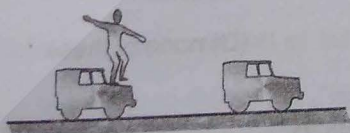
System (three blocks + two springs)

- (C) There is no friction between plank and ground and initially system is at rest. Man starts moving on a large plank with constant velocity.



System (man and plank)

- (D) Two trolleys are resting on a smooth horizontal surface and a man standing on one of the trolleys jumps to the other with relative velocity of 4 m/s



System (two trolleys + man)

**Column-II**

- (p) Centre of mass of the complete system shown will not move horizontally

- (q) Centre of mass of the complete system shown will move horizontally

- (r) Mechanical energy of the system will be conserved

- (s) Mechanical energy of the system will increase

**9.40** In column-II di friction is abse  
You have to on object A c  
Column-I

(A) Along the

(B) Perpen

(C) In hori

(D) In ver

(A)

(B)

(C)

(D)

**SECTION -**

**9.41** Block stick

9.40

In column-II different situations are shown in which one object collides with the another object. In each case friction is absent and neglect effect of non-impulsive forces. In column-I different direction are given. You have to match the directions for each case in which momentum conservation can be applied on object A or object B or system A & B. (Assume that objects do not bounce off the ground)

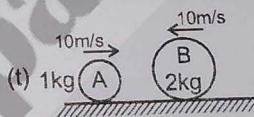
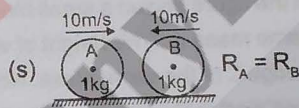
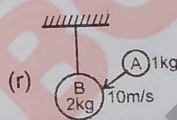
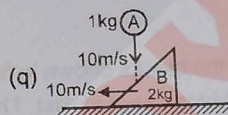
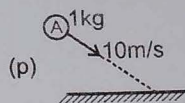
(A) Along the line of impact

(B) Perpendicular to line of impact

(C) In horizontal direction

(D) In vertical direction

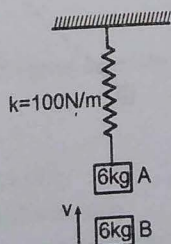
Column-II



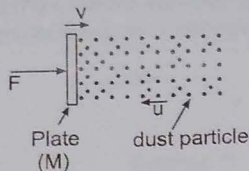
- (A) The component of normal force from ground lies along the line of impact. Hence not an answer.
- (B) No external force perpendicular to the line of impact for A.
- (C) For the system A + B there is no external force along horizontal direction. Hence an answer.
- (D) For B the normal force from ground is balanced by the impulsive force by A. Initial and final momentum is zero. Hence an answer.

SECTION - VI : INTEGER TYPE

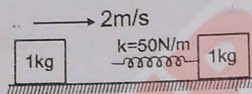
9.41 Block 'A' is hanging from a vertical spring and is at rest. Block 'B' strikes the block 'A' with velocity 'v' and sticks to it. Then the value of 'v' for which the spring just attains natural length is:



- 9.42 A plate of mass  $M$  is moved with constant velocity  $v$  against dust particles moving with velocity  $u$  in opposite direction as shown. The density of the dust is  $\rho$  and plate area is  $A$ . Find the force  $F$  required to keep the plate moving uniformly is  $A\rho(u+v)^N$ , then  $N$  is



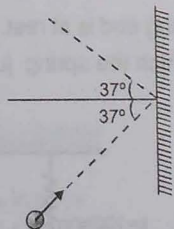
- 9.43 Each of the blocks shown in figure has mass 1 kg. The rear block moves with a speed of 2 m/s towards the front block kept at rest. The spring attached to the front block is light and has a spring constant 50 N/m. Find the maximum compression of the spring. (in cm.)



- 9.44 In the figure shown a small block B of mass  $m$  is released from the top of a smooth movable wedge A of the same mass  $m$ . The height of wedge A shown in figure is  $h = 100$  cm. B ascends another movable smooth wedge C of the same mass. Neglecting friction anywhere find the maximum height (in cm) attained by block B on wedge C.



- 9.45 A particle moving on a smooth horizontal surface strikes a stationary wall. The angle of strike is equal to the angle of rebound & is equal to  $37^\circ$  and the coefficient of restitution with wall is  $e = \frac{1}{5}$ . Find the friction coefficient between wall and the particle in the form  $\frac{X}{10}$  and fill value of  $X$ .



- 10.1 A uniform moment paper.

(A)  $\frac{m}{3}$

- 10.2 Two particles separated  
 (A)  $\frac{3}{r}$

- 10.3 In the acceleration

(A)

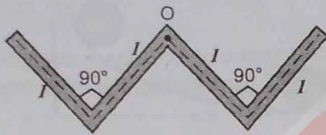
- 10.4 A uniform end

(A)

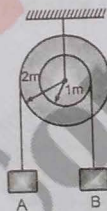
- 10.5 A solid is:  
 (A)  
 (B)  
 (C)  
 (D)

**TOPIC**  
**10**
**RIGID BODY DYNAMICS**
**SECTION - I : STRAIGHT OBJECTIVE TYPE**

- 10.1 A uniform thin rod of length  $4l$ , mass  $4m$  is bent at the points as shown in the figure. What is the moment of inertia of the rod about the axis passing through point O & perpendicular to the plane of the paper.

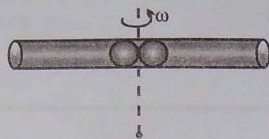


- (A)  $\frac{m\ell^2}{3}$       (B)  $\frac{10m\ell^2}{3}$       (C)  $\frac{m\ell^2}{12}$       (D)  $\frac{m\ell^2}{24}$
- 10.2 Two points of a rod move with velocities  $3v$  &  $v$  perpendicular to the rod and in the same direction, separated by a distance ' $r$ '. Then the angular velocity of the rod is :
- (A)  $\frac{3v}{r}$       (B)  $\frac{4v}{r}$       (C)  $\frac{5v}{r}$       (D)  $\frac{2v}{r}$
- 10.3 In the pulley system shown, if radii of the bigger and smaller pulley are  $2m$  and  $1m$  respectively and the acceleration of block A is  $5 \text{ m/s}^2$  in the downward direction, then the acceleration of block B will be:



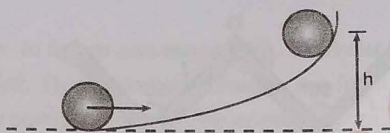
- (A)  $0 \text{ m/s}^2$       (B)  $5 \text{ m/s}^2$       (C)  $10 \text{ m/s}^2$       (D)  $5/2 \text{ m/s}^2$
- 10.4 A uniform thin rod of mass ' $m$ ' and length  $L$  is held horizontally by two vertical strings attached to the two ends. One of the string is cut. Find the angular acceleration soon after it is cut :
- (A)  $\frac{g}{2L}$       (B)  $\frac{g}{L}$       (C)  $\frac{3g}{2L}$       (D)  $\frac{2g}{L}$
- 10.5 A sphere is released on a smooth inclined plane from the top. When it moves down its angular momentum is:
- (A) conserved about every point  
 (B) conserved about the point of contact only  
 (C) conserved about the centre of the sphere only  
 (D) conserved about any point on a line parallel to the inclined plane and passing through the centre of the ball.

- 10.6 A smooth tube of certain mass is rotated in gravity free space and released. The two balls shown in the figure move towards ends of the tube. For the whole system which of the following quantity is not conserved?



- (A) Angular momentum  
(B) Linear momentum  
(C) Kinetic energy  
(D) Angular speed

- 10.7 In the figure shown a ball rolls without sliding. On a horizontal surface. It ascends a curved track upto height  $h$  and returns. Value of  $h$  is  $h_1$  for sufficiently rough curved track to avoid sliding and  $h_2$  for smooth curved track, then:



- (A)  $h_1 = h_2$   
(B)  $h_1 < h_2$   
(C)  $h_1 > h_2$   
(D)  $h_2 = 2h_1$

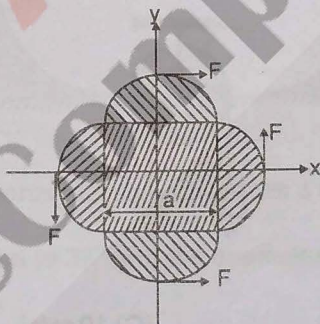
- 10.8 A uniform ring of radius  $R$  rolls without sliding. The radius of curvature of the path followed by any particle of the ring at the highest point of its path will be :

- (A)  $R$   
(B)  $2R$   
(C)  $4R$   
(D) none of these

- 10.9 A uniform ring of radius  $R$  is given a back spin of angular velocity  $V_0/2R$  and thrown on a horizontal rough surface with velocity of center to be  $V_0$ . The velocity of the centre of the ring when it starts pure rolling will be

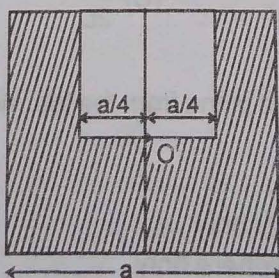
- (A)  $V_0/2$   
(B)  $V_0/4$   
(C)  $3V_0/4$   
(D)  $0$

- 10.10 A planar object made up of a uniform square plate and four semicircular discs of the same thickness and material is being acted upon by four forces of equal magnitude as shown in figure. The coordinates of point of application of forces is given by



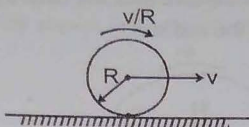
- (A)  $(0, a)$   
(B)  $(0, -a)$   
(C)  $(a, 0)$   
(D)  $(-a, 0)$

- 10.11 A square plate of edge  $a/2$  is cut out from a uniform square plate of edge 'a' as shown in figure. The mass of the remaining portion is  $M$ . The moment of inertia of the shaded portion about an axis passing through 'O' (centre of the square of side  $a$ ) and perpendicular to plane of the plate is :



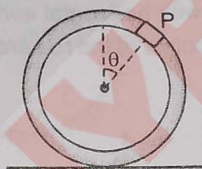
- (A)  $\frac{9}{64} Ma^2$   
(B)  $\frac{3}{16} Ma^2$   
(C)  $\frac{5}{12} Ma^2$   
(D)  $\frac{Ma^2}{6}$

- 10.12 A uniform disc is performing pure rolling on a smooth stationary surface with constant angular velocity as shown in figure. At any instant, for the lowermost point of the disc



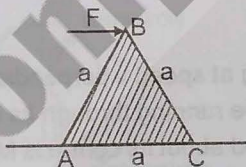
- (A) Velocity is  $v$ , acceleration is zero  
 (B) Velocity is zero, acceleration is zero  
 (C) velocity is  $v$ , acceleration is  $\frac{v^2}{R}$   
 (D) velocity is zero, acceleration is  $\frac{v^2}{R}$

- 10.13 A small block of mass ' $m$ ' is rigidly attached at 'P' to a ring of mass ' $3m$ ' and radius ' $r$ '. The system is released from rest at  $\theta = 90^\circ$  and rolls without sliding. The angular acceleration of hoop just after release is -



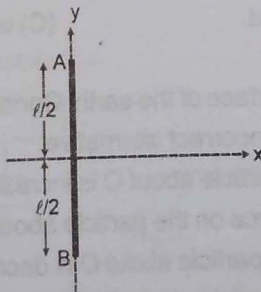
- (A)  $\frac{g}{4r}$  (B)  $\frac{g}{8r}$  (C)  $\frac{g}{3r}$  (D)  $\frac{g}{2r}$

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



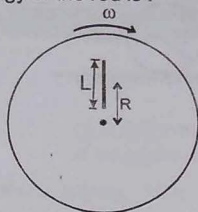
- (A)  $\frac{mg}{\sqrt{3}}$  (B)  $\frac{mg}{4}$  (C)  $\frac{\mu mg}{\sqrt{3}}$  (D)  $\frac{\mu mg}{4}$

- 10.15 A uniform rod of mass  $m$ , length  $\ell$  is placed over a smooth horizontal surface along  $y$ -axis and is at rest as shown in figure. An impulsive force  $F$  is applied for a small time  $\Delta t$  along  $x$ -direction at point A. The  $x$ -coordinate of end A of the rod when the rod becomes parallel to  $x$ -axis for the first time is (initially the coordinate of centre of mass of the rod is  $(0, 0)$ ) :



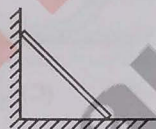
- (A)  $\frac{\pi \ell}{12}$  (B)  $\frac{\ell}{2} \left( 1 + \frac{\pi}{12} \right)$  (C)  $\frac{\ell}{2} \left( 1 - \frac{\pi}{6} \right)$  (D)  $\frac{\ell}{2} \left( 1 + \frac{\pi}{6} \right)$

- 10.16 A uniform rod of mass  $M$  and length  $L$  lies radially on a disc rotating with angular speed  $\omega$  in a horizontal plane about its axis. The rod does not slip on the disc and the centre of the rod is at a distance  $R$  from the centre of the disc. Then the kinetic energy of the rod is :



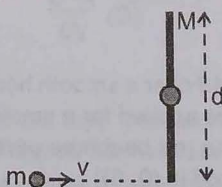
- (A)  $\frac{1}{2} m\omega^2 \left( R^2 + \frac{L^2}{12} \right)$  (B)  $\frac{1}{2} m\omega^2 R^2$  (C)  $\frac{1}{24} m\omega^2 L^2$  (D) None of these

- 10.17 A uniform rod of length  $\ell$  is sliding such that one of its ends is always in contact with a vertical wall and its other end is always in contact with horizontal surface. Just after the rod is released from rest, the magnitude of acceleration of end points of the rod are  $a$  and  $b$  respectively. The angular acceleration of rod at this instant will be



- (A)  $\frac{a+b}{\ell}$  (B)  $\frac{\sqrt{|a^2 - b^2|}}{\ell}$  (C)  $\frac{\sqrt{a^2 + b^2}}{\ell}$  (D) None of these

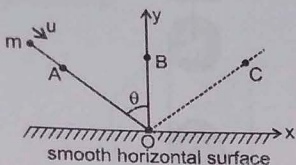
- 10.18 A particle of mass  $m$  is moving at speed  $v$  perpendicular to a rod of length  $d$  and mass  $M = 6m$  which pivots around a frictionless axle running through its centre. It strikes and sticks to the end of the rod. The moment of inertia of the rod about its centre is  $Md^2/12$ . Then the angular speed of the system just after the collision is



- (A)  $2v/3d$ . (B)  $2v/d$ . (C)  $v/d$ . (D)  $3v/2d$ .

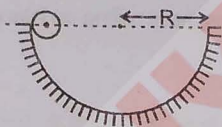
- 10.19 A particle falls freely near the surface of the earth. Consider a fixed point  $O$  (not vertically below the particle) on the ground. Then pick up the incorrect alternative
- (A) Angular momentum of the particle about  $O$  is increasing.  
 (B) Torque of the gravitational force on the particle about  $O$  is decreasing.  
 (C) The moment of inertia of the particle about  $O$  is decreasing.  
 (D) The angular velocity of the particle about  $O$  is increasing.

10.20 A ball of mass  $m$  moving with constant velocity  $u$  collides with a smooth horizontal surface at  $O$  as shown. Neglect gravity and friction. The  $y$ -axis is drawn normal to the horizontal surface at the point of impact  $O$  and  $x$ -axis is horizontal as shown in the figure. About which point will the angular momentum of ball be conserved.



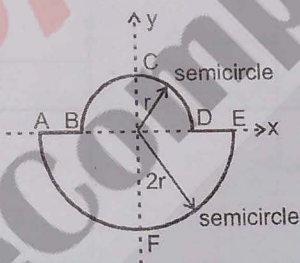
- (A) point A                      (B) point B                      (C) point C                      (D) None of these

10.21 In the figure shown, a small solid spherical ball of mass ' $m$ ' can move without sliding in a fixed semicircular track of radius  $R$  in vertical plane. It is released from the top. The resultant force on the ball at the lowest point of the track is



- (A)  $\frac{10mg}{7}$                       (B)  $\frac{17mg}{7}$                       (C)  $\frac{3mg}{7}$                       (D) zero

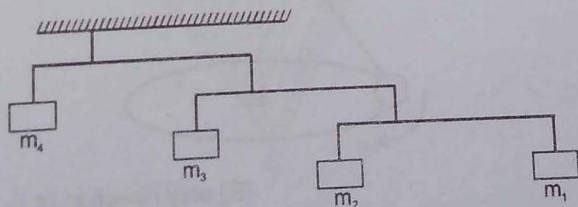
10.22 A uniform thin rod is bent in the form of closed loop ABCDEFA as shown in the figure.



The ratio of moment of inertia of the loop about  $x$ -axis to that about  $y$ -axis is.

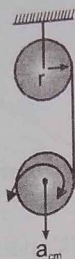
- (A)  $> 1$                       (B)  $< 1$                       (C)  $= 1$                       (D)  $= 1/2$

10.23 Figure shows an arrangement of masses hanging from a ceiling. In equilibrium, each rod is horizontal, has negligible mass and extends three times as far to the right of the wire supporting it as to the left. If mass  $m_4$  is 48 kg then mass  $m_1$  is equal to



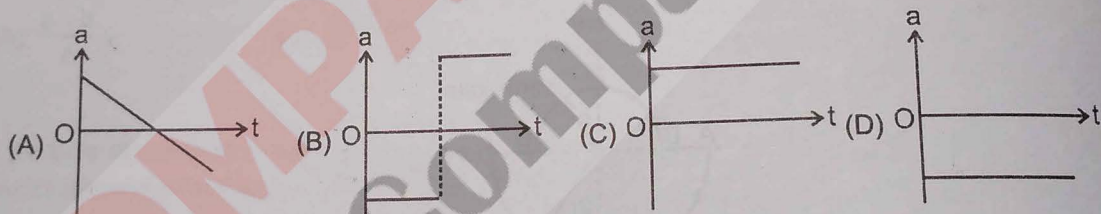
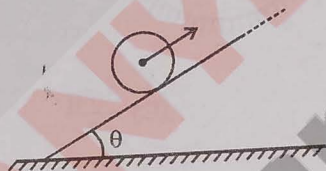
- (A) 1 kg                      (B) 2 kg                      (C) 3 kg                      (D) 4 kg

10.24 Two identical uniform discs of mass  $m$  and radius  $r$  are arranged as shown in the figure. If  $\alpha$  is the angular acceleration of the lower disc and  $a_{cm}$  is acceleration of centre of mass of the lower disc, then relation among  $a_{cm}$ ,  $\alpha$  &  $r$  is :

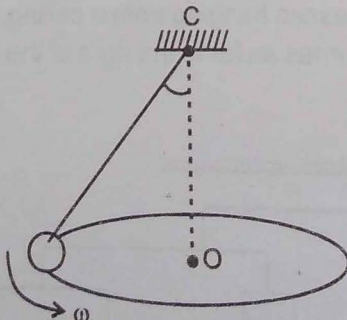


- (A)  $a_{cm} = \frac{\alpha}{r}$       (B)  $a_{cm} = 2 \alpha r$       (C)  $a_{cm} = \alpha r$       (D) none of these

10.25 A uniform solid sphere rolls up (without slipping) the rough fixed inclined plane, and then back down. Which is the correct graph of acceleration 'a' of centre of mass of solid sphere as function of time  $t$  (for the duration sphere is on the incline) ? Assume that the sphere rolling up has a positive velocity.

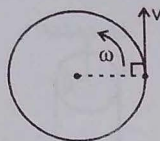


10.26 A conical pendulum consists of a simple pendulum moving in a horizontal circle as shown in the figure.  $C$  is the pivot,  $O$  the centre of the circle in which the pendulum bob moves and  $\omega$  the constant angular velocity of the bob. If  $\vec{L}$  is the angular momentum about point  $C$ , then

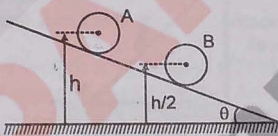


- (A)  $\vec{L}$  is constant      (B) only direction of  $\vec{L}$  is constant  
 (C) only magnitude of  $\vec{L}$  is constant      (D) none of the above.

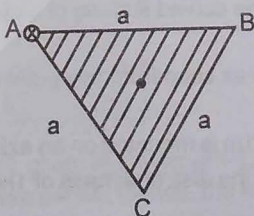
- 10.27 A child with mass  $m$  is standing at the edge of a playground merry-go-round (A large uniform disc which rotates in horizontal plane about a fixed vertical axis in parks) with moment of inertia  $I$ , radius  $R$ , and initial angular velocity  $\omega$  as shown in figure. The child jumps off the edge of the merry-go-round with a velocity  $v$  with respect to the ground in direction tangent to periphery of the disc as shown. The new angular velocity of the merry-go-round is:



- (A)  $\sqrt{\frac{I\omega^2 - mv^2}{I}}$  (B)  $\sqrt{\frac{(I + mR^2)\omega^2 - mv^2}{I}}$   
 (C)  $\frac{I\omega - mvR}{I}$  (D)  $\frac{(I + mR^2)\omega - mvR}{I}$
- 10.28 Two identical uniform solid spherical balls A & B of mass  $m$  each are placed on a fixed wedge as shown in figure. Ball B is kept at rest and it is released just before two balls collide. Ball A rolls down without slipping on inclined plane & collide elastically with ball B. The kinetic energy of ball A just after the collision with ball B is :



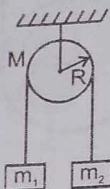
- (A)  $\frac{mgh}{7}$  (B)  $\frac{mgh}{2}$  (C)  $\frac{2mgh}{5}$  (D)  $\frac{7mgh}{5}$
- 10.29 A uniform triangular plate ABC of moment of mass  $m$  and inertia  $I$  (about an axis passing through A and perpendicular to plane of the plate) can rotate freely in the vertical plane about point 'A' as shown in figure. The plate is released from the position shown in the figure. Line AB is horizontal. The acceleration of centre of mass just after the release of plate is :



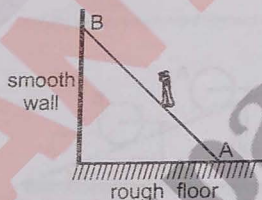
- (A)  $\frac{mga^2}{\sqrt{3}I}$  (B)  $\frac{mga^2}{4I}$  (C)  $\frac{mga^2}{2\sqrt{3}I}$  (D)  $\frac{mga^2}{3I}$

## SECTION - II : MULTIPLE CORRECT ANSWER TYPE

- 10.30 In the shown figure, the pulley of mass  $M$  and radius  $R$  can rotate about its fixed horizontal axis (axle) without friction. Friction between light inextensible string and pulley is sufficient to prevent slipping of string over pulley. The masses of blocks are  $m_1$  and  $m_2$  such that  $m_2 > m_1$ . The system is released from rest as shown. Before the block of mass  $m_1$  touches the pulley, pick up the correct statements.

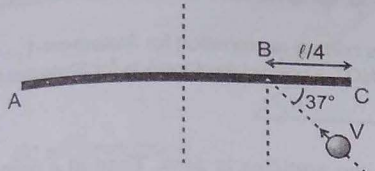


- (A) The magnitude of acceleration of any small length  $d\ell$  of string is constant throughout the motion.  
 (B) Magnitude of force exerted by string on mass  $m_2$  is larger as compared to that exerted by string on mass  $m_1$ .  
 (C) Accelerations of both blocks are same.  
 (D) The acceleration of small length  $d\ell$  of string in contact with block of mass  $m_2$  remains constant.
- 10.31 A ladder AB is supported by a smooth vertical wall and rough horizontal floor as shown. A boy starts moving from A to B slowly. The ladder remains at rest, then pick up the correct statement(s) :



- (A) Magnitude of normal reaction by wall on ladder at point B will increase.  
 (B) Magnitude of normal reaction by wall on ladder at point B will decrease.  
 (C) Magnitude of normal reaction by floor on ladder at point A will remain unchanged.  
 (D) Magnitude of friction force by floor on ladder at point A will increase.
- 10.32 A rigid body is in pure rotation, that is, undergoing fixed axis rotation. Then which of the following statement(s) are true?
- (A) You can find two points in the body in a plane perpendicular to the axis of rotation having same velocity.  
 (B) You can find two points in the body in a plane perpendicular to the axis of rotation having same acceleration.  
 (C) Speed of all the particles lying on the curved surface of a cylinder whose axis coincides with the axis of rotation is same.  
 (D) Angular speed of the body is same as seen from any point in the body.
- 10.33 A uniform disc of mass 2kg and radius 1m is mounted on an axle supported on fixed frictionless bearings. A light cord is wrapped around the rim of the disc and mass of 1kg is tied to the free end. If it is released from rest,
- (A) the tension in the cord is 5N  
 (B) in first 4 seconds the angular displacement of the disc is 40 rad.  
 (C) the work done by the torque on the disc in first 4 sec. is 200J  
 (D) the increase in the kinetic energy of the disc in the first 4 seconds is 200J.

10.34 A uniform rod AC of length  $\ell$  and mass  $m$  is kept on a horizontal smooth plane. It is free to rotate and move. A particle of same mass  $m$  moving on the plane with velocity  $v$  strikes the rod at point B making an angle  $37^\circ$  with the rod. The collision is elastic. After collision :



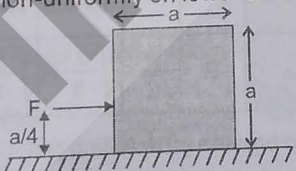
- (A) The angular velocity of the rod will be  $\frac{72v}{55\ell}$
- (B) The centre of the rod will travel a distance  $\frac{\pi\ell}{3}$  in the time in which it makes half rotation
- (C) Impulse of the impact force is  $\frac{24mv}{55}$
- (D) None of these

SECTION - III : ASSERTION AND REASON TYPE

10.35 **Statement-1** : A uniform rigid disc rolls without slipping on a fixed rough horizontal surface with uniform angular velocity. Then the acceleration of lowest point on the disc is zero.  
**Statement-2** : For a uniform rigid disc rolling without slipping on a fixed rough horizontal surface, the velocity of the lowest point on the disc is always zero.  
 (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1  
 (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1  
 (C) Statement-1 is True, Statement-2 is False  
 (D) Statement-1 is False, Statement-2 is True.

10.36 **Statement-1** : A uniform thin rod of length  $L$  is hinged about one of its end and is free to rotate about the hinge without friction. Neglect the effect of gravity. A force  $F$  is applied at a distance  $x$  from the hinge on the rod such that force is always perpendicular to the rod. As the value of  $x$  is increased from zero to  $L$ , the component of reaction by hinge on the rod perpendicular to length of rod increases.  
**Statement-2** : Under the conditions given in statement-1 as  $x$  is increased from zero to  $L$ , the angular acceleration of rod increases.  
 (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1  
 (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1  
 (C) Statement-1 is True, Statement-2 is False  
 (D) Statement-1 is False, Statement-2 is True.

10.37 **Statement-1** : A uniform cubical block (of side  $a$ ) undergoes translational motion on a smooth horizontal surface under action of horizontal force  $F$  as shown. Under the given condition, the horizontal surface exerts normal reaction non-uniformly on lower surface of the block.



**Statement-2** : For the cubical block given in statement-1, the horizontal force  $F$  has tendency to rotate the cube about its centre in clockwise sense. Hence, the lower right edge of cube presses the horizontal surface harder in comparison to the force exerted by lower left edge of cube on horizontal surface.  
 (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1  
 (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1  
 (C) Statement-1 is True, Statement-2 is False  
 (D) Statement-1 is False, Statement-2 is True.

- 10.38 **Statement-1** : A uniform solid sphere and a uniform hollow sphere of same radius and same material are released (at rest) from the top of a fixed inclined plane at the same time. They will reach the bottom simultaneously, if they roll with sliding.  
**Statement-2** : In the situation of statement-1, the centres of both spheres have the same acceleration and they travel the same distance. Hence time taken is same.  
 (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1  
 (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1  
 (C) Statement-1 is True, Statement-2 is False  
 (D) Statement-1 is False, Statement-2 is True.
- 10.39 **Statement-1** : The net momentum of a system of two moving particles is zero. Then at a particular instant of time, the net angular momentum of system of given two particle is same about any point.  
**Statement-2** : If net momentum of a system of two moving particle is zero, then angular momentum of system of given two particles is zero about any point.  
 (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1  
 (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1  
 (C) Statement-1 is True, Statement-2 is False  
 (D) Statement-1 is False, Statement-2 is True.

**SECTION - IV : COMPREHENSION TYPE**

**COMPREHENSION - 1**

In this passage a brief idea is given of the motion of the rolling bodies on an inclined plane.

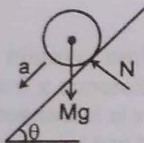
We will consider three cases : Objects are released on an incline plane

**Case A** : which is smooth. ;

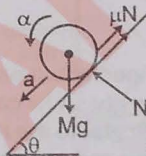
**Case B** : where friction is insufficient to provide pure rolling.

**Case C** : where friction is sufficient to provide pure rolling.

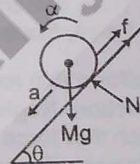
Force diagram for three cases are as follows : (where symbols have their usual meanings)



Case (A)  
 $\alpha = 0$



Case (B)  
 $a \neq \alpha R$



Case (C)  
 $a = \alpha R$

**Equations for case (C) :**

$$Mg \sin \theta - f = Ma$$

$$fR = (Mk^2)\alpha \quad ; \quad \text{where } k = \text{radius of gyration and } f \text{ is force of friction.}$$

$$a = \alpha R$$

on solving the above equations we will get

$$a = \frac{g \sin \theta}{\left(1 + \frac{k^2}{R^2}\right)}$$

Object	Ring	Disc	Hollow sphere	Solid sphere
k	R	$\frac{R}{\sqrt{2}}$	$\sqrt{\frac{2}{3}}R$	$\sqrt{\frac{2}{5}}R$

To decide the minimum friction coefficient to provide pure rolling put

$$f = \mu Mg \cos \theta$$

And we will get

$$\mu_{\min} = \frac{\tan \theta \left(\frac{k^2}{R^2}\right)}{\left(1 + \frac{k^2}{R^2}\right)}$$