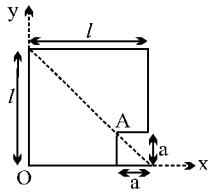
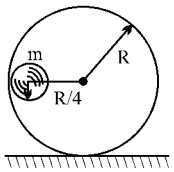
GUIDED REVISION

CENTRE OF MASS

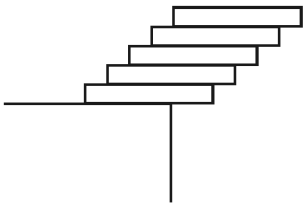
1. The figure shows a square metal plate of side l from which a square plate of side a has been cut as shown in the figure. Find the ratio (a/l)so that the centre of mass of the remaining L-shaped plate coincides with the point A.



2. Inside a smooth spherical shell of the radius R a ball of the same mass is released from the shown position (Fig.) Find the distance travelled by the shell on the horizontal floor when the ball comes to the lowest point of the shell.



3. Some identical bricks are placed on top of each other at the edge of table as shown. It is possible to slide them horizontally on each other in such a way that the projection of the top most one is completely outside the table. What is the least number of bricks needed?

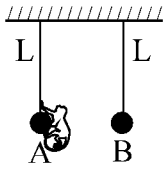


4. A plate in the form of a semicircle of radius R has a mass per unit area of kr where k is a constant and r is the distance from the centre of the straight edge. By dividing the plate into semicircular rings find the distance of the centre of mass of the plate from the centre of its straight edge.

(A) $\frac{4R}{3\pi}$ (B) $\frac{2R}{\pi}$ (C) $\frac{3R}{2\pi}$ (D) $\frac{3R}{4\pi}$

MOMENTUM CONSERVATION

5. A monkey jumps from ball A onto ball B which are suspended from inextensible light strings each of length L. The mass of each ball & monkey is same. What should be the minimum relative velocity of jump w.r.t. ball, if both the balls manage to complete the circle?



(A) $\sqrt{5gL}$ (B) $\sqrt{20gL}$ (C) $4\sqrt{5gL}$ (D) none

6. A man of mass m on an initially stationary boat gets off of the boat by leaping to the left in an exactly horizontal direction. Immediately after the leap, the boat of mass M, is observed to be moving to the right at speed v.

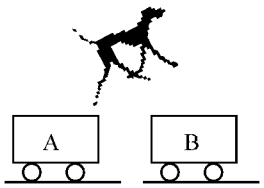
(A) Work done by man on boat is $\frac{1}{2}(m)v^2$.

(B) Increase in the mechanical energy of system of man and boat is $\frac{1}{2}\left(\frac{M^2}{m}+M\right)v^2$.

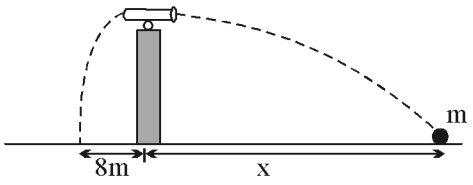
(C) Velocity of centre of mass of system is v.

(D) Increase in kinetic energy of man is $\frac{1}{2}\frac{M^2}{m}v^2$.

7. In a circus act, a 4kg dog is trained to jump from B cart to A and then immediately back to the B cart. The carts each have a mass of 20kg and they are initially at rest. In both cases the dog jumps at 6m/s relative to the cart. If the cart moves along the same line with negligible friction calculate the final velocity of each cart with respect to the floor.



8. A cannon of mass M = 200 kg is positioned a top a narrow wall as shown. It fires a ball of mass m = 2kg horizontally across a plane. Unfortunately the gunners forgot to lock the frictionless wheels of the cannon and it immediately rolls backwards off the wall, landing a distance 8 m from the wall as shown. Neglecting air friction, at what distance x (in meters) from the base of the wall does the ball land ?



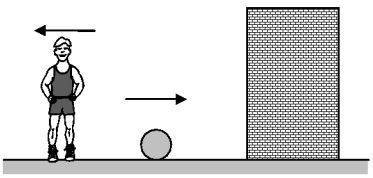
IMPULSE

9. A man of mass M is carrying a ball of the mass M/2. The man is initially in the state of rest at a distance D from fixed vertical wall. He throws the ball along the floor towards the wall with a velocity v with respect to earth at t = 0. Because of throwing, the man also starts moving backwards. The ball rebounds elastically from the wall. The man finally collects the ball. Assume friction is absent.

(A) The velocity of the man + ball system after the man has collected the ball is $\frac{2v}{3}$

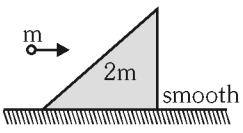
(B) Linear impulse by ball on man is $\frac{Mv}{3}$

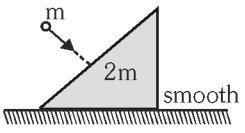
(C) Total linear impulse by ball on man is $\frac{Mv}{6}$

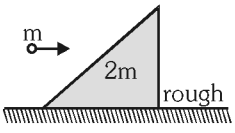


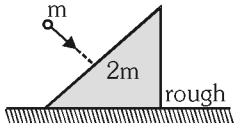
(D) He collects the ball at $t = \frac{4D}{v}$

10. In which of the following system (s) linear momentum cannot be conserved during collision along horizontal line (parallel to base) ?

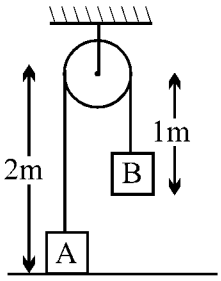
(A) 

(B) 

(C) 

(D) 

11. Two masses A & B each of 5 kg are suspended by a light inextensible string passing over a smooth massless pulley such that mass A rest on smooth table & B is held at the position shown. Mass B is now gently lifted up to the pulley and allowed to fall from rest. Determine up to what height will A rise for the ensuing motion.



12. A projectile of 2 kg is launched from ground at an angle of 30° from horizontal. At the highest point of its trajectory the radius of curvature is 16 km.

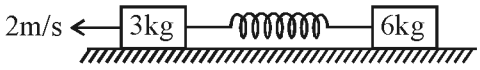
(a) Find its speed at highest point.

(b) Calculate its range on level ground

(c) Calculate impulse due to gravity during total time of flight.

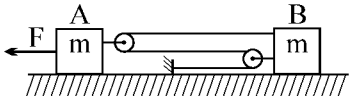
COM FRAME OF REFERENCE

13. Two blocks of masses 3 kg and 6 kg are connected by an ideal spring and are placed on a frictionless horizontal surface. The 3 kg block is imparted a speed of 2 m/s towards left.



Column-I	**Column-II**
(A) When the speed of 3 kg block is $\frac{2}{3}$ m/s	(P) Velocity of centre of mass is $\frac{2}{3}$ m/s.
(B) When the speed of 6 kg block is $\frac{2}{3}$ m/s	(Q) Deformation of the spring is zero.
(C) When the speed of 3 kg block is maximum	(R) Deformation of the spring is maximum
(D) When the speed of 6 kg block is minimum	(S) Both the blocks are at rest with respect to each other.
	(T) Both the blocks are at rest with respect to ground

14. Two blocks A and B of equal mass are connected by a light inextensible taut string passing over two light smooth pulleys fixed to the blocks. The parts of the string not in contact with the pulleys are horizontal. A horizontal force F is applied to the block A as shown. There is no friction, then



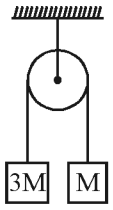
(A) the acceleration of A will be more that of B

(B) the acceleration of A will be less than that of B

(C) the sum of rate of changes of momentum of A and B is greater than the magnitude of F.

(D) the sum of rate of changes of momentum of A and B is equal to the magnitude of F.

15. Two blocks of mass M and 3 M are connected by a light cord which passes over a light frictionless pulley as shown in the figure. The blocks are released from rest and are at the same height at t = 0.



(A) Tension in string connecting masses is $\frac{3Mg}{4}$

(B) The acceleration of both masses is $\frac{g}{2}$ in magnitude

(C) The centre of mass accelerates down.

(D) The net force on system having M and 3M is zero.

COLLISION

16. Two balls A & B mass 1 kg & 2 kg are moving with speeds 21 m/s & 4 m/s respectively in opposite direction collide head on. After collision A moves with speed 1 m/s in its initial direction. Which is /are correct ?

(A) Velocity of B after collision is 6 m/s opposite to its direction before collision

(B) e = 0.2

(C) Loss of kinetic energy due to collision is 200J

(D) Impulse of force between 2 balls is 400 N-s

17. A particle moving with kinetic energy = 3J makes an elastic head–on collision with a stationary particle which has twice its mass. During the impact–

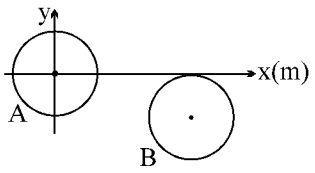
(A) the minimum kinetic energy of the system is 1 J.

(B) the maximum elastic potential energy of the system is 2J.

(C) momentum and total energy are conserved at every instant.

(D) All of the above are correct

18. Two smooth balls A and B, each of mass m and radius R, have their centres at (0,0,R) and at (5R,–R,R) respectively, in a coordinate system as shown. Ball A, moving along positive x axis, collides with ball B. Just before the collision, speed of ball A is 4 m/s and ball B is stationary. The collision between the balls is elastic.



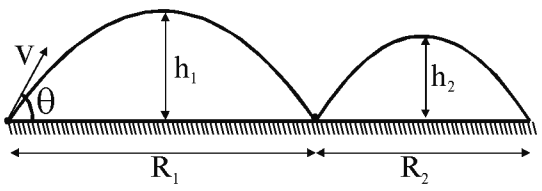
(A) Velocity of the ball A just after the collision is $(\hat{i} + \sqrt{3}\hat{j})$ m/s

(B) Velocity of B just after collision is zero.

(C) Impulse of the force exerted by A on B during the collision, is equal to $(3m\hat{i} - \sqrt{3}m\hat{j})$ kg-m/s

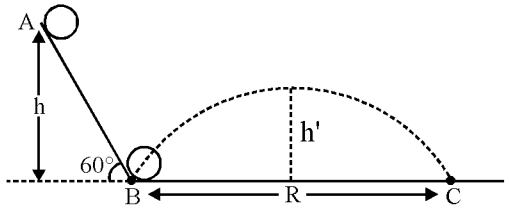
(D) Impulse of the force exerted by A on B is $(4m\hat{i})$ kg-m/s.

19. A ball is projected with velocity V at an angle θ with horizontal. Its maximum height is h_1, range R_1 and time of flight T_1. It collides the ground and collision have coefficient of restitution e = 1/2, then



(A) $h_2 = \frac{1}{2}h_1$ (B) $R_2 = \frac{1}{2}R_1$ (C) $T_2 = \frac{1}{2}T_1$ (D) $R_2 = \frac{1}{4}R_1$

20. In the figure shown, a ball is released from the smooth track. If the ball strikes the horizontal surface of the track and bounces off, it again strikes the horizontal surface at some distance R from B and rises to a height maximum of h' above the surface (If the coefficient of restitution for the collision is e) :-



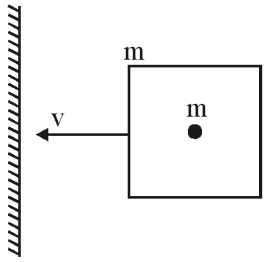
(A) R is maximum for e = $\frac{1}{\sqrt{3}}$

(B) R is maximum for e = 1

(C) $h' \leq \frac{3h}{4}$ for all values of e

(D) h' = h for e = 1

21. In the middle of a box of mass m is a weight of the same mass m. The whole structure is moving at a speed v in the horizontal plane toward the wall (see figure). Friction is absent everywhere, all the collision are absolutely elastic. Choose the correct option:



(A) There will be a total of three collisions

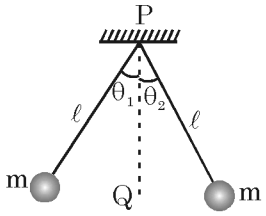
(B) Finally the box will be moving towards right with speed v.

(C) Finally the weight will be at the edge of the box.

(D) The weight will oscillate back and forth relative to the box after the collision with the wall is over.

22. Two simple pendulums of equal lengths and equal bob masses are hung from same point. When strings of pendulums are displaced from vertical positions, by angles θ_1 and θ_2 and released, they make elastic collisions with each other in subsequent motion. Neglecting sizes of bobs of pendulums and assuming θ_1 and θ_2 are small enough to hold approximation $\sin\theta = \theta$, mark the **CORRECT** alternative.

(A) If $\theta_1 > \theta_2$, collision will take place to the left of line PQ.

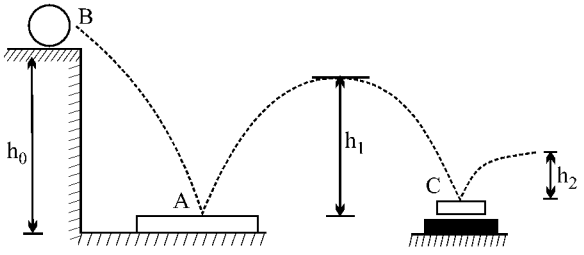


(B) If $\theta_2 > \theta_1$, time period of oscillation is $2\pi\sqrt{\frac{\ell}{g}}$.

(C) If $\theta_1 > \theta_2$, time period of oscillation is $2\pi\sqrt{\frac{\ell}{g}}$.

(D) If $\theta_1 = \theta_2$, time period of oscillation is $\pi\sqrt{\frac{\ell}{g}}$.

23. A 70g ball B droped from a height h_0 = 9 m reaches a height h_2 = 0.25m after bouncing twice from identical 210g plates. Plate A rests directly on hard ground, while plate C rests on a foam-rubber mat. Determine



(a) the coefficient of resitution between the ball and the plates,

(b) the height h_1 of the ball's first bounce.

VARIABLE MASS

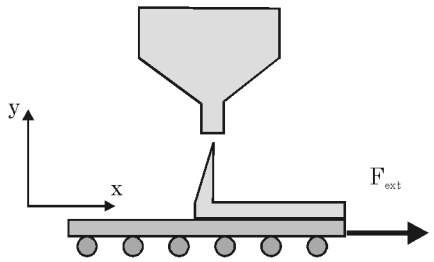
24. A rocket ascends from rest in a uniform gravitational field g by ejecting exhaust with a uniform relative speed u. Assume that the rate at which mass is expelled is given by $\left|\frac{dm}{dt}\right| = km$ where m is the instantaneous mass of the rocket & k is a constant & that the rocket is retarded by air resistance with a force mbv where b is a constant & v is instantaneous velocity of rocket.

(a) Find the acceleration of rocket as a function of time.

(b) Find the velocity of rocket as a function of time

(c) What will be its velocity after a long time.

25. Sand from a stationary hopper falls onto a moving conveyor belt at a rate of 5.00 kg/s as shown in the figure. The conveyor belt is supported by frictionless rollers and moves at a constant speed of 0.750 m/s under the action of a constant horizontal external force F_{ext} supplied by the motor that drives the belt.



(A) The force of friction exerted by the belt on the sand is 3.75 N.

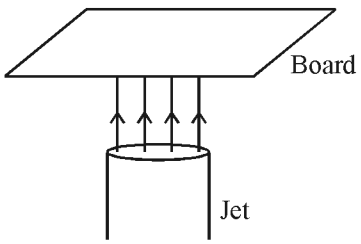
(B) The external force F_{ext} is 3.75 N.

(C) The work done by F_{ext} in 1 sec is 2.81 J.

(D) The kinetic energy acquired by the falling sand each second due to the change in its horizontal motion is 1.41 J.

Paragraph for Question No 26 and 27

A jet shoots a stream of water vertically upward. The water leaves the jet with a velocity v_0 and at a mass rate R kg/s. A horizontal board with mass m faces the water stream as shown. Water jet strikes the board normally and then bounces off sideways. Assume area of cross-section of water stream, does not change as it goes up.



26. When board is placed vary close to the jet and then released, it stays in equilibrium. What is the value of m?

(A) $\frac{2Rv_0}{g}$ (B) $\frac{Rv_0}{g}$ (C) $\frac{Rv_0}{2g}$ (D) $\frac{Rv_0}{4g}$

27. If we break the board into half so that its mass is $\frac{m}{2}$, how high from jet, should the board be placed so that it remains in equilibrium.

(A) $\frac{v_0^2}{2g}$ (B) $\frac{2v_0^2}{5g}$ (C) $\frac{3v_0^2}{7g}$ (D) $\frac{3v_0^2}{8g}$

ANSWER KEY		CENTRE OF MASS & COLLISION	
1. Ans. 0.62 = $\frac{\sqrt{5}-1}{2}$	**2. Ans. 3R/8**	**3. Ans. 4**	**4. Ans. (C)**
5. Ans. (C)	**6. Ans. (B, D)**	**7. Ans.** v_B **= 55/36m/s,** v_A **= 11/6 m/s, solved**	
8. Ans. 0800.00	**9. Ans. (A,D)**	**10. Ans. (C,D)**	**11. Ans. 1.25 m**
12. Ans. 400m/s, $\frac{32000}{\sqrt{3}}m$ **,** $\frac{1600}{\sqrt{3}}kg-m/s$		**13. Ans. (A)-P,Q,R,S; (B)-P,R,S; (C)-P,Q; (D)-P,Q**	
14. Ans. (A, C)	**15. Ans. (B, C)**	**16. Ans. (A,B,C)**	**17. Ans. (A,B,C,D)**
18. Ans. (A,C)	**19. Ans. (B,C)**	**20. Ans. (B, C)**	**21. Ans. (A,B)**
22. Ans. (B,C,D)	**23. Ans. (a) 0.66, (b) 4 m**		
24. Ans. (a) $(ku-g)e^{-bt}$ **(b)** $[\{(ku-g)/b\}(1-e^{-bt})]$**, (c)** $(ku-g)/b$			**25. Ans. (A,B,C,D)**
26. Ans. (B)	**27. Ans. (D)**		