COLLISIONS AND CENTRE OF MASS

1. A thin rod of length 6 m is lying along the x-axis with its ends at x=0 and x = 6 m. Its linear density (mass/length) varies with x as kx^4. Find the position of centre of mass of rod in meters.

(1) 5 m (2) 3 m (3) 2 m (4) 4 m

2. A man of mass M stands at one end of a plank of length L which lies at rest on a frictional surface. The man walks to the other end of the plank. If mass of the plank is 3M, the distance that man moves relative to the ground is :-

(1) $\frac{L}{4}$ (2) $\frac{3L}{4}$ (3) $\frac{2L}{3}$ (4) $\frac{L}{3}$

3. There are three small particles A, B and C where A & B has mass 5m & m respectively but C is very light and all three particles are moving under their mutual interaction. At t = 0, C is at (2, 3, 5) and at t = 2 sec, C is at (5, –1, 5). If centre of mass of system always lies on C and at t = 2 sec velocity of A is $2\hat{i}$ then velocity of B at this instant. (Assume all units in SI)

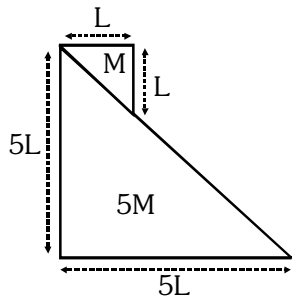
(1) $\left(\hat{i}+\hat{j}\right)$

(2) Zero

(3) $\left(-\hat{i}-12\hat{j}\right)$

(4) Can not find because velocity of centre of mass is not constant

4. In the figure shown, the small prism of mass M slides down on the bigger prism of mass 5M from top of the bigger prism to the bottom of the bigger prism. By what distance does the combination move to the left if the bigger prism initially rests on a frictionless floor.



(1) $\frac{L}{5}$ (2) $\frac{4L}{5}$ (3) $\frac{2L}{3}$ (4) $\frac{L}{6}$

5. A non–zero external force acts on a system of particles. The velocity and acceleration of the centre of mass are found to be v_0 and a_C respectively at any instant t. It is possible that

(i) $v_0=0$, $a_C=0$

(ii) $v_0 \neq 0$, $a_C=0$

(iii) $v_0= 0$, $a_C\neq0$

(iv) $v_0\neq 0$, $a_C\neq0$

Then

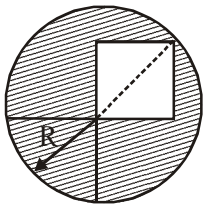
(1) (iii) and (iv) are true.

(2) (i) and (ii) are true.

(3) (i) and (iii) are true.

(4) (ii), (iii) and (iv) are true.

6. From a circular disc of radius R, a square is cut out with a radius as its diagonal. The center of mass of remainder part is at a distance (from the centre):-



(1) $\frac{R}{(4\pi-2)}$

(2) $\frac{R}{2\pi}$

(3) $\frac{R}{(\pi-2)}$

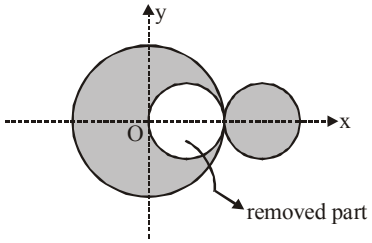
(4) $\frac{R}{(2\pi-2)}$

7. A uniform thin rod AB of length L has linear mass density $\mu(x) = a + \frac{bx}{L}$, where x is measured from A. If the CM of the rod lies at a distance of $\left(\frac{7}{12}L\right)$ from A, then a and b are related as :-

(1) a = b (2) a = 2b

(3) 2a = b (4) 3a = 2b

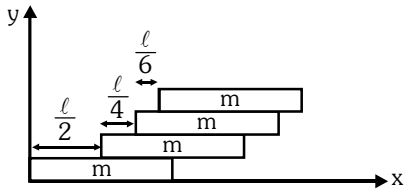
8. Figure shows a disc of radius R = 20 cm with a portion of it removed symmetrically. The removed part is a disc of radius R/2. The removed part is now placed in contact with the larger disc as shown in figure. Disc has uniform mass distribution. With respect to origin at centre of larger disc find x-coordinate of centre of mass of system.



(1) 20cm (2) 10cm

(3) 15cm (4) 5 cm

9. Find the x coordinate of the centre of mass of the bricks shown in figure : (Each rod has length ℓ)



(1) $\frac{24}{25}\ell$ (2) $\frac{25}{24}\ell$

(3) $\frac{15}{16}\ell$ (4) $\frac{16}{15}\ell$

10. Mass centers of a system of three particles of masses 1, 2, 3 kg is at the point (1 m, 2 m, 3 m) and mass center of another group of two particles of masses 2 kg and 3 kg is at point (–1 m, 3 m, –2 m). Where a 5 kg particle should be placed, so that mass center of the system of all these six particles shifts to mass center of the first system?

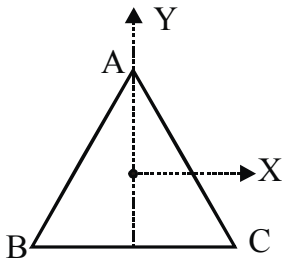
(1) (1 m, –3 m, 2 m)

(2) (3 m, 3 m, 2 m)

(3) (–1 m, 2 m, 3 m)

(4) (3 m, 1 m, 8 m)

11. A uniform wire frame ABC is in the shape of an equilateral triangle in xy-plane with centroid at the origin. Then :-



(1) If AB is removed, the centre of mass of the remaining figure is in fourth quadrant.

(2) If BC is removed, the centre of mass of the remaining figure is on the positive Y-axis.

(3) If AC is removed, the centre of mass of the remaining figure is in third quadrant.

(4) All of above

12. Two equal rods joined at one end are kept on a smooth surface as shown and released. Trajectory of centre of mass of both rods is -

(1) parabola

(2) straight vertical line

(3) straight inclined line

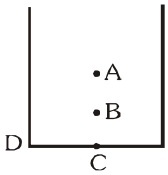
(4) straight horizontal line

13. The centre of mass of a non uniform rod of length L whose mass per unit length varies as $\rho = kx^2/L$ (where k is a constant and x is the distance measured form one end) is at the following distance from the same end.

(1) $\frac{3L}{4}$ (2) $\frac{L}{4}$

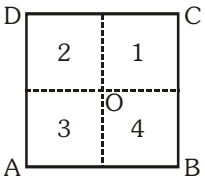
(3) $\frac{2L}{3}$ (4) $\frac{L}{3}$

14. A thick uniform wire is bent into the shape of the letter "U" as shown. Which point indicates the location of the center of mass of this wire? A is the midpoint of the line joining mid points of two parallel sides of 'U' shaped wire.



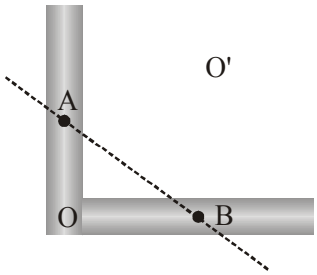
(1) A (2) B (3) C (4) D

15. In the given figure four rods AB, BC, CD and DA have mass m, 2m,3m and 4m respectively. In which of the regions (numberd 1, 2, 3, 4) the centre of mass of system lies?



(1) 1 (2) 2 (3) 3 (4) 4

16. Figure shows two cylindrical rods whose center of mass is marked as A and B. Line AB divides the region in two parts one containing point O (region 1) and other containing point O' (region 2). Choose the correct option regarding the center of mass of the combined system ?



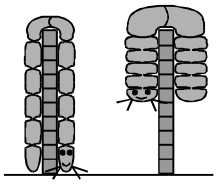
(1) The center of mass of the system lies in region 1

(2) The center of mass of the system lies in region 2

(3) The center of mass of the system lies on line AB

(4) The center of mass of the system may lie in region 1 or region 2 depending on the mass of the rods

17. Two 20 g worms climb over a 10 cm high, very thin wall. One worm is thin and 20 cm long the other is fat and only 10 cm long. What is the ratio of the potential energy (w.r.t. the base of wall) of the thin worm as compared to that of the fat worm when each is half way over the top of the wall as shown?



(1) 1 : 1 (2) 2 : 1

(3) 2 : 3 (4) 1 : 2

18. A cubical block of ice of mass m and edge L is placed in a large tray of mass M. If the ice melts, how far does the centre of mass of the system "ice plus tray" come down ?

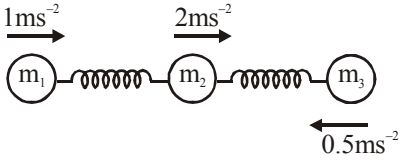
(1) $\frac{mL}{2(m+M)}$ (2) $\frac{2mL}{m+M}$

(3) $\frac{mL}{2m+M}$ (4) $\frac{mL}{m+2M}$

19. The reduced mass of two particles having masses m and 2m is :-

(1) 2m (2) 3m (3) $\frac{2m}{3}$ (4) $\frac{m}{2}$

20. Shown in the figure is a system of three particles having masses m_1 = 1 kg, m_2 = 2 kg and m_3 = 4kg connected by two springs. At an instant, accelerations of these particles are 1 m/s^2, 2 m/s^2 and 0.5 m/s^2 respectively as shown? The external force at this instant acting on the system is



(1) 1 N rightward

(2) 3 N leftward

(3) 3 N rightward

(4) Zero

21. A system of particles consists of several particles. Total mass of all the particles is 10 kg. To apply Newton's laws of motion in centroidal frame to one of the particles of mass 2 kg, you have to assume a pseudo force of $\left(4\hat{i}-2\hat{j}\right)$ N acting on it. What is the net external force acting on the whole system?

(1) $\left(10\hat{\mathrm{i}}-20\hat{\mathrm{j}}\right)\mathrm{N}$

(2) $\left(-10\hat{\mathrm{i}}+20\hat{\mathrm{j}}\right)\mathrm{N}$

(3) $\left(20\hat{\mathrm{i}}-10\hat{\mathrm{j}}\right)\mathrm{N}$

(4) $\left(-20\hat{\mathrm{i}}+10\hat{\mathrm{j}}\right)\mathrm{N}$

22. The linear density of a non-uniform rod of length 2m is given by $\lambda(x)=a\left(1+bx^2\right)$ where a and b are constants and $0\le x\le 2$. The centre of mass of the rod will be at, X =

(1) $\dfrac{3+6b}{6+8b}$

(2) $\dfrac{6+2b}{3+4b}$

(3) $\dfrac{3+6b}{3+4b}$

(4) $\dfrac{(1+2b)}{(3+4b)}$

23. A bullet of mass m moving with velocity v strikes a block of mass M at rest and gets embedded into it. The kinetic energy of the composite block will be :-

(1) $\dfrac{1}{2}\mathrm{mv}^2\times\dfrac{\mathrm{m}}{(\mathrm{m}+\mathrm{M})}$

(2) $\dfrac{1}{2}\mathrm{mv}^2\times\dfrac{\mathrm{M}}{(\mathrm{m}+\mathrm{M})}$

(3) $\dfrac{1}{2}\mathrm{mv}^2\times\dfrac{(\mathrm{M}+\mathrm{m})}{\mathrm{M}}$

(4) $\dfrac{1}{2}\mathrm{Mv}^2\times\dfrac{\mathrm{m}}{(\mathrm{M}+\mathrm{m})}$

24. One projectile moving with velocity v in space, gets burst into 2 parts of masses in the ratio 1 : 3. The smaller part becomes stationary. What is the velocity of the other part ?

(1) 4v (2) v

(3) $\dfrac{4\mathrm{v}}{3}$ (4) $\dfrac{3\mathrm{v}}{4}$

25. A body of mass 4m at rest explodes into three fragments. Two of the fragments, each of mass m move with speed v in mutually perpendicular directions.

(1) Total kinetic energy released in the process is mv^2

(2) Total kinetic energy released in the process is $3\mathrm{mv}^2/2$

(3) Velocity of third fragment is $\sqrt{2}$ v

(4) Velocity of third fragment is 2v

26. A canon shell moving along a straight line bursts into two parts. One part moves with momentum 20 N-s making an angle 30º with original line of motion. The minimum momentum other part of shell can have is.

(1) 0 N-s

(2) 5 N-s

(3) 10 N-s

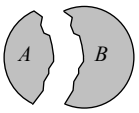
(4) Depends on mass of individual particles.

27. A particle of mass 4m which is at rest explodes into masses m, m and 2m, two of the fragments of masses m and 2m are found to move with equal speed v each in opposite directions. The total mechanical energy released in the process of explosion is

(1) mv^2 (2) $2\mathrm{mv}^2$

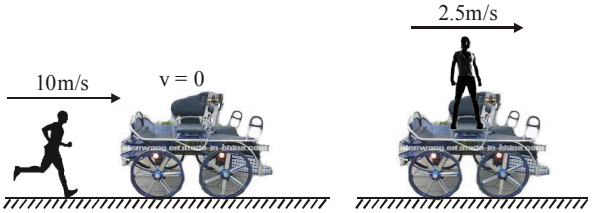
(3) $\dfrac{1}{2}\mathrm{mv}^2$ (4) $4\mathrm{mv}^2$

28. A shell in free space initially at rest explodes into two pieces, A and B, which then move in opposite directions. Piece A has less mass than piece B. Ignore all external forces. Identify correct statement ?



(1) Both have the same momentum after the explosion.
(2) Piece B has greater magnitude of momentum after the explosion.
(3) Piece A has greater kinetic energy after the explosion.
(4) Both have the same kinetic energy after the explosion.

29. A 50 kg boy runs at a speed of 10 m/s and jumps onto a cart as shown in the figure. The cart is initially at rest. If the speed of the cart with the boy on it is 2.50 m/s, what is the mass of the cart?
(Assuming friction is absent between cart and ground)



(1) 150 kg (2) 210 kg
(3) 175 kg (4) 260 kg

30. A ball is thrown with a velocity of 6 m/s vertically from a height H = 3.2 m above a horizontal floor. If it rebounds back to same height then coefficient of restitution e is [g = 10 m/s^2]

(1) 0.5 (2) 0.6 (3) 0.7 (4) 0.8

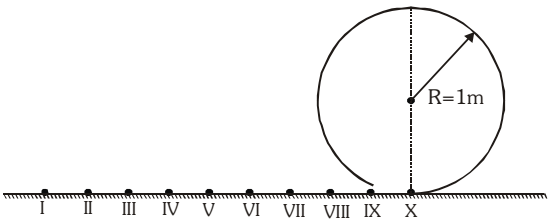
31. A particle strikes a smooth horizontal surface at an angle of 45° with a velocity of 100 m/s and rebounds. If the coefficient of restitution between the floor and the particle is 0.57 then the angle which the velocity of the particle after it rebounds will make with the floor is

(1) 30° (2) 45°
(3) 60° (4) 90°

32. Two balls of equal mass have a head-on collision with speed 6 m/s each. If the coefficient of restitution is $\frac{1}{3}$, find the speed of each ball after impact in m/s.

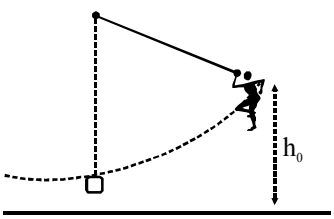
(1) 2 (2) 3 (3) 4 (4) 6

33. There are 10 small identical elastic balls placed at rest on a smooth horizontal surface as shown in figure. Find the least velocity which should be provided to the first ball such that 10th ball completes the circle. [g = 9.8 m/s^2]



(1) 70 m/s (2) 7 m/s
(3) 35 m/s (4) 14 m/s

34. Starting from rest on her swing at initial height h_0 above the ground, Saina swings forward. At the lowest point of her motion, she grabs her bag that lies on the ground. Saina continues swinging forward to reach maximum height h_1. She then swings backward and when reaching the lowest point of motion again, she simple lets go off the bag, which falls freely. Saina's backward swing then reaches maximum height h_2. Neglecting air resistance, how are the three heights related?



(1) $h_0 > h_1 > h_2$ (2) $h_0 = h_1 = h_2$
(3) $h_0 > h_1 = h_2$ (4) $h_0 = h_2 > h_1$

35. A particle is thrown vertically upward with a speed u from the top of a tower of height h from ground level. If after first impact with ground it just reaches to height h from ground the coefficient of restitution for the collision is:-

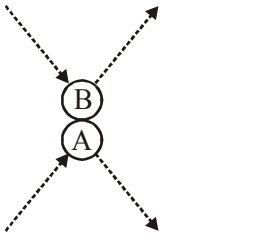
(1) 1

(2) u^2

(3) $\sqrt{\frac{2gh}{u^2+2gh}}$

(4) $\frac{\sqrt{2gh}}{u}$

36. The figure below depicts the paths of two colliding steel balls, A and B. Which of the arrows 1-4 best represents the impulse applied to ball A during the collision?



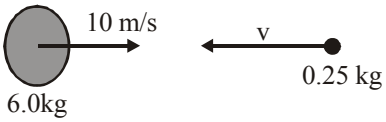
(1) 

(2) 

(3) 

(4) 

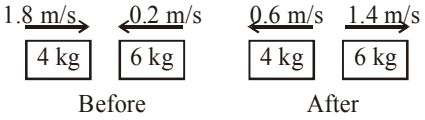
37. A 6.0 kg mass is moving to the right at 10 m/s. A 0.25 kg mass is fired towards left at the larger mass. What speed (v) must the smaller mass have to completely stop both masses?



(1) 4.2 m/s (2) 15 m/s

(3) 150 m/s (4) 240 m/s

38. In figure, determine the character of the collision. The masses of the blocks, and the velocities before and after are given. The collision is



(1) Perfectly elastic

(2) Partially inelastic

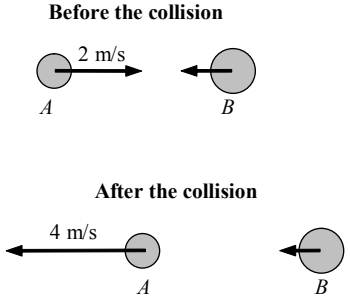
(3) Completely inelastic

(4) This collision is not possible

39. A small sphere of mass 1kg is moving with a velocity $(6\hat{i}+\hat{j})ms^{-1}$. It hits a fixed smooth wall and rebound with velocity $(-4\hat{i}+\hat{j})ms^{-1}$. The coefficient of restitution between the sphere and the wall is-

(1) 3/2 (2) 2/3 (3) 9/16 (4) 4/9

40. Ball A of mass 1 kg moving right with speed 2 m/s bounces off ball B of mass 1.5 kg, and then moves left with speed 4 m/s. Calculate magnitude of impulse (SI Units) received by ball B.



(1) 2 (2) 3 (3) 6 (4) 4

41. A mass m_1 moves with a large velocity. It strikes another mass m_2 at rest in a head on elastic collision. It comes back along its path with lesser speed after collision. Then :

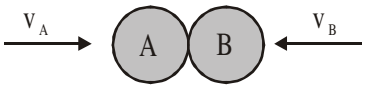
(1) $m_1 > m_2$

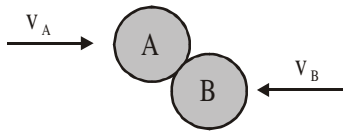
(2) $m_1 < m_2$

(3) $m_1 = m_2$

(4) There is no relation between m_1 and m_2

42. Two bodies, A and B, collide as shown in Figures a and b below.

(a) 

(b) 

Which statement is true?

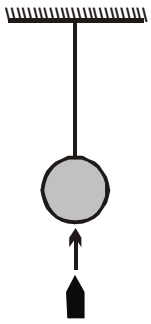
(1) They exert equal and opposite forces on each other in (a) but not in (b).

(2) They exert equal and opposite force on each other in both (a) and (b).

(3) The forces are equal and opposite to each other in (a), but only the components of the forces parallel to the velocities are equal in (b).

(4) The forces are equal and opposite in (a), but only the components of the forces perpendicular to the velocities are equal in (b)

43. A bullet of mass 50 g is fired from below into the bob of mass 450 g of a long simple pendulum as shown in Figure. The bullet stays inside the bob and the bob rises through a vertical height 1.8 m. What was the speed of bullet when it striked the bob?



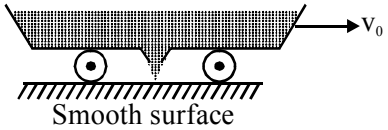
(1) 40 m/sec

(2) 50 m/sec

(3) 60 m/sec

(4) 35 m/sec

44. A trolley filled with sand moves on a smooth horizontal surface with a velocity v_0. A small hole is made at the base of it from which sand is leaking out at constant rate. As the sand leaks out then which of the following is **incorrect**?



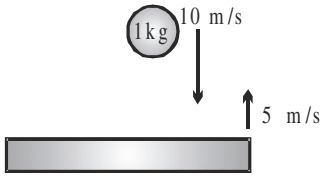
(1) The velocity of the trolley increases

(2) The velocity of the trolley remains constant

(3) The momentum of the trolley is conserved

(4) The momentum of the total system (trolley with sand + leaked out sand) is conserved in horizontal direction

45. A ball of mass 1 kg strikes a heavy platform, elastically, moving upwards with a velocity of 5m/s. The speed of the ball just before the collision is 10 m/s downwards. Then the impulse imparted by the platform on the ball is



(1) 15 N–s (2) 10 N–s

(3) 20 N–s (4) 30 N–s

46. A steel ball strikes a fixed smooth steel plate placed on a horizontal surface at an angle θ with the vertical. If the coefficient of restitution is e, the angle at which the rebound will take place is:

(1) θ (2) $\tan^{-1}\left[\frac{\tan\theta}{e}\right]$

(3) $e\tan\theta$ (4) $\tan^{-1}\left[\frac{e}{\tan\theta}\right]$

47. A ball of mass m moving with speed u undergoes a head on elastic collision with a ball of mass nm initially at rest. The fraction of the initial energy transferred to the second ball is :-

(1) $\frac{n}{1+n}$

(2) $\frac{n}{(1+n)^2}$

(3) $\frac{2n}{(1+n)^2}$

(4) $\frac{4n}{(1+n)^2}$

48. Two billiard balls P and Q, each of mass 20g and moving in opposite directions with speed of 5 m/s each, collide and rebound with the same speed. If the collision lasts for 10^{-3}sec, which of the following statements are true?

(a) The impulse imparted to each ball is 0.2 N-s

(b) The impulse imparted to each ball is 0.4 N-s and the force exerted on each ball is 400N

(c) The impulse imparted to each ball is 0.4 kgm/s and the force exerted on each ball is 4×10^{-5} N

(d) The impulse and the force on each ball are equal in magnitude and opposite in direction

(1) a & d (2) b & d

(3) c & d (4) b only

ANSWER KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	2	3	3	1	1	3	4	2	4	4	2	1	2	2	3	3	1	3	3
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	4	3	1	3	2	3	2	3	1	4	1	1	2	3	3	2	4	1	2	3
Que.	41	42	43	44	45	46	47	48												
Ans.	2	2	3	1	4	2	4	1												