EXERCISE # I

Only one option is correct.

1. A uniform sphere is placed on a smooth horizontal surface and a horizontal force F is applied on it at a distance h above the surface. The acceleration of the centre is :

(a) maximum when h=0 (b) maximum when h=R

(c) maximum when h=2R (d) is independent of h

2. A ball kept in a closed box moves in the box making collisions with the walls. The box is kept on a smooth surface. The velocity of the centre of mass :

(a) of the box remains constant. (b) of the box-ball system remains constant.

(c) of the ball remains constant. (d) of the ball relative to the box remains constant.

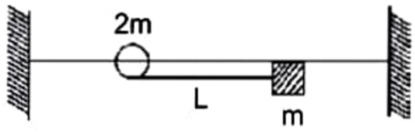
3. A heavy ring of mass m is fitted onto the periphery of a light circular disc. A small particle of equal mass is clamped at the centre of the disc. The system is rotated in such a way that center of mass moves in a circle of radius r with a uniform speed v. We conclude that an external force :

(a) mv^2/r must be acting on the central particle (b) $2mv^2/r$ must be acting on the central particle

(c) $(2mv^2/r)$ must be acting on the system (d) $(2mv^2/r)$ must be acting on the ring

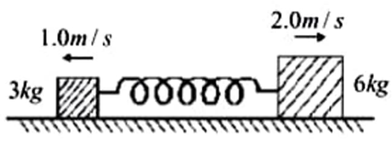
4. The centre of mass of a system of particles is at the origin. It follows that :
(a) the number of particles to the right of the origin is equal to the left of origin.
(b) the total mass of the particles to the right of the origin is same as total mass to the left of the origin.
(c) the number of particles on the X-axis should be equal to the number of particles on the Y-axis.
(d) if there is a particle on the +ve X-axis, there should be atleast one particle on the -ve X axis.
(e) None of these.

5. A bead can slide on a smooth straight wire and a particle of mass m is attached to the bead by light string of length L. The particle is held in contact with the wire with the string taut and is then let to fall. If the bead has mass $2m$, then when the string makes an angle θ with the wire the bead will have slipped a distance.



(a) $L(1-\cos\theta)$ (b) $\frac{L}{2}(1-\cos\theta)$ (c) $\frac{L}{3}(1-\cos\theta)$ (d) $\frac{L}{6}(1-\cos\theta)$

6. Two blocks of mass ***3 kg*** and ***6 kg*** respectively are placed on a smooth horizontal surface. They are connected by a light spring of force constant ***k = 200 N/M***. Initially the spring is unstretched. The indicated velocities are imparted to the blocks. The speed of $6\,kg$ block when extension of the spring is maximum will be



(a) $2\,m/s$ (b) $1\,m/s$ (c) $3\,m/s$ (d) $\frac{1}{2}\,m/s$

7. A dog weighting 5 kg is standing on a flat boat so that it is 10 m from the shore. The dog walks 4 m on the boat towards the shore and then halts. The boat weighs 20 kg and one can assume that there is no friction between it and the water. How far is the dog from the shore at the end of this time ?

(a) 3.2 m (b) 0.8 m (c) 10 m (d) 6.8 m

8. A system consists of two identical particles. One particle is at rest and the other particle has an acceleration 'a'. The centre of mass of the system has an acceleration of

(a) 2a (b) a (c) a/2 (d) a/4

9. Two bodies of mass 10 kg and 2 kg are moving with velocities 2i-7j+3k and -10i+35j-3k m/s respectively. The velocity of their CM is

(a) 2i m/s (b) 2k m/s (c) (2i+2k) m/s (d) 2i+2j+2k) m/s

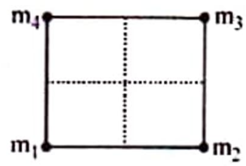
10. A rope thrown over a pulley has a ladder with a man of mass m on one of its ends and a counter balancing mass M on its other end. The man climbs with a velocity v_r relative to the ladder. Ignoring the masses of pulley and the rope as well as the friction on the pulley axis, the velocity of the CM of this system is

(a) mv_r/M (b) $mv_r/2M$ (c) Mv_r/m (d) $2Mv_r/m$

11. Two particles A and B, initially at rest, move towards each other under a mutual force of attraction. At the instant when the speed of A is v and the speed of B is 2v, the speed of centre of mass is
(a) Zero (b) v (c) 1.5V (d) 3V

12. A shell is fired from a gun with a muzzle velocity u m/s an angle θ with the horizontal. At the top of the trajectory the shell explodes into two fragments P and Q of equal mass. If the speed offragment P immediately after explosion becomes zero, where does the centre of mass of fragments hit the ground ?
(a) $\frac{u^2\sin^2\theta}{g}$ (b) $\frac{u^2\sin 2\theta}{g}$ (c) $\frac{u^2\sin^2\theta}{2g}$ (d) $\frac{u\sin\theta}{g}$

13. Four particles of masses $m_1 = 2m, m_2 = 4m, m_3 = m,$ and m_4 are placed at four corners of a square. What should be the value of m_4 so that the centre of mass of all the four particles are exactly at the centre of the square?
(a) $2m$ (b) $8m$
(c) $6m$ (d) Can never be at the centre of the square



14. A cart of mass M is tied to one end of a massless string of length $10m$. The other end of the rope is in the hands of a man of mass M , the entire system is on a smooth horizontal surface. The man is at $x = 0$ and the cart at $x = 10m$. If the man pulls the cart by a rope, the man and the cart will meet at the point

(a) $x = 0$ (b) $x = 5m$ (c) $x = 10m$ (d) They will never meet

15. A loaded spring gun of mass M fires a shot of mass m with a velocity V at an angle of elevation θ. The gun is initially at rest on a horizontal frictionless surface. Just after firing, the centre of mass of the gun-shot system:

(a) moves with a velocity $V\frac{m}{M}$ (b) moves with a velocity $\frac{Vm}{M}\cos\theta$ in horizontal direction

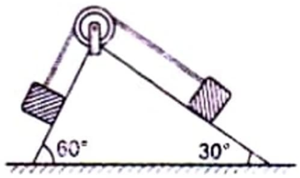
(c) remains at rest (d) moves with a velocity $\frac{V(M-m)}{(M+m)}$ in the horizontal direction.

16. Velocity of centre of mass of two particles is v and the sum of the masses of two particles is m. Kinetic energy of the system

(a) will be equal to $1/2\,mv^2$ (b) will always be less then $1/2\,mv^2$

(c) will be greater than or equal to $1/2\,mv^2$ (d) will always be greater than $1/2\,mv^2$

17. Two blocks of equal mass are tied with a light string, which passes over a massless pulley as shown in figure. The magnitude of acceleration of centre of mass of both the blocks is (neglect friction everywhere)



(a) $\left(\frac{\sqrt{3}-1}{4\sqrt{2}}g\right)$ (b) $\left(\sqrt{3}-1\right)g$ (c) $\frac{g}{2}$ (d) $\left(\frac{\sqrt{3}-1}{\sqrt{2}}\right)g$

18. Two particles of equal mass have velocities $\vec{v_1}=2i\,m/s$ and $\vec{v_2}=2j\,m/s$. First particle has an acceleration $\vec{a_1}=(3i+3j)\,m/s^2$, while the acceleration of the other particle is zero. The centre of mass of the two particles moves in a

(a) circle (b) parabola (c) straight line (d) ellipse

19. A particle of mass $2m$ is projected at an angle of 45° with horizontal with a velocity of $20\sqrt{2}\,m/s$. After $1s$ explosion takes place and the particle is broken into two equal pieces. As a result of explosion one part comes to rest. The maximum height from the ground attained by the other part is $\left(g=10\,m/s^2\right)$

(a) $50\,m$ (b) $25\,m$ (c) $40\,m$ (d) $35\,m$

20. Two particles of equal mass m are projected from the ground with speed v_1 and v_2 at angles θ_1 and θ_2 as shown in figure. The centre of mass of the two particles

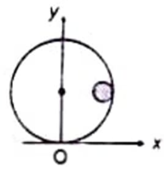
(a) will move in a parabolic path for any values of v_1, v_2, θ_1 and θ_2

(b) can move in a vertical line

(c) can move in a horizontal line

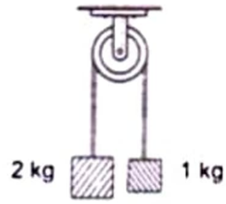
(d) will move in a straight line for any values of v_1, v_2, θ_1 and θ_2

21. A small sphere of radius R held against the inner surface of a smooth spherical shell of radius $6R$ as shown in figure. The masses of the shell and small spheres are $4M$ and M respectively. This arrangement is placed on a smooth horizontal table. The small sphere is now released. The $x-$coordinate of the centre of the shell when the smaller sphere reaches the other extreme position is



(a) R (b) $2R$ (c) $3R$ (d) $4R$

22. Two blocks of masses $2kg$ and $1kg$ respectively are tied to the ends of a string which passes over a light frictionless pulley. The masses are held at rest at the same horizontal level and then released. The distance traversed by centre of mass in $2s$ is $\left(g = 10\,m/s^2\right)$

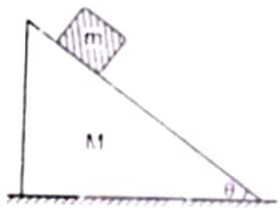


(a) $1.42m$ (b) $2.22m$
(c) $3.12m$ (d) $3.33m$

23. A boy of mass $60kg$ is standing over a platform of mass $40kg$ placed over a smooth horizontal surface. He throws a stone of mass $1kg$ with velocity $u = 10m/s$ at an angle 45° with respect to ground. The displacement of platform (with boy) on the horizontal surface, when the stone lands on the ground is $\left(g = 10\,m/s^2\right)$

(a) $25cm$ (b) $5cm$ (c) $10cm$ (d) $50cm$

24. A block of mass m slides over a smooth wedge of mass M which is placed over a rough horizontal surface. The centre of mass of the system will move towards left(μ : coeff. of friction between wedge and ground)



(a) if $mg\cos\theta\sin\theta > \mu(M+m)g$
(b) if $mg\sin\theta > \mu Mg$
(c) if $mg\cos\theta\sin\theta > \mu Mg$
(d) None of the above

25. Internal forces can change :

(a) linear momentum but not kinetic energy
(b) kinetic energy but not linear momentum
(c) linear momentum as well as kinetic energy
(d) neither linear momentum nor kinetic energy

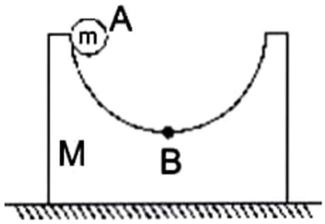
26. A nucleus with a velocity $\vec{v}$ emits an α particle. Let the velocity of the α particle and the remaining nucleus be $\vec{v_1}$ & $\vec{v_2}$ and their masses be m_1 and m_2.

(a) $\vec{v}, \vec{v_1}$ & $\vec{v_2}$ must be parallel to each other.
(b) none of the two $\vec{v}, \vec{v_1}$ & $\vec{v_2}$ should be parallel to each other
(c) $\vec{v_1} + \vec{v_2}$ must be parallel to $\vec{v}$
(d) $\vec{v}$ must be parallel to $m_1\vec{v_1} + m_2\vec{v_2}$

27. A shell is fired from a canon with a velocity V at an angle θ with the horizontal direction. At the highest point of its path, it explodes into two small pieces of equal mass. One of the pieces retraces its path back to the canon. The speed of the other piece immediately after the explosion is:

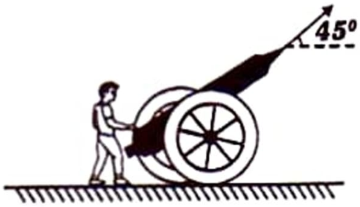
(a) 3Vcosθ (b) 2Vcosθ (c) 1.5Vcosθ (d) Vcosθ

28. A block of mass $M = 2kg$ with a semicular track of radius $R = 1.1m$ rests on a horizontal frictionless surface. A uniform cylinder of radius $r = 10\ cm$ and mass $m = 1\ kg$ is released from rest from the top pointA. The cylinder slips on the semicircular frictionless track. The speed of the block when the cylinder reaches the bottom of the track at$B$ is $(g = 10\ m/s^2)$



(a) $\sqrt{\frac{10}{3}}\,m/s$ (b) $\sqrt{\frac{4}{3}}\,m/s$ (c) $\sqrt{\frac{5}{2}}\,m/s$ (d) $\sqrt{10}\,m/s$

29. A gun fires a bullet as shown in figure. The barrel of the gun is inclined at an angle of 45° with horizontal. When the bullet leaves the barrel, it will be travelling at an angle to the horizontal ,of

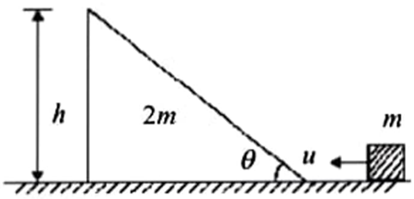


(a) 45° (b) less than 45° (c) more than 45° (d) zero

30. A small block of superdense material has a mass M/3 where$M$ is the mass of earth. It is released from rest from a height$h$(<< **radius of earth**) from the surface of earth. The speed of the block at a height h/2 is

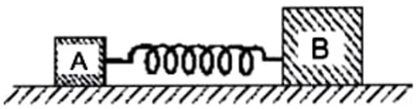
(a) $\sqrt{gh}$ (b) $\frac{\sqrt{3gh}}{2}$ (c) $\sqrt{\frac{2gh}{3}}$ (d) $\sqrt{2gh}$

31. A block of mass m is pushed towards a movable wedge of mass $2m$and height$h$ with a velocity u. All surfaces are smooth . The minimum value of u for which the block will reach the top of the wedge is



(a) $2\sqrt{gh}$ (b) $\sqrt{3gh}$ (c) $\sqrt{6gh}$ (d) $\sqrt{\frac{3}{2}gh}$

32. Two blocks A and B of mass m and $2\ m$ are connected by a massless spring of force constant k. They are placed on a smooth horizontal plane. Spring is stretched by an amount x and then released. The relative velocity of the blocks when the spring comes to its natural length is

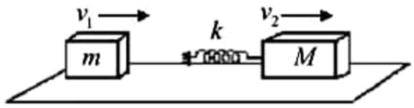


(a) $\left(\sqrt{\frac{3k}{2m}}\right)x$ (b) $\left(\sqrt{\frac{2k}{3m}}\right)x$ (c) $\left(\sqrt{\frac{2kx}{m}}\right)$ (d) $\left(\sqrt{\frac{3km}{2x}}\right)$

33. A particle of mass $1kg$ is projected at an angle of 30° with horizontal with velocity $v = 40\,m/s$. The change in linear momentum of the particle after time $t = 1s$ will be $\left(g = 10\,m/s^2\right)$

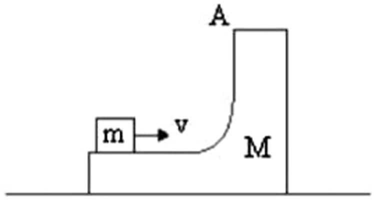
(a) $7.5\,kg - m/s$ (b) $15\,kg - m/s$ (c) $10\,kg - m/s$ (d) $20\,kg - m/s$

34. Two blocks of masses m and M are moving with speeds v_1 and $v_2 (v_1 > v_2)$ in the same direction on the frictionless surface respectively, M being ahead of m. An ideal spring of force constant k is attached to the back side of M (as shown). The eventual maximum compression of the spring will be :



(a) $\upsilon_1\sqrt{\frac{m}{k}}$ (b) $\upsilon_2\sqrt{\frac{M}{k}}$ (c) $(v_1 - v_2)\sqrt{\frac{mM}{(m+M)k}}$ (d) None of above is correct

35. A small block of mass m is projected with a speed v on the horizontal part of a larger block of massM placed on a horizontal floor. The curved part of the surface of large block is semicircular with radius r as shown. Assume all the surfaces in contact to be frictionless. The speed of the larger block when the smaller block reaches the point A of the surface is



(a) mv (b) Mv (c) $\frac{m\upsilon}{M+m}$ (d) ZERO

36. A stationary body explodes into two fragments of masses m_1 and m_2. If momentum of one fragment is p, the energy of the explosion is

(a) $\frac{p^2}{2(m_1+m_2)}$ (b) $\frac{p^2}{2\sqrt{m_1 m_2}}$ (c) $\frac{p^2(m_1+m_2)}{2m_1 m_2}$ (d) $\frac{p^2}{2(m_1-m_2)}$

37. A particle of mass M is moving in a horizontal circle of radius R with uniform speed V. When it moves from one point to a diametrically opposite point its

(a) Momentum does not change (b) Momentum changes by 2MV

(c) KE changes by MV^2 (d) KE changes by $(1/4)MV^2$

38. A lead ball strikes a wall and falls down. A tennis ball having the same mass and same velocity strikes the same wall and bounces back. Which is the correct statement?

(a) The tennis ball suffers a greater change in momentum

(b) The lead ball suffers a greater change in momentum

(c) Both the balls suffers equal change in momentum

(d) The momentum of lead ball is greater than that of tennis ball

39. A bomb of mass $9\,kg$ explodes into pieces of masses $3\,kg$ and $6\,kg$. The velocity of mass $3\,kg$ is $16\,m/s$. The K.E. of mass $6\,kg$ in joule is

(a) 96 (b) 384 (c) 192 (d) 768

40. A body of mass $1\,kg$ initially at rest, explodes and breaks into three fragments of masses in the ratio 1:1:3. The two pieces of equal mass fly off perpendicular to each other with a speed of $15\,m/s$. The speed of heavier fragment is

(a) $5\sqrt{2}\,m/s$ (b) $45\,m/s$ (c) $5\,m/s$ (d) $15\,m/s$

41. Two blocks of masses $10\,kg$ and $4kg$ are connected by a spring of negligible mass and placed on a frictionless horizontal surface. An impulse gives a velocity of $28\,ms^{-1}$ to the heavier block in the direction of the lighter block. The velocity of the centre of mass is:

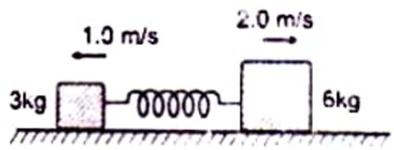
(a) $30\,ms^{-1}$ (b) $20\,ms^{-1}$ (c) $10\,ms^{-1}$ (d) $5\,ms^{-1}$

42. A gun fires a shell and recoils horizontally. If the shell travels along the barrel with speed v, the ratio of speed with which the gun recoils if (i) the barrel is horizontal (ii) inclined at an angle of 30° with horizontal is

(a) 1 (b) $\frac{2}{\sqrt{3}}$ (c) $\frac{\sqrt{3}}{2}$ (d) $\frac{1}{2}$

43. The momentum of a particle is $\overline{P} = \overline{A} + \overline{B}t^2$, where $\overline{A}$ and $\overline{B}$ are constant perpendicular vectors. The force acting on the particle when its acceleration is at 45° with its velocity is

(a) $2\sqrt{\frac{A}{B}}\overline{B}$ (b) $2\overline{B}$ (c) zero (d) Data is insufficient



44. Two blocks of mass $3\,kg$ and $6\,kg$ respectively are placed on a smooth horizontal surface. They are connected by a light spring of force constant $k = 200\,N/m$. Initially the spring is unstretched. The indicated velocities are imparted to the blocks. The maximum extension of the spring will be

(a) 30 cm (b) 25 cm (c) 20 cm (d) 15 cm

45. A force $\vec{F} = \left(2\hat{i} + \hat{j} + 3\hat{k}\right)N$ acts on a particle of mass $1kg$ for $2\,s$. If initial velocity of particle is $\vec{u} = \left(2\hat{i} + \hat{j}\right)m/s$. Speed of particle at the end of $2s$ will be

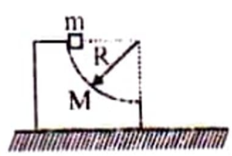
(a) $12\,m/s$ (b) $6\,m/s$ (c) $9\,m/s$ (d) $4\,m/s$

46. A bullet is fired from a gun. The force on the bullet is given by

$F = 600 - \left(2 \times 10^5\right)t$

Here, F is in newton and t in second. The force on the bullet becomes zero as soon as it leaves the barrel. The impulse imparted to the bullet is

(a) $8\,N-s$ (b) $0.9\,N-s$ (c) $1.8\,N-s$ (d) $2.4\,N-s$



47. A small cube of mass m slides down a circular path of radius R cut into a larger block of mass M, as shown in the figure. M rests on a table, and both blocks move without friction. The blocks are initially at rest, and m starts from the top of the path. The velocity v of the cube as it leaves the block is

(a) $\sqrt{\frac{2mgR}{M}}$ (b) $\sqrt{2gR}$ (c) $\sqrt{\frac{2mgR}{m+M}}$ (d) $\sqrt{\frac{2MgR}{m+M}}$

48. A block of metal weighing $2kg$ is resting on a frictionless plane. It is struck by jet releasing water at a rate of $1 kg/s$ and at a speed of $5 m/s$. The initial acceleration of the block is

(a) $\frac{5}{3} m/s^2$ (b) $\frac{25}{4} m/s^2$ (c) $\frac{25}{8} m/s^2$ (d) $\frac{5}{2} m/s^2$

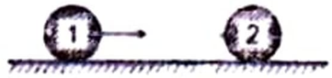
49. A block of mass m moving with speed v collides with another block of mass $5m$ at rest. The lighter block comes to rest after the collision. The coefficient of restitution is:

(a) $1/5$ (b) $4/5$ (c) $1/\sqrt{5}$ (d) $1/25$

50. A $1 kg$ ball, moving at $12 ms^{-1}$, collides head-on with a $2 kg$ ball moving in the opposite direction at $24 ms^{-1}$. If the coefficient of restitution is $\frac{2}{3}$, then the energy lost in the collision is:

(a) $60 J$ (b) $120 J$ (c) $240 J$ (d) $480 J$

51. Ball 1 collides with an another identical ball 2 at rest as shown in figure. For what value of coefficient of restitution e, the velocity of second ball becomes two times that of 1 after collision?



(a) $1/3$ (b) $1/2$ (c) $1/4$ (d) $1/6$

52. A ball of mass $10 g$ is dropped on the ground from a height of $10 m$. It rebounds to a height of $2.5 m$. If the ball is in contact with the ground for $0.01 s$, then which statement is correct?

(a) Impulse force between the ground and a ball is $45 N$

(b) Impulse force between the ground and ball is $15\sqrt{2} N$

(c) Coefficient of restitution between the ground and ball is $1/4$

(d) Coefficient of restitution between the ground and ball is $1/2$

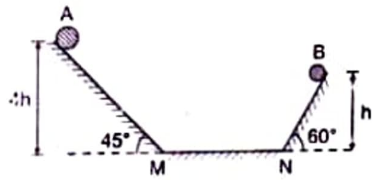
53. Two billiard balls of the same size and mass are in contact on a billiard table. A third ball of the same size and mass strikes them symmetrically and remains at rest after the impact. The coefficient of restitution between the ball is

(a) $\frac{1}{2}$ (b) $\frac{1}{3}$ (c) $\frac{2}{3}$ (d) $\frac{3}{4}$

54. A ball strikes a horizontal floor at an angle $\theta = 45^\circ$. The coefficients of restitution between the ball and the floor is $e = \frac{1}{2}$. The fraction of its kinetic energy lost in first collision is

(a) $5/8$ (b) $3/8$ (c) $3/4$ (d) $1/4$

55. Two identical balls A and B are released from the position shown in figure. They collides elastically on horizontal portion MN. The ratio of heights attained by A and B after collision will be (neglect friction)



(a) $1:4$ (b) $2:1$ (c) $4:13$ (d) $2:5$

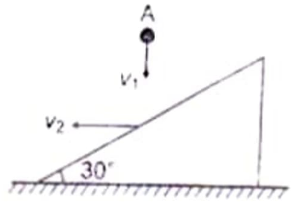
56. A smooth sphere is moving on a horizontal surface with velocity vector $a\hat{i}+b\hat{j}$ immediately before it hits a vertical wall. The wall is parallel to $\hat{j}$ vector and the coefficient of restitution between the sphere and the wall is e. The velocity vector of the sphere after it hits the wall is

(a) $a\hat{i}-eb\hat{j}$ (b) $-ae\hat{i}+b\hat{j}$ (c) $-ae\hat{i}-be\hat{j}$ (d) $ae\hat{i}+b\hat{j}$

57. A small block of mass M moves with velocity $5 m/s$ towards an another block of same mass M placed at a distance of $2m$ on a rough horizontal surface. Coefficient of friction between the blocks and ground is 0.25. Collision between the two blocks is elastic, the separation between the blocks when both of them come to rest, is $\left(g=10\, m/s^2\right)$

(a) 3m (b) 4m (c) 2m (d) 1.5 m

58. A ball A is falling vertically downwards with velocity v_1. It strikes elastically with a wedge moving horizontally with velocity v_2 as shown in figure. What must be the ratio $\frac{v_1}{v_2}$, so that the ball bounces back in vertically upward direction relative to the wedge

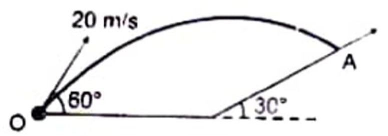


(a) $\sqrt{3}$ (b) $\frac{1}{\sqrt{3}}$ (c) 2 (d) $\frac{1}{2}$

59. A girl throws a ball with initial velocity v at an inclination of 45°. The ball strikes a smooth vertical wall at a horizontal distance d from the girl and after bouncing returns to her hand. What is the coefficient of restitution between the wall and the ball?

(a) v^2-gd (b) $\frac{gd}{v^2-gd}$ (c) $\frac{gd}{v^2}$ (d) $\frac{v^2}{gd}$

60. A ball is projected from the point O with velocity $20 m/s$ at an angle 60° with horizontal as shown in figure. At highest point of its trajectory it strikes a smooth plane of inclination 30° at point A. The collision is perfectly inelastic. The maximum height from the ground attained by the ball is $\left(g=10\, m/s^2\right)$



(a) $18.75 m$ (b) $15 m$ (c) $22.5 m$ (d) $20.25 m$

EXERCISE # II

More than option(s) may be correct.

1. A body has its centre of mass at the origin. The x-coordinates of the particles :
(a) may be all positive
(b) may be all negative
(c) may be all non negative
(d) may be positive for some cases and negative for others.

2. In which of the following cases is the centre of mass of a rod certainly not at its center?
(a) the density continuously increasing from left to right
(b) the density continuously decreasing from left to right
(c) the density decreasing from left to right upto centre and then increasing
(d) the density increasing from left to right upto centre and then decreasing

3. 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_0 at an instant t. It is possible that :
(a) $a_0 = 0, v_0 = 0$
(b) $a_0 \neq 0, v_0 = 0$
(c) $a_0 = 0, v_0 \neq 0$
(d) $a_0 \neq 0, v_0 \neq 0$

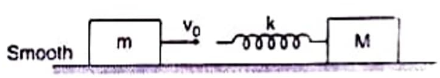
4. A man of mass ***m*** is at rest on a stationary flat car. The car can move without friction along horizontal rails. The man starts walking with velocity ***u*** relative to the car, work done by him
(a) is less than $\frac{1}{2}mu^2$ if he walks along the rails
(b) is equal to $\frac{1}{2}mu^2$ if he walks normal to rails
(c) can never be less than $\frac{1}{2}mu^2$
(d) is greater than $\frac{1}{2}mu^2$ if he walks along the rails

5. Velocity of centre of mass of two particles is ***V*** and total mass of the particles is ***M***. Kinetic energy of the system
(a)can not be equal to $\frac{1}{2}MV^2$
(b)can not be less than $\frac{1}{2}MV^2$
(c)may be equal to $\frac{1}{2}MV^2$
(d)can not be calculated without other informations.

6. Two particles of equal mass are projected simultaneously from the roof of a tower of height 20 m with same speed $20\,m/s$, one horizontally and the other vertically upwards. Choose the correct alternative(s).
(a) The acceleration of centre of mass is $g/2$ downwards
(b) The acceleration of centre of mass is g downwards
(c) Maximum height of centre of mass from the ground is 25 m
(d) Maximum height of centre of mass from the ground is 40 m.

7. Two identical balls are thrown obliquely from the ground simultaneously. The acceleration of centre of mass
(a) does not depend on the mass of the two balls
(b) depends on the direction in which two balls are projected
(c) is equal to g
(d) is zero

8. A block of mass m moving with a velocity v_0 collides with a stationary block of mass M at the back of which a spring of spring constant k is attached, as shown in the figure. Select the correct alternative(s).



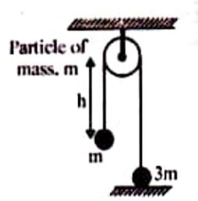
(a) The velocity of centre of mass is $\frac{m}{m+M}v_0$

(b) The initial kinetic energy of the system in the centre of mass frame is $\frac{1}{4}\left(\frac{mM}{M+m}\right)v_0^2$

(c) The maximum compression in the spring is $v_0\sqrt{\frac{mM}{(m+M)}\frac{1}{k}}$

(d) When the spring is in the state of maximum compression the kinetic energy in the centre of mass frame is zero.

9. A particle of mass m falls from a height h on a mass m and gets stuck to it.



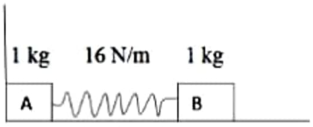
(a) acceleration of the pulley mass system after impact is given by $g/5$

(b) the height to which 3m mass rises is $h/5$

(c) the height to which 3m mass rises is $h/3$

(d) acceleration of the pulley mass system after impact is $g/3$

10. In the system shown in the figure block A is not attached with the wall. Block B is pushed by 1mtowards left and then released at time t = 0. Then



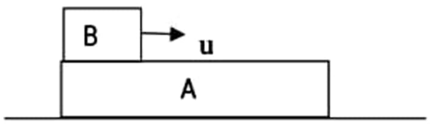
(a) net force on the system is non zero for t < π/2 sec

(b) net force on the system is non zero all the time

(c) final velocity of centre of mass is 4 m/s

(d) final velocity of centre of mas is 2 m/s

11. A horizontal block A is at rest on a smooth horizontal surface. A small block B, whose mass is half of A, is placed on A at one end and projected along other end with some velocity u. The coefficient of friction between blocks is μ. Then



(a) the blocks will reach a final common velocity $u/3$

(b) the work done against friction is two-third of the initial kinetic energy of B

(c) before the blocks reach a common velocity, the acceleration of A relative to B is $(2/3)\mu g$

(d) before the blocks reach a common velocity, the acceleration of A relative to B is $(3/2)\mu g$

12. In a one-dimensional collision between two particles B is stationary and A has momentum p before impact. During impact, A gives impulse J to B. Then

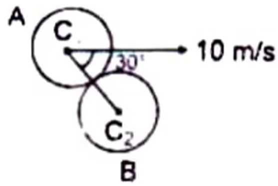
(a) the total momentum of A plus B system is p before and after the impact and $(p-J)$ during the impact

(b) during the impact B gives impulse $-J$ to A

(c) the coefficient of restitution is $(2J/p)-1$

(d) the coefficient of restitution is $(2J/p)+1$

13. A ball A collides elastically with an another identical ball B with velocity $10 m/s$ at an angle of 30° with the line joining their centres C_1 and C_2. Select the correct alternative(s)

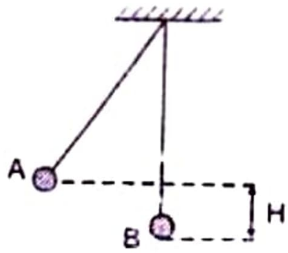


(a) Velocity of ball A after collision is $5 m/s$.
(b) Velocity of ball B after collision is $5\sqrt{3}\, m/s$
(c) Both the balls moves at right angles after collision
(d) Kinetic energy will not be conserved here, because collision is not head on

14. A projectile is fired on a horizontal ground. Coefficient of restitution between the projectile and the ground is e. Let a, b and c be the ratio of time of flight $\left(\frac{T_1}{T_2}\right)$, maximum height $\left(\frac{H_1}{H_2}\right)$ and Horizontal range $\left(\frac{R_1}{R_2}\right)$ in first two collisions with the ground. Then

(a) $a = \frac{1}{e}$ (b) $b = \frac{1}{e^2}$ (c) $c = \frac{1}{e^2}$ (d) All of these

15. Two small balls A and B of mass M and $3M$ hang from the ceiling by strings of equal length. The ball A is drawn aside so that it is raised to a height H. It is then released and collides with ball B. Select the correct answer (s)

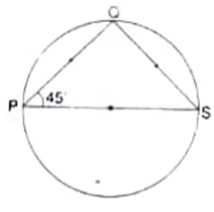


(a) If collision is elastic, ball B will rise to a height $H/4$
(b) If the collision is elastic ball A will rise to a height $H/4$
(c) If the collision is perfectly inelastic, the combined mass will rise to a height $H/16$
(d) If the collision is perfectly inelastic, the combined mass will rise to a height $H/4$

16. Ball A of mass m strikes a stationary ball B of mass M and undergoes an elastic collision. After collision ball A has speed one third of its initial speed. The ratio of $\frac{M}{m}$ is

(a) 0.25 (b) 0.5 (c) 2 (d) 4

17. A body is fired from point P and strikes at Q inside a smooth circular wall as shown in the figure. It rebounds to point S (diametrically opposite to P), then

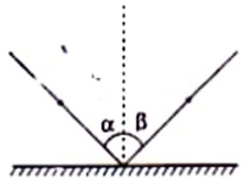


(a) the coefficient of restitution is zero
(b) the coefficient of restitution is 1.
(c) kinetic energy is conserved in this collision
(d) the coefficient of restitution is $\frac{1}{\sqrt{3}}$

18. A particle moving with kinetic energy E makes a head on elastic collision with an identical particle at rest. During the collision

(a) elastic potential energy of the system is always zero
(b) maximum elastic potential energy of the system is $E/2$
(c) minimum kinetic energy of the system is $E/2$
(d) kinetic energy of the system is constant.

19. A ball strikes the ground at an angle α and rebound at an angle β with vertical as shown in the figure. Then



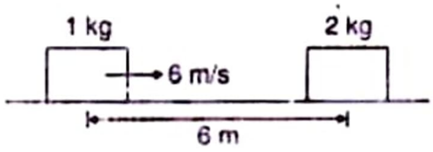
(a) coefficient of restitution is $\frac{\tan\alpha}{\tan\beta}$

(b) if $\alpha < \beta$ the collision is inelastic

(c) if $\alpha = \beta$ the collision is elastic

(d) if $\alpha > \beta$ the collision is inelastic.

20. A block of mass $1\,kg$ is pushed towards another block of mass $2kg$ from $6\,m$ distance as shown in figure. Just after collision velocity of $2\,kg$ block becomes $4\,m/s$



(a) coefficients of restitution between two blocks is 1

(b) coefficient of restitution between two blocks is 1/2

(c) velocity of centre of mass after $2\,s$ is $2\,m/s$

(d) velocity of centre of mass after $2\,s$ is $1\,m/s$

21. Velocity of a particle of mass $2\,kg$ changes from $\vec{v}_1 = -2\hat{j} - 2\hat{j}\,m/s$ to $\vec{v}_2 = \left(\hat{i} - \hat{j}\right)m/s$ after colliding with a plane surface

(a) the angle made by the plane surface with the positive $x-$axis is $90^\circ + \tan^{-1}\left(\frac{1}{3}\right)$

(b) the angle made by the plane surface with the positive $x-$axis is $\tan^{-1}\left(\frac{1}{3}\right)$

(c) the direction of change in momentum makes an angle $\tan^{-1}\left(\frac{1}{3}\right)$ with the $+ve\,x-$ axis

(d) the direction of change in momentum makes an angle $90^\circ + \tan^{-1}\left(\frac{1}{3}\right)$ with the plane surface.

22. A ball A collides elastically with an another identical ball B with velocity V_0 m/s at an angle of θ from the joining their centres C_1 and C_2. Select the correct alternative (s)

(a) velocity of ball A after collision is $V_0\sin\theta$ m/s.

(b) velocity of ball B collision is $V_0\cos\theta$ m/s.

(c) both the balls moves at right angle after collision

(d) kinetic energy will not be conserved here, because collision is not head on

23. In an elastic collision between two particles

(a) the total kinetic energy of the system is always conserved

(b) the kinetic energy of the system before collision is equal to the kinetic energy of the system after collision

(c) the linear momentum of the system may be conserved

(d) the mechanical energy of the system before collision is equal to the mechanical energy of system after collision.

24. A ball of mass m moving horizontally at a speed v collides with the bob of a simple pendulum at rest. The mass of the bob is also m.

(a) If the collision inelastic, the height to which the two masses rise after the collision is $\frac{v^2}{8g}$

(b) If the collision is inelastic, the kinetic energy of the system immediately after the collision becomeshalf of that before collision.

(c) If the collision is perfectly elastic, the bob of the pendulum will rise to a height of $\frac{v^2}{2g}$

(d) If the collision is perfectly elastic, the kinetic energy of the system immediately after the collision is equal to that before collision.

25. A ball A of mass m moving with velocity v collides head on with a stationary ball B of mass m. If e be the coefficient of restitution, then which of the following is/are correct?

(a) The ratio of velocities of balls A and B after the collision is $\frac{1+e}{1-e}$

(b) The ratio of the final and initial velocities of ball A is $\frac{1-e}{2}$

(c) The ratio of velocities of balls A and B after collision is $\frac{1-e}{1+e}$

(d) The ratio of the final and initial velocities of the ball B is $\frac{1+e}{2}$

EXERCISE # III

1. Match the column I (different uniform rigid bodies) with column II (height of their centre of mass) from the centre: (R is radius of body)

Column I	Column II
(a) Semi-circular ring	(p) $\frac{4R}{3\pi}$
(b) Semi-circular disc	(q) $\frac{R}{2}$
(c) Solid hemisphere	(r) $\frac{2R}{\pi}$
(d) Hollow hemisphere	(s) $\frac{3R}{8}$

2. Four point masses are placed at four corners of a square of side $4m$ as shown. Match the following table.

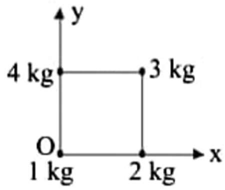


Table-1	Table-2
(a) $x-$ co-ordinate of centre of mass of $4\,kg$ and $2\,kg$	(p) $(7/2)m$
(b) $x-$co- ordinate of centre of mass of $4\,kg, 2kg$ and $3kg$	(q) $(4/3)m$
(c) $y-$co-ordinate of centre of mass of $1\,kg, 4kg$ and $3\,kg$	(r) $3\,m$
(d) $y-$co-ordinate of centre of mass of $1\,kg$ and $3\,kg$	(s) $(20/9)m$

3. A system consists of two particles. The first particle of mass $1\,kg$ has velocity $\vec{v}_1 = (2t)\hat{i}$ and another particle of mass $2\,kg$ has velocity $\vec{v}_2 = (t^2)\hat{j}$. Match the following

Table-1	Table-2
(a) Net force on centre of mass at $2\,s$	(p) $\frac{20}{9}$ *unit*
(B) Velocity of centre of mass at $2s$	(q) $\sqrt{68}$ *units*
(c) Displacement of centre of mass in $2\,s$	(r) $\frac{\sqrt{80}}{3}$ *unit*
	(s) None

4. In a two block system shown in figure match the following

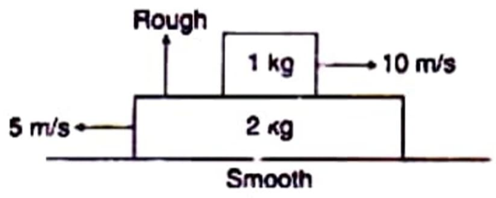


Table-1	**Table-2**
(a) Velocity of centre of mass	(p) Keep on changing all the time
(b) Momentum of centre of mass	(q) First decreases then becomes zero
(c) Momentum of $1 kg$ block	(r) Zero
(d) Kinetic energy of $2 kg$ block	(s) Constant

5. Match the following

(P= Momentum of particle , K = kinetic energy of particle)

Table-1	**Table-2**
(a) P is increased by 200%, corresponding change in K	**(p)** 800%
(b) K is increased by 300%,corresponding change in P	**(q) 200%**
(c) P is increased by 1%,corresponding change in K	**(r)** 0.5%
(d) K is increased by 1%, corresponding change in P	**(s)** 2%
	(t) None

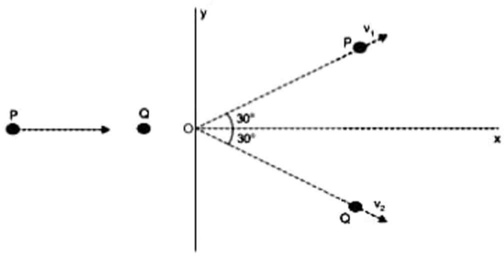
6. Match the Statements in Column I with the processes in Column II

Column I	**Column II**
(a) Collision of the two light nuclei to form a heavier nucleus.	(p) Elastic Collision
(b) A speeding bullet getting embedded in a wooden plank	(q) Inelastic Collision
(c) Collision of neutron with a heavy unstable nucleus.	(r) Nuclear Fission
(d) Collision in which there is no loss of kinetic energy	(s) Nuclear Fusion

Based on the passages given, answer the questions that follow the passage

Passage I

A ball P moving with a velocity u strikes an identical stationary ball Q such that after the collision, the direction of motion of ball P and Q make an angle of 30^0 with the original direction of motion of ball P, as shown in the figure.



7. The speed of v_1 of the ball P after the collision is:

(a) $u/2$ (b) $u/3$

(c) $u/\sqrt{2}$ (d) $u/\sqrt{3}$

8. The speed v_2 of ball Q after the collision is:

(a) $u/\sqrt{3}$ (b) $u/3$ (c) $2u/3$ (d) 3u/2

9. The ratio of the total kinetic energy of the balls after the collision to that before collision is

(a) 1/3 (b) $1/\sqrt{3}$ (c) 2/3 (d) $1/\sqrt{2}$

Passage II

A ball of m is dropped from a height h on a smooth horizontal floor. The coefficient of restitution for collision between the floor and the ball is e.

10. The total distance covered by the ball before it comes to rest is:

(a) $h\left(\frac{1+e}{1-2}\right)$ (b) $h\left(\frac{1+e}{1-e}\right)^2$ (c) $h\left(\frac{1+e^2}{1-e^2}\right)$ (d) $h\left(\frac{1+e^2}{1-e^2}\right)^{1/2}$

11. The total time taken by the ball to come to rest is:

(a) $\sqrt{\frac{2h}{g}}\left(\frac{1+e}{1-e}\right)$ (b) $\sqrt{\frac{2h}{g}}\left(\frac{1+e^2}{1-e^2}\right)$ (c) $\sqrt{\frac{2h}{g}}\left(\frac{1+e}{1-e}\right)^{1/2}$ (d) $\sqrt{\frac{2h}{g}}\left(\frac{1+e^2}{1-e^2}\right)^{1/2}$

12. The total momentum imparted by the ball to the floor is:

(a) $m\sqrt{2gh}\left(\frac{1+e^2}{1-e^2}\right)$ (b) $m\sqrt{2gh}\left(\frac{1+e}{1-e}\right)$ (c) $m\sqrt{2gh}$ (d) $me\sqrt{2gh}$

Passage-III

One particle of mass $1kg$ is moving along positive $x-$axis with velocity $3m/s$. Another particle of mass $2kg$ is moving along $y-$ axis with velocity $6m/s$. At time $t=0$, $1kg$ mass is at $(3m,0)$ and $2kg$ at (0, 9m). x-y plane is the horizontal plane. (surface is smooth for question 13 and rough for question 14 and 15)

13. The centre of mass of the two particles is moving in a straight line:

(a) $y=x+2$ (b) $y=4x+2$ (c) $y=2x-4$ (d) $y=2x+4$

14. If both the particles have the same value of coefficient of friction $\mu = 0.2$. The centre of mass will stop at time

(a) 1.5 sec (b) 4.5 sec (c) 3.0 sec (d) 2.0 sec

15. Co-ordinates of centre of mass where it will stop finally are

(a) $(2.0m, 14.25m)$ (b) $(2.25m, 10m)$ (c) $(3.75m, 9m)$ (d) $(1.75m, 12m)$

Passage-IV

A cracker is thrown into air with a velocity of $10\, m/s$ at an angle of 45° with the vertical. When it is at a height of $(1/2)\, m$ from the ground, it explodes into a number of pieces which follow different parabolic paths.

16. What is the velocity of centre of mass, when it is at a height of 1 m from the ground? $\left(g = 10\, ms^{-2}\right)$

(a) $4\sqrt{5}\, ms^{-1}$ (b) $2\sqrt{5}\, ms^{-1}$ (c) $5\sqrt{4}\, ms^{-1}$ (d) $10\, ms^{-1}$

17. What is the time taken by the centre of mass to hit the ground?

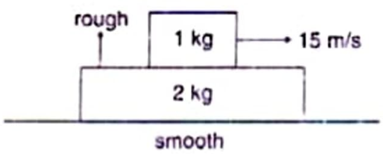
(a) $2s$ (b) $\sqrt{2}\, s$ (c) $1s$ (d) $\sqrt{1/2}$

18. What is the minimum velocity of centre of mass in its path?

(a) $10\, ms^{-1}$ (b) $5\, ms^{-1}$ (c) $5\sqrt{2}\, ms^{-1}$ (d) $10\sqrt{2}\, ms^{-1}$

Passage-V

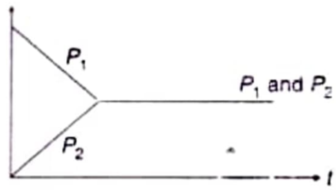
A $1kg$ block is given a velocity of $15\, m/s$ towards right over a very long rough plank of mass $2\, kg$ as shown in figure.



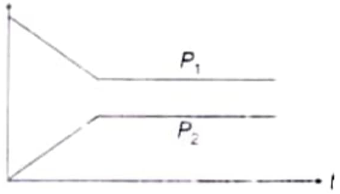
19. The correct graph showing linear momentum of $1\, kg$ $(i.e\, P_1)$ and of $2\, kg$ $(i.e\, P_2)$ versus time is

(a) P_1 and P_2

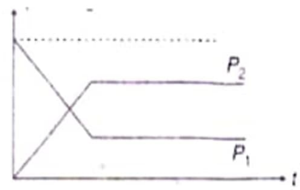
(b) P_1 and P_2



(c) P_1 and P_2



(d) P_1 and P_2



20. If coefficient of friction between the two blocks is equal to 0.4 , then magnitude of initial slope of P_1 versus t and p_2 versus t (in SI unit) will be

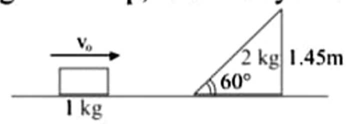
(a) 4 and 2 (b) 2 and 4 (c) 4 and 4 (d) 2 and 2

21. Momentum of both the blocks are equal at time equal to (in sec)

(a) 1.75 (b) 1.875 (c) 2.5 (d) 1.25

Passage- VI

A block of mass $1kg$ is moving towards a movable wedge of mass $2kg$ as shown in figure. All surfaces are smooth. When the block leaves the wedge from top, its velocity is making an angle $\theta = 30^\circ$ with horizontal.



22. The value of v_0 in m/s is

(a) 4 (b) 7 (c) 10 (d) 9

23. To what maximum height will the block rise

(a) 1.9 m (b) 2.7 m (c) 1.6 m (d) 1.45 m

24. In the whole process let J be the magnitude of net impulse given to the block by the wedge , J_H its horizontal component and J_v its vertical component. Then

(a) $J = \frac{8}{\sqrt{3}} N-s$ (b) $J_H = 4\, N-s$ (c) $J_v = \frac{4}{\sqrt{3}} N-s$ (d) All of these

EXERCISE # 1

1. D	11. A	21. B	31. B	41. B	51. A
2. B	12. B	22. B	32. A	42. B	52. D
3. C	13. D	23. C	33. C	43. A	53. C
4. E	14. B	24. D	34. C	44. A	54. B
5. C	15. C	25. B	35. C	45. C	55. C
6. B	16. C	26. D	36. C	46. B	56. B
7. D	17. A	27. A	37. B	47. D	57. A
8. C	18. C	28. A	38. A	48. D	58. B
9. B	19. D	29. C	39. C	49. A	59. B
10. B	20. B	30. B	40. A	50. C	60. A

EXERCISE # 2

1. C,D	6. B, C	11. A,B,D	16. B,C	21. A,C,D
2. A,B	7. A,C	12. B, C	17. B,C	22. A,B,C
3. B,D	8. A,C,D	13. A,B,C	18. B,C	23. B,C,D
4. A,B	9. A,B	14. A,B	19. A,B,C	24. A,B,C,D
5. B,C,D	10. A,D	15. A,B,C	20. A,C	25. B,C

EXERCISE # 3

1. A – r, B-p, C-s, D-q	9. c	17. b
2. A – q, B-s, C-p, D-r	10. c	18. c
3. A – q, B-r, C-p	11. a	19. d
4. A – r, s B-r,s C-q, D-q	12. b	20. c
5. A – p, B-t, C-s, D-r	13. b	21. b
6. A – r, B-p, C-s, D-q	14. c	22. b
7. d	15. d	23. c
8. a	16. a	24. d