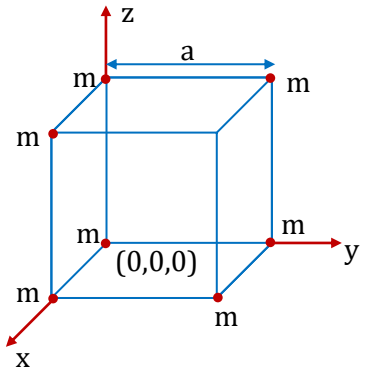
EXERCISE - O

SINGLE CORRECT TYPE QUESTIONS

Centre of Mass

1. Seven particles, each of mass *m* are placed at the seven corners of a cube of side '*a*' but one corner is vacant, as shown in figure. The co-ordinates of the centre of mass of the system is :-



(A) $\left(\frac{2a}{7},\frac{2a}{7},\frac{2a}{7}\right)$ (B) $\left(\frac{3a}{7},\frac{3a}{7},\frac{3a}{7}\right)$

(C) $\left(\frac{a}{3},\frac{a}{3},\frac{a}{3}\right)$ (D) $\left(\frac{5a}{11},\frac{5a}{11},\frac{5a}{11}\right)$

PCM079

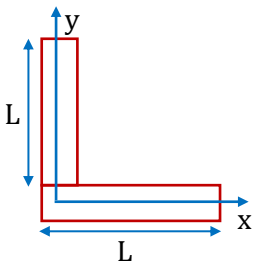
2. Particles of masses *m*, 2*m*, 3*m*.....*nm* grams are placed on the same line at distances ℓ, 2ℓ, 3ℓ,....$n\ell$ *cm* from a fixed point. The distance of centre of mass of the particles from the fixed point in centimetres is

(A) $\frac{(2n+1)\ell}{3}$ (B) $\frac{\ell}{n+1}$

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

PCM080

3. Centre of mass of two thin uniform rods of same length but made up of different materials and kept as shown, can be, if the meeting point is the origin of co-ordinates

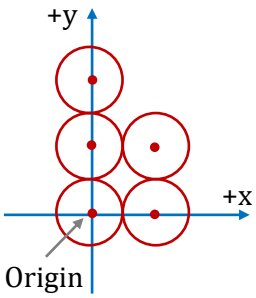


(A) $(L/2, L/2)$ (B) $(2L/3, L/2)$

(C) $(L/3, L/3)$ (D) $(L/3, L/6)$

PCM081

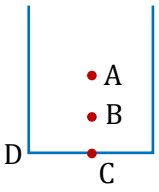
4. Five uniform circular plates, each of diameter D and mass m are laid out in a pattern shown. Using the origin shown, find the y co–ordinate of the centre of mass of the five–plate system.



(A) $2D/5$ (B) $4D/5$ (C) $D/3$ (D) $D/5$

PCM082

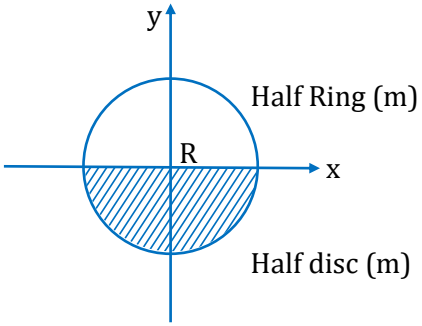
5. A thick uniform wire is bent into the shape of the letter "U" as shown. Which point indicates the location of the center of mass of this wire? A is the midpoint of the line joining mid points of two parallel sides of 'U' shaped wire.



(A) D (B) A (C) B (D) C

PCM083

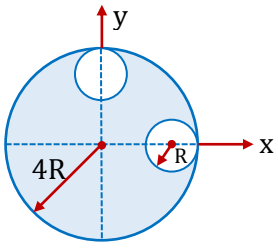
6. y coordinate of COM of given system will be at



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

PCM086

7. From the circular disc of radius $4R$ two small disc of radius R are cut off. The centre of mass of the new structure will be :



(A) $i\frac{R}{5}+j\frac{R}{5}$ (B) $-i\frac{R}{5}+j\frac{R}{5}$ (C) $\frac{-3R}{14}(\hat{i}+\hat{j})$ (D) None of these

PCM088

Motion of CM

8. Seven identical birds are flying in south together at constant velocity. A hunter shoots one of them, which immediately dies and falls to the ground. The other six continue flying south at the original velocity. After the one bird has hit the ground, the centre of mass of all seven birds:

(A) continues south at the original speed, but is now located some distance behind the flying birds

(B) continues south, but at 6/7 the original velocity

(C) continues south, but at 1/7 the original velocity

(D) stops with the dead bird

PCM090

9. There are some passengers inside a stationary railway compartment. The track is frictionless. The centre of mass of the compartment itself (without the passengers) is C_1, while the centre of mass of the 'compartment plus passengers' system is C_2. If the passengers move about inside the compartment along the track.

(A) both C_1 and C_2 will move with respect to the ground.

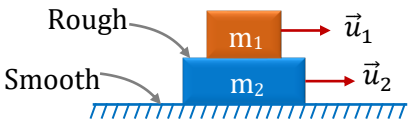
(B) neither C_1 nor C_2 will move with respect to the ground.

(C) C_1 will move but C_2 will be stationary with respect to the ground.

(D) C_2 will move but C_1 will be stationary with respect to the ground.

PCM094

10. In a two-block system shown in the figure, the two blocks have velocities in same horizontal direction. Mark the CORRECT statement about 'the velocity of the centre of mass' of the SYSTEM (length of lower block is large enough for the blocks to remain always in contact):



(A) $\vec{V}_{cm}$ is a function of time and will become zero at some instant(s).

(B) $\vec{V}_{cm}$ is non-zero at all times.

(C) $\vec{V}_{cm}$ is zero at all times.

(D) $\vec{V}_{cm}$ may be zero at some instant(s).

PCM095

11. 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) $v_0 = 0, a_C \neq 0$ (iv) $v_0 \neq 0, a_C \neq 0$

Then:

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

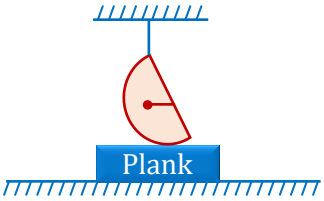
(B) (i) and (ii) are true.

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

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

PCM096

12. Lower surface of a plank is rough and lying at rest on a rough horizontal surface. Upper surface of the plank is smooth and has a smooth hemisphere placed over it through a light string as shown in the figure. After the string is burnt, trajectory of centre of mass of the sphere is :-



(A) a circle (B) an ellipse (C) a straight line (D) a parabola

PCM097

13. Three interacting particles of masses 100 g, 200 g and 400 g each have a velocity of 20 m/s magnitude along the positive direction of x-axis, y-axis and z-axis. Due to force of interaction the third particle stops moving. The velocity of the second particle is $\left(10\hat{j} + 5\hat{k}\right)$. What is the velocity of the first particle?

(A) $20\hat{\imath} + 20\hat{\jmath} + 70\hat{k}$ (B) $10\hat{\imath} + 20\hat{\jmath} + 8\hat{k}$ (C) $30\hat{\imath} + 10\hat{\jmath} + 7\hat{k}$ (D) $15\hat{\imath} + 5\hat{\jmath} + 60\hat{k}$

PCM098

14. An isolated particle of mass m is moving in horizontal plane (x–y), along the x–axis, at a certain height above the ground. It suddenly explodes into two fragments of masses $\frac{m}{4}$ and $\frac{3m}{4}$. An instant later, the smaller fragment is at y = +15 cm. The larger fragment at this instant is at :–

(A) y = –5 cm (B) y = +20 cm (C) y = +5 cm (D) y = –20 cm

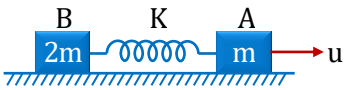
PCM099

15. In gravity free region a body of mass 1 kg moving on the x-axis, suddenly explodes into fragments of mass 1/8 kg and 7/8 kg. An instant later, the smaller fragment is 0.14 m above the x-axis. The position of the heavier fragment is :-

(A) 0.02 m above x-axis (B) 0.02 m below x-axis
(C) 0.14 m below x-axis (D) 0.14 m above x-axis

PCM101

16. 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 spring is at its natural length at this instant. Which of the following is INCORRECT for subsequent motion.



Smooth horizontal surface

(A) Maximum elongation in spring is $\sqrt{\frac{2mu^2}{3K}}$.
(B) Velocity of centre of mass of the system consisting A and B will be constant.
(C) Acceleration of block B will be constant.
(D) At maximum elongation, velocity of A and B is same in ground frame.

PCM155

Momentum Conservation

17. A system of *N* particles is free from any external forces.

(i) Which of the following is true for the magnitude of the total momentum of the system?

(A) It must be zero

(B) It could be non–zero, but it must be constant

(C) It could be non–zero, and it might not be constant

(D) The answer depends on the nature of the internal forces in the system

(ii) Which of the following must be true for the sum of the magnitudes of the momenta of the individual particles in the system?

(A) It must be zero

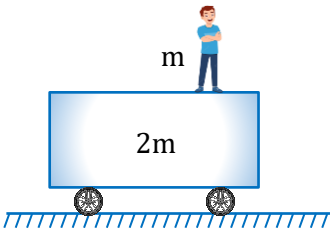
(B) It could be non–zero, but it must be constant

(C) It could be non–zero, and it might not be constant

(D) It could be zero, even if the magnitude of the total momentum is not zero

PCM106

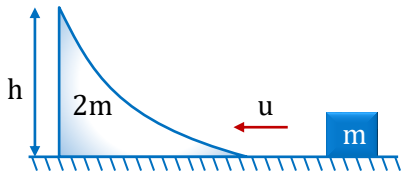
18. A man is standing on a cart of mass double the mass of man. Initially cart is at rest. Now man jumps horizontally with relative velocity 'u' with respect to cart. Then work done by internal forces of the man during the process of jumping will be :



(A) $\frac{1}{2}mu^2$ (B) $\frac{3mu^2}{4}$ (C) mu^2 (D) $\frac{mu^2}{3}$

PCM116

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



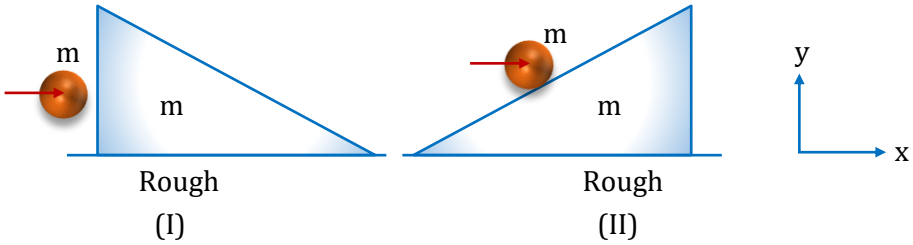
(A) $\sqrt{2gh}$ (B) $2\sqrt{2gh}$ (C) $\sqrt{3gh}$ (D) $\sqrt{gh}$

PCM131

20. A ball of mass m collides horizontally with a stationary wedge on a rough horizontal surface, in the two orientations as shown. Neglect friction between ball and wedge. Two student comment on system of ball and wedge in these situations

Saurav : Momentum of system in x-direction will change by significant amount in both cases.

Rahul : There are no impulsive external forces in y-direction in both cases hence the total momentum of system in y-direction can be treated as conserved in both cases.



(A) Saurav is wrong and Rahul is correct
(B) Saurav is correct and Rahul is wrong
(C) Both are correct
(D) Both are wrong

PCM134

Impulse

21. A boy hits a baseball with a bat and imparts an impulse J to the ball. The boy hits the ball again with the same force, except that the ball and the bat are in contact for twice the amount of time as in the first hit. The new impulse equals:

(A) half the original impulse
(B) the original impulse
(C) twice the original impulse
(D) four times the original impulse

PCM109

22. A particle of mass m moving with a velocity $(3\hat{\imath} + 2\hat{\jmath})\ m/s$ collides with stationary body of mass M and finally moves with velocity $(-2\hat{\imath} + \hat{\jmath})\ m/s$. Then

(A) Impulse received by $m = m(5\hat{\imath} - 5\hat{\jmath})$
(B) Impulse received by $m = m(-5\hat{\imath} - \hat{\jmath})$
(C) Impulse received by $m = m(5\hat{\imath} + \hat{\jmath})$
(D) Impulse received by $M = m(5\hat{\imath} - \hat{\jmath})$

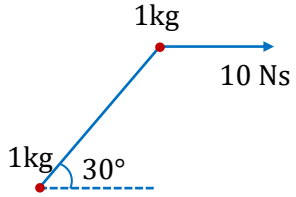
PCM110

23. Two balls of same mass are dropped from the same height h, on to the floor. The first ball bounces to a height $h/4$, after the collision and the second ball to a height $h/16$. The impulse applied by the first and second ball on the floor are I_1 and I_2 respectively. Then

(A) $5I_1 = 6I_2$
(B) $6I_1 = 5I_2$
(C) $I_1 = 2I_2$
(D) $2I_1 = I_2$

PCM111

24. Two balls of masses 1 kg each are connected by an inextensible massless string. The system is resting on a smooth horizontal surface. An impulse of 10 Ns is applied to one of the balls at an angle 30° with the line joining two balls in horizontal direction as shown in the figure. Assuming that the string remains taut after the impulse, the magnitude of impulse of tension is :-



(A) $6Ns$
(B) $\frac{5}{2}\sqrt{3}Ns$
(C) $5\ Ns$
(D) $\frac{5}{\sqrt{3}}Ns$

PCM112

Collision

25. A particle of mass 1 *kg* moving with velocity 1 *m/s*, collides elastically with another particle of mass *m*. In the collision particle of mass 1 *kg* loses $\frac{3}{4}$ of its *K.E.* The value of *m* is :

(A) $\frac{1}{2}$ *kg* (B) $\frac{1}{3}$ *kg* (C) $\frac{1}{4}$ *kg* (D) $\frac{1}{5}$ *kg*

PCM119

26. A block of mass *m* sliding on a horizontal frictionless surface has kinetic energy *K*. It collides head on with another stationary identical block. The collision is perfectly inelastic. How much energy is lost in this collision?

(A) *K*/4 (B) *K*/2 (C) *K*/3 (D) 3*K*/4

PCM120

27. Two bodies, *A* and *B*, collide as shown in figures *a* and *b* below. Circle the true statement :

(A) They exert equal and opposite forces on each other in (a) but not in (b).
(B) They exert equal and opposite force on each other in (b) but not in (a).
(C) They exert equal and opposite force on each other in both (a) and (b).
(D) 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).

PCM121

28. A smooth small spherical ball of mass *m*, moving with velocity *u* collides head on with another small spherical ball of mass 3*m*, which was initially at rest. Two-third of the initial kinetic energy of the system is lost. The coefficient of restitution between the spheres is

(A) $\frac{1}{3}$ (B) $\frac{1}{\sqrt{3}}$ (C) $\frac{1}{2}$ (D) zero

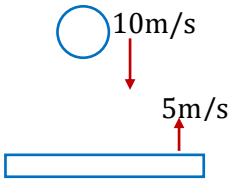
PCM123

29. A body *A* of mass 2*kg* is projected upward from the surface of the ground at $t = 0$ with a velocity of 20*m/s*. One second later a body *B*, also of mass 2*kg*, is dropped from a height of 20*m*. If they collide elastically, then velocities just after collision are

(A) $V_A = 5$ *m/s* downward, $V_B = 5$ *m/s* upward
(B) $V_A = 10$ *m/s* downward, $V_B = 5$ *m/s* upward
(C) $V_A = 10$ *m/s* upward, $V_B = 10$ *m/s* downward
(D) both move downward with velocity 5 *m/s*

PCM124

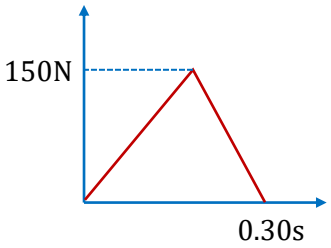
30. A ball of mass $1kg$ strikes a heavy platform, elastically, moving upwards with a velocity of $5m/s$. The speed of the ball just before the collision is $10m/s$ downwards. Then the impulse imparted by the platform on the ball is :-



(A) $15\ N-s$ (B) $10\ N-s$ (C) $20\ N-s$ (D) $30\ N-s$

PCM125

31. Two bodies A and B of masses 5.00 kg and 10.0 kg respectively moving in opposite directions with velocities 4.00 m/s and 0.50 m/s respectively make head-on collision in free space. The force of their mutual interaction varies according to the given graph. The coefficient of restitution is



(A) 0.25 (B) 0.33
(C) 0.50 (D) 0.75

PCM128

32. 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 :-

(A) 1 (B) u^2 (C) $\sqrt{\frac{2gh}{u^2+2gh}}$ (D) $\frac{\sqrt{2gh}}{u}$

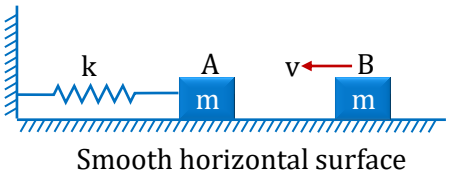
PCM137

33. A particle is projected from a smooth horizontal surface with velocity v at an angle θ from horizontal. Coefficient of restitution between the surface and ball is e. The distance of the point where ball strikes the surface second time from the point of projection is

(A) $\frac{v^2\sin 2\theta(1+e^2)}{g}$ (B) $\frac{v^2\sin 2\theta(1+e^4)}{g}$ (C) $\frac{v^2\sin 2\theta(1+e^3)}{g}$ (D) $\frac{v^2\sin 2\theta(1+e)}{g}$

PCM138

34. Maximum acceleration of block A after its collision with block B has magnitude (Assume the collision to be elastic and spring is initially relaxed) :-



(A) $\sqrt{\frac{k}{m}}v$ (B) $\sqrt{\frac{m}{k}}v$ (C) $\sqrt{\frac{k}{m}}\frac{v}{2}$ (D) $2\sqrt{\frac{k}{m}}v$

PCM139

35. A ball strikes a smooth horizontal ground at an angle of 45° with the vertical. What cannot be the possible angle of its velocity with the vertical after the collision. (Assume $e \leq 1$).

(A) 45° (B) 30° (C) 53° (D) 60°

PCM140

36. A smooth sphere is moving on a horizontal surface with a velocity vector $(2\hat{\imath} + 2\hat{\jmath})\ m/s$ immediately before it hit a vertical wall. The wall is parallel to vector $\hat{\jmath}$ and coefficient of restitution between the sphere and the wall is $e = \frac{1}{2}$. The velocity of the sphere after it hits the wall is

(A) $\hat{\imath} - \hat{\jmath}$ (B) $-\hat{\imath} + 2\hat{\jmath}$ (C) $-\hat{\imath} - \hat{\jmath}$ (D) $2\hat{\imath} - \hat{\jmath}$

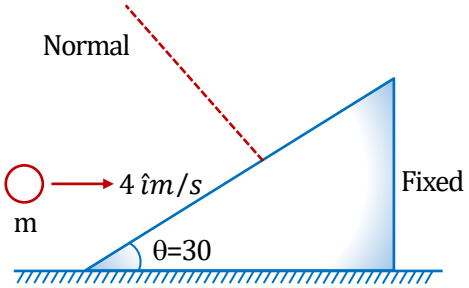
PCM141

37. A ball of mass m hits the floor with a speed v making an angle of incidence $\theta = 45°$ with the normal to the floor. If the coefficient of restitution $e = \frac{1}{\sqrt{2}}$, then the speed of the reflected ball and the angle of reflection are :-

(A) $\frac{\sqrt{3}}{2}v, \tan^{-1}\sqrt{2}$ (B) $\frac{\sqrt{3}}{4}v, \tan^{-1}\sqrt{3}$ (C) $\frac{2\sqrt{3}}{5}v, \tan^{-1}\sqrt{3}$ (D) $\frac{\sqrt{3}}{5}v, \tan^{-1}\sqrt{2}$

PCM142

38. A ball of mass 'm' is moving with initial velocity m/sec. It strike a fix incline plane such that angle of incident of the ball with normal = angle of reflection of ball with normal. Velocity vector of ball just after collision will be :- (No friction is present between surfaces of ball and wedge)



(A) $(\hat{\imath} + \sqrt{3}\hat{\jmath})m/s$ (B) $\frac{1}{2}(\hat{\imath} + \sqrt{3}\hat{\jmath})m/s$ (C) $2(\hat{\imath} + \sqrt{3}\hat{\jmath})m/s$ (D) $4(\hat{\imath} + \sqrt{3}\hat{\jmath})m/s$

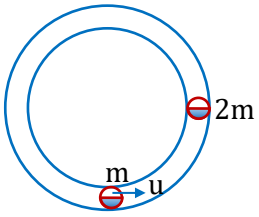
PCM144

39. A ball is thrown downwards with initial speed = 6 m/s, from a point at height = 3.2 m above a horizontal floor. If the ball rebounds back to the same height then coefficient of restitution equals to

(A) 1/2 (B) 0.75 (C) 0.8 (D) None

PCM147

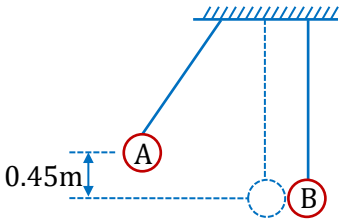
40. Two masses m and $2m$ are placed in fixed horizontal circular smooth hollow tube of radius r as shown. The mass m is moving with speed u and the mass $2m$ is stationary. After their first collision, the time elapsed for next collision is: (coefficient of restitution $e = 1/2$)



(A) $\frac{2\pi r}{u}$ (B) $\frac{4\pi r}{u}$ (C) $\frac{3\pi r}{u}$ (D) $\frac{12\pi r}{u}$

PCM148

41. Two massless string of length 5 m hang from the ceiling very near to each other as shown in the figure. Two balls A and B of masses 0.25 kg and 0.5 kg are attached to the string. The ball A is released from rest at a height 0.45 m as shown in the figure. The collision between two balls is completely elastic. Immediately after the collision, the kinetic energy of ball B is 1 J. The velocity of ball A just after the collision is

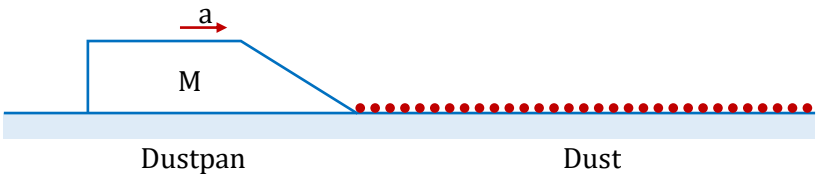


(A) 5 ms^{-1} to the right (B) 5 ms^{-1} to the left
(C) 1 ms^{-1} to the right (D) 1 ms^{-1} to the left

PCM149

Variable Mass

42. A dustpan is accelerated with constant acceleration a across a frictionless floor, and it gathers up dust as it moves, as shown in figure. The mass of the dustpan itself is M, and the linear mass density of the dust on the floor is λ. If the dustpan starts empty at $x = 0$, then the force that must be applied to it later on when it is moving with speed v at position x is :



(A) $(M + \lambda x)\, a + \lambda v^2$ (B) $Ma + \lambda v^2$ (C) $(M + \lambda x)\, a$ (D) λv^2

PCM157

43. 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. (neglect gravity)

PCM158

(A) ℓ n 2 (B) 2 ℓn 4 (C) 2 ℓn 2 (D) none of these

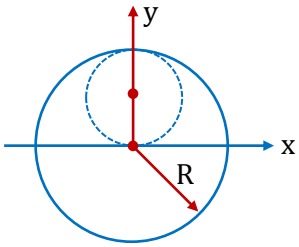
44. A rocket of mass 4000 kg is set for vertical firing. How much gas must be ejected per second so that the rocket may have initial upwards acceleration of magnitude 19.6 m/s^2. [Exhaust speed of fuel = 980 m/s.]

(A) 240 $kg\ s^{-1}$ (B) 60 $kg\ s^{-1}$ (C) 120 $kg\ s^{-1}$ (D) None

PCM159

MULTIPLE CORRECT TYPE QUESTIONS

45. A lamina is made by removing a disc of diameter R from a uniform disc of radius R and mass m.

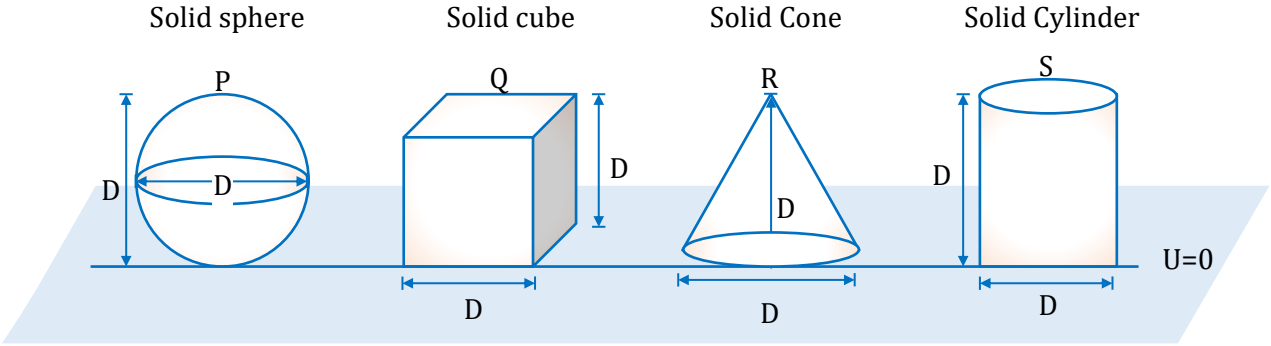


(A) Mass of remaining lamina is $m/2$ (B) mass of remaining lamina is $\frac{3m}{4}$

(C) the y-coordinate of COM is $-\frac{R}{6}$ (D) x-coordinate of COM of lamina is zero

PCM087

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



All objects are made up of same material.

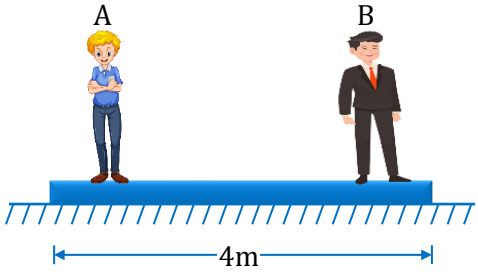
U_P = Potential energy of solid sphere U_Q = Potential energy of solid cube

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) $U_S > U_R$

PCM089

47. In the arrangement shown two men A and B of mass 50kg and 60 kg respectively are standing on the ends of a plank of mass 90 kg. Plank is kept on a smooth plane. Now man starts moving and exchange their positions on the plank. Then,



(A) The distance moved by centre of mass of the system A + B + plank is 20 cm.

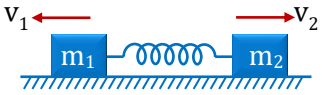
(B) The distance moved by plank is 20 cm.

(C) The distance moved by man A with respect to ground is 420cm.

(D) The distance moved by man B with respect to ground is 600 cm.

PCM100

48. Two blocks of mass m_1 and m_2 are connected by a spring in its natural length having spring constant k and are placed on a smooth surface. Block m_1 and m_2 are given velocities v_1 and v_2 as shown in figure. Choose **CORRECT** statements :-



(A) Momentum of the system of m_1 and m_2 in the ground frame is conserved

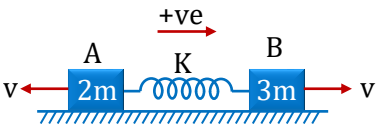
(B) Momentum of the system of m_1 and m_2 in the frame attached to center of mass of m_1 and m_2 is always zero

(C) The term $\frac{1}{2}(m_1 + m_2)v_C^2$ is always constant, where v_C is velocity of center of mass of m_1 and m_2

(D) Kinetic energy in center of mass frame remains constant

PCM150

49. Two blocks A and B of masses $2m$ and $3m$ placed on smooth horizontal surface are connected with a light spring. The two blocks are given velocities as shown when spring is at natural length. Select the correct alternative (s)



(A) Velocity of centre of mass of the system is $v/5$.

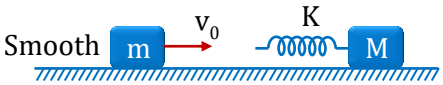
(B) In centre of mass frame initial velocity of B is positive.

(C) In centre of mass frame initial velocity of A is negative.

(D) Velocity of centre of mass of the system is v.

PCM151

50. 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 $\frac{m}{m+M}v_0$.

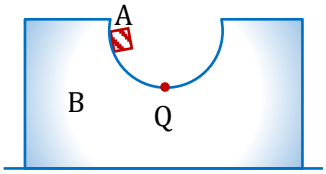
(B) The initial kinetic energy of the system in the centre of mass frame is $\frac{1}{12}\left(\frac{mM}{M+m}\right)v_0^2$.

(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.

PCM152

51. Block *A* is released on the circular track of bigger block *B* from rest from the position as shown in figure. Friction is absent everywhere. Choose **INCORRECT** statements :-



(A) Acceleration of center of mass of *A* and *B* is zero initially.

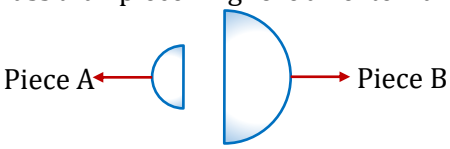
(B) When *A* reaches *Q* acceleration of center of mass of *A* and *B* is zero.

(C) Normal force of the surface below is greater than combined weight of *A* and *B*, when *A* reaches at point *Q*.

(D) Acceleration of *B* is maximum when *A* reaches *Q*.

PCM105

52. An asteroid in 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 statements.



(A) Piece *A* has greater speed after the explosion.

(B) Piece *B* has greater magnitude of momentum after the explosion.

(C) Piece *A* has greater kinetic energy after the explosion.

(D) Both have the same kinetic energy after the explosion.

PCM107

53. If a projectile explodes in mid air, then just before and just after explosion, choose **CORRECT** option(s) :-

(A) Conservation of momentum is applicable.

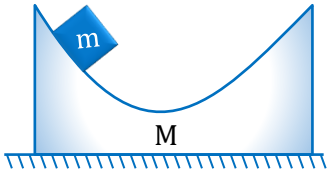
(B) Path of the centre of mass of the projectile must be same original parabola till any one part of it, hits the ground.

(C) Energy released during explosion is equal to increase in kinetic energy of the projectile.

(D) Conservation of momentum is not applicable.

PCM117

54. Figure shows a wedge on which a small block is released from rest. All the surfaces are smooth system comprises of wedge and blocks. Mark the correct statement(s) regarding motion of block on wedge till block attains maximum height on wedge.



(A) Acceleration of centre of mass of system is initially vertically down then vertically up.

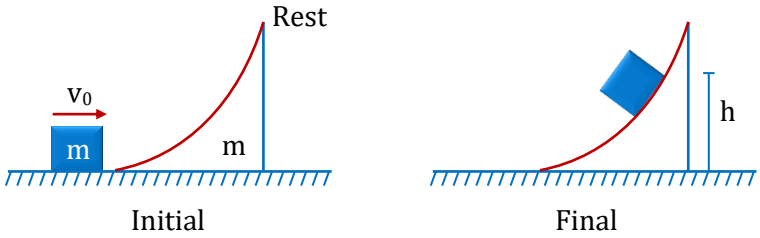
(B) Initially centre of mass moves down and then up.

(C) At the maximum height block and wedge move with common velocity.

(D) Centre of mass of wedge moves towards left then right

PCM132

55. In the arrangement shown, horizontal surface is smooth, but friction is present between the block and the surface of the wedge. Block is given velocity v_0 at $t = 0$. After achieving height 'h' on the wedge, block comes to rest with respect to wedge at $t = t_0$. Then from $t = 0$ to $t = t_0$:-



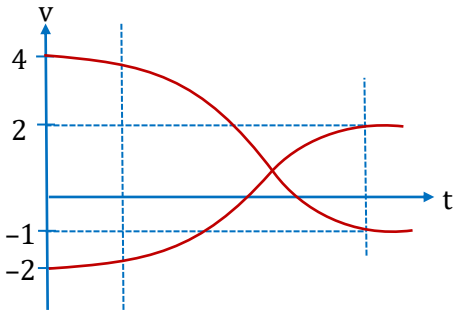
(A) Work done by friction on the block is negative
(B) Work done by friction on the wedge is negative
(C) Work done by block on the wedge is positive
(D) Work done by wedge on the block is positive

PCM130

56. Two charges moving under their only own mutual attraction separated by large distance initially. Then choose the correct statement(s)
(A) If both are free, mechanical energy is conserved.
(B) If one is fixed and other is free, mechanical energy is conserved.
(C) If one is fixed and other is free, momentum is conserved.
(D) If both are free momentum is conserved.

PCM133

57. Two particles are moving with speed $4m/s$ and $2m/s$ before collision. Mass of the particle moving with $4m/s$ is $4kg$. They collide with each other and variation in their velocities 'v_1' and 'v_2' with time is shown in figure. Select the **CORRECT** statement(s) :



(A) Coefficient of restitution for the given collision is $\frac{3}{4}$
(B) Mass of other particle is $5kg$
(C) Maximum potential energy stored in the system is 40 joule.
(D) Impulse of deformation is 13.33 $N\text{-}S$

PCM126

58. A projectile is fired on a horizontal ground. Coefficient of restitution between projectile and ground is e. Let a, b and c be the ratio of time of flight, maximum height and horizontal range 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 the above

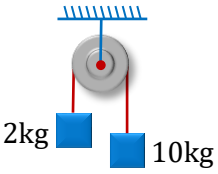
PCM143

COMPREHENSION TYPE QUESTIONS

Motion of CM

PARAGRAPH FOR QUESTION NO. 59 TO 61

Two blocks of mass 2 *kg* and 10 *kg* are attached as shown in figure. Pulley and rope are massless. Pulley is also frictionless.



59. Find acceleration of centre of mass of two block system

(A) $\frac{4g}{9}$ downward (B) $\frac{4g}{9}$ upward (C) $\frac{2g}{3}$ downward (D) $\frac{2g}{3}$ upward

PCM091

60. Which quantity is changing during motion

(A) tension in the string (B) magnitude of acceleration of blocks

(C) velocity of blocks (D) mechanical energy of both block system

PCM092

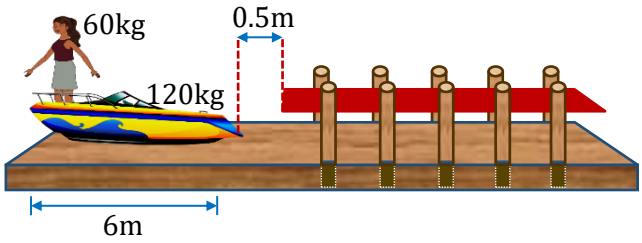
61. Work done by tension on block 10 *kg* and 2 *kg* are respectively

(A) *+ve, +ve* (B) *–ve, +ve* (C) *–ve, –ve* (D) *+ve, –ve*

PCM093

PARAGRAPH FOR QUESTION NO. 62 AND 63

A 60*kg* woman stands on the back of a 6*m* long, 120*kg* raft that is floating at rest in still water with no friction. The raft is 0.5 *m* from a fixed pier, as shown in Figure.



62. The woman walks to the front of the raft and stops. How far (in *m*) is the raft from the pier now?

(A) 2 (B) 1.5 (C) 0.5 (D) 2.5

PCM102

63. While the woman walks, she maintains a constant speed of 3 *m/s* relative to the raft. Find the total kinetic energy (in *J*) of the system (woman plus raft)

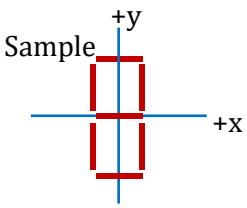
(A) 270 (B) 180 (C) 210 (D) 330

PCM103

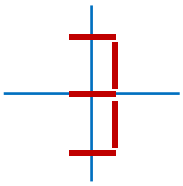
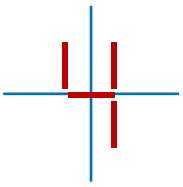
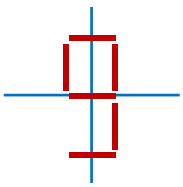
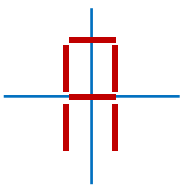
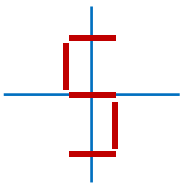
MATRIX MATCH TYPE QUESTION

Centre of Mass

64. On the left are statements about the location of the center of mass of the objects depicted on the right. The objects on the right are symbols constructed out of sticks of equal length and mass. The location of the center of mass is described using the coordinate system depicted in the sample.



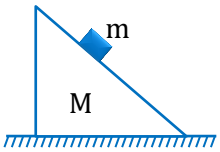
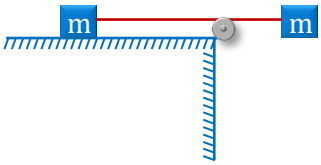
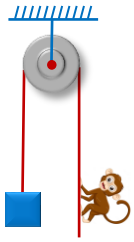
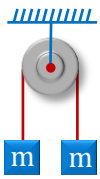
The centre of mass lies at $x = 0, y = 0$

	Column-I		**Column-II**
(A)	The center of mass is at $x > 0$ and $y = 0$	(P)	
(B)	The center of mass is at $x = 0$ and $y > 0$	(Q)	
(C)	The center of mass is at $x > 0$ and $y > 0$	(R)	
(D)	The center of mass is at $x = 0$ and $y = 0$	(S)	
		(T)	

PCM084

Motion of CM

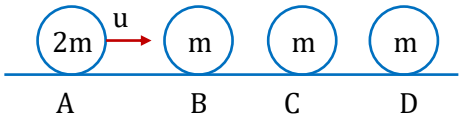
65. In each situation of column–I, a system involving two bodies is given. All strings and pulleys are light and friction is absent everywhere. Initially each body of every system is at rest. Consider the system in all situation of column-I from rest till any collision occurs. Then match the statements in column-I with the corresponding results in column–II.

	Column-I		**Column-II**
(A)	The block plus wedge system is placed over smooth horizontal surface. After the system is released from rest, the centre of mass of system 	(P)	Shifts towards right
(B)	The string connecting both the blocks of mass *m* is horizontal. Left block is placed over smooth horizontal table as shown. After the two-block system is released from rest, the centre of mass of system 	(Q)	Shifts downwards
(C)	The block and monkey have same mass. The monkey starts climbing up the rope. After the monkey starts climbing up, the centre of mass of monkey + block system 	(R)	Shifts upwards
(D)	Both block of mass *m* are initially at rest. The left block is given initial velocity *u* downwards. Then, the centre of mass of two block system afterwards 	(S)	Does not shift

PCM104

Collision

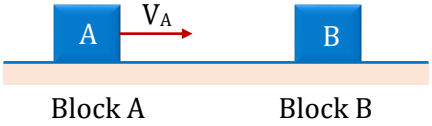
66. Four balls *A*, *B*, *C* and *D* are kept on a smooth horizontal surface as shown in figure. Ball *A* is given velocity *u* towards *B*- (Assume each collision to be elastic)

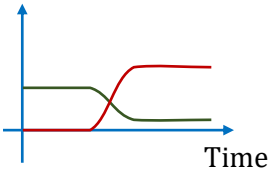
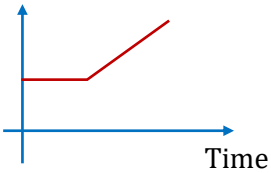
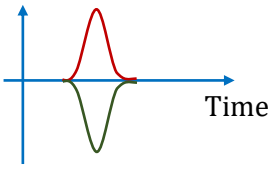
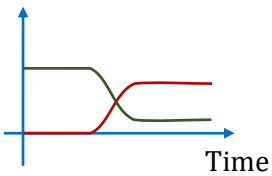
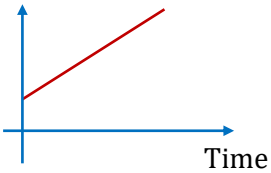


	Column-I		**Column-II**
(A)	Total impulse of all collisions on *A*	(P)	$\frac{4mu}{9}$
(B)	Total impulse of all collisions on *B*	(Q)	$\frac{4mu}{27}$
(C)	Total impulse of all collision on *C*	(R)	$\frac{4mu}{3}$
(D)	Total impulse of all collisions on *D*	(S)	$\frac{52}{27}mu$

PCM122

67. Block *A* moving on frictionless horizontal plane collides head-on with block *B* initially at rest. The collision is **NOT** (0 < e < 1) perfectly elastic.



	Column-I		**Column-II**
(A)	Forces exerted by the blocks	(P)	
(B)	The position of mass centres of the two block system	(Q)	
(C)	Velocity of blocks	(R)	
(D)	Position of block *B*	(S)	
		(T)	

PCM127

EXERCISE - S

Centre of Mass

1. Four particles of masses 5, 3, 2, 4 *kg* are at the points (1, 6), (–1, 5), (2, –3), (–1, –4). Find the coordinates of their centre of mass.

PCM076

2. A rigid body consists of a 3 *kg* mass connected to a 2 *kg* mass by a massless rod. The 3*kg* mass is located at $\vec{r}_1 = (2\hat{\imath} + 5\hat{\jmath})$ *m* and the 2 *kg* mass at $\vec{r}_2 = (4\hat{\imath} + 2\hat{\jmath})$ m. Find the length of rod and the coordinates of the centre of mass.

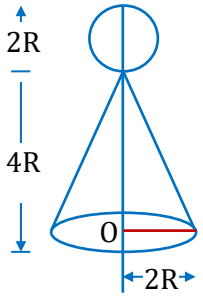
PCM077

3. 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?

PCM078

4. A man has constructed a toy as shown in figure. If density of the material of the sphere is 12 times of the cone compute the position of the centre of mass.

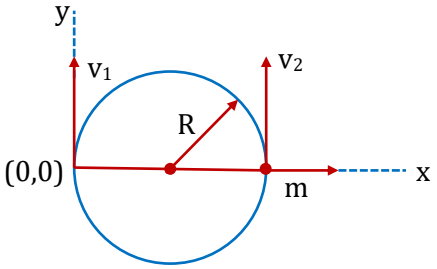
[Centre of mass of a cone of height *h* is at height of *h*/4 from its base.]



PCM085

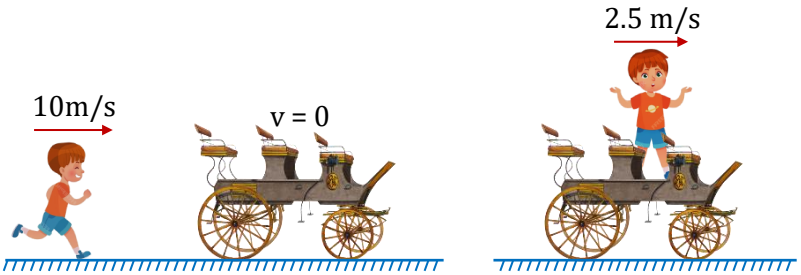
Momentum Conservation

5. A particle of mass *m*, moving in a circular path of radius *R* with a constant speed v_2 is located at point (2*R*, 0) at time *t* = 0 and a man starts moving with a velocity v_1 along the +*ve y*-axis from origin at time *t* = 0. Calculate the linear momentum of the particle w.r.t. the man as a function of time.



PCM108

6. 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)

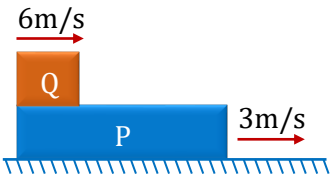


PCM113

7. A spaceship is moving with constant speed v_0 in gravity free space along +Y-axis suddenly shoots out one third of its part with speed $2v_0$ along + X-axis. Find the speed of the remaining part.

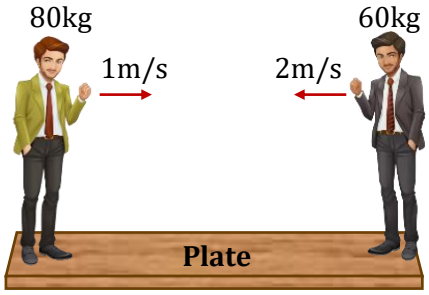
PCM114

8. A plank P and block Q are arranged as shown on a smooth table top. They are given velocities 3 m/s and 6 m/s respectively. The length of plank is 1m and block is of negligible size. After some time when the block has reached the other end of plank it stops slipping on plank. Find the coefficient of friction between plank P and block Q if mass of plank is double of block).



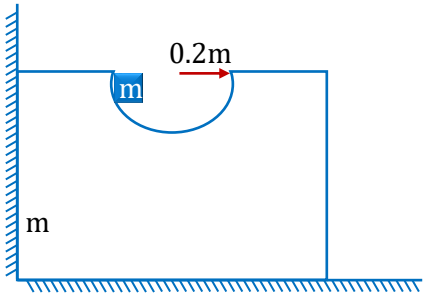
PCM115

9. Two men of masses 80 kg and 60 kg are standing on a wood plate of mass 100 kg, that has been placed over a smooth surface. If both the men start moving toward each other with speeds 1 m/s and 2 m/s respectively, then the velocity of the plate by which it starts moving is $\frac{x}{10}$ m/s find x.



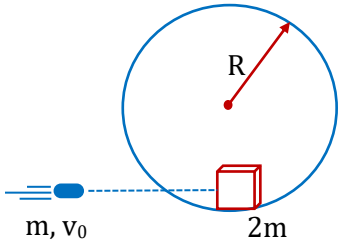
PCM118

10. A wedge of mass m with a circular groove is placed resting against a wall. An identical mass m is released from the top point of wedge surface and it moves along the groove. If radius of groove is 0.2 m find the maximum velocity (in m/s) of wedge in subsequent motion. Neglect friction everywhere. (Take : g = 10 m/s^2)



PCM135

11. A small block of mass $2m$ initially rests at the bottom of a fixed circular, vertical track, which has a radius R. The contact surface between the mass and the loop is frictionless. A bullet of mass m strikes the block horizontally with initial speed v_0 and remain embedded in the block as the block and the bullet circle the loop. Determine each of the following in terms of m, v_0, R and g.

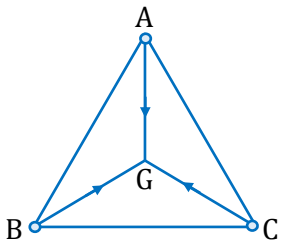


(i) The speed of the masses immediately after the impact.

(ii) The minimum initial speed of the bullet if the block and the bullet are to successfully execute a complete ride on the loop.

PCM136

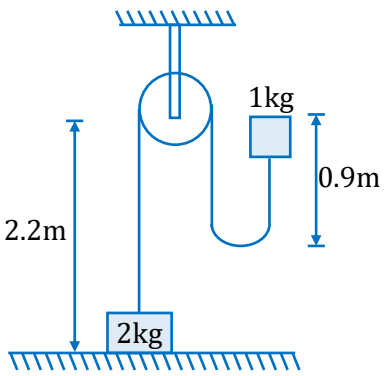
12. Three particles A, B and C of equal mass move with equal speed v along the medians of an equilateral triangle as shown in fig. They collide at the centroid G of the triangle. After the collision, A comes to rest, B retraces its path with the speed v. What is the velocity of C ?



PCM160

Impulse

13. In the shown figure, the heavy block of mass 2 kg rests on the horizontal surface and the lighter block of mass 1 kg is dropped from a height of 0.9 m. At the instant the string gets taut, find the upward speed (in m/s) of the heavy block.



PCM161

14. Two particles A and B of mass $2m$ and m respectively are attached to the ends of a light inextensible string of length $4a$ which passes over a small smooth peg at a height $3a$ from an inelastic table. The system is released from rest with each particle at a height a from the table. Find

(i) The speed of B when A strikes the table.

(ii) The time that elapses before A first hits the table.

(iii) The time for which A is resting on the table after the first collision & before it is first jerked off.

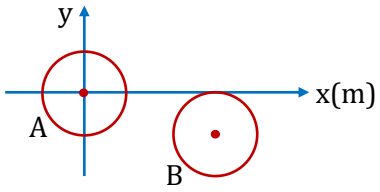
PCM162

15. A bullet of mass m strikes an obstruction and deviates off at 60° to its original direction. If its speed is also changed from u to v, find the magnitude of the impulse acting on the bullet.

PCM163

Collision

16. 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. Find Velocity of the ball A just after the collision and impulse of the force exerted by A on B during the collision.



PCM145

17. Two particles, each of mass m, are connected by a light inextensible string of length 2ℓ. Initially they lie on a smooth horizontal table at points A and B, ℓ distance apart. The particle at A is projected across the table with velocity u. Find the speed with which the second particle begins to move if the direction of u is :-

(i) along BA.

(ii) at an angle of 120° with AB.

(iii) perpendicular to AB.

In each case calculate (in terms of m and u) the impulsive tension in the string.

PCM146

18. Mass m_1 hits and sticks with m_2 while sliding horizontally with velocity v along the common line of centres of the three equal masses ($m_1 = m_2 = m_3 = m$). Initially masses m_2 and m_3 are stationary and the spring is unstretched. Find the

Frictionless

(i) velocities of m_1, m_2 and m_3 immediately after impact.

(ii) maximum kinetic energy of m_3.

(iii) minimum kinetic energy of m_2.

(iv) maximum compression of the spring.

PCM153

Variable Mass

19. Bullets of mass 10 g each are fired from a machine gun at rate of 60 bullets/minute. The muzzle velocity of bullets is 100 m/s. The thrust force due to firing bullets experienced by the person holding the gun stationary is _____.

PCM164

20. A uniform chain of mass M and length L is held vertically in such a way that its lower end just touches the horizontal floor. The chain is released from rest in this position. Any portion that strikes the floor comes to rest. Assuming that the chain does not form a heap on the floor, calculate the force exerted by it on the floor when a length x has reached the floor.

PCM165

21. During a heavy rain, hailstones of average size 1.0 cm in diameter fall with an average speed of 20 m/s. Suppose 2000 hailstones strike every square meter of a 10 m × 10 m roof perpendicularly in one second and assume that the hailstones do not rebound. Calculate the average force exerted by the falling hailstones on the roof. Density of a hailstone is 900 kg/m^3.

PCM166

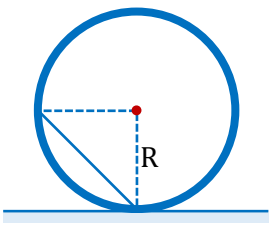
22. The linear mass density of a ladder of length ℓ increases uniformly from one end A to the other end B,

(i) Form an expression for linear mass density as a function of distance x from end A where linear mass density λ_0. The density at one end being twice that of the other end. (ii) Find the position of the centre of mass from end A.

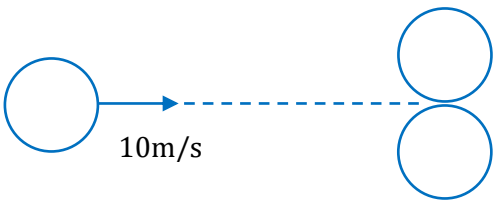
PCM167

23. Inside a hollow uniform sphere of inner radius R a uniform rod of length is released from the state of rest as shown. The mass of the rod is same as that of the sphere. Assume friction to be absent everywhere. Horizontal displacement of sphere with respect to earth in the time in which the rod becomes horizontal, is.

PCM168



24. A ball with initial speed of 10 m/s collides elastically with two other identical ball whose centres are on a line perpendicular to the initial velocity and which are initially in contact with each other. All the three ball are lying on a smooth horizontal table. The first ball is aimed directly at the contact point of the other two balls All the balls are smooth. Find the velocities of the three balls after the collision.



PCM169

EXERCISE - JEE (Main) PYQ

1. This question has Statement I and Statement II. Of the four choices given after the Statements, choose the one that best describes the two Statements. **[JEE (Main) 2013]**

Statement - I : *A* point particle of mass m moving with speed *v* collides with stationary point particle of mass *M*. If the maximum energy loss possible is given as $f\left(\frac{1}{2}mv^2\right)$ then $f=\left(\frac{m}{M+m}\right)$.

Statement - II : Maximum energy loss occurs when the particles get stuck together as a result of the collision.

(1) Statement–I is true, Statement–II is true, Statement–II is a correct explanation of Statement–I.

(2) Statement–I is true, Statement–II is true, Statement–II is a not correct explanation of Statement–I.

(3) Statement–I is true, Statement–II is false.

(4) Statement–I is false, Statement–II is true

PCM031

2. A particle of mass *m* moving in the *x* direction with speed 2*v* is hit by another particle of mass 2*m* moving in the *y* direction with speed *v*. If the collision is perfectly inelastic, the percentage loss in the energy during the collision is close to : **[JEE (Main) 2015]**

(1) 56 % (2) 62 % (3) 44 % (4) 50 %

PCM032

3. Distance of the centre of mass of a solid uniform cone from its vertex is z_0. If the radius of its base is *R* and its height is *h* then z_0 is equal to :- **[JEE (Main) 2015]**

(1) $\frac{5h}{8}$ (2) $\frac{3h^2}{8R}$ (3) $\frac{h^2}{4R}$ (4) $\frac{3h}{4}$

PCM033

4. It is found that if a neutron suffers an elastic collinear collision with deuterium at rest, fractional loss of its energy is p_d ; while for its similar collision with carbon nucleus at rest, fractional loss of energy is p_c. The values of p_d and p_c are respectively : **[JEE (Main) 2018]**

(1) (0.28, 0.89) (2) (0, 0) (3) (0, 1) (4) (0.89, 0.28)

PCM034

5. In a collinear collision, a particle with an initial speed v_0 strikes a stationary particle of the same mass. If the final total kinetic energy is 50% greater than the original kinetic energy, the magnitude of the relative velocity between the two particles, after collision, is : **[JEE (Main) 2018]**

(1) $\sqrt{2}v_0$ (2) $\frac{v_0}{2}$ (3) $\frac{v_0}{\sqrt{2}}$ (4) $\frac{v_0}{4}$

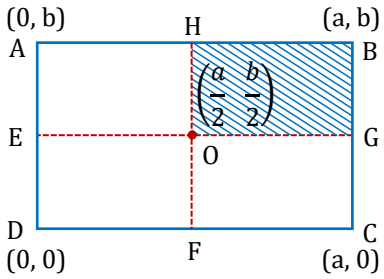
PCM035

6. The mass of a hydrogen molecule is 3.32×10^{-27} *kg*. If 10^{23} hydrogen molecules strike, per second, a fixed wall of area 2 cm^2 at an angle of 45° to the normal, and rebound elastically with a speed of 10^3 *m/s*, then the pressure on the wall is nearly : **[JEE (Main) 2018]**

(1) $4.70 \times 10^3\ N/m^2$ (2) $2.35 \times 10^2\ N/m^2$ (3) $4.70 \times 10^2\ N/m^2$ (4) $2.35 \times 10^3\ N/m^2$

PCM036

7. A uniform rectangular thin sheet *ABCD* of mass *M* has length *a* and breadth *b*, as shown in the figure. If the shaded portion *HBGO* is cut-off, the coordinates of the centre of mass of the remaining portion will be :- **[JEE (Main) 2019]**



(1) $\left(\frac{2a}{3}, \frac{2b}{3}\right)$ (2) $\left(\frac{5a}{3}, \frac{5b}{3}\right)$ (3) $\left(\frac{3a}{4}, \frac{3b}{4}\right)$ (4) $\left(\frac{5a}{12}, \frac{5b}{12}\right)$

PCM037

8. A wedge of mass $M = 4m$ lies on a frictionless plane. A particle of mass m approaches the wedge with speed v. There is no friction between the particle and the plane or between the particle and the wedge. The maximum height climbed by the particle on the wedge is given by **[JEE (Main) 2019]**

(1) $\frac{2v^2}{7g}$ (2) $\frac{v^2}{g}$ (3) $\frac{2v^2}{5g}$ (4) $\frac{v^2}{2g}$

PCM038

9. A man (mass = 50 *kg*) and his son (mass = 20 *kg*) are standing on a frictionless surface facing each other. The man pushes his son so that he starts moving at a speed of 0.70 ms^{-1} with respect to the man. The speed of the man with respect to the surface is : **[JEE (Main) 2019]**

(1) 0.20 ms^{-1} (2) 0.14 ms^{-1} (3) 0.47 ms^{-1} (4) 0.28 ms^{-1}

PCM039

10. A particle of mass *m* is dropped from a height *h* above the ground. At the same time another particle of the same mass is thrown vertically upwards from the ground with a speed of $\sqrt{2gh}$. If they collide head-on completely inelastically, the time taken for the combined mass to reach the ground, in units of $\sqrt{\frac{h}{g}}$ is : **[JEE (Main) 2020]**

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

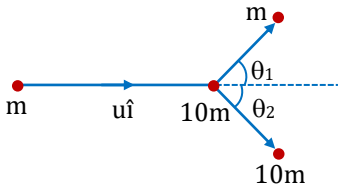
PCM040

11. Two particles of equal mass m have respective initial velocities $u\hat{i}$ and $u\left(\frac{\hat{i}+\hat{j}}{2}\right)$. They collide completely inelastically. The energy lost in the process is : **[JEE (Main) 2020]**

(1) $\frac{3}{4}mu^2$ (2) $\frac{1}{8}mu^2$ (3) $\sqrt{\frac{2}{3}}mu^2$ (4) $\frac{1}{3}mu^2$

PCM041

12. A particle of mass m is moving along the x-axis with initial velocity $u\hat{i}$. It collides elastically with a particle of mass 10 m at rest and then moves with half its initial kinetic energy (see figure). If $\sin\theta_1 = \sqrt{n}\sin\theta_2$, then value of n is _____. **[JEE (Main) 2020]**



PCM042

13. A block of mass 1.9 kg is at rest at the edge of a table, of height 1 m. A bullet of mass 0.1 kg collides with the block and sticks to it. If the velocity of the bullet is 20 m/s in the horizontal direction just before the collision then the kinetic energy just before the combined system strikes the floor, is [Take g = 10 m/s^2. Assume there is no rotational motion and loss of energy after the collision is negligible.] **[JEE (Main) 2020]**

(1) 21 J (2) 23 J (3) 19 J (4) 20 J

PCM043

14. Particle A of mass m_1 moving with velocity $\left(\sqrt{3}\hat{i}+\hat{j}\right)ms^{-1}$ collides with another particle B of mass m_2 which is at rest initially. Let $\vec{V}_1$ and $\vec{V}_2$ be the velocities of particles A and B after collision respectively. If $m_1 = 2m_2$ and after collision $\vec{V}_1 = \left(\hat{i}+\sqrt{3}\hat{j}\right)ms^{-1}$, the angle between $\vec{V}_1$ and $\vec{V}_2$ is : **[JEE (Main) 2020]**

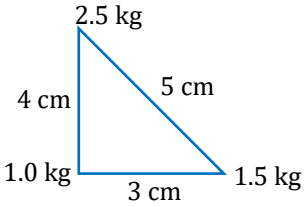
(1) 60° (2) 15° (3) –45° (4) 105°

PCM044

15. The centre of mass of a solid hemisphere of radius 8 cm is X cm from the centre of the flat surface. Then value of x is _____. **[JEE (Main) 2020]**

PCM045

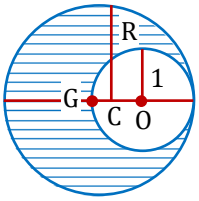
16. Three point particles of masses 1.0 kg, 1.5 kg and 2.5 kg are placed at three corners of a right angle triangle of sides 4.0 cm, 3.0 cm and 5.0 cm as shown in the figure. The center of mass of the system is at a point: **[JEE (Main) 2020]**



(1) 1.5 cm right and 1.2 cm above 1 kg mass
(2) 0.9 cm right and 2.0 cm above 1 kg mass
(3) 0.6 cm right and 2.0 cm above 1 kg mass
(4) 2.0 cm right and 0.9 cm above 1 kg mass

PCM046

17. As shown in figure, when a spherical cavity (centred at O) of radius 1 is cut out of a uniform sphere of radius R (centred at C), the centre of mass of remaining (shaded) part of sphere is at G, i.e, on the surface of the cavity. R can be determined by the equation: **[JEE (Main) 2020]**



(1) $(R^2 - R + 1)(2 - R) = 1$ (2) $(R^2 + R - 1)(2 - R) = 1$

(3) $(R^2 + R + 1)(2 - R) = 1$ (4) $(R^2 - R - 1)(2 - R) = 1$

PCM047

18. Two particles having masses 4 g and 16 g respectively are moving with equal kinetic energies. The ratio of the magnitudes of their linear momentum is n : 2. The value of n will be _____.

[JEE (Main) 2021]

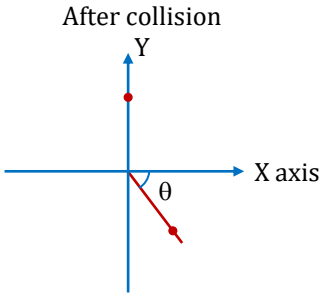
PCM048

19. The initial mass of a rocket is 1000 kg. Calculate at what rate the fuel should be burnt so that the rocket is given an acceleration of 20 ms^{-2}. The gases come out at a relative speed of 500 ms^{-1} with respect to the rocket : [Use $g = 10\ m/s^2$] **[JEE (Main) 2021]**

(1) $6.0 \times 10^2\ kg\ s^{-1}$ (2) $500\ kg\ s^{-1}$ (3) $10\ kg\ s^{-1}$ (4) $60\ kg\ s^{-1}$

PCM049

20. A ball of mass 10 kg moving with a velocity $10\sqrt{3}\ ms^{-1}$ along X-axis, hits another ball of mass 20 kg which is at rest. After collision, the first ball comes to rest and the second one disintegrates into two equal pieces. One of the pieces starts moving along Y-axis at a speed of 10 m/s. The second piece starts moving at a speed of 20 m/s at an angle θ (degree) with respect to the X-axis. The configuration of pieces after collision is shown in the figure. The value of θ to the nearest integer is _____. **[JEE (Main) 2021]**



PCM050

21. The momentum of a body is increased by 50%. The percentage increase in the kinetic energy of the body is _____%. **[JEE (Main) 2023]**

PCM170

22. A bullet of mass 0.1 kg moving horizontally with speed 400 ms^{-1} hits a wooden block of mass 3.9 kg kept on a horizontal rough surface. The bullet gets embedded into the block and moves 20 m before coming to rest. The coefficient of friction between the block and the surface is_____.

(Given $g = 10\ ms^2$) **[JEE (Main) 2023]**

(1) 0.50 (2) 0.90 (3) 0.65 (4) 0.25

PCM171

23. A body of mass 5 kg is moving with a momentum of 10 $kg\ ms^{-1}$. Now a force of 2 N acts on the body in the direction of its motion for 5s. The increase in the Kinetic energy of the body is _____ J.

[JEE (Main) 2023]

PCM172

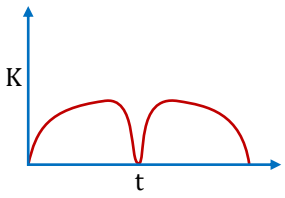
EXERCISE - JEE (Advanced) PYQ

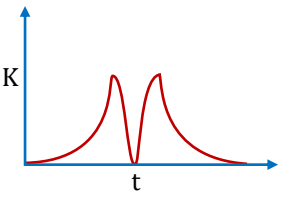
1. A bob of mass m suspended by a string of length ℓ_1 is given a minimum velocity required to complete a full circle in the vertical plane. At the highest point, it collides elastically with another bob of mass m suspended by a string of length ℓ_2, which is initially at rest. Both the strings are mass-less and inextensible. If the second bob, after collision acquires the minimum speed required to complete a full circle in the vertical plane, the ratio $\frac{\ell_1}{\ell_2}$ is. **[JEE (Advanced) 2013]**

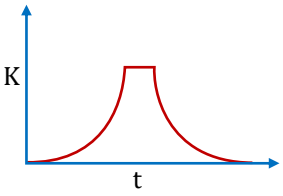
PCM068

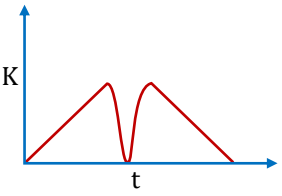
2. A tennis ball is dropped on a horizontal smooth surface. It bounces back to its original position after hitting the surface. The force on the ball during the collision is proportional to the length of compression of the ball. Which one of the following sketches describes the variation of its kinetic energy K with time t most appropriately ? The figures are only illustrative and not to the scale.

[JEE (Advanced) 2014]

(A) 

(B) 

(C) 

(D) 

PCM069

3. A block of mass M has a circular cut with a frictionless surface as shown. The block rests on the horizontal frictionless surface of a fixed table. Initially the right edge of the block is at $x = 0$, in a co-ordinate system fixed to the table. A point mass m is released from rest at the topmost point of the path as shown and it slides down. When the mass loses contact with the block, its position is x and the velocity is v. At that instant, which of the following options is/are **correct** ?

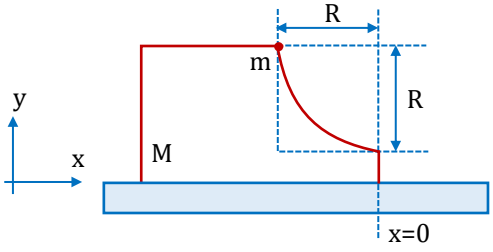
[JEE (Advanced) 2017]

(A) The x component of displacement of the centre of mass of the block M is $\frac{mR}{M+m}$

(B) The position of the point mass is $x = -\sqrt{2}\frac{mR}{M+m}$

(C) The velocity of the point mass m is $v = -\sqrt{\frac{2gR}{1+\frac{m}{M}}}$

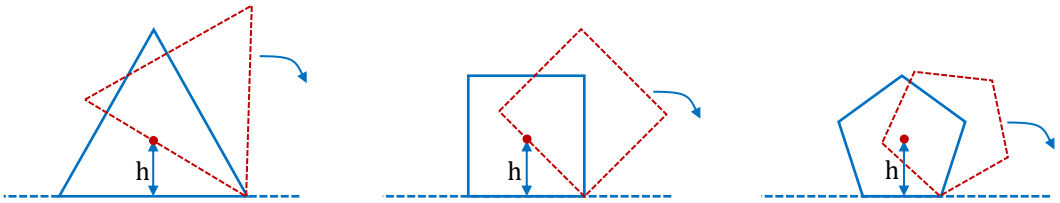
(D) The velocity of the block M is $V = -\frac{m}{M}\sqrt{2gR}$



PCM070

4. Consider regular polygons with number of sides $n = 3, 4, 5$ ..... as shown in the figure. The centre of mass of all the polygons is at height h from the ground. They roll on a horizontal surface about the leading vertex without slipping and sliding as depicted. The maximum increase in height of the locus of the centre of mass for each polygon is Δ. Then Δ depends on n and h as :

[JEE (Advanced) 2017]



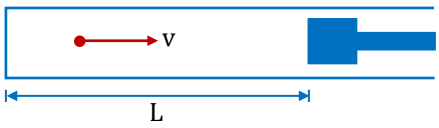
(A) $\Delta = h\sin^2\left(\frac{\pi}{n}\right)$ (B) $\Delta = h\sin\left(\frac{2\pi}{n}\right)$ (C) $\Delta = h\left(\frac{1}{\cos\left(\frac{\pi}{n}\right)} - 1\right)$ (D) $\Delta = h\tan^2\left(\frac{\pi}{2n}\right)$

PCM071

5. A solid horizontal surface is covered with a thin layer of oil. A rectangular block of mass $m = 0.4kg$ is at rest on this surface. An impulse of 1.0 $N\,s$ is applied to the block at time to $t = 0$ so that it starts moving along the x-axis with a velocity $v(t) = v_0 e^{-t/\tau}$, where v_0 is a constant and $\tau = 4s$. The displacement of the block, in metres, at $t = \tau$ is ..... Take $e^{-1} = 0.37$? **[JEE (Advanced) 2018]**

PCM072

6. A small particle of mass m moving inside a heavy, hollow and straight tube along the tube axis undergoes elastic collision at two ends. The tube has no friction and it is closed at one end by a flat surface while the other end is fitted with a heavy movable flat piston as shown in figure. When the distance of the piston from closed end is $L = L_0$ the particle speed is $v = v_0$. The piston is moved inward at a very low speed V such that $V << \frac{dL}{L}v_0$, where dL is the infinitesimal displacement of the piston. Which of the following statement(s) is/are correct ? **[JEE (Advanced) 2019]**



(A) The rate at which the particle strikes the piston is v/L.

(B) After each collision with the piston, the particle speed increases by $2V$.

(C) The particle's kinetic energy increases by a factor of 4 when the piston is moved inward from L_0 to $\frac{1}{2}L_0$.

(D) If the piston moves inward by dL, the particle speed increases by $2v\frac{dL}{L}$.

PCM073

QUESTION STEM FOR QUESTION NO. 7 AND 8

A projectile is thrown from a point O on the ground at an angle 45° from the vertical and with a speed $5\sqrt{2}$ m/s. The projectile at the highest point of its trajectory splits into two equal parts. One part falls vertically down to the ground, 0.5 s after the splitting. The other part, t seconds after the splitting, falls to the ground at a distance x meters from the point O. The acceleration due to gravity $g = 10$ m/s^2. **[JEE (Advanced) 2021]**

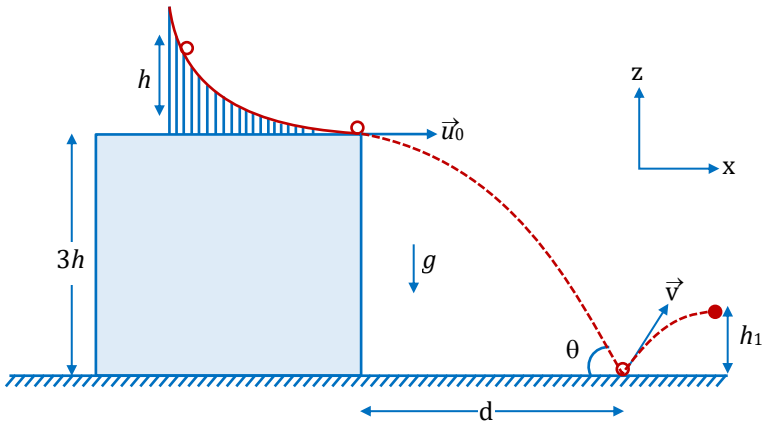
7. The value of t is _____.

PCM074

8. The value of x is _____.

PCM075

9. A slide with a frictionless curved surface, which becomes horizontal at its lower end, is fixed on the terrace of a building of height $3h$ from the ground, as shown in the figure. A spherical ball of mass m is released on the slide from rest at a height h from the top of the terrace. The ball leaves the slide with a velocity $\vec{u}_0 = u_0\hat{x}$ and falls on the ground at a distance d from the building making an angle θ with the horizontal. It bounces off with a velocity $\vec{v}$ and reaches a maximum height h_1. The acceleration due to gravity is g and the coefficient of restitution of the ground is $\frac{1}{\sqrt{3}}$. Which of the following statement(s) is(are) correct?



[JEE (Advanced) 2023]

(A) $\vec{u}_0 = \sqrt{2gh}\hat{x}$

(B) $\vec{v} = \sqrt{2gh}(\hat{x} - \hat{z})$

(C) $\theta = 60°$

(D) $\frac{d}{h_1} = 2\sqrt{3}$

PCM173

JEE (Main) Practice Paper

This paper is for yourself practice and assessment the discussion of this paper is optional though you can see PDF solutions or video solutions or solutions in hardcopy whichever is provided.

SECTION–A

- This section contains **TWENTY** questions.
- Each question has **FOUR** options (1), (2), (3) and (4). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories:

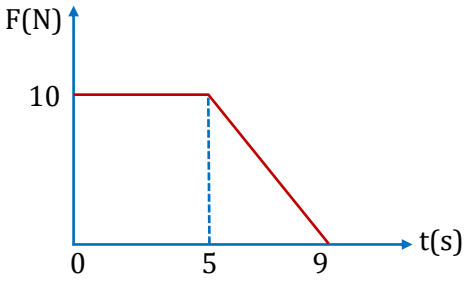
Full Marks : +4, if only the bubble corresponding to the correct option is darkened.
Zero Marks : 0, if none of the bubbles is darkened.
Negative Marks : –1 in all other cases.

1. A man weighing 80 *kg* is standing at the centre of a flat boat and he is 20 *m* from the shore. He walks 8 *m* on the boat towards the shore and then halts. The boat weight 200 *kg*. How far is he from the shore at the end of this time ?

(1) 11.2 *m* (2) 13.8 *m* (3) 14.3 *m* (4) 15.4 *m*

PCM001

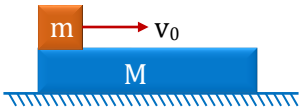
2. A body of mass 4 *kg* is acted on by a force which varies as shown in the graph below. The momentum acquired is



(1) 280 *N–s* (2) 140 *N–s* (3) 70 *N–s* (4) 210 *N–s*

PCM002

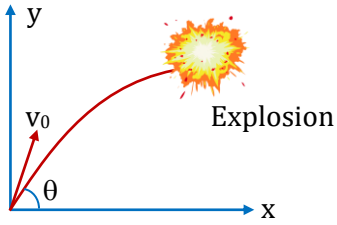
3. The coefficient of friction between the block and plank is μ and ground is smooth. The value of μ is such that block becomes stationary with respect to plank before it reaches the other end. Then which of the following statement is incorrect.



(1) The work done by friction on the block is negative.
(2) The work done by friction on the plank is positive.
(3) The net work done by friction is negative.
(4) Net work done by the friction is zero.

PCM003

4. A projectile is projected in *x-y* plane with velocity v_0. At top most point of its trajectory projectile explodes into two identical fragments. Both the fragments land simultaneously on ground and stick there. Taking point of projection as origin and *R* as range of projectile if explosion had not taken place. Which of the following can not be position vectors of two pieces, when they land on ground.



(1) $\frac{R}{2}\hat{i}, \frac{3R}{2}\hat{i}$ (2) $0\hat{i}, 2R\hat{i}$ (3) $R\hat{i} - R\hat{k}, R\hat{i} + R\hat{k}$ (4) $2R\hat{i} + \frac{R}{2}\hat{k}, R\hat{i} - \frac{R}{2}\hat{k}$

PCM004

5. Ball *A* of mass 5.0 kilograms moving at 20 *m/s* collides with ball *B* of unknown mass moving at 10 *m/s* in the same direction. After the collision, ball A moves at 10 *m/s* and ball *B* at 15 *m/s,* both still in the same direction. What is the mass of ball *B*?

(1) 6.0 *kg* (2) 10 *kg* (3) 2.0 *kg* (4) 12 *kg*

PCM005

6. A mass '*m*' moves with a velocity '*v*' and collides inelastically with another identical mass at rest. After collision the 1st mass moves with velocity $\frac{v}{\sqrt{3}}$ in a direction perpendicular to the initial direction of motion. Find the speed of the 2nd mass after collision :-

(1) $\frac{2v}{\sqrt{3}}$

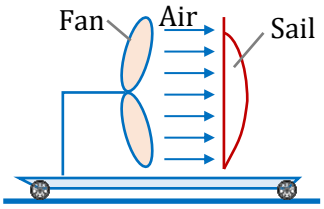
(2) $\frac{v}{\sqrt{3}}$

(3) $v\sqrt{\frac{2}{3}}$

(4) the situation of the problem is not possible without external impulse

PCM006

7. A fan and a sail are mounted vertically on a cart that is initially at rest on a horizontal table as shown in the diagram. When the fan is turned on, an air stream is blown towards the right and is incident on the sail. The cart is free to move with negligible resistance forces. After the fan has been turned on the cart will



(1) move to the right and then to the left (2) remain at rest

(3) move towards the right (4) move towards the left

PCM007

8. Two identical carts constrained to move on a straight line, on which sit two twins of same mass, are moving with same velocity. At some time snow begins to drop uniformly vertically downward. Ram, sitting on one of the trolleys, throws off the falling snow sideways with respect to himself and in the second cart Shyam is asleep. (Assume that friction is absent)

(1) Cart carrying Ram will speed up while cart carrying Shyam will slow down.

(2) Cart carrying Ram will remain at the same speed while cart carrying Shyam will slow down.

(3) Cart carrying Ram will speed up while cart carrying Shyam will remain at the same speed.

(4) Cart carrying Ram as well as Shyam will slow down.

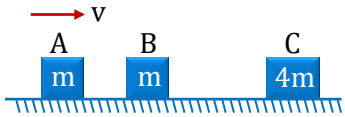
PCM008

9. A force exerts an impulse I on a particle changing its speed from u to $2u$. The applied force and the initial velocity are oppositely directed along the same line. The work done by the force is

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

PCM009

10. Three blocks are initially placed as shown in the figure. Block A has mass m and initial velocity v to the right. Block B with mass m and block C with mass $4m$ are both initially at rest. Neglect friction. All collisions are elastic. The final velocity of block A is



(1) $0.6v$ to the left (2) $1.4v$ to the left (3) v to the left (4) $0.4v$ to the right

PCM010

11. Two billiard balls undergo a head-on collision. Ball 1 is twice as heavy as ball 2. Initially, ball 1 moves with a speed v towards ball 2 which is at rest. Immediately after the collision, ball 1 travels at a speed of $v/3$ in the same direction. What type of collision has occurred?

(1) inelastic

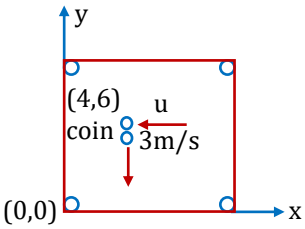
(2) elastic

(3) completely inelastic

(4) cannot be determined from the information given

PCM011

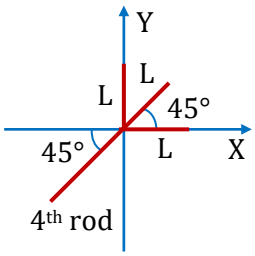
12. On a smooth carom board, a coin moving in negative y–direction with a speed of 3 m/s is being hit at the point (4, 6) by a striker moving along negative x–axis. The line joining centres of the coin and the striker just before the collision is parallel to x–axis. After collision the coin goes into 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



(1) (1.2, 0) (2) (2, 0) (3) (3, 0) (4) None of these

PCM012

13. Three identical uniform rods of the same mass M and length L are arranged in xy plane as shown in the figure. A fourth uniform rod of mass $3M$ has been placed as shown in the xy plane. What should be the value of the length of the fourth rod such that the center of mass of all the four rods lie at the origin?



(1) $\frac{L\left(\sqrt{2+1}\right)}{3}$ (2) $\frac{L\left(\sqrt{2+1}\right)}{5}$ (3) $L\left(\sqrt{2+1}\right)$ (4) $\frac{L\left(\sqrt{2+1}\right)}{9}$

PCM013

14. From a circle of radius a, an isosceles right angled triangle with the hypotenuse as the diameter of the circle is removed. The distance of the centre of gravity of the remaining position from the centre of the circle is

(1) $\frac{a}{3(\pi-1)}$ (2) $\frac{a}{4(\pi-1)}$ (3) $\frac{a}{(\pi-1)}$ (4) $\frac{a}{2(\pi-1)}$

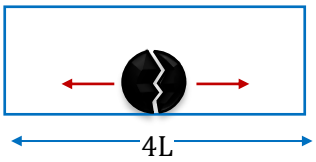
PCM014

15. In the arrangement shown in the figure, m_A = 2 kg and m_B = 1 kg. String is light and inextensible. Find the acceleration of centre of mass of both the blocks. Neglect friction everywhere.

(1) $g/3$ downwards (2) $g/9$ downwards (3) $g/3$ upwards (4) $g/9$ upwards

PCM015

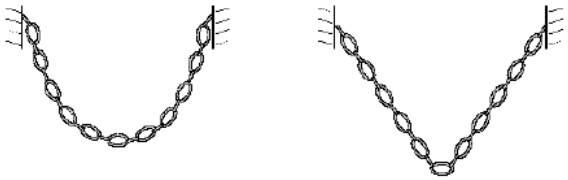
16. A bomb of mass $3m$ is kept inside a closed box of mass $3m$ and length $4L$ at it's centre. It explodes in two parts of mass m and $2m$. The two parts move in opposite direction and stick to the opposite side of the walls of box. Box is kept on a smooth horizontal surface. What is the distance moved by the box during this time interval.



(1) $\frac{L}{3}$ (2) $\frac{L}{6}$ (3) $\frac{L}{9}$ (4) L

PCM016

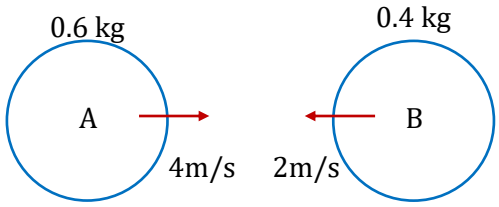
17. Pull down in the middle of a heavy chain, fixed at both ends, in such a way that it forms a triangle. Does the centre of mass takes up a higher or lower position ?



(1) Centre of mass comes down
(2) Centre of mass goes up
(3) Centre of mass remains stationary
(4) Cannot be predicted

PCM201

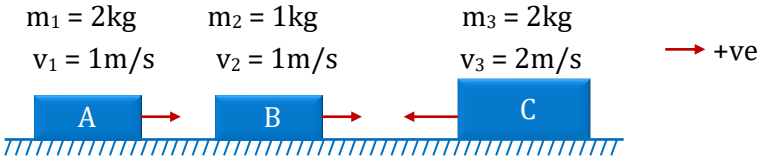
18. The velocities of two steel balls before impact are shown. If after head on impact the velocity of ball *B* is observed to be 3 *m/s* to the right, the coefficient of restitution is



(1) $\frac{6}{18}$ (2) $\frac{7}{18}$ (3) $\frac{8}{18}$ (4) $\frac{9}{18}$

PCM018

19. Three carts move on a frictionless track with inertias and velocities as shown. The carts collide and stick together after successive collisions.

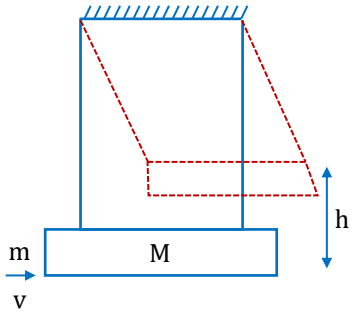


(i) Find loss of mechanical energy when *B* and *C* stick together.
(ii) Find magnitude of impulse experienced by *A* when it sticks to combined mass (*B* and *C*).

(1) $3J, \frac{12}{5}N-s$ (2) $4J, \frac{14}{5}N-s$ (3) $5J, \frac{11}{5}N-s$ (4) $6J, \frac{18}{5}N-s$

PCM019

20. A large block of wood of mass $M = 5.99\ kg$ is hanging from two long massless cords. A bullet of mass $m = 10g$ is fired into the block and gets embedded in it. The (block + bullet) then swing upwards, their centre of mass rising *a* vertical distance $h = 9.8\ cm$ before the (block + bullet) pendulum comes momentarily to rest at the end of its arc. The speed of the bullet just before collision is : (Take g = 9.8 ms^{-2})



(1) 841.4 *m/s* (2) 811.4 *m/s* (3) 831.4 *m/s* (4) 821.4 *m/s*

PCM020

SECTION–B

- This section will have **TEN questions**. Candidate can choose to attempt any 5 questions out of these 10 questions. In case if candidate attempts more than 5 questions, first 5 attempted questions will be considered for marking.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value (Answer should be rounded off to the nearest integer).
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks	:	+4, if only correct answer is given.
Zero Marks	:	0, if no answer is given.
Negative Marks	:	–1 for incorrect answer.

---

1. The figure shows the positions and velocities of two particles. If the particles move under the mutual attraction of each other, then find the position of centre of mass (in *m*) at $t = 1\ s$.

PCM021

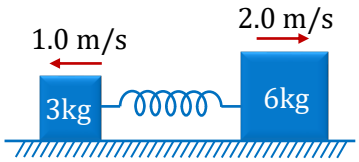
2. Two cars initially at rest are free to move in the *x* direction. Car *A* has mass 4 *kg* and car *B* has mass 2 *kg*. They are tied together, compressing a spring in between them. When the spring holding them together is burned, car *A* moves off with a speed of 2 *m/s*. With what speed does car *B* leave.

PCM022

3. A 24 *kg* projectile is fired at an angle of 53° above the horizontal with an initial speed of 50 *m/s*. At the highest point in its trajectory, the projectile explodes into two fragments of equal mass, the first of which falls vertically with zero initial speed. The energy (in *J*) released during the explosion was 100*x*. Then the value of *x* is?

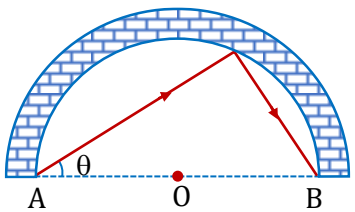
PCM023

4. 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 (in *cm*) of the spring will be



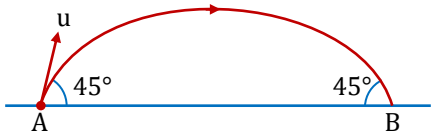
PCM024

5. Line *AB* is a diameter of the semi-circular wall shown. The ground is frictionless. A ball thrown along the ground collides the ball and reaches point *B*. If $\theta = 30°$ and coefficient of restitution is *e*, find the value of 9*e*.



PCM202

6. The projectile motion of a particle of mass 5 g is shown in the figure.



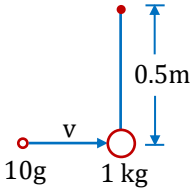
The initial velocity of the particle is $5\sqrt{2}\ ms^{-1}$ and the air resistance is assumed to be negligible. The magnitude of the change in momentum between the points A and B is $x \times 10^{-2}\ kgms^{-1}$. The value of x, to the nearest integer, is _____.

PCM026

7. A body of mass 2 kg moving with a speed of 4 m/s. makes an elastic collision with another body at rest and continues to move in the original direction but with one fourth of its initial speed. The speed of the COM of the two bodies is $\frac{x}{10} m/s$. Then the value of x is_____.

PCM027

8. A bullet of 10 g, moving with velocity ν, collides head-on with the stationary bob of a pendulum and recoils with velocity 100 m/s. The length of the pendulum is 0.5 m and mass of the bob is 1 kg. The minimum value of ν = ____ m/s so that the pendulum describes a circle.
(Assume the string to be inextensible and $g = 10\ m/s^2$)



PCM028

9. A block moving horizontally on a smooth surface with a speed of 40 ms^{-1} splits into two equal parts. If one of the parts moves at 60 ms^{-1} in the same direction, then the fractional change in the kinetic energy will be $x : 4$ where x = _____.

PCM029

10. A batsman hits back a ball of mass 0.4 kg straight in the direction of the bowler without changing its initial speed of 15 ms^{-1}. The impulse imparted to the ball is _____Ns.

PCM030

JEE (Advanced) Practice Paper

This paper is for yourself practice and assessment the discussion of this paper is optional though you can see PDF solutions or video solutions or solutions in hardcopy whichever is provided.

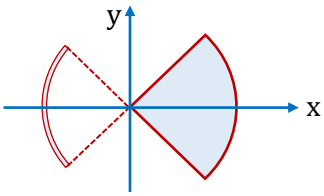
SECTION–I

- This section contains **SIX** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories:

Full Marks : +3 if only the bubble corresponding to the correct option is darkened.
Zero Marks : 0 if none of the bubbles is darkened.
Negative Marks : –1 in all other cases.

---

1. A sector cut from a uniform disk of radius 12 *cm* and a uniform rod of the same mass bent into shape of an arc are arranged facing each other as shown in the figure. If center of mass of the combination is at the origin, what is the radius of the arc?



(A) 8 *cm* (B) 9 *cm* (C) 12 *cm* (D) 18 *cm*

PCM051

2. A piece of paper (shown in figure-1) is in form of a square. Two corners of this square are folded to make it appear like figure-2. Both corners are put together at centre of square '*O*'. If *O* is taken to be (0, 0), the centre of mass of new system will be at

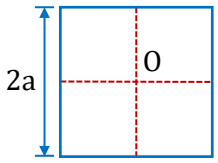


Figure-1

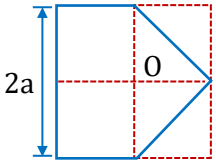
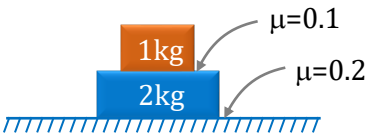


Figure-2

(A) $\left(\frac{-a}{8},0\right)$ (B) $\left(\frac{-a}{6},0\right)$ (C) $\left(\frac{a}{12},0\right)$ (D) $\left(\frac{-a}{12},0\right)$

PCM052

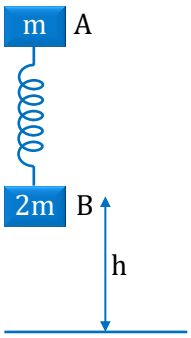
3. If both the blocks as shown in the given arrangement are given together a horizontal velocity towards right. If a_{cm} be the subsequent acceleration of the centre of mass of the system of blocks then a_{cm} equals



(A) 0 m/s^2 (B) $\frac{5}{3}m/s^2$ (C) $\frac{7}{3}m/s^2$ (D) 2 m/s^2

PCM053

4. From what minimum height h must the system be released when spring is unstretched so that after perfectly inelastic collision ($e = 0$) with ground, B may be lifted off the ground (Spring constant = k).



(A) $mg/(4k)$ (B) $4\ mg/k$ (C) $mg/(2k)$ (D) none

PCM054

5. 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 collisions, the first particle has come to rest, and the second particle has split into two equal-mass pieces that move at equal angles $\theta > 0$ with the x-axis, as shown in the figure. Which of the following statements correctly describes the speeds of the two pieces?

Before Collision **After Collision**

(A) Each piece moves with speed v

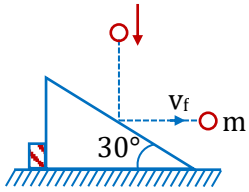
(B) One of the pieces moves with speed v, the other moves with speed less than v

(C) Each piece moves with speed $v/2$

(D) Each piece moves with speed greater than $v/2$

PCM055

6. As shown in the figure a body of mass m moving vertically with speed 3 m/s hits a smooth fixed inclined plane and rebounds with a velocity v_f in the horizontal direction. If $\angle$ of inclined is 30°, the velocity v_f will be



(A) $3\ m/s$ (B) $\sqrt{3}\ m/s$ (C) $\frac{1}{\sqrt{3}}\ m/s$ (D) this is not possible

PCM056

SECTION-II

- This section contains **THREE** questions.
- Each question has **FOUR** options for correct answer(*s*). **ONE OR MORE THAN ONE** of these four option(*s*) is (are) correct option(*s*).
- For each question, choose the correct option(*s*) to answer the question.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks	: +4	if only (all) the correct option(*s*) is (are) chosen.
Partial Marks	: +3	if all the four options are correct but ONLY three options are chosen.
Partial Marks	: +2	if three or more options are correct but ONLY two options are chosen, both of which are correct options.
Partial Marks	: +1	if two or more options are correct but ONLY one option is chosen and it is a correct option.
Zero Marks	: 0	if none of the options is chosen (i.e. the question is unanswered).
Negative Marks	: –2	in all other cases.

For Example : If first, third and fourth are the **ONLY** three correct options for a question with second option being an incorrect option; selecting only all the three correct options will result in +4 marks. Selecting only two of the three correct options (e.g. the first and fourth options), without selecting any incorrect option (second option in this case), will result in +2 marks. Selecting only one of the three correct options (either first or third or fourth option), without selecting any incorrect option (second option in this case), will result in +1 marks. Selecting any incorrect option(*s*) (second option in this case), with or without selection of any correct option(*s*) will result in –2 marks.

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7. A blast breaks a body initially at rest of mass 0.5 *kg* into three pieces, two smaller pieces of equal mass and the third double the mass of either of small piece. After the blast the two smaller masses move at right angles to one another with equal speed. Find the statements that is/are true for this case assuming that the energy of blast is totally transferred to masses.

(A) All the three pieces share the energy of blast equally.

(B) The speed of bigger mass is $\sqrt{2}$ times the speed of either of the smaller mass.

(C) The direction of motion of bigger mass makes an angle of 135° with the direction of smaller pieces.

(D) The bigger piece carries double the energy of either piece.

PCM057

8. A particle moving with kinetic energy = 3 joule 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 joule.

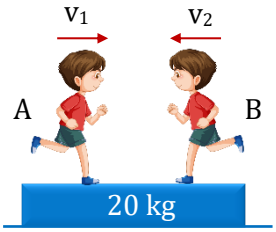
(B) The maximum elastic potential energy of the system is 2 joule.

(C) Momentum and total kinetic energy of the system are conserved at every instant.

(D) The ratio of kinetic energy to potential energy of the system first decreases and then increases.

PCM058

9. In the figure shown the system is at rest initially. Two persons '*A*' and '*B*' of masses 40 *kg* each move with speeds v_1 and v_2 respectively towards each other on a plank lying on a smooth horizontal surface as shown in figure. Plank travels a distance of 20 *m* towards right direction in 5 sec. (Here v_1 and v_2 are given with respect to the plank). Then the possible condition(s) can be



(A) $v_1 = 0\ m/s, v_2 = 10\ m/s$

(B) $v_1 = 5\ m/s, v_2 = 15\ m/s$

(C) $v_1 = 10\ m/s, v_2 = 20\ m/s$

(D) $v_1 = 2\ m/s, v_2 = 12\ m/s$

PCM059

SECTION-III

- This section contains **THREE** paragraphs.
- Based on each paragraph, there are **TWO/THREE** questions.
- Each question has **FOUR** options (A), (B), (C) and (D) **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories :

Full Marks : +3 if only the bubble corresponding to the correct answer is darkened.

Zero Marks : 0 in all other cases.

PARAGRAPH FOR QUESTION NO. 10 AND 11

A projectile of mass "*m*" is projected from ground with a speed of 50 *m/s* at an angle of 53° with the horizontal. It breaks up into two equal parts at the highest point of the trajectory. One particle coming to rest immediately after the explosion.

10. The ratio of the radii of curvatures of the moving particle just before and just after the explosion are:

(A) 1 : 4 (B) 1 : 3 (C) 2 : 3 (D) 4 : 9

PCM060

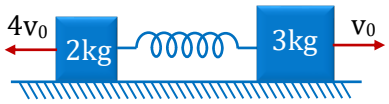
11. The distance between the pieces of the projectile when they reach the ground are:

(A) 240 (B) 360 (C) 120 (D) none

PCM061

PARAGRAPH FOR QUESTION NO. 12 TO 14

2 *kg* and 3 *kg* blocks are placed on a smooth horizontal surface and connected by spring which is unstretched initially. The blocks are imparted velocities as shown in the figure.



12. The maximum energy stored in the spring in the subsequent motion will be

(A) 5 v_0^2 (B) 15 v_0^2 (C) zero (D) 10 v_0^2

PCM062

13. Maximum speed of 3 *kg* block in the subsequent motion will be

(A) v_0 (B) $2v_0$ (C) $3v_0$ (D) $4v_0$

PCM063

14. Maximum speed of 2 *kg* block in the subsequent motion will be

(A) v_0 (B) $2v_0$ (C) $3v_0$ (D) $4v_0$

PCM064

PARAGRAPH FOR QUESTION NO. 15 AND 16

A uniform chain of length $2L$ is hanging in equilibrium position, if end B is given a slightly downward displacement the imbalance causes an acceleration. Here pulley is small and smooth and string is inextensible

15. The acceleration of end B when it has been displaced by distance x, is

(A) $\frac{x}{L}g$ (B) $\frac{2x}{L}g$ (C) $\frac{x}{2}g$ (D) g

PCM065

16. The velocity v of the string when it slips out of the pulley (Height of pulley from floor > $2L$)

(A) $\sqrt{\frac{gL}{2}}$ (B) $\sqrt{2gL}$ (C) $\sqrt{gL}$ (D) none of these

PCM066

SECTION-IV

- This section contains **ONE** question.
- Each question contains two columns, **Column-I** and **Column-II.**
- **Column-I** has **four** entries (A), (B), (C) and (D).
- **Column-II** has **five** entries (P), (Q), (R), (S) and (T).
- Match the entries in **Column-I** with the entries in **column-II.**
- One or more entries in **Column-I** may match with one or more entries in **Column-II.**
- The ORS contains a 4 × 5 matrix whose layout will be similar to the one shown below:

(A) (P) (Q) (R) (S) (T)
(B) (P) (Q) (R) (S) (T)
(C) (P) (Q) (R) (S) (T)
(D) (P) (Q) (R) (S) (T)

- For each entry in **column-I,** darken the bubbles of all the matching entries. For example, if entry (A) in **Column-I** matches with entries (Q), (R) and (T), then darken these three bubbles in the ORS. Similarly, for entries (B), (C) and (D).
- For each question, marks will be awarded in one of the following categories :

For each entry in **Column-I**

Full Marks : +2 if only the bubble(s) corresponding to all the correct match(es) is (are) darkened.
Zero Marks : 0 if none of the bubbles is darkened.
Negative Marks : –1 in all other cases.

---

17. A particle of mass m, kinetic energy K and momentum p collides head on elastically with another particle of mass 2 m at rest. After collision :

	Column I		**Column II**
(A)	Momentum of first particle	(P)	$3/4\ p$
(B)	Momentum of second particle	(Q)	$-K/9$
(C)	Kinetic energy of first particle	(R)	$-p/3$
(D)	Kinetic energy of second particle	(S)	$\frac{8K}{9}$
		(T)	None

PCM067

ANSWER KEY

EXERCISE - O

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	B	A	D	B	C	A	C	B	C	B
Que.	11	12	13	14	15	16	17	18	19	20
Ans.	A	C	A	A	B	C	(i)- B, (ii)- C	D	C	D
Que.	21	22	23	24	25	26	27	28	29	30
Ans.	C	B	A	B	B	B	C	A	A	D
Que.	31	32	33	34	35	36	37	38	39	40
Ans.	C	C	D	A	B	B	A	C	C	B
Que.	41	42	43	44	45	46	47	48	49	50
Ans.	D	A	C	C	BCD	ABD	BC	ABC	ABC	ACD
Que.	51	52	53	54	55	56	57	58	59	60
Ans.	ABD	AC	ABC	BC	AC	ABD	BCD	AB	A	C
Que.	61	62	63	64			65			
Ans.	B	D	B	(A-P), (B-S), (C-Q,R), (D-T)			(A-Q), (B-P,Q), (C-R), (D-S)			
Que.	66				67					
Ans.	(A-S), (B-Q), (C-P), (D-R)				(A-R), (B-T), (C-S), (D-Q)					

EXERCISE - S

1. 1/7, 23/14

2. $\sqrt{13}\ m, \left(\frac{14}{5}, \frac{19}{5}\right)$

3. 3 m, 1 m, 8 m

$$\frac{6(\hat{\imath}+2\hat{\jmath}+3\hat{k})+5(-\hat{\imath}+3\hat{\jmath}-2\hat{k})+5\vec{r}}{16} = (\hat{\imath}+2\hat{\jmath}+3\hat{k})$$

$$\vec{r} = (3\hat{\imath}+\hat{\jmath}+8\hat{k})$$

4. $4R$ from O

5. $\vec{P}_{PM} = m\vec{v}_{PM} = -mv_2 \sin\omega t\hat{\imath} + m(v_2\cos\omega t - v_1)\hat{\jmath}$

6. 150 kg

7. $\frac{\sqrt{13}}{2}v_0$

8. 0.3

9. 4

10. 2

11. (i) $v_0/3$, (ii) $3\sqrt{5gR}$

12. $\vec{v}_C = -\vec{v}_B$

13. 2

14. (i) $\sqrt{\frac{2ag}{3}}$ (ii) $\frac{3v}{g}$ (iii) $\frac{2v}{g}$

15. $m \times \sqrt{u^2 - uv + v^2}$

16. $(\hat{\imath}+\sqrt{3}\hat{\jmath})\ m/s, (3m\hat{\imath}-\sqrt{3}m\hat{\jmath})\ kg\text{-}m/s$

17. (i) $\frac{u}{2}, \frac{mu}{2}$ (ii) $\frac{u\sqrt{13}}{8}, \frac{mu\sqrt{13}}{8}$ (iii) $\frac{u\sqrt{3}}{4}, \frac{mu\sqrt{3}}{4}$

18. (i) $v/2, v/2, 0$; (ii) $2mv^2/9$; (iii) $mv^2/72$; (iv) $x = \sqrt{\frac{m}{6k}}\, v$

19. $1N$

20. $3\,Mgx/L$

21. $1900\,N$

22. (i) $\lambda(x) = \lambda_0 + \frac{\lambda_0 x}{\ell}$, (ii) $\frac{5}{9}\ell$

23. $\frac{R}{4}$

24. $-2m/s, 6.93\,m/s \angle 30°$

EXERCISE - JEE (Main) PYQ

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	4	1	4	4	1	4	4	3	1	4
Que.	11	12	13	14	15	16	17	18	19	20
Ans.	2	10	1	4	3	2	3	1	4	30
Que.	21	22	23							
Ans.	125	4	30							

EXERCISE - JEE (Advanced) PYQ

Que.	1	2	3	4	5	6	7	8	9
Ans.	5	B	AC	C	(6.3) [6.29, 6.31]	BC	0.50	7.50	ACD

JEE (Main) Practice Paper

Section-A	Q.	1	2	3	4	5	6	7	8	9	10
	A.	3	3	4	4	2	4	2	4	2	1
	Q.	11	12	13	14	15	16	17	18	19	20
	A.	2	2	1	1	2	1	2	2	1	3
Section-B	Q.	1	2	3	4	5	6	7	8	9	10
	A.	6	4	108	30	3	5	25	400	1	12

JEE (Advanced) Practice Paper

Section-I	Q.	1	2	3	4	5	6	
	A.	A	D	D	B	D	B	
Section-II	Q.	7	8	9				
	A.	AC	ABD	ABCD				
Section-III	Q.	10	11	12	13	14	15	16
	A.	A	A	B	C	D	A	C
Section-IV	Q.	17						
	A.	(A-R), (B-T), (C-T), (D-S)						

Important Notes