Exercise-1

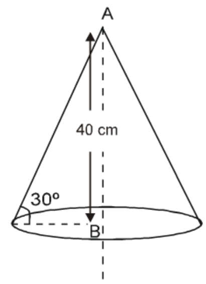
✍ **Marked Questions can be used as Revision Questions.**

OBJECTIVE QUESTIONS

Section (A) : Calculation OF centre of mass

A-1. The centre of mass of a body :
(1) Lies always at the geometrical centre
(2) Lies always inside the body
(3) Lies always outside the body
(4) Lies within or outside the body

A-2.✍ A uniform solid cone of height 40 cm is shown in figure. The distance of centre of mass of the cone from point B (centre of the base) is :
(1) 20 cm
(2) 10/3 cm
(3) 20/3 cm
(4) 10 cm



A-3. A body has its centre of mass at the origin. The x-coordinates of the particles
(1) may be all positive
(2) may be all negative
(3) must be all non-negative
(4) may be positive for some particles and negative in other particles

Section (B) : Motion of centre of mass

B-1. A bomb travelling in a parabolic path under the effect of gravity, explodes in mid air. The centre of mass of fragments will:
(1) Move vertically upwards and then downwards
(2) Move vertically downwards
(3) Move in irregular path
(4) Move in the parabolic path which the unexploded bomb would have travelled.

B-2. If a ball is thrown upwards from the surface of earth and during upward motion :
(1) The earth remains stationary while the ball moves upwards
(2) The ball remains stationary while the earth moves downwards
(3) The ball and earth both moves towards each other
(4) The ball and earth both move away from each other

B-3. Internal forces can change :
(1) the linear momentum but not the kinetic energy of the system.
(2) the kinetic energy but not the linear momentum of the system.
(3) linear momentum as well as kinetic energy of the system.
(4) neither the linear momentum nor the kinetic energy of the system.

B-4. If the external forces acting on a system have zero resultant, the centre of mass
(1) must not move
(2) must accelerate
(3) may move
(4) may accelerate

B-5. Two balls are thrown in air. The acceleration of the centre of mass of the two balls while in air (neglect air resistance)
(1) depends on the direction of the motion of the balls
(2) depends on the masses of the two balls
(3) depends on the speeds of the two balls
(4) is equal to g

B-6. Two particles of mass 1 kg and 0.5 kg are moving in the same direction with speed of 2m/s and 6m/s respectively on a smooth horizontal surface. The speed of centre of mass of the system is :
(1) $\frac{10}{3}$ m/s (2) $\frac{10}{7}$ m/s (3) $\frac{11}{2}$ m/s (4) $\frac{12}{3}$ m/s

B-7. Two particles having mass ratio n : 1 are interconnected by a light inextensible string that passes over a smooth pulley. If the system is released, then the acceleration of the centre of mass of the system is :
(1) $(n-1)^2$ g (2) $\left(\frac{n+1}{n-1}\right)^2 g$ (3) $\left(\frac{n-1}{n+1}\right)^2 g$ (4) $\left(\frac{n+1}{n-1}\right) g$

Section (C) : Conservation of linear momentum

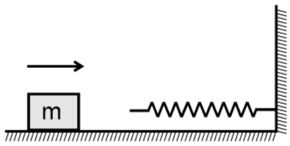
C-1. Two particles A and B initially at rest move towards each other under a mutual force of attraction. The speed of centre of mass at the instant when the speed of A is v and the speed of B is 2v is :
(1) v (2) Zero (3) 2 v (4) 3 v /2

C-2. If the KE of a body becomes four times its initial value, then the new momentum will be more than its initial momentum by;
(1) 50% (2) 100% (3) 125% (4) 150%

C-3. A man of mass 'm' climbs on a rope of length L suspended below a balloon of mass M. The balloon is stationary with respect to ground. If the man begins to climb up the rope at a speed v_{rel} (relative to rope). In what direction and with what speed (relative to ground) will the balloon move?
(1) downwards, $\frac{mv_{rel}}{m+M}$ (2) upwards, $\frac{Mv_{rel}}{m+M}$
(3) downwards, $\frac{mv_{rel}}{M}$ (4) downwards, $\frac{(M+m)v_{rel}}{M}$

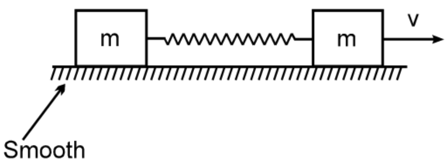
Section (D) : spring - mass system

D-1. In the figure shown the change in magnitude of momentum of the block when it comes to its initial position if the maximum compression of the spring is x_0 will be :



(1) $2\sqrt{km}\ x_0$ (2) $\sqrt{km}\ x_0$
(3) zero (4) none of these

D-2. Two masses are connected by a spring as shown in the figure. One of the masses was given velocity v = 2 k, as shown in figure where 'k' is the spring constant. Then maximum extension in the spring will be



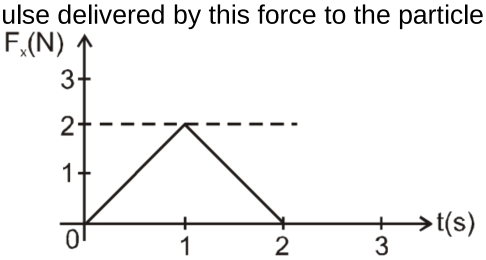
(1) 2 m (2) m (3) $\sqrt{2mk}$ (4) $\sqrt{3mk}$

Section (E) : Impulse

E-1. A ball of mass 50 gm is dropped from a height h = 10 m. It rebounds losing 75 percent of its kinetic energy. If it remains in contact with the ground for $\Delta t = 0.01$ sec., the impulse of the impact force is :
(1) 1.3 N–s (2) 1.05 N-s (3) 1300 N–s (4) 105 N–s

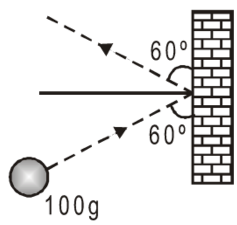
E-2. The area of F-t curve is A, where 'F' is the force on one mass due to the other. If one of the colliding bodies of mass M is at rest initially, its speed just after the collision is :
(1) A/M (2) M/A (3) AM (4) $\sqrt{\frac{2A}{M}}$

E-3. The given figure shows a plot of the time dependent force F_x acting on a particle in motion along the x-axis. What is the total impulse delivered by this force to the particle from time t = 0 to t = 2second?



(1) 0 (2) 1 kg-m/s (3) 2 kg-m/s (4) 3 kg-m/s

E-4. A mass of 100g strikes the wall with speed 5m/s at an angle as shown in figure and it rebounds with the same speed. If the contact time is 2×10^{-3} sec., what is the force applied on the mass by the wall :



(1) $250\sqrt{3}$ to right (2) 250 N to right
(3) $250\sqrt{3}$ N to left (4) 250 N to left

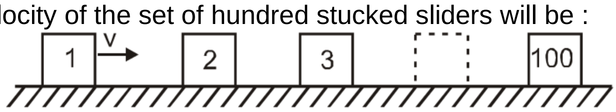
Section (F) : Collision

F-1. A block moving in air explodes in two parts then just after explosion
(1) the total momentum must be conserved
(2) the total kinetic energy of two parts must be same as that of block before explosion.
(3) the total momentum must change
(4) the total kinetic energy must not be increased

F-2. In head on elastic collision of two bodies of equal masses, it is not possible :
(1) the velocities are interchanged
(2) the speeds are interchanged
(3) the momenta are interchanged
(4) the faster body speeds up and the slower body slows down

F-3. A bullet of mass m = 50 gm strikes a sand bag of mass M = 5 kg hanging from a fixed point, with a horizontal velocity $\vec{v}_p$. If bullet sticks to the sand bag then the ratio of final & initial kinetic energy of the bullet is (approximately) :
(1) 10^{-2} (2) 10^{-3} (3) 10^{-6} (4) 10^{-4}

F-4. There are hundred identical sliders equally spaced on a frictionless track as shown in the figure. Initially all the sliders are at rest. Slider 1 is pushed with velocity v towards slider 2. In a collision the sliders stick together. The final velocity of the set of hundred stucked sliders will be :



(1) $\frac{v}{99}$ (2) $\frac{v}{100}$ (3) zero (4) v

F-5.✍ A massive ball moving with speed v collides head-on with a tiny ball at rest having a mass very less than the mass of the first ball. If the collision is elastic, then immediately after the impact, the second ball will move with a speed approximately equal to:

(1) v (2) 2v (3) v/2 (4) ∞.

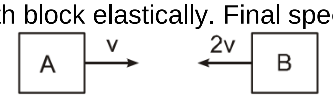
F-6.✍ A ball of mass 'm', moving with uniform speed, collides elastically with another stationary ball. The incident ball will lose maximum kinetic energy when the mass of the stationary ball is

(1) m (2) 2m (3) 4m (4) infinity

F-7. During the head on collision of two masses 1 kg and 2 kg the maximum energy of deformation is $\frac{100}{3}$ J. If before collision the masses are moving in the opposite direction, then their velocity of approach before the collision is :

(1) 10 m/sec. (2) 5 m/sec. (3) 20 m/sec. (4) $10\sqrt{2}$ m/sec.

F-8.✍ A block A of mass m moving with a velocity 'v' along a frictionless horizontal track and a blocks of mass m/2 moving with 2v collides with block elastically. Final speed of the block A is :

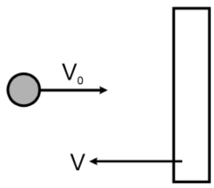


(1) $\frac{5v}{3}$ (2) v (3) $\frac{2v}{3}$ (4) none of these

F-9. In a collision between two solid spheres, velocity of separation along the line of impact (assume no external forces act on the system of two spheres during impact) :

(1) cannot be greater than velocity of approach
(2) cannot be less than velocity of approach
(3) cannot be equal to velocity of approach
(4) none of these

F-10.✍ A particle of mass m moves with velocity v_0 = 20 m/sec towards a wall that is moving with velocity v = 5 m/sec. If the particle collides with the wall elastically, the speed of the particle just after the collision is :

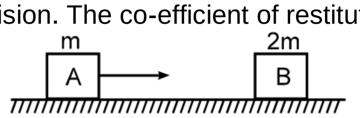


(1) 30 m/s
(2) 20 m/s
(3) 25 m/s
(4) 22 m/s

F-11.✍ A super-ball is to bounce elastically back and forth between two rigid walls at a distance d from each other. Neglecting gravity and assuming the velocity of super-ball to be v_0 horizontally, the average force being exerted by the super-ball on one wall is :

(1) $\frac{1}{2}\frac{mv_0^2}{d}$ (2) $\frac{mv_0^2}{d}$ (3) $\frac{2mv_0^2}{d}$ (4) $\frac{4mv_0^2}{d}$

F-12.✍ In the figure shown the block A collides head on with another block B at rest. Mass of B is twice the mass of A. The block A stops after collision. The co-efficient of restitution is :



(1) 0.5 (2) 1 (3) 0.25 (4) it is not possible

F-13.✍ A sphere of mass m moving with a constant velocity hits another stationary sphere of the same mass. If e is the coefficient of restitution, then ratio of speed of the first sphere to the speed of the second sphere after collision will be :

(1) $\left(\frac{1-e}{1+e}\right)$ (2) $\left(\frac{1+e}{1-e}\right)$ (3) $\left(\frac{e+1}{e-1}\right)$ (4) $\left(\frac{e-1}{e+1}\right)$

Section (G) : Variable mass

G-1. If the force on a rocket which is ejecting gases with a relative velocity of 300 m/s, is 210 N. Then the rate of combustion of the fuel will be :
(1) 10.7 kg/sec (2) 0.07 kg/sec (3) 1.4 kg/sec (4) 0.7 kg/sec

Exercise-2

✍ **Marked Questions can be used as Revision Questions.**

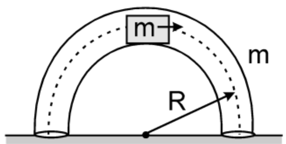
PART - I : OBJECTIVE QUESTIONS

1. All the particles of a body are situated at a distance R from the origin. The distance of the centre of mass of the body from the origin is
(1) = R (2) ≤ R (3) > R (4) ≥ R

2. A uniform thin rod of mass M and Length L is standing vertically along the y-axis on a smooth horizontal surface, with its lower end at the origin (0,0). A slight disturbance at t = 0 causes the lower end to slip on the smooth surface along the positive x-axis, and the rod starts falling. The acceleration vector of centre of mass of the rod during its fall is :
[$\vec{R}$ is reaction from surface]
(1) $\vec{a}_{CM} = \frac{M\vec{g} + \vec{R}}{M}$ (2) $\vec{a}_{CM} = \frac{M\vec{g} - \vec{R}}{M}$ (3) $\vec{a}_{CM} = M\vec{g} - \vec{R}$ (4) None of these

3.✍ A skater of mass m standing on ice throws a stone of mass M with a velocity of v in a horizontal direction. The distance over which the skater will move back (the coefficient of friction between the skater and the ice is μ) :
(1) $\frac{M^2v^2}{2m\mu g}$ (2) $\frac{Mv^2}{2m^2\mu g}$ (3) $\frac{M^2v^2}{2m^2\mu g}$ (4) $\frac{M^2v^2}{2m^2\mu^2 g}$

4.✍ In a vertical plane inside a smooth hollow thin tube a block of same mass as that of tube is released as shown in figure. When it is slightly disturbed it moves towards right. By the time the block reaches the right end of the tube then the displacement of the tube will be (where 'R' is mean radius of tube). Assume that the tube remains in vertical plane.



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

5.✍ A stationary body explodes into two fragments of masses m_1 and m_2. If momentum of one fragment is p, the minimum energy of explosion is
(1) $\frac{p^2}{2(m_1+m_2)}$ (2) $\frac{p^2}{2\sqrt{m_1m_2}}$ (3) $\frac{p^2(m_1+m_2)}{2m_1m_2}$ (4) $\frac{p^2}{2(m_1-m_2)}$

6. A train of mass M is moving on a circular track of radius ' R ' with constant speed V. The length of the train is half of the perimeter of the track. The linear momentum of the train will be
(1) 0 (2) $\frac{2MV}{\pi}$ (3) MVR (4) MV

7. Two particles approach each other with different velocities. After collision, one of the particles has a momentum $\vec{p}$ in their center of mass frame. In the same frame, the momentum of the other particle is
(1) 0 (2) $-\vec{p}$ (3) $-\vec{p}/2$ (4) $-2\vec{p}$

8. A particle of mass 'm' and velocity '$\vec{v}$' collides oblique elastically with a stationary particle of mass 'm'. The angle between the velocity vectors of the two particles after the collision is :
(1) 45° (2) 30° (3) 90° (4) None of these

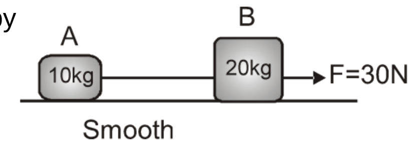
9. Two homogenous spheres A and B of masses m and 2m having radii 2a and a respectively are placed in touch. The distance of centre of mass from first sphere is :
(1) a (2) 2a (3) 3a (4) none of these

10. A non–uniform thin rod of length L is placed along x-axis as such its one of ends at the origin. The linear mass density of rod is $\lambda = \lambda_0 x$. The distance of centre of mass of rod from the origin is :
(1) L/2 (2) 2L/3 (3) L/4 (4) L/5

11. A ball kept in a closed box moves in the box making collisions with the walls. The box is kept on a smooth surface. The centre of mass :
(1) of the box remains constant
(2) of the box plus the ball system remains constant
(3) of the ball remains constant
(4) of the ball relative to the box remains constant

12. A man of mass M stands at one end of a plank of length L which lies at rest on a frictionless surface. The man walks to the other end of the plank. If the mass of plank is M/3, the distance that the plank moves relative to the ground is :
(1) 3L/4 (2) L/4 (3) 4L/5 (4) L/3

13. Two blocks A and B are connected by a massless string (shown in figure) A force of 30 N is applied on block B. The distance travelled by centre of mass in 2s starting from rest is :



(1) 1m
(2) 2m
(3) 3m
(4) none of these

14. The motion of the centre of mass of a system of two particles is unaffected by their internal forces :
(1) irrespective of the actual directions of the internal forces
(2) only if they are along the line joining the particles
(3) only if they are at right angles to the line joining the particles
(4) only if they are obliquely inclined to the line joining the particles.

15. Two bodies of masses m and 4m are moving with equal linear momentum. The ratio of their kinetic energies is :
(1) 1 : 4 (2) 4 : 1 (3) 1 : 1 (4) 1 : 2

16. If the momentum of a body increases by 20%, the percentage increase in its kinetic energy is equal to :
(1) 44 (2) 88 (3) 66 (4) 20

17. Two observers are situated in different inertial reference frames. Then :
(1) the momentum of a body by both observers may be same
(2) the momentum of a body measured by both observers must be same
(3) the kinetic energy measured by both observes must be same
(4) none of the above

18. A man is sitting in a moving train, then :
(1) his momentum must not be zero
(2) his kinetic energy is zero
(3) his kinetic energy is not zero
(4) his kinetic energy may be zero

19. A bomb dropped from an aeroplane explodes in air. Its total :
(1) momentum decreases
(2) momentum increases
(3) kinetic energy increases
(4) kinetic energy decreases

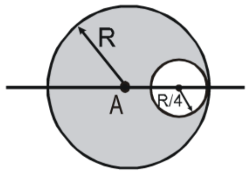
20. Two blocks of masses m_1 and m_2 are connected by a massless spring and placed on smooth surface. The spring initially stretched and released. Then :

(1) the momentum of each particle remains constant separately
(2) the momentums of each body are equal
(3) the magnitude of momentums of each body are equal to each other
(4) the mechanical energy of system remains constant
(5) both (3) and (4) are correct

21. A shell is fired from a cannon with a velocity v at an angle θ with the horizontal direction. At the highest point in its path, it explodes into two equal pieces, one retraces its path to the cannon and the speed of the other piece immediately after the explosion is :

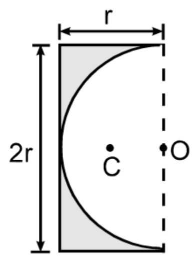
(1) $3\upsilon \cos\theta$ (2) $2\upsilon \cos\theta$ (3) $\left(\frac{3}{2}\right) \upsilon \cos\theta$ (4) $\frac{\sqrt{3}}{2} \upsilon \cos\theta$

22. The centre of mass of the shaded portion of the disc is : (The mass is uniformly distributed in the shaded portion) :



(1) $\frac{R}{20}$ to the left of A (2) $\frac{R}{12}$ to the left of A
(3) $\frac{R}{20}$ to the right of A (4) $\frac{R}{12}$ to the right of A

23. A semicircular portion of radius ‘r’ is cut from a uniform rectangular plate as shown in figure. The distance of centre of mass 'C' of remaining plate, from point ‘O’ is :



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

24. In an elastic collision in absence of external force, which of the following is/are correct :
(1) The linear momentum is not conserved
(2) The potential energy is conserved in collision
(3) The final kinetic energy is less than the initial kinetic energy
(4) The final kinetic energy is equal to the initial kinetic energy

25. A bag of mass M hangs by a long thread and a bullet (mass m) comes horizontally with velocity v and gets caught in the bag. Then for the combined system (bag + bullet) :
(1) Momentum is $mMv/(M + m)$ (2) KE is $(1/2)\ Mv^2$
(3) Momentum is mv (4) KE is $m^2v^2/(M + m)$

26. A shell explodes in a region of negligible gravitational field, giving out n fragments of equal mass m. Then its total
(1) Kinetic energy is smaller than that before the explosion
(2) Kinetic energy is equal to the before the explosion
(3) Momentum and kinetic energy depend on n
(4) Momentum is equal to that before the explosion.

PART - II : MISCELLANEOUS QUESTIONS

Section (A) : Assertion/Reasoning

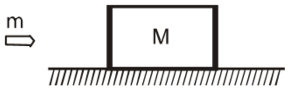
A-1. **STATEMENT-1 :** A sphere of mass m moving with speed u undergoes a perfectly elastic head on collision with another sphere of heavier mass M at rest (M > m), then direction of velocity of sphere of mass m is reversed due to collision [no external force acts on system of two spheres]
STATEMENT-2 : During a collision of spheres of unequal masses, the heavier mass exerts more force on lighter mass in comparison to the force which lighter mass exerts on heavier mass.
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

A-2. **STATEMENT-1 :** In a perfectly inelastic collision between two spheres, velocity of both spheres just after the collision are not always equal.
STATEMENT-2 : For two spheres undergoing collision, component of velocities of both spheres along line of impact just after the collision will be equal if the collision is perfectly inelastic. The component of velocity of each sphere perpendicular to line of impact remains unchanged due to the impact.
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

A-3. **Statement 1 :** If the mass of the colliding particles remains constant, then the linear velocity of the individual particles change during collision along common normal direction.
Statement 2 : A pair of equal and opposite impulses act along common normal direction.
(1) Both statements 1 and 2 are true and statement 2 is the correct explanation of statement 1.
(2) Both statements 1 and 2 are true but statement 2 is not correct explanation of statement 1.
(3) Statement 1 is true but statement 2 is false
(4) Both statements 1 and 2 are false.

Section (B) : Match the Column

B-1. A bullet fired with speed u sticks to the block after penetrating some distance 'X' inside the block after that both move together with same velocity, if average force of resistance on bullet by block was P, 'S' is distance moved by bullet during time of collision. 'y' is distance moved by block in duration of collision.



	Column-I		Column-II
(1)	maximum possible heat generated in collision	(p)	$\left(\frac{M^2+2Mm}{2P}\right)u^2m$
(2)	Distance 'S' is equal to	(q)	$\frac{1}{2}\left(\frac{mM}{m+M}\right)u^2$
(3)	Work done by bullet on block	(r)	Py
(4)	Distance 'y' moved by block in duration of collision	(s)	$\frac{1}{2}\frac{m^2u^2}{(M+m)^2}\frac{M}{P}$

Section (C) : One or More Than One Options Correct

C-1. A system of particles has its centre of mass at the origin. The x-coordinates of all the particles
(1) may be positive
(2) may be negative
(3) may be non-negative
(4) may be non-positive

C-2. In which of the following cases the centre of mass of a system is certainly not at its centre ?
(1) A rod whose density continuously increases from left to right
(2) A rod whose density continuously decreases from left to right
(3) A rod whose density decreases from left to right upto the centre and then increases
(4) A rod whose density increases from left to right upto the centre and then decreases

C-3. ✍ If the net external force acting on a system is zero, then the centre of mass
(1) must not move (2) must not accelerate (3) may move (4) may accelerate

C-4. In an elastic collision in absence of external force, which of the following is/are correct :
(1) The linear momentum is conserved
(2) The potential energy is conserved in collision
(3) The final kinetic energy is less than the initial kinetic energy
(4) The final kinetic energy is equal to the initial kinetic energy

C-5. A block moving in air explodes in two parts then just after explosion (neglect change in momentum duet to gravity)
(1) The total momentum of two parts must be equal to the momentum of the block before explosion.
(2) The total kinetic energy of two parts must be equal as that of block before explosion.
(3) The total momentum must change
(4) The total kinetic energy must increase

Exercise-3

✍ **Marked Questions can be used as Revision Questions.**

PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

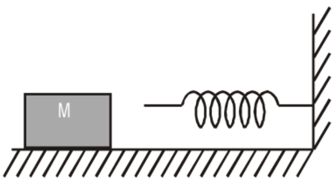
1. Two identical particles move towards each other with velocity 2v and v respectively. This velocity of centre of mass is – **[AIEEE 2002,4/300]**
(1) v (2) v/3 (3) v/2 (4) zero

2. Consider the following two statements : **[AIEEE 2003,4/300]**
A. Linear momentum of a system of particles is zero
B. Kinetic energy of a system of particles is zero,
Then,
(1) A does not imply B and B does not imply A (2) A implies B but B does not imply A
(3) A does not imply B but B implies A (4) A implies B and B implies A

3. A rocket with a lift-off mass 3.5×10^4 kg is blasted upwards with an intial acceleration of 10 m/s^2. Then the initial thrust of the blast is : **[AIEEE 2003,4/300]**
(1) 3.5×10^5 N (2) 7.0×10^5 N (3) 14.0×10^5 N (4) 1.75×10^5 N

4. A body A of mass M while falling vertically downwards under gravity breaks into two parts; a body B of mass $\frac{1}{3}$M and, a body C of mass $\frac{2}{3}$M. The centre of mass of bodies B and C taken together shifts compared to that of body A towards : **[AIEEE 2005,4/300]**
(1) depends on height of breaking (2) does not shift
(3) shift towards body C (4) shift towards body B

5. The block of mass M moving on the frictionless horizontal surface collides with the spring of spring constant k and compresses it by length L. The maximum momentum of the block after collision is : **[AIEEE 2005,4/300]**



(1) $\sqrt{Mk}$ L (2) $\frac{kL^2}{2M}$
(3) zero (4) $\frac{ML^2}{k}$

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 : **[AIEEE 2005,4/300]**

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

7. A bomb of mass 16 kg at rest explodes into two pieces of masses of 4 kg and 12 kg. The velocity of the 12 kg mass is 4 ms^{-1} . The kinetic energy of the other mass is : **[AIEEE 2006, 1.5/180]**
(1) 96 J (2) 144 J (3) 288 J (4) 192 J

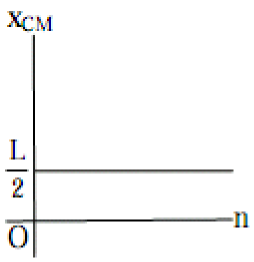
8. Consider a two particle system with particles having masses m_1 and m_2. If the first particle is pushed towards the centre of mass through a distance d, by what distance should the second particle be moved, so as to keep the centre of mass at the same position ? **[AIEEE 2006, 3/180]**

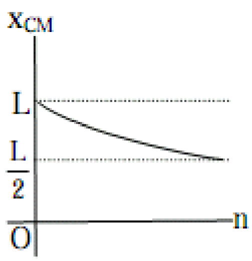
(1) d (2) $\frac{m_2}{m_1}d$ (3) $\frac{m_1}{m_1+m_2}d$ (4) $\frac{m_1}{m_2}d$

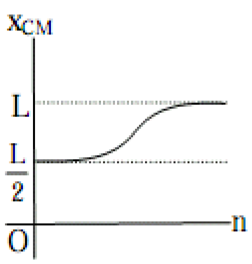
9. A circular disc of radius R is removed from a bigger circular disc of radius 2R such that the circumferences of the discs coincide. The centre of mass of the new disc is αR from the centre of the bigger disc. The value of α is : **[AIEEE 2007, 3/120]**
(1) 1/3 (2) 1/2 (3) 1/6 (4) 1/4

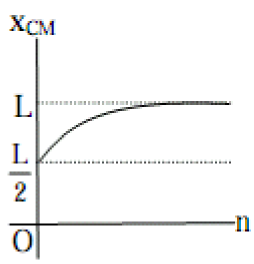
10. A block of mass 0.50 kg is moving with a speed of 2.00 ms^{-1} on a smooth surface. It strikes another mass of 1.00 kg and then they move together as a single body. The energy loss during the collision is : **[AIEEE 2008, 3/105]**
(1) 1.00 J (2) 0.67 J (3) 0.34 J (4) 0.16 J

11. A thin rod of length 'L' is lying along the x-axis with its ends at x = 0 and x = L. Its linear density (mass/length) varies with x as $k\left(\frac{x}{L}\right)^n$, where n can be zero or any positive number. If the position x_{CM} of the centre of mass of the rod is plotted against 'n', which of the following graphs best approximates the dependence of x_{CM} on n ? **[AIEEE 2008, 3/105]**

(1)


(2)


(3)


(4)


12. **STATEMENT-1 :** Two particles moving in the same direction do not lose all their energy in a completely inelastic collision.
STATEMENT-2 : Principle of conservation of momentum holds true for all kinds of collisions. **[AIEEE 2010, 4/144]**
(1) Statement-1 is true, Statement-2 is true; Statement-2 is the correct explanation of Statement-1.

(2) Statement-1 is true, Statement-2 is true; Statement-2 is not the correct explanation of Statement-1
(3) Statement-1 is false, Statement-2 is true.
(4) Statement-1 is true, Statement-2 is false.

13. 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.
Statement - I : A point particle of mass m moving with speed υ collides with stationary point particle of mass M. If the maximum energy loss possible is given as $f\left(\frac{1}{2}m\upsilon^2\right)$ 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. **[JEE (Main) 2013, 4/120]**
(1) Statement -I is true, Statment -II is true, Statement -II is the correct explanation of Statement -I.
(2) Statement -I is true, Statment - II is true, Statement - II is not the correct explanation of Statement - I.
(3) Statement -I is true, Statment - II is false.
(4) Statement -I is false, Statment - II is true.

14. A particle of mass m moving in the x direction with speed 2v is hit by another particle of mass 2m 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; 4/120, –1]**
(1) 44% (2) 50% (3) 56% (4) 62%

15. 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; 4/120, –1]**
(1) $\frac{h^2}{4R}$ (2) $\frac{3h}{4}$ (3) $\frac{5h}{8}$ (4) $\frac{3h^2}{8R}$

16. 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; 4/120,–1]**
(1) (0, 0) (2) (0, 1) (3) (.89, .28) (4) (.28, .89)

17. 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 $2cm^2$ 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; 4/120,–1]**
(1) 2.35×10^2 N/m^2 (2) 4.70×10^2 N/m^2
(3) 2.35×10^3 N/m^2 (4) 4.70×10^3 N/m^2

18. 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; 4/120,–1]**
(1) $\frac{v_0}{2}$ (2) $\frac{v_0}{\sqrt{2}}$
(3) $\frac{v_0}{4}$ (4) $\sqrt{2}v_0$

PART - II : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

*** Marked Questions may have more than one correct option.**

1. **STATEMENT-1**
In an elastic collision between two bodies, the relative speed of the bodies after collision is equal to the relative speed before the collision.

because
STATEMENT-2
In an elastic collision, the linear momentum of the system is conserved
(A) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True. **[JEE-2007, 3/162]**
(E) Statement-1 is False, Statement-2 is False

2. Two balls, having linear momenta $\vec{p}_1 = p\hat{i}$ and $\vec{p}_2 = -p\hat{i}$, undergo a collision in free space. There is no external force acting on the balls. Let $\vec{p'}_1$ and $\vec{p'}_2$ be their final momenta. Which of the following option(s) is(are) **NOT ALLOWED** for any non-zero value of p, a_1, a_2, b_1, b_2, c_1 and c_2.**[JEE-2008, 3/163]**

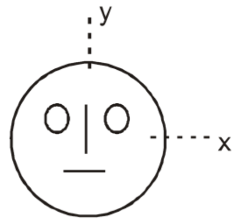
(A) $\vec{p'}_1 = a_1\hat{i} + b_1\hat{j} + c_1\hat{k}$
$\vec{p'}_2 = a_2\hat{i} + b_2\hat{j}$

(B) $\vec{p'}_1 = c_1\hat{k}$
$\vec{p'}_2 = c_2\hat{k}$

(C) $\vec{p'}_1 = a_1\hat{i} + b_1\hat{j} + c_1\hat{k}$
$\vec{p'}_2 = a_2\hat{i} + b_2\hat{j} - c_1\hat{k}$

(D) $\vec{p'}_1 = a_1\hat{i} + b_1\hat{j}$
$\vec{p'}_2 = a_2\hat{i} + b_1\hat{j}$

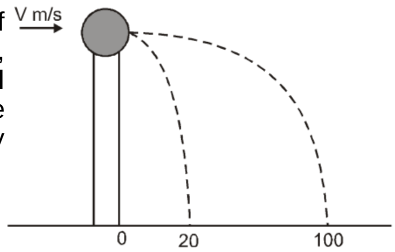
3.✍ Look at the drawing given in the figure which has been drawn with ink of uniform line-thickness. The mass of ink used to draw each of the two inner circles, and each of the two line segments is m. The mass of the ink used to draw the outer circle is 6m. The coordinates of the centres of the different parts are: outer circle (0, 0), left inner circle (–a, a), right inner circle (a, a), vertical line (0, 0) and horizontal line (0, –a). The y-coordinate of the centre of mass of the ink in this drawing is **[JEE-2009, 3/160, –1]**



(A) $\frac{a}{10}$ (B) $\frac{a}{8}$ (C) $\frac{a}{12}$ (D) $\frac{a}{3}$

4*.✍ A point mass of 1kg collides elastically with a stationary point mass of 5 kg. After their collision, the 1 kg mass reverses its direction and moves with a speed of 2 ms^{-1}. Which of the following statement(s) is/are correct for the system of these two masses ? **[JEE-2010, 3/163]**
(A) Total momentum of the system is 3 kg ms^{-1}
(B) Momentum of 5 kg mass after collision is 4 kg ms^{-1}
(C) Kinetic energy of the centre of mass is 0.75 J
(D) Total kinetic energy of the system is 4 J

5.✍ A ball of mass 0.2 kg rests on a vertical post of height 5 m. A bullet of mass 0.01 kg, traveling with a velocity V m/s in a horizontal direction, hits the centre of the ball. After the collision, the ball and bullet travel independently. The ball hits the ground at a distance of 20 m and the bullet at a distance of 100 m from the foot of the post. The initial velocity V of the bullet is **[JEE-2011, 3/160. –1]**

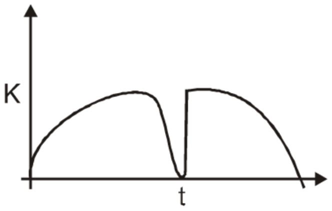


(A) 250 m/s (B) 250 $\sqrt{2}$ m/s
(C) 400 m/s (D) 500 m/s

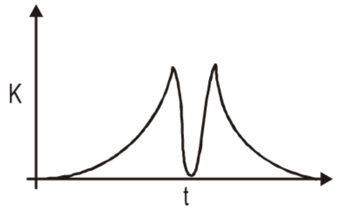
6.✍ A particle of mass m is projected from the ground with an initial speed u_0 at an angle α with the horizontal. At the highest point of its trajectory, it makes a completely inelastic collision with another identical particle, which was thrown vertically upward from the ground with the same initial speed u_0. The angle that the composite system makes with the horizontal immediately after the collision is :
[JEE -2013, 3/60, –1]

(A) $\frac{\pi}{4}$ (B) $\frac{\pi}{4} + a$ (C) $\frac{\pi}{4} - a$ (D) $\frac{\pi}{4}$

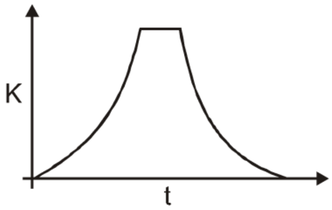
7.✍ A tennis ball is dropped on a horizontal smooth surface. It bounces back to its original position after hitting the surface. The force on the ball during the collision is proportional to the length of compression of the ball. Which one of the following sketches describes the variation of its kinetic energy K with time t most appropriately ? The figures are only illustrative and not to the scale.
[JEE (Advanced)-2014, 3/60, –1]



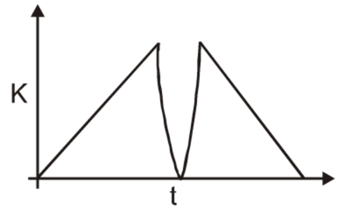
(A)



(B)



(C)



(D)

Answers

EXERCISE-1

Section (A)

A-1.	(4)	**A-2.**	(4)	**A-3.**	(4)

Section (B)

B-1.	(4)	**B-2.**	(4)	**B-3.**	(2)
B-4.	(3)	**B-5.**	(4)	**B-6.**	(1)
B-7.	(3)				

Section (C)

C-1.	(2)	**C-2.**	(2)	**C-3.**	(1)

Section (D)

D-1.	(1)	**D-2.**	(3)

Section (E)

E-1.	(2)	**E-2.**	(1)	**E-3.**	(3)
E-4.	(3)				

Section (F)

F-1.	(1)	**F-2.**	(4)	**F-3.**	(4)
F-4.	(2)	**F-5.**	(2)	**F-6.**	(1)
F-7.	(1)	**F-8.**	(2)	**F-9.**	(1)
F-10.	(1)	**F-11.**	(2)	**F-12.**	(1)
F-13.	(1)				

Section (G)

G-1.	(4)

EXERCISE-2

PART– I

1.	(2)	**2.**	(1)	**3.**	(3)
4.	(3)	**5.**	(3)	**6.**	(2)
7.	(2)	**8.**	(3)	**9.**	(2)
10.	(2)	**11.**	(2)	**12.**	(1)
13.	(2)	**14.**	(1)	**15.**	(2)
16.	(1)	**17.**	(1)	**18.**	(4)
19.	(3)	**20.**	(5)	**21.**	(1)
22.	(1)	**23.**	(4)	**24.**	(4)
25.	(3)	**26.**	(4)		

PART – II

Section (A)

A-1.	(3)	**A-2.**	(1)	**A-3.**	(1)

Section (B)

B-1. $(1 \rightarrow q)$; $(2 \rightarrow p)$; $(3 \rightarrow r)$; $(4 \rightarrow s)$

Section (C)

C-1.	(3,4)	**C-2.**	(1,2)	**C-3.**	(2,3)
C-4.	(1,4)	**C-5.**	(1,4)		

EXERCISE-3

PART - I

1.	(3)	**2.**	(3)	**3.**	(2)
4.	(2)	**5.**	(1)	**6.**	(3)
7.	(3)	**8.**	(4)	**9.**	(1)
10.	(2)	**11.**	(4)	**12.**	(1)
13.	(4)	**14.**	(3)	**15.**	(2)
16.	(3)	**17.**	(3)	**18.**	(4)

PART–II

1.	(D)	**2.**	(A)	**3.**	(A)
4.	(A,C)	**5.**	(D)	**6.**	(A)
7.	(B)				