THE GURUKUL INSTITUTE
PLOT 5C, 2ND FLOOR, COMPLEX, SEC-13, OPP. JAIPURIA SCHOOL,
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Conservation Of Momentum

Centre of Mass

1.Particee of masses 2 kg, 2 kg, 1 kg and 1 kg are placed at the corners A,B,C,D, of a square of side L as shown in the figure. Find the centre of mass of the system.

2. (i) Must there necessarily be any mass at the center of mass of a system?
(ii) Can a high jumper clear a height even if his center of mass dose not clear the height?

3. Find the center of mass of a uniform semi-circular ring of radius R and mass M.

4.If the linear mass density of a rod of length L varies as $\lambda = A + Bx$(where A and B are constants), then find the coordinates of center mass.

5. Find the centre of mass of a thin uniform hemispherical shell.

6. A thin homogeneous of the lamina is in the from of a circular disc of radius R. From it a circular hole exactly half the radius of the lamina and touching the lamina's circumference is cut off. Find the center of mass of the remaining part.

7. Find the center of mass of the section. Consider the mass of the lamina to be uniformly distributed.

8. A dog of mass 10 kg is standing on a flat 10 m long boat so that it is 20 meters from the shore. It walks 8 m on the boat towards the shore and then stops. The mass of the boat is 40 kg and friction between the boat the water surface is negligible. How far is the dog from the shore now?

9.Can a sailboat be propelled by air blown at the sails from a fan attached to the boat?

10. A dog of mass 10 kg chases a rabbit running with a speed of 7 kg/hr and mass 2 kg with a sped of 13 kg/hr along a straight line. Find the speed of the center of mass of the dog rabbit system.

Conservation of Linear Momentum Of the System of Particle

11. A man of mass m is standing on a stationary wooden board of mass M kept on smooth ice. The man starts running on the board and acquires a speed u relative to the board. Find the speed of the man relative to a stationary observer. The board is long enough.

12. A gun is mounted on a stationary rail road car. The mass of the car, the gun, the shells and the operator is 50m, where m is the mass of one shell are fired one after the other along same horizontal line in same direction. If the muzzle velocity (velocity with respect to gun) of the shells is 200 m/s, then find the speed of the car after second shot.

13. An explosion blows a rock in to three parts. Two pieces of mass 1 kg and 2 kg go off at right angle to each other. 1 kg piece with a velocity of 12 m/sc and 2 kg piece with a velocity of 8 m/sec. The third piece flies off with a velocity 40 m/sec. Compute the mass of third part of rock.

14. (i) You are marooned on a big frictionless surface with your school bag in you hand. How will you get out of it?
(ii) When a ball is thrown up, the magnitude of its momentum first decreases, then increases. Dose this violate conservation of momentum principle?

15. Two men, each of mass m, stand on the edge of a stationary car and jump off with a horizontal velocity u relative to the car, first simultaneously and then one after the other. If friction be negligible, in which case will they impart greater speed to the car?

IMPULE

16. A 2 kg ball drops on floor from a height of 20 m and rebound with 20% of the initial speed. Find the impulse received by the ball.

17. An inextensible string is passing over a light frictionless pulley. One end of the string is connected to a block of mass k4m which is resting on a horizontal surface. To another end a p;ate of mass m is attached and is handing in the air. A particle of mass m strikes from above with velocity vo and sticks to the plate. Calculate maximum height attained by block of mass 4m.

18.A heavy book is suspended with a length of thread. Another piece of same thread is tied lower end of the book as shown in the figure.

(a) The lower thread is pulled gradually, harder and harder in download direction, so as to apply force on the upper thread. Which of the threads will break? Explain.

(b) In case the threads is pulled with a sharp jerk, will the same thread break as in case (a).Explain.

Newton's Experimental Low

1(i) Is it possible to have a collision in which all the kinetic energy is lost? If so, cite an example.

(ii) Two objects collide and one is initially at rest. (a) Is it possible for both of them to be at rest collision? (b) Is it possible for one of them to be at rest after collision? Explain.

2.A disc of mass m is moving with constant speed vo on a smooth horizontal table. Another disc of mass M is placed on the table at rest as shown in the figure. If the collision is elastic, find the velocity of the discs after collision. Both discs lie on the same horizontal plane o the table.

3. A ball of mass m moving with velocity v strikes head on elastically with number of balls of the same mass in a line. Only one ball from other side moves with the same velocity. Explain why not balls move simultaneously each with velocity v/2.

4.A ball moving with a speed of 9 m/s strikes an identical stationary ball such that after the collision. The direction of ach ball m makes angle of 30^{o} with the original line of motion. Find the speed of the two balls after the collision. Is kinetic energy conserved in this collision process?

5. A ball of mass m, experiences a perfectly elastic collision with stationary ball of mass m_2. What fraction of the K.M dose the striking ball lose, if

(a) it recoils at right angle to the original direction of motion, and

(b) the collision is head -on one.

6. Two particles A and B with different but unknown masses, A is initially at rest while B has speed v. After collision, B has a speed v/2 and moves ay right angles to its original direction of motion. Find the direction in which A moves after collision. Can you determine the sped of A from the information give? Explain.

PROBLEMS

1.Two blocks of masses m_1 and m_2 connected by a light spring of stiffness k, rest on a smooth horizontal plane, such that the block m_1 touches a vertical wall shown in the figure. The block m_2 is shifted by a small distance x towards the wall and then released. Find the velocity of the centre of mass of the system after block m_1 breaks off the wall.

2. A bullet of mass ma moving with a horizontal u strikes a stationary block of mass M suspended by a string of length L. The bullet gets embedded in the block. What is the maximum angle made by the string after impact?

3. A particle of mass 4m which is at rest explodes into three fragments. Two of the fragment, each of mass m, are found to move with a speed v each in mutually perpendicular direction. Calculate.
(a) momentum of the fragment 2m after explosion.
(b) the energy released in the process of explosion.

4. Two bodies A and B of masses m and 2m, respectively, are placed on a smooth floor. "They are connected by a light spring of stiffness k. A third body C of mass m moves with velocity v_o along the line joining A and B and collides elastically with A. If ℓ_0 be the nature length of the spring. Than find the minimum separation between the block A and B.

5.A uniform chain of mass m and length ℓ hangs by a thread and just touches the surface of a table by its lower and. Find the force exerted by the chain on the surface when half of its length has fallen on the table.
Assume that the fallen part dose not bounce back and does not form a heap.

6. A small steel ball is suspended by a light inextensible string of length form a fixed point O. When the ball is in equilibrium, it just touches a vertical wall as shown in the figure. The ball is first taken away from the wall perpendicularly , such that the string becomes horizontal and then released from rest .If co-efficient of restitution is a e, then find the maximum deflection of the sting after n^{th} collision

7. 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 cause the lower end to slip on the smooth surface along the positive x- axis, and the rod starts falling.
(a) What is the path followed by the centre of mass of the rod during its fall.
(b) Find the equation of trajectory of a point on the rod located at a distance from the lower end. What is the shape of the path of this point?

8. A wedge of mass M rests on a horizontal surface. The inclination of the wedge is α. A ball of mass m moving horizontally with speed u hits the inclined face of the wedge inelastically and after hitting slides up the inclined face of the wedge. Find the velocity of the wedge just after collision.[Neglect any friction.]

9. Two identical buggies move one after the other due to inertia (without friction) with the same velocity v_0 .A man of mass m rides the rear buggy. At a certain moment, the man jumps into the front buggy with a velocity u_0 relative to his buggy. Knowing that the mass of each buggy is equal to M, find the velocity with which thee buggies will move after that.

10. A cart is moving along '+x' direction with a velocity of 4 m/s. A person on the cart throws a stone with a velocity of 6 m,/s relative to himself. In the frame of reference of the cart, the stone is throw in y-z plane making an angle an angle of 30^o with vertical z-axis. At the highest point of its trajectory , the stone hits an object of equal mass hung vertically from the branch of tree by means of a string of length L. A completely inelastic collision occurs, in which the stone gets embedded in object. Determine.

(a) the speed of the combined mass immediately after the collision with respect to an observer on the ground,
(b) the length L of the string such that the tension in the string becomes zero when the string becomes horizontal the subsequent motion of the combined mass.

OBJECTIVE

1. A bullet of mass m leaves a gun of mass M kept on a smooth horizontal surface. If the speed of the bullet relative to the gun is v, the recoil speed of the gun will be.

(A) $\frac{m\,v}{M}$ (B) $\frac{mv}{M+m}$ (C) $\frac{Mv}{M+m}$ (D) $\frac{Mv}{m}$

2.Shown in the figure is a system of three particles having masses m_1=1 kg, m_2=2 kg and m_3=4 kg, respectively, connected by two springs. The accelerations of A , B and C at any instant are 1 m/sec^2, 2 m/sec^{-2} and (1/2) m/sec^2, respectively, directed as shown in the figure. The external force acting on the system is

(A) 1N rightward (B) 3N leftward (C) 3N rightward (D) zero

3. A particle of mass m collides with another stationary particle of mass M. If the particle m stops just after the collision, the coefficient of restitution of collision is equal to:

(A) 1 (B)m/M (C) $\frac{M-m}{M+m}$ (D) $\frac{m}{M+m}$

4. A ping –pong ball of mass is floating in air by a jet of water emerging out of a nozzle. If the water strikes the ping-pong ball with a speed v and just after collision water falls dead, the rate of mass flow of water in the nozzle is equal to:

(A) $\frac{2mg}{V}$ (B) $\frac{mv}{g}$ (C) $\frac{mg}{v}$ (D) None of these

5. A block m_1 strikes a stationary block m_3 perfectly inelastically in a head on collision. Another block m_2 is kept on m_3. Neglecting the friction between all contacting surfaces, the fractional decrease of K.M. of the system in collision is:

A) $\frac{m_1}{m_1+m_2+m_3}$ (B) $\frac{m_1}{m_2+m_3}$ (C) $\frac{m_3}{m_1+m_3}$ (D) $\frac{m_2+m_3}{m_1+m_2+m_3}$

6. Two block of masses m_1 and m_2 interconnected with a spring of stiffness K are kept on a smooth horizontal surface. Which of the following ration is/are correct, when the spring is extended and released?

(A)$F_1/F_2 = 1$ & $X_1/X_2 = 1$ (B) $v_1/v_2 = m_2/m_1$ & $K.E_1/K.E_2 = m_2/m_1$
(C)$P_1/P_2 = 1$ & $K.E_1/K.E_2 = m_1/m_2$ (D) $X_1/X_2 = m_2/m_1$ & $a_1/a_2 = m_2/m_1$

[where X= magnitude of displacement, v = speed , P= momentum, a=magnitude of acceleration, all relative to the surface, K.E. = kinetic energy , F= magnitude of force.]

7. A bomb of mass p kg explodes into two fragment of masses 3 kg and 6 kg . The velocity of mass 3 kg is 16 m/sec. the energy of explosion in mechanical from is equal to:

(A) 384 J (B) 576 J (C) 192 J (D) 1152 J

8. A dumbell consisting of two masses of mass nm each, connected by a light rigid rod of length ℓ , falls on two pads of equal height (one steel and other brass) through a height h. the co-efficients of

restitution are e_1 and e_2 ($e_1 < e_2$) To what maximum height will the centre of mass of the dumbell rise after bouncing off the pads?

(A) $\frac{h}{e_1 + e_2}$ (B) $\frac{h}{(e_1+e_2)^2\, 4}$ (C) $\frac{(e^2_1 + e^2_2)\, h}{4}$ (D) $\frac{4h}{e^2_1 + e^2_2}$

9. A ball strikes a well with a velocity u at an angle θ with the normal to the wall surface and rebounds from it at an angle β with the surface. Then:

(A) $(\theta + \beta) > 90^o$, if the wall is smooth

(B) if the wall is smooth, coefficient of restitution = $\tan\frac{\beta}{\cot\theta}$

(C) if wall is smooth, coefficient of restitution< $\tan\frac{\beta}{\text{Cot}\,\theta}$

(D) none of the above

10. Two balls are dropped from same height h, one on a smooth plane and the order on a rough plane both having same inclination θ with horizontal as show in figure. Both plans have same coefficient of the restitution . If range and time of flight of first and second balls are R_1, T_1 and R_2, T_2, respectively , then:

(A) $T_1=T_2$, $R_1=R_2$ B) $T_1<T_2$, $R_1>R_2$

(C) $T_1=T_2$, $R_1>R_2$ D) $T_1>T_2$, $R_1>R_2$

11. Two identical balls marked 2 and 3, in contact with each other and at rest on a horizontal frictionless table, are hit head-on and elastically by another identical ball marked 1 moving initially with a speed v as shown in the adjacent figure. What is observed, if the collision is elastic?

(A) Ball 1 come to rest and ball 2 and 3 move with speed (v/2) each.

(B) Ball 1 and 2 come to rest and ball 3 move with sped v.

(C) Ball 1,2 and 3 come with speed(v/3) each.

(D) Balls 1,2 and 3 come to rest.

12. The ball marked 1 and 2 of the same mass m and third ball marked 3 of mass M are arranged over a smooth horizontal surface as show in adjacent figure. Ball 1 move with a velocity v_1 towards stationary ball 2 and 3. All collision are assumed to be elastic. If M >m, the number of collision between the balls with be

(A) one (B) two (C)three (D) four

13. A ball of mass m moving horizontally at a speed v collides with the bob of a long simple pendulum at rest. The mass of the bob is also m. If the collision is perfectly inelastic, the height to which the two balls rise after the collision will be give by

a) v^2/g b) $v^2/2g$ c) $v^2/4g$ d)$v^2/8g$

14. A ball is dropped from a height of 10 m. It is embedded 1 m in sand and stop. In this process, If we consider the ball and t hath as our system,

(A) only momentum is conserved

(B) only kinetic energy is conserved

(C) both momentum and kinetic energy are conserved

(D) neither momentum nor kinetic energy is conserved

15. A rubber ball is dropped from a height of 5 m on a planet where the acceleration du to gravity is not know. On bouncing, it rises to 1.8 m. Ratio of velocity of the ball just aft and before the collision.

(A)16/25 (B) 2/5 (C) 3/5 (D) 9/2

ASSIGNMENTS
SECTION-I
PART-A
LEVEL-1

1.There is a U- shaped uniform wire with sides 2ℓ, ℓ and ℓ.The x and y Coordinate system is shown in figure. Calculate the x and y coordinates of the center of mass of the wire.

2. A uniform steel rod of 1 m in length is a 90^{o} angle at its mid point. Determine the position of its center of mass form the corner at bent.

3. A non- uniform thin rod of length ℓ lies along the x-axis with one end at the origin. It has a linear mass density λ kg/m, give by $\lambda = \lambda_0 (1+x/\ell)$. Find the center of mass of the rod.

4. Two bodies of masses m_1 and m_2(, m_1) are connected to the ends of a massless cord and allowed to move as shown. The pulley is massless and frictionless. Determine the acceleration of the center of the center of mass.

5. A 1000 kg automobile is moving along a straight highway at 10 m/s. Another car with mass 2000 kg is moving at speed 20 m/s at a distance of 30 m ahead of the first car.

A) Find the total momentum from the above data

B) Find the velocity of the centre of mass.

C) Find the total momentum, using the velocity of the centre of mass. Compare your result with that of part (a).

6. Two balls of mass m each moving in opposite direction with equal speed v collide head on and elestically with each other. Find the final speeds of the ball s after collision.

7. A 10 gm bullet is shot from a 5 kg gon with a speed of 4400 ms^{-1}. What is the speed of recoil of the gun?

8. A body of mass m is moving with speed v makes an elastic one dimensional collision with a stationary body of same mass. They contact for very small time interval Δt. The contact force between them varies as shown in graph. Find the magnitude of F_{max}.

9. A shell of mass 5 kg moving with a speed of 20 m./s explodes into two particles into two particles of 3 kg and 2 kg. If the 3 kg particle just comes to rest after the explosion, find the speed of the 2 kg particle.

10. A ball is dropped from a height 100m on the ground. If the coefficient of restitution is j0.2, with is the height to which the ball will go up after it rebounds for the second time.

LEVEL-II

1. A disc of radius R is placed on a square plate of edge 4R made up of the same sheet with their plans parallel such that any two adjacent sides of square touch the disc. Find the distance if the centre of mass of the system from the centre of square plate.

2. From the base of a hemisphere, a right come of height R/2 and same bas has been scooped out. Find the C.M. of the remaining part.

3. An acrobat of mass m cling to a rope ladder hanging blow a balloon of mass M. The balloon is stationary with respect to ground.
(A) If the acrobat begins to climb the ladder at a speed v (with respect to the ladder), in what direction and with what speed (with respect to the Earth) will the balloon move?
(B) If the acrobat stop climbing, what will be the velocity of the balloon?

4. A pulley fixed to a rigid support caries a rope whose one end is tied to a ladder with a man and the other end to the counterweight of mass M. The man of mass m a climbs up a distance h with respect to the ladder and then stops. If the mass of the rope and the friction in the pulley axle are negligible, find the displacement of the centre of mass of this system.

5. A railroad car is moving along a straight frictionless track. In each of the following cases, the car initially has a total mass (car and contents) of 200 kg and is travelling with a velocity of 4 m/s.
Find the final velocity of the car in each of the three cases.

(a) A 290 kg mass is thrown sideways out of the car with a velocity of 2 m/s of the following cases, the car.
(b) A 20 kg mass is thrown backward out of the ca with a velocity of 4 m/s relative to the car.
(c) A 20 kg mass is thrown into the car with a velocity of 6 m/s relative to the ground and opposite in direction to the velocity of the car

6. A cubical block of mass m is released from rest at a height h on a frictionless surface of a movable of mass M, which is, in turn is placed on a horizontal frictionless surface as shown in the figure. Find the velocity of the triangular block when the smaller block reaches the bottom.

7. A projectile of mass ma is fried with a velocity v_o at an angle θ with the horizontal. At the highest position in its fight, it explodes into two fragments of masses $m_1 = m/3$ and $m_2 = 2m/3$.
The fragment of mass m_1 falls vertically with zero initial speed.
(a) Find the initial velocity of the fragment m.
(b) Find the distance d at which the fragment m_2 will land with respect to m_1.

8. Block A in the figure has a mass of 1 kg and block B has a mass of 2 kg. The blocks are forced together compressing a massless spring between them and the system is released from rest on a level frictionless surface. The spring is not fastened to either of the blocks, when spring regain is not fastened to either of the block, when spring regains its nature length, block B acquired a speed of 0.5 m/s . How much potential energy was stored in the compressed spring?

9. A particle of mass m moving with a speed u strikes a smooth horizontal surface at an angle α. The particle rebounds at angle β with a speed v. Determine the expression for v and β if the coefficient of restitution is e.

10. A bulled of mass 20 g travelling horizontally with a speed of 500 m/s passes through a wooden of mass 10.0 kg initially at a level surface. The bullet emerges with a speed of 100 m/s and the block slides 20 cm on the surface before coming to rest. Find the friction coefficient between the block and the surface in the figure.($g=10\ m/s^2$)

11. A spring of spring constant k connects two block of masses m_1 and m_2 as shown in the figure. The block of mass m_2 is given a sharp impulse so that it acquires a velocity v_o towards right . Find

(a) the velocity of the centre of mass; and
(b) the maximum elongation of the spring.

12. Two beads of masses m_1 and m_2 are threaded on a smooth circular wire of radius 'a' fixed in a vertical plane. B is stationary at the lowest point when A is gently dislodged from rest at the highest point. A collides with B at the lowest point. The impulse given to B due to collision is just great enough to carry it to the level of the centre of the circle while A is immediately brought to rest by the impact. Find m_1: m_2.

13. Three identical balls are connected by light inextensible string with each other as shown and rest over a smooth horizontal table. At the moment t=0, ball B is imparted a velocity. Calculate the velocity of A when it collides with ball C.

14. In the figure shown, a ball of mass m collides perpendicularly on a smooth stationary wedge of mass m_1 kept on a smooth horizontal plane. If the coefficient of restitution of collision is e, then determine the velocity of the wedge after collision.

15. A small particle travelling v collides elastically with a smooth spherical body of equal mass and of radius r initially kept at rest. The center of this spherical body is located a distance p(<r) away from the direction of motion of the particle. Find the final velocities of the two bodies.

PART-B

OBJECTIVE

(MULTI CHOICE SINGLE CORRECT)

1. The center of mass of a body:
   (A) always lies at the geometrical centre
   (B) always lies inside the body
   (C) always lies outside the body
   (D) lies within or outside the body

2. A bomb, travelling in a parabolic path under gravity, explodes in mid air. The center of mass of the fragments will:
   (A) move vertically upwards and then downwards
   B) move vertically downwards
   (C) move in an irregular path
   (D) move in the parabolic path as the unexploded bomb would have travelled

3. Consider a system of two identical particles. One of the particles is at rest and the other has acceleration 'a'. The center of mass has acceleration
   (A) zero (B) a/2 (C) a (D) 2a

4. An object comprises of a uniform ring of radius R and a uniform chord AB (not necessarily made of the same material) as shown. Which of the following cannot be the centre of mass of the object?
   (A) (R/3, R/3) (B) (R/ $\sqrt{2}$, R/$\sqrt{2}$) (C) (R/4, R/4)
   (D) none of the above

5. A non-uniform rod of length L is lying along positive x-axis with one end at origin. The rod has mass per unit length, which varies with x as $\lambda = \frac{Kx^2}{L}$, where K is a constant and x is the distance from one

end at origin. The x co-ordinates of center of center of mass is

(A) $\frac{3L}{4}$ (B) $\frac{L}{8}$ (C) $\frac{K}{L}$ (D) $\frac{3L}{L}$

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

(A) L(1-cos θ) (B) L/2 (1 – cosθ) (C) L/3 (1 – cosθ)
(D)L/6(1 – cosθ)

7. A rope passing over a pulley has a ladder with a man of mass m on one of its ends and a counterbalancing mass M on it other end.The man climb with a velocity v_r relative to ladder. Ignoring the masses of the pulley and the rope a well as the friction on the pulley axis, the velocity of the centre of mass of this system is:

(A) $\frac{m\,v_r}{M}$ (B) $\frac{m\,v_r}{2M}$ (C) $\frac{M\,v_r}{m}$ (D) $\frac{2M\,v_r}{m}$

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

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

9. A bullet in motion hits and gets embedded in a solid block resting on a frictional table. What is conserved for the bullet- block system?

(A) Momentum and KE
(B) Kinetic energy alone
(C) Neither KE nor momentum
(D) Momentum alone

10. A ball I thrown upward from the surface of earth. While the ball I moving up.

(A) the earth remain stationary while the ball move upwards
(B) the ball remains stationary while the earth moves downwards
(C) the ball and earth both move towards each other
(D) the ball and earth both move away from each other

11. A particle of mass 1 kg is projected at an angle of 30^O WITH HORIZONTAL WITH A VELOCITY V=40 M/S. The change in linear momentum of the particle after time t=1 s will be: (g= 10 $m/^2$)

(A) 7.5 kg-m/s (B) 15 kg-m/s (C) 10 kg-m/s (D) 20 kg-m/s

12. A particle of mass m is made to move with uniform speed v along the perimeter of regular polygon of 2n sides. The magnitude of impulse applied at each corner of the polygon is:

(A)$2mv \sin\frac{\pi}{2n}$ (B) $mv \sin\frac{\pi}{2n}$ (C) $2mv \cos\frac{\pi}{2n}$ (D) $mv \cos\frac{\pi}{2n}$

13. A force F=(2î + ĵ+3k) N acts on a particle of mass 1 kg for 2s. If initial velocity of particle is u=(2î+ĵ) m/s. Speed of particle at the end of 2 will be;

(A) 12 m/s (B) 6 m/s (C) 9 m/s (D) 4 m/s

14. A bullet is fired from a gun. The force on the bullet is give by F = 600 – (2×10^5)t. Here, F I in newton and t in second. The force on the bullet becomes zero as given by the equation a soon as it leave the barrel. The impulse imparted to the bullet is:

(A) 8 N-s (B) 0.9 N-s (C) 1.8 N-s (D) 2.4 N-s

15. A block of mass M = 2 kg with a semicircular track of radius R= 1.1 m rests on a horizontal frictionless surface. A uniform cylinder of radius r=10 cm and mass m=1.0 kg is released from rest from the top point A. The cylinder slips on the semicircular frictionless track. The speed of the block when the cylinder reaches the bottom of the track at B is: (g=10 m/s^2)

(A)$\sqrt{10}/\sqrt{3}\ m/s$ (B) $\sqrt{4}/\sqrt{3}\ m/s$ (C) $\sqrt{5}/\sqrt{2}\ m/s$ (D) $\sqrt{10}\ m/s$

16. A man of mass m moves with a constant speed on a plank of mass M and length L kept initially at rest on a frictionless horizontal surface, from one end to the other in time t. The speed of the plank relative to ground while man is moving is:

(A) $\frac{L}{t}\left(\frac{M}{m}\right)$ (B) $\frac{L}{t}\left(\frac{m}{M+m}\right)$ (C) $\frac{L}{t}\left(\frac{M}{M-m}\right)$ (D) none of these

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

(A) will be equal to ½ mv^2
(B) will always be less than ½ mv^2
(C) will be greater than or equal to ½ mv^2
(D) will always be greater than ½ mv^2

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

(A) 1/3 (B) ½ (C) 1/4 (D) 1/6

19. Two smooth object with a coefficient of restitution e, collides directly and bounce as shown just before impact

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(A) $e\times4u=v_{2+}v_1$
(B) $e\times2u=v_1-v_2$
(C) $e\times2u=v_2-v_1$
(D) it cannot be applied as the masses are not known

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

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

21. A ball of mass m approaches a wall of mass M (≪m) with speed of 4 m/s along the normal to the wall. The speed of wall 1 m/s toward the ball. The speed of the ball after an elastic collision with the wall be

(A) 5 m/ away from the wall

(B) 9 m/s away from the wall
(C) 3 m/s away from the wall
(D) 6 m/s away from the wall

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

(A) 5/8 (B) 3/8 (C) 3/4 (D) 1/4

23. Two particles A and B each of mass m are attached by a light inextensible string of length 2ℓ. The whole system line on a smooth horizontal table with B initially at a distance ℓ from A . The particle at end B is projected across the table with speed u perpendicular to AB. Velocity of ball A just after the string is taut, is :

(A) u√3/4 (B) u√3 (C)u√3/2 (D)u/2

24. A particle of mass m moving with a speed v hits elastically another stationary particle of mass 2m on a smooth horizontal circular tube of radius r. The time in which the next collision will take place is equal to:

(A) 2πr/v (B) 4πr/v (C)3πr/2v (D) πr/v

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

(A) 30 cm (B) 25 cm (C) 20 cm (D) 15 cm

MULTI CHOICE MULTI CORRECT

1. A cricket ball of mass 150 g is moving with a velocity of 12 m/s and hit by a bat so that turns back with a velocity of 20 m/s The force of blow acts for a time of 0.01s. Then,

(A) the change in momentum of ball is 4.8 kg m/s.
(B) the average force exerted by the bat on the ball is 480 N.
(C) change in momentum of the ball is 1.2 kg m/s
(D) the average force exerted by the bat on the ball is 120 N.

2. Two blocks A and B each of mass m are connected by a massless spring of natural length L and spring constant K. The blocks are initially resting on a smooth horizontal floor with the spring at its natural length, as shown in figure . A third identical block C, also of mass m , moves on the floor with a speed v along the line joining A and B , and collides with A elastically. Then

(A) The kinetic energy of the A-B system at maximum compression of the spring , is zero
(B) The kinetic energy of the A-B system , at maximum compression of the spring , is $mv^2/4$
(C) The maximum compression of the spring is v√(m/K)
(D) The maximum compression of the spring is v√(m/2K)

3. A ball A collides elastically with an another identically ball B with velocity 10 m/s at an angle of 30^0 from the line joining their centres C_1 and C_2. Select the correct alternative (s)

(A) Velocity of ball A after collision is 5 m/s.
(B) Velocity of ball B after collision is 5√3 m/s
(C) Both the balls move at right angles after collision.
(D) Kinetic energy will not be conserved here, because collision is not head on.

4. If the external forces acting on a system have zero resultant, the centre of mass

(A) must not move (B) must not accelerate

(C) may move (D) may accelerate

5. A net non-zero external force acts on a system of particles. At any instant t, the velocity and the acceleration of CM are found to be u_0 and a_0. It is possible that

(A) $u_0 = 0, a_0 = 0$ (B) $u_0 \neq 0, a_0 \neq 0$ (C) $u_0 \neq 0, a_{0=} 0$ (D) $u_0 = 0, a_0 \neq 0$

NUMERICAL , BASED TYPE

1. Three object A,B and C are kept in a straight line on a frictionless horizontal surface. These have masses m, 2m and m, respectively. The object A moves towards B with a speed 9 m/s and makes an elastic collision with it. Thereafter, B makes completely inelastic collision with C. All motion occur on the same straight line. Find the final speed(in m/s) of the object C.

2. 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 ball at an angle 30^0 with the line joining tow balls in horizontal direction as shown in the figure. Assuming that the starting remains taut after the impulse , the magnitude of impulse of tension is $k\sqrt{3}$ Ns. Find the value of K.

2

LINKED COMPREHENSION TYPE

Two persons, A of mass 80 kg and B of mass 50 kg are standing on a stationary horizontal platform of mass 20 kg. The platform is supported on wheels on a horizontal frictionless surface and is initially at rest. Consider the following situations.

(i) Both A and B jump from the platform simultaneously and in the same jumps in the same horizontal direction.

(ii) A jump first in horizontal direction and after a few seconds B also jumps in the same direction.

In all the two situations above, just after the jump, any person (A or B) move away from the platform with a speed 5 m/s relative to the platform and along the horizontal

1. In situation (i) just after both A and B jump from the platform, velocity of centre of mass of the system (A ,B and the platform) is

(A) 1.4 m/s (B) 3.2 m/s (C) 2.8 m/s (D) zero

2. Final speed of the platform in situation (i) ,I.e., just after both A and B have jumped will be nearly

(A) 4.3 m/s (B) 5.6 m/s (C) 1.8 m/s (D) 3.4 m/s

3. Final speed of the platform in situation (ii) ,i.e., just after B has jumped , will be nearly

(A) 3.7 m/s (B) 5.3 m/s (C) 1.8 m/s (D) 6.2 m/s

MATRIX- MATCH TYPE

Each question contains statements gives in two columns which have to be matched. Statements (A,B,C,D) in column I have to be matched with statements (p, q, r, s,) in column II.

1. In a two block system shown in figure, velocities are given to the blocks at an instant as shown. Mitch the following:

Column I	Column II
(A) Velocity of centre of mass	(p) Keep on changing all the time
(B) Momentum of centre of mass	(q) First decreases then become zero
(C) Magnitude of momentum of 1 kg block	(r) increases from zero

(D) Kinetic energy of 2 kg block (s) constant
(t) zero

SECTION-II

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

(A) L (B) $\frac{L}{4}$ (C) $\frac{3L}{4}$ (D) $\frac{L}{3}$

2. An isosceles triangle is to be cut from one edge of a square lamina (as shown in the figure) such that the remaining portion when suspended from the apex P of the cut will remain in equilibrium in any position.

The value of h is

(A) $\frac{(3=\sqrt{3})\ell}{2}$ (B) $\frac{(3+\sqrt{3})\ell}{2}$ (C) $\frac{(2-\sqrt{2})\ell}{2}$ (D) $\frac{(2+\sqrt{2})\ell}{2}$

3. A circular plate of diameter 'd' is kept in contact with a square plate of edge 'd' as shown in figure. The density of material and thickness are same everywhere. The center of mass of the composite system will be

(A) inside the circular plate
(B) inside the square plate
(C) at the point of contact
(D) outside the system

4. A wedge of mass M and a cube of mass m are shown in figure. The system is released. Considering no frictional force between any two surface, the distance moved by the wedge, when the cube just reaches on the ground is

(A) $\frac{m^2\sqrt{2}}{(m + M)}$ (C)2m (C)$2\sqrt{2}$m (D)$\frac{2m}{m + M}$

5. A smooth ball of mass m strikes a horizontal surface with a velocity v in a direction making an angle 30^o with the normal to the surface as shown in the figure. If the coefficient of restitution for the collision between the ball and the surface is e and the ball was in contact with the surface for a small time 'Δt', the average force action on the ball during collision is

(A) mg (B) $\frac{mv(1+e)}{2\Delta t}$ (C) $\frac{\sqrt{3}\, mv(1-e)}{2\Delta T}$ (D) $\frac{\sqrt{3}\, mv(1+e)}{2\Delta T}$

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6. A shell fired from a cannon with velocity v m/s at an angle θ with the horizontal direction. At the highest point in its path the shell explodes into two pieces of equal ma. One of the pieces retaces it path, the speed (in m/s)) of the other piece immediately after the explosion is

(A) 3v cos θ (B) 2v cos θ (C) 3/2 v cos θ (D) $\frac{\sqrt{3}\, v \cos\theta}{2}$

8. a bomb of mass 7m explodes into two fragment of masses 4m and 3m. If the momentum of the lighter fragment is 'P' then the energy released in the explosion is

(A) $7P^2/24m$ (B) $9P^2/16m$ (C) $11P^2/24m$ (D) 5P+2+ /14m

9. A particle of ma m is made to move with uniform speed v_o along the perimeter of a regular hexagon. The magnitude of impulse applied at each corner of the hexagon i

(A) $2mv_o \sin\frac{\pi}{6}$ (B) $mv_o \sin\frac{\pi}{6}$ (C) $mv_o \sin\frac{\pi}{3}$ (D) $2mv_o \sin\frac{\pi}{3}$

10. A small spherical ball strikes a frictionless horizontal plane with a velocity v making an angle θ to the normal at the surface. If the coefficient of restitution I e, the particle will again strike the surface after time

(A) 2vsinθ/g (B) 2evcosθ/g
(C) 2evsinθ/g (D) 2vcosθ/g

11. A neutron travelling with a velocity v and kinetic energy E collide elastically head on with the nucleus of an atom of ma number A at rest. The fraction of total energy retained by the neutron is:

(A) $\left(\frac{A-1}{A+1}\right)^2$ (B) $\left(\frac{A+1}{A-1}\right)^2$ (C) $\left(\frac{A-1}{A}\right)^2$ (D) $\left(\frac{A+1}{A}\right)^2$

12. A sphere A of ma m moving with a constant velocity u hits stationary sphere B of the same ma in a head on collision. If e is the coefficient of restitution, then ratio of velocities of sphere A to the sphere B after collision will be:

(A) $\left(\frac{1-e}{1+e}\right)$ (B) $\left(\frac{1+e}{1-e}\right)$ (C) $\left(\frac{e+1}{e+1}\right)$ (D) $\left(\frac{1-e}{1+e}\right)$

13. A particle strikes a horizontal frictional floor with a speed u at an angle θ with the vertical, and rebound with peed v at an angle φ with vertical. The coefficient of restitution between the particle and the floor is e. The magnitude of v is

(A) e u (B) (1-e)u (C) $u\sqrt{\sin^2\theta+e^2\cos^2\theta}$ (D) $u\sqrt{e^2\sin^2\theta+\cos^2\theta}$

14. Four particles A,B,C and D of equal ma move with equal speed v along the diagonals of a square in a horizontal plane a shown in the figure. After the collision, A comes to rest while B and C retrace their path with same speeds. Then, the particle D will

(A) continue to move along the same line with peed v
(B) retrace its path with speed 2v
(C) come to rest
(D) move with speed v√2 along a line parallel to CD

15. A ball is dropped from a height h on the ground. If the coefficient of restitution is e, find the height to which the ball will go up[after it rebound for the n^{th} time.

(A) $e.h^n$ (B) $h.e^n$ (C) $e.h^{2n}$ (D) $h.e^{2n}$