

PHYSICS

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CRASH COURSE

CENTRE OF MASS,
MOMENTUM & COLLISION

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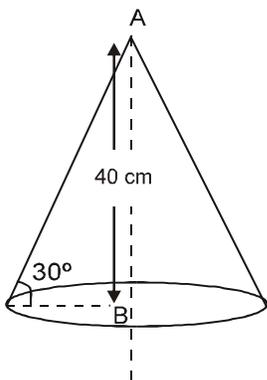
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CENTRE OF MASS, MOMENTUM & COLLISION

Q.1 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 :

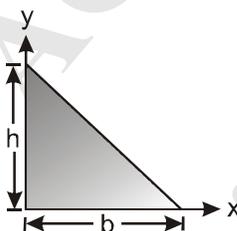


- (1) 20 cm (2) 10/3 cm (3) 20/3 cm (4) 10 cm

Q.2 In the HCl molecule, the separation between the nuclei of the two atoms is about 1.27 Å (1 Å = 10⁻¹⁰ m). The approximate location of the centre of mass of the molecule, distance from hydrogen atom assuming the chlorine atom to be about 35.5 times massive as hydrogen is

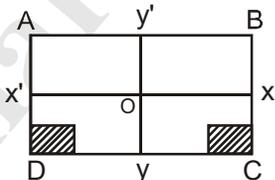
- (1) 1Å (2) 2.5 Å (3) 1.24 Å (4) 1.5 Å

Q.3 The centre of mass of triangle shown in figure has coordinates



- (1) $x = \frac{h}{2}, y = \frac{b}{2}$ (2) $x = \frac{b}{2}, y = \frac{h}{2}$ (3) $x = \frac{b}{3}, y = \frac{h}{3}$ (4) $x = \frac{h}{3}, y = \frac{b}{3}$

Q.4 A uniform square plate ABCD has a mass of 10 kg. If two point masses of 3 kg each are placed at the corners C and D as shown in the adjoining figure, then the centre of mass shifts to the point which is lie on -



- (1) OC (2) OD (3) OY (4) OX

Q.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

Q.6 Two objects of masses 200 gm and 500 gm possess velocities $10\hat{i}$ m/s and $3\hat{i} + 5\hat{j}$ m/s respectively. The velocity of their centre of mass in m/s is :

- (1) $5\hat{i} - 25\hat{j}$ (2) $\frac{5}{7}\hat{i} - 25\hat{j}$ (3) $5\hat{i} + \frac{25}{7}\hat{j}$ (4) $25\hat{i} - \frac{5}{7}\hat{j}$

Q.7 Two particles whose masses are 10 kg and 30 kg and their position vectors are $\hat{i} + \hat{j} + \hat{k}$ and $-\hat{i} - \hat{j} - \hat{k}$ respectively would have the centre of mass at -

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

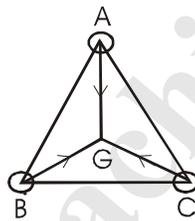
Q.8 If the KE of a body becomes four times its initial value, then the new momentum will be more than its initial momentum by;

- (1) 50% (2) 100% (3) 125% (4) 150%

Q.9 A bullet of mass m is being fired from a stationary gun of mass M . If the velocity of the bullet is v , the velocity of the gun is-

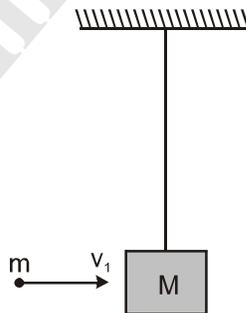
- (1) $\frac{Mv}{m + M}$ (2) $\frac{mv}{M}$ (3) $\frac{(M + m)v}{M}$ (4) $\frac{M + m}{Mv}$

Q.10 Three particles A, B and C of equal mass move with equal speeds v along the medians of an equilateral triangle as shown in the figure. They collide at the centroid G of the triangle. After collision A comes to rest, B retraces its path with speed v . The velocity of C is-



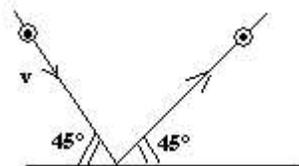
- (1) \vec{v} , direction \vec{GA} (2) $2\vec{v}$ & direction GA (3) $2v$, direction \vec{GB} (4) \vec{v} , & direction \vec{BG}

Q.11 A bullet of mass m moving with a velocity v_1 strikes a suspended wooden block of mass M as shown in the figure and sticks to it. If the block rises to a height h the initial velocity of the bullet is-

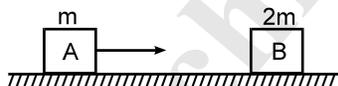


- (1) $\frac{m + M}{m} \sqrt{2gh}$ (2) $\sqrt{2gh}$ (3) $\frac{M + m}{M} \sqrt{2gh}$ (4) $\frac{m}{M + m} \sqrt{2gh}$

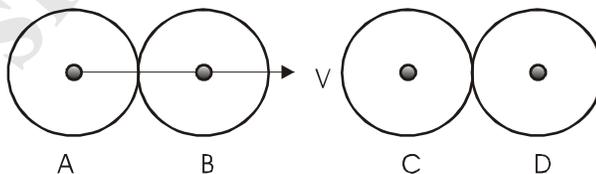
- Q.12 If a lighter body (mass M_1 and velocity V_1) and a heavier body (mass M_2 and velocity V_2) have the same kinetic energy, then-
- (1) $M_2V_2 < M_1V_1$ (2) $M_2V_2 = M_1V_1$ (3) $M_2V_1 = M_1V_2$ (4) $M_2V_2 > M_1V_1$
- Q.13 A space craft of mass M is travelling in space with velocity v . It then breaks up into two parts such that the smaller part m comes to the rest, then the velocity of the remaining part is-
- (1) $\frac{Mv}{M-m}$ (2) $\frac{Mv}{M+m}$ (3) $\frac{mv}{M-m}$ (4) $\frac{Mv}{m}$
- Q.14 With how much velocity a block of mass 2 kg should move on a frictionless surface so as to compress a spring with force constant 2 newton/meter by 4 meter :
- (1) 4 m/s (2) 16 m/s (3) 2 m/s (4) 8 m/s
- Q.15 A body of mass M moving with a speed V collides on a surface at an angle 45 degree without changing its speed the change in momentum of the body will be-



- (1) $MV(\hat{j} - \hat{i})$ (2) $MV(\hat{i} + \hat{j})$ (3) $2MV\hat{j}$ (4) $\sqrt{2}MV\hat{j}$
- Q.16 A body of mass 'M' collides against a wall with a velocity v and retraces its path the same speed. The change in momentum is (take initial direction of velocity as positive) :
- (1) zero (2) $2Mv$ (3) Mv (4) $-2Mv$
- Q.17 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 :

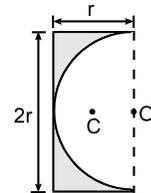


- (1) 0.5 (2) 1 (3) 0.25 (4) it is not possible
- Q.18 A particle of mass m_1 moving with a velocity of 5m/s collides head on with a stationary particle of mass m_2 . After collision both the particle move with a common velocity of 4m/s, then the value of m_1/m_2 is-
- (1) 4 : 1 (2) 2 : 1 (3) 1 : 8 (4) 1 : 1
- Q.19 Two identical smooth spheres A and B are moving with same velocity and collides with similar spheres C and D, then after collision- (Consider one dimensional collision)

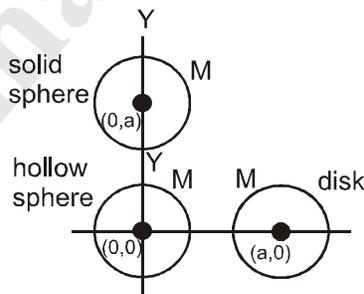


- (1) D will move with greater speed
 (2) C and D will move with same velocity v
 (3) C will stop and D will move with velocity v
 (4) All spheres A, B, C & D will move with velocity $v/2$

- Q.20 After falling from a height h and striking the ground twice, a ball rise up to the height $[e = \text{coefficient of restitution}]$
 (1) he (2) he^2 (3) he^3 (4) he^4
- Q.21 A steel ball of radius 2cm is initially at rest on a horizontal frictionless surface. It is struck head on by another steel ball of 4 cm radius travelling with a velocity of 81 cm/s. The velocities of two balls after collision are-
 (1) 72 cm/s and 56 cm/s (2) 144 cm/s and 56 cm/s
 (3) 144 cm/s and 63 cm/s (4) 63 cm/s and 72 cm/s
- Q.22 If a ball of mass 10 gm strikes perpendicular on a hard floor with speed 5 m/sec. and rebounds with the same speed and remains in contact with floor for 1 sec, then the force applied on the ball by the floor is-
 (1) 100 N (2) 10 N (3) 1.0 N (4) 0.1 N
- Q.23 A belt is moving horizontally with a speed of 2m/s and sand is falling on it at the rate of 150 gm/sec. The additional force require to keep constant the speed of belt, is-
 (1) 0.015 N (2) 0.30 N (3) 3N (4) 300 N
- Q.24 Fuel is consumed at the rate of 100 kg/sec. in a rocket. The exhaust gases are ejected as a speed of 4.5×10^4 m/s. What is the thrust experience by the rocket-
 (1) 3×10^6 N (2) 4.5×10^6 N (3) 6×10^6 N (4) 9×10^6 N
- Q.25 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) $L/5$
- Q.26 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) $\frac{2r}{3(4 - \pi)}$

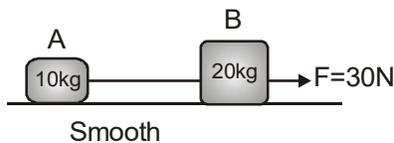


- Q.27 The coordinate of the centre of mass of a system as shown in figure : -



- (1) $\left(\frac{a}{3}, 0\right)$ (2) $\left(\frac{a}{2}, \frac{a}{2}\right)$ (3) $\left(\frac{a}{3}, \frac{a}{3}\right)$ (4) $\left(0, \frac{a}{3}\right)$

Q.28 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

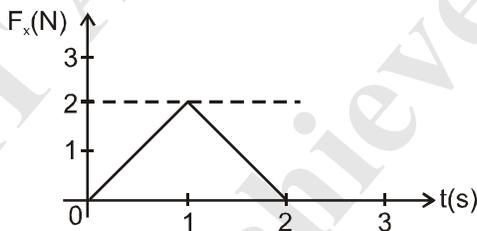
Q.29 A man of mass 'm' climbs on a rope of length L suspended below a balloon of mass M. The balloon is stationary with respect to ground. If the man begins to climb up the rope at a speed v_{rel} (relative to rope). In what direction and with what speed (relative to ground) will the balloon move?

- (1) downwards, $\frac{mv_{rel}}{m+M}$ (2) upwards, $\frac{Mv_{rel}}{m+M}$
 (3) downwards, $\frac{mv_{rel}}{M}$ (4) downwards, $\frac{(M+m)v_{rel}}{M}$

Q.30 In the figure shown the initial velocity of boat (30 kg) + person (15 kg) is 2 m/s. Find velocity of person w.r.t. boat so that velocity of boat will be 1 m/s in right (Neglect friction between boat and water)

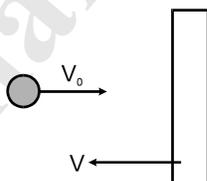
- (1) 3 m/s towards right (2) 3 m/s towards left
 (3) 4 m/s towards right (4) 4 m/s towards left

Q.31 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 $t = 2$ second?



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

Q.32 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

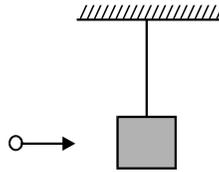
Q.33 A sphere of mass m moving with a constant velocity collides with another stationary sphere of same mass. The ratio of velocities of two spheres after collision will be, if the co-efficient of restitution is e-

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

Q.34 A person of mass m is standing on one end of a plank of mass M and length L and floating in water. The person moves from one end to another and stops. The displacement of the plank is –

- (1) $\frac{Lm}{(m + M)}$ (2) $Lm(M + m)$ (3) $\frac{(M + m)}{Lm}$ (4) $\frac{LM}{(m + M)}$

Q.35 A bullet of mass m moving with a speed v strikes a wooden block of mass M and gets embedded into the block. The final speed is:-

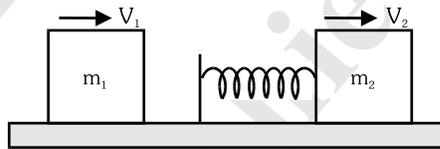


- (1) $\sqrt{\frac{M}{M+m}} v$ (2) $\sqrt{\frac{m}{M+m}} v$ (3) $\frac{m}{M+m} v$ (4) $\frac{v}{2}$

Q.36 A ball is dropped from height h on the ground level. If the coefficient of restitution is e then the height upto which the ball will go after n^{th} jump will be –

- (1) $\frac{h}{e^{2n}}$ (2) $\frac{e^{2n}}{h}$ (3) he^n (4) he^{2n}

Q.37 Two masses $m_1 = 2\text{kg}$ and $m_2 = 5\text{kg}$ are moving on a frictionless surface with velocities 10m/s and 3 m/s respectively. m_2 is ahead of m_1 . An ideal spring of spring constant $k = 1120\text{ N/m}$ is attached on the back side of m_2 . The maximum compression of the spring will be.



- (1) 0.51 m (2) 0.062 m (3) 0.25 m (4) 0.72 m

Q.38 A 5 kg body collides with another stationary body. After the collision, the bodies move in the same direction with one-third of the velocity of the first body. The mass of the second body will be –

- (1) 5 kg (2) 10 kg (3) 15 kg (4) 20 kg

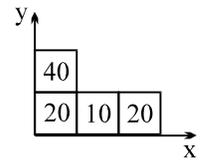
Q.39 A ball after falling from a height of 10m strikes the roof of a lift which is descending down with a velocity of 1 m/s . The recoil velocity of the ball will be ($e = 1$) –

- (1) 8 m/s (2) 11 m/s (3) 12 m/s (4) 15 m/s

Q.40 A shell is fired from a canon with velocity $V\text{ m/s}$ at an angle θ with the horizontal direction. At the highest point in its path with same speed it explodes into two pieces of equal masses. One of the pieces retraces its path to the cannon. The speed in m/sec. of the other piece immediately after the explosion is :-

- (1) $\frac{\sqrt{3}}{2} V \cos \theta$ (2) $3V \cos \theta$ (3) $2V \cos \theta$ (4) $\frac{3}{2} V \cos \theta$

Q.41 Four cubes of side "a" each of mass 40gm, 20gm, 10gm and 20gm are arranged in XY plane as shown in figure. The coordinates of centre of mass of the combination with respect to O, are :

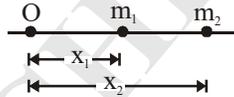


- (1) $19a/18, 17a/18$ (2) $17a/18, 11a/18$
 (3) $17a/18, 13a/18$ (4) $13a/18, 17a/18$

Q.42 If a particle of mass m_1 is located at $(x, y, z) = (0, a, 0)$ and a second particle of mass m_2 is located at $(x, y, z) = (b, c, 0)$, what is the location of their center of mass ?

- (1) $\left(\frac{b}{2}, \frac{a+c}{2}, 0\right)$ (2) $\left(\frac{m_2 b}{m_1 + m_2}, \frac{m_1 a + m_2 c}{m_1 + m_2}, 0\right)$
 (3) $\left(\frac{m_1 b}{m_1 + m_2}, \frac{m_2 a + m_1 c}{m_1 + m_2}, 0\right)$ (4) None of these

Q.43 In the diagram shown below, m_1 and m_2 are the masses of two particles and x_1 and x_2 are the respectively distances from the origin O. The centre of mass of the system is :



- (1) $\frac{m_1 x_2 + m_2 x_1}{m_1 + m_2}$ (2) $\frac{m_1 + x_2}{2}$ (3) $\frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$ (4) $\frac{m_1 m_2 + x_1 x_2}{m_1 + m_2}$

Q.44 The centre of mass of a system of three particles of masses 1 g, 2 g and 3 g is taken as the origin of a coordinate system. The position vector of a fourth particle of mass 4 g such that the centre of mass of the four particle system lies at the point $(1, 2, 3)$ is $\alpha(\hat{i} + 2\hat{j} + 3\hat{k})$, where α is a constant. The value of α is:

- (1) $\frac{10}{3}$ (2) $\frac{5}{2}$ (3) $\frac{1}{2}$ (4) $\frac{2}{5}$

Q.45 The velocity of centre of mass in absence of external force is -

- (1) constant (2) zero (3) increases (4) decreases

Q.46 A body of mass m collides against a wall with the velocity v and rebounds with the same speed. The change in momentum of body is-

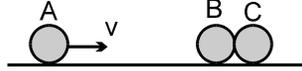


- (1) $-2mv$ (2) mv (3) $-mv$ (4) 0

Q.47 Which of the following statements is true for collisions-

- (1) momentum is conserved in elastic collisions but not in inelastic collisions.
 (2) total-kinetic energy is conserved in elastic collisions but momentum is not conserved.
 (3) total kinetic energy is not conserved in inelastic collisions but momentum is conserved
 (4) total kinetic energy and momentum both are conserved in all types of collisions

- Q.48 As shown in figure A, B and C are identical balls B and C are at rest and, the ball A moving with velocity v collides elastically with ball B, then after collision:



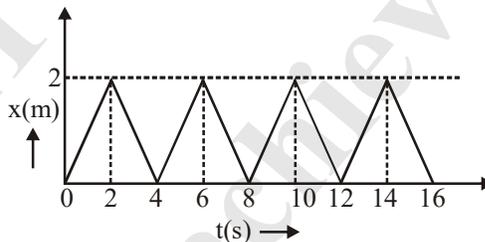
- (1) All the three balls move with velocity $v/2$
 (2) A comes to rest and (B + C) moves with velocity $v/\sqrt{2}$
 (3) A moves with velocity v and (B + C) moves with velocity v
 (4) A and B come to rest and C moves with velocity v
- Q.49 A nucleus of mass number A originally at rest, emits alpha particle with speed v . The recoil speed of the daughter nucleus is :

- (1) $\frac{4v}{A-4}$ (2) $\frac{4v}{A+4}$ (3) $\frac{v}{A-4}$ (4) $\frac{v}{A+4}$

- Q.50 A body of mass m having an initial velocity v makes head on collision with a stationary body of mass M . After the collision, the body of mass m comes to rest and only the body having mass M moves. This will happen only when :

- (1) $m \gg M$ (2) $m \ll M$ (3) $m = M$ (4) $m = \frac{M}{2}$

- Q.51 The figure shows the position-time ($x-t$) graph of one-dimensional motion of a body of mass 0.4 kg. The magnitude of each impulse is :-



- (1) 0.4 Ns (2) 0.8 Ns (3) 1.6 Ns (4) 0.2 Ns

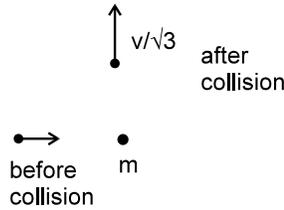
- Q.52 The linear momentum p of a body moving in one dimension varies with time according to the equation $p = a + bt^2$, where a and b are positive constants. The net force acting on the body is :

- (1) proportional to t^2 (2) a constant
 (3) proportional to t (4) inversely proportional to t

- Q.53 A bomb of mass M at rest explodes into two fragments of masses m_1 and m_2 . The total energy released in the explosion is E . If E_1 and E_2 represent the energies carried by masses m_1 and m_2 respectively, then which of the following is correct ?

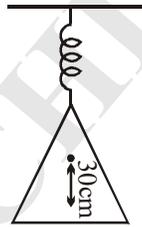
- (1) $E_2 = \frac{m_1}{M} E$ (2) $E_1 = \frac{m_1}{m_2} E$ (3) $E_1 = \frac{m_1}{M} E$ (4) $E_1 = \frac{m_2}{m_1} E$

Q.54 A mass 'm' moves with a velocity 'v' and collides inelastically with another identical mass. 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) v (2) $\sqrt{3} v$ (3) $\frac{2}{\sqrt{3}} v$ (4) $\frac{v}{\sqrt{3}}$

Q.55 A frame of mass 200 g when suspended from a massless spring extends it by 10 cm. A lump of clay of mass 200 g is dropped from rest on to the frame from a height of 30 cm as shown in figure. As a result, the speed of pan after the clay drops on it is :

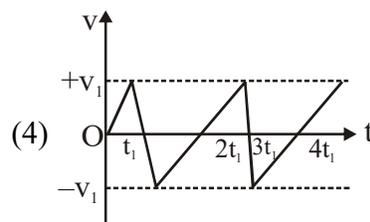
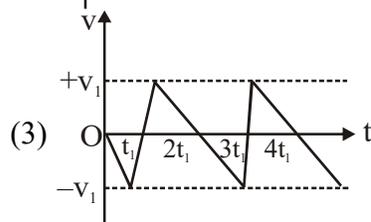
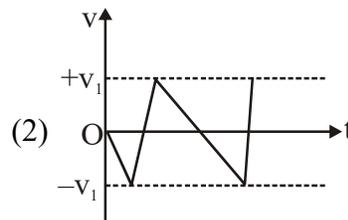
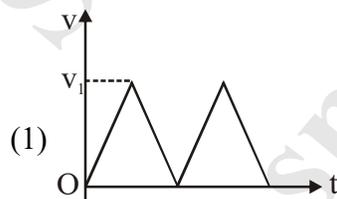


- (1) $\sqrt{6}m/s$ (2) 6 m/s (3) $\sqrt{3/2}m/s$ (4) $\sqrt{3}m/s$

Q.56 A body x with a momentum p collides with another identical stationary body y one dimensionally. During the collision y gives an impulse J to the body x. Then, the coefficient of restitution is :

- (1) $\frac{2J}{p} - 1$ (2) $\frac{J}{p} + 1$ (3) $\frac{J}{p} - 1$ (4) $\frac{J}{2p} - 1$

Q.57 Consider a rubber ball freely falling from a height $h = 4.9$ m onto a horizontal elastic plate. Assume that the duration of collision is negligible and the collision with the plate is totally elastic. Then the velocity as a function of time will be :-



Q.58 A ball is dropped from a height h on the ground. If the coefficient of restitution is e , the height to which the ball goes up after it rebounds for the n th time is :

- (1) he^{2n} (2) he^n (3) $\frac{e^{2n}}{h}$ (4) $\frac{h}{e^{2n}}$

Q.59 A particle falls from a height ' h ' upon a fixed horizontal plane and rebounds. If ' e ' is the coefficient of restitution the total distance travelled before rebounding has stopped is :

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

Q.60 A cricket bat is cut at the the location of its centre of mass as shown. Then :



- (1) The two pieces will have equal mass
 (2) The bottom piece will have larger mass
 (3) The handle piece will have larger mass
 (4) Mass of handle piece is double the mass of bottom piece

Direction for following questions :

- A. Both Assertion and Reason are true, and Reason is the correct explanation of Assertion.
 B. Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
 C. Assertion is true but Reason is false.
 D. Assertion and Reason both are false.

Q.61 **Assertion :** In a perfectly inelastic collision between two spheres, velocity of both spheres just after the collision are not always equal.

Reason : 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) A (2) B (3) C (4) C

Q.62 **Assertion :** The centre of mass of a two particle system lies on the line joining the two particles, being closer to the heavier particle.

Reason : Product of mass of one particle and its distance from centre of mass is numerically equal to product of mass of other particle and its distance from centre of mass.

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

Q.63 **Assertion :** The position of centre of mass of a body does not depend upon shape and size of the body.
Reason : Centre of mass of a body lies always at the centre of the body.

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

ANSWER KEY

Q.1	4	Q.2	3	Q.3	3	Q.4	3	Q.5	4
Q.6	3	Q.7	1	Q.8	2	Q.9	2	Q.10	4
Q.11	1	Q.12	4	Q.13	1	Q.14	1	Q.15	4
Q.16	4	Q.17	1	Q.18	1	Q.19	2	Q.20	4
Q.21	3	Q.22	1	Q.23	2	Q.24	2	Q.25	2
Q.26	4	Q.27	3	Q.28	2	Q.29	1	Q.30	1
Q.31	3	Q.32	1	Q.33	1	Q.34	1	Q.35	3
Q.36	4	Q.37	3	Q.38	2	Q.39	3	Q.40	2
Q.41	1	Q.42	2	Q.43	3	Q.44	2	Q.45	1
Q.46	1	Q.47	3	Q.48	4	Q.49	1	Q.50	3
Q.51	2	Q.52	3	Q.53	1	Q.54	3	Q.55	3
Q.56	1	Q.57	3	Q.58	1	Q.59	1	Q.60	1
Q.61	1	Q.62	1	Q.63	4				