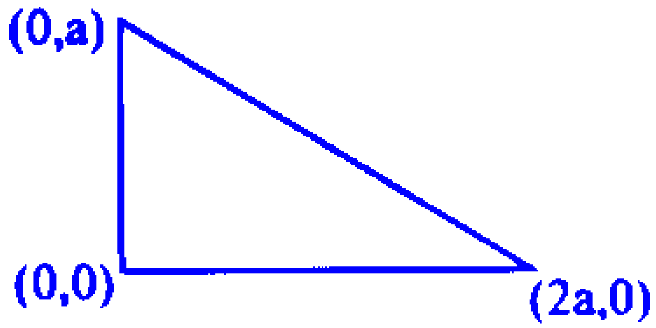
Center of Mass and Collision

Question1

Three rods of same mass are placed as shown in figure. The co-ordinates of centre of mass of the system are



MHT CET 2025 5th May Evening Shift

Options:

A.

$\left(\frac{a}{3}, \frac{a}{3}\right)$

B.

$\left(a, \frac{a}{2}\right)$

C.

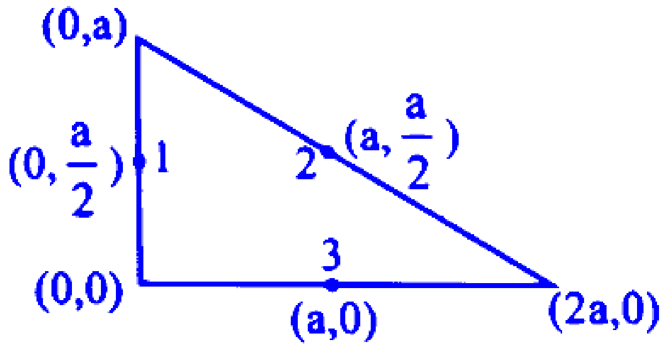
$\left(2a \frac{a}{2}\right)$

D.

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

Answer: D

Solution:



The center of mass of each rod is located at its midpoint. The rods can be treated as point masses positioned at their respective centres of mass.

$$\begin{aligned} X_{cm} &= \frac{m_1 x_1 + m_2 x_2 + m_3 x_3}{m_1 + m_2 + m_3} \\ &= \frac{m(0) + m(a) + m(a)}{3m} \\ &= \frac{2a}{3} \\ Y_{cm} &= \frac{m_1 y_1 + m_2 y_2 + m_3 y_3}{m_1 + m_2 + m_3} \\ &= \frac{m\left(\frac{a}{2}\right) + m\left(\frac{a}{2}\right) + m(0)}{3m} = \frac{a}{3} \end{aligned}$$

Question2

A sphere of mass ' m ', moving with velocity ' $3u$ ' collides head-on with another identical sphere at rest. If ' e ' is coefficient of restitution then what will be the ratio of velocity of the second sphere to that of first sphere after collision?

MHT CET 2025 26th April Morning Shift

Options:

A. $\frac{1-e}{1+e}$

B. $\frac{1+e}{1-e}$

C. $\frac{e+1}{e-1}$

D. $\frac{e-1}{e+1}$

Answer: B

Solution:

Coefficient of restitution:

$$e=\frac{v_2-v_1}{u_1-u_2}$$

Given: $u_1=3u, u_2=0$

$$\therefore \quad e=\frac{v_2-v_1}{3u}=\frac{v_2}{3u}-\frac{v_1}{3u}$$

$$v_2-v_1=3ue \qquad \ldots(i)$$

By law of conservation of momentum,

$$mu_1+mu_2=mv_1+mv_2$$
$$3mu=mv_1+mv_2$$
$$v_1+v_2=3u$$
$$v_1=3u-v_2 \qquad \ldots(ii)$$

From equation (i) and (ii),

$$v_2-(3u-v_2)=3ue \Rightarrow 2v_2-3u=3ue$$
$$v_2=\frac{3u(1+e)}{2} \qquad \ldots(iii)$$

For v_1

$$v_1=3u-v_2=3u-\frac{3u(1+e)}{2}$$
$$v_1=\frac{3u(1-e)}{2} \qquad \ldots(iv)$$

From equation (iii) and (iv),

$$\text{Ratio }=\frac{v_2}{v_1}=\frac{\frac{3u(1+e)}{2}}{\frac{3u(1-e)}{2}}=\frac{1+e}{1-e}$$

Question3

An object of mass ' m ' moving with velocity ' u ' collides with another stationary object of mass ' M ' and stops just after the collision. The coefficient of restitution is

Options:

A. $\frac{\mathrm{m}}{\mathrm{M+m}}$

B. $\frac{M-m}{M+m}$

C. $\frac{\mathrm{m}}{\mathrm{M}}$

D. 1

Answer: C

Solution:

Step 1: Write momentum conservation

Collision is assumed to be in 1D and no external force acts.

Initial momentum:

$p_i = mu + M \cdot 0 = mu$

Final momentum (since mass m stops after collision, its velocity = 0; velocity of $M = V$):

$p_f = m \cdot 0 + MV = MV$

By conservation of momentum:

$mu = MV \quad \Rightarrow \quad V = \frac{m}{M}u$

Step 2: Coefficient of restitution formula

Coefficient of restitution e is defined as:

$e = \frac{\text{relative velocity after}}{\text{relative velocity before}}$

Relative velocity before collision:

$u_{\text{rel,before}} \quad = u - 0 = u$

Relative velocity after collision:

Object m has velocity = 0, object M has velocity $V = \frac{m}{M}u$.

So relative velocity after collision:

$u_{\text{rel,after}} \quad = V - 0 = \frac{m}{M}u$

Thus,

$e = \frac{\frac{m}{M}u}{u} = \frac{m}{M}$

Final Answer:

The coefficient of restitution is

$$\boxed{\frac{m}{M}}$$

Correct option: C

Question4

There is head-on elastic collision between the two particles moving in the same direction with speeds $5 \mathrm{~m/s}$ and $3 \mathrm{~m/s}$ respectively. After collision, the velocity of the first particle becomes $4 \mathrm{~m/s}$ in the same direction. The velocity of the second particle should be

MHT CET 2025 19th April Morning Shift

Options:

A. $6 \mathrm{~m/s}$ in the same direction.

B. $4 \mathrm{~m/s}$ in the same direction.

C. $2 \mathrm{~m/s}$ in the opposite direction.

D. $3 \mathrm{~m/s}$ in the same direction.

Answer: A

Solution:

Step 1: List the Information Given

The first particle starts with a speed of $5 \mathrm{~m/s}$.

The second particle starts with a speed of $3 \mathrm{~m/s}$, in the same direction as the first.

After the collision, the first particle moves at $4 \mathrm{~m/s}$, still in the same direction.

The type of collision is elastic, and both particles move along a straight line (head-on).

We need to find the new speed of the second particle (v_2) after the collision.

Step 2: Use Elastic Collision Formula for Head-On Collisions

In an elastic head-on collision, the difference in the starting speeds equals the difference in the speeds after the collision, but in the opposite order:

$u_1 - u_2 = v_2 - v_1$

Step 3: Put in the Numbers

Plug in the values we have:

$5\ \mathrm{m/s} - 3\ \mathrm{m/s} = v_2 - 4\ \mathrm{m/s}$

$2\ \mathrm{m/s} = v_2 - 4\ \mathrm{m/s}$

Step 4: Solve for v_2

Add $4\ \mathrm{m/s}$ to both sides to find v_2:

$v_2 = 2\ \mathrm{m/s} + 4\ \mathrm{m/s}$

$v_2 = 6\ \mathrm{m/s}$

Step 5: Check the Direction

Because the answer is positive, this means the second particle moves in the same direction as before, just faster.

Step 6: Final Answer

The second particle's speed after the collision is $6\ \mathrm{m/s}$, in the same direction as before.

The matching answer choice is:

Option A: $6\ \mathrm{m/s}$ in the same direction.

So, the correct answer is $\boxed{6\ \mathrm{m/s} \text{ in the same direction.}}$

Question5

Three identical metal balls each of radius ' r ' are placed such that an equilateral triangle is formed when centres of three ball are joined. The centre of mass of the system is located at

MHT CET 2024 16th May Evening Shift

Options:

A. centre of one of the balls.

B. point of intersection of medians.

C. line joining centres of any two balls.

D. on the circumference of any one of the balls.

Answer: B

Solution:

Three identical metal balls, each with radius r, are arranged such that the centers of these balls form an equilateral triangle. The center of mass of this system can be determined as follows:

Since the balls are identical with equal volumes and densities, their masses are also the same. This simplifies the calculation of the center of mass.

The expressions for the coordinates of the center of mass, X_{cm} and Y_{cm}, are derived as follows:

$$X_{cm} = \frac{mx_1 + mx_2 + mx_3}{m+m+m} = \frac{x_1 + x_2 + x_3}{3},$$
$$Y_{cm} = \frac{my_1 + my_2 + my_3}{m+m+m} = \frac{y_1 + y_2 + y_3}{3}.$$

Here, X_{cm} and Y_{cm} represent the centroid of the equilateral triangle formed by the centers of the three balls. Since all masses are equal and symmetrically distributed around the centroid, the center of mass coincides with the centroid of the triangle, which is also the point where the medians intersect.

Question6

In case of system of two-particles of different masses, the centre of mass lies

MHT CET 2024 16th May Morning Shift

Options:

A. at the mid-point of line joining the two particles.

B. on the line joining the two particles.

C. at one end of the line joining the two particles.

D. on the line perpendicular to the line joining the two particles.

Answer: B

Solution:

The center of mass for a system of two particles with masses m_1 and m_2, positioned at coordinates x_1 and x_2 respectively, is given by the formula:

$x_{\text{cm}} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$

This clearly indicates that the center of mass resides on the line joining the two particles, but not necessarily at the midpoint unless the masses are equal. Therefore, if $m_1 \neq m_2$, the center of mass will be closer to the particle with the larger mass.

Option B: on the line joining the two particles.

Question7

A particle of mass m collides with another stationary particle of mass M. The particle m stops just after collision. The coefficient of restitution is

MHT CET 2024 15th May Evening Shift

Options:

A. $\frac{m}{M}$

B. $\frac{M-m}{M+m}$

C. 1

D. $\frac{\mathrm{m}}{\mathrm{M}+\mathrm{m}}$

Answer: A

Solution:

Let v be the velocity of mass m and v' be the velocity of mass M after collision.

By law of conservation of momentum,

$\mathrm{mv} = \mathrm{Mv}'$

$\therefore \quad \frac{\mathrm{v}'}{\mathrm{v}} = \frac{\mathrm{m}}{\mathrm{M}}$

Coefficient of restitution $= \frac{v_2 - v_1}{u_2 - u_1}$

Here, $\mathrm{v}_1 = 0$ and $\mathrm{u}_2 = 0$

$\therefore \quad e = \frac{v'}{v} = \frac{m}{M}$

Question8

1000 small balls, each weighing 1 gram, strike one square cm of area per second with a velocity $50 \mathrm{~m/s}$ in a normal direction and rebound with the same velocity. The value of pressure on the surface will be

MHT CET 2024 15th May Evening Shift

Options:

A. $10^7 \mathrm{~N/m^2}$

B. $10^6 \mathrm{~N/m^2}$

C. $5 \times 10^6 \mathrm{~N/m^2}$

D. $2 \times 10^6 \mathrm{~N/m^2}$

Answer: B

Solution:

Given that,
$\mathrm{N} = 10^3,\ \mathrm{m} = 1 \mathrm{~g} = 10^{-3} \mathrm{~kg},$
$\mathrm{A} = 1 \mathrm{~cm}^2 = 10^{-4} \mathrm{~m}^2, \mathrm{v} = 50 \mathrm{~m/s}$

Change in momentum in each collision $= \mathrm{m}[\mathrm{v} - (-\mathrm{v})] = 2\mathrm{mv}$

$\therefore$ Force exerted on the surface

$= 10^3 \times 2\mathrm{mv}$
$= 10^3 \times 2 \times 10^{-3} \times 50 = 100 \mathrm{~N}$
Now, Pressure $= \frac{\mathrm{F}}{\mathrm{A}} = \frac{100}{10^{-4}} = 10^6 \mathrm{~N/m^2}$

Question9

A moving body with mass ' m_1 ' strikes a stationary mass ' m_2 '. What should be the ratio $\frac{m_1}{m_2}$ so as to decrease the velocity of first by (1.5) times the velocity after the collision?

MHT CET 2024 11th May Evening Shift

Options:

A. 1 : 25

B. 1 : 5

C. 5 : 1

D. 25 : 1

Answer: C

Solution:

Let initial velocity of mass m_1 be v_1 and final velocity of mass m_2 be v_2

According to the given condition,

Final velocity of mass m_1 is $\frac{v_1}{1.5}=\frac{2}{3} v_1$

Coefficient of restitution,

$$e=\frac{\text{Velocity after collision}}{\text{Velocity beforecollision}}$$

$$1=\frac{\left(\mathrm{v}_2-\frac{2 \mathrm{v}_1}{3}\right)}{\mathrm{v}_1} \quad \ldots(\mathrm{e}=1, \text{ for elastic collision })$$

$$\therefore \quad \mathrm{v}_2=\frac{5 \mathrm{v}_1}{3} \quad \text{.... (i)}$$

By following conservation of momentum

$$\mathrm{m}_1 \mathrm{v}_1=\frac{\mathrm{m}_1 \mathrm{v}_1}{1.5}+\mathrm{m}_2 \mathrm{v}_2$$

$$\mathrm{m}_1 \mathrm{v}_1=\mathrm{m}_1 \frac{2}{3} \mathrm{v}_1+\mathrm{m}_2 \frac{5}{3} \mathrm{v}_1$$

$$\frac{1}{3} \mathrm{m}_1 \mathrm{v}_1=\mathrm{m}_2 \frac{5}{3} \mathrm{v}_1 \Rightarrow \frac{\mathrm{m}_1}{\mathrm{m}_2}=\frac{5}{1}$$

Question10

A metal rod of weight ' W ' is supported by two parallel knife-edges A and B . The rod is in equilibrium in horizontal position. The distance ' between two knife-edges is ' r '. The centre of mass of the rod is at a distance ' x ' from A. The normal reaction on A is

MHT CET 2024 9th May Evening Shift

Options:

A. $\frac{W \cdot r}{x}$

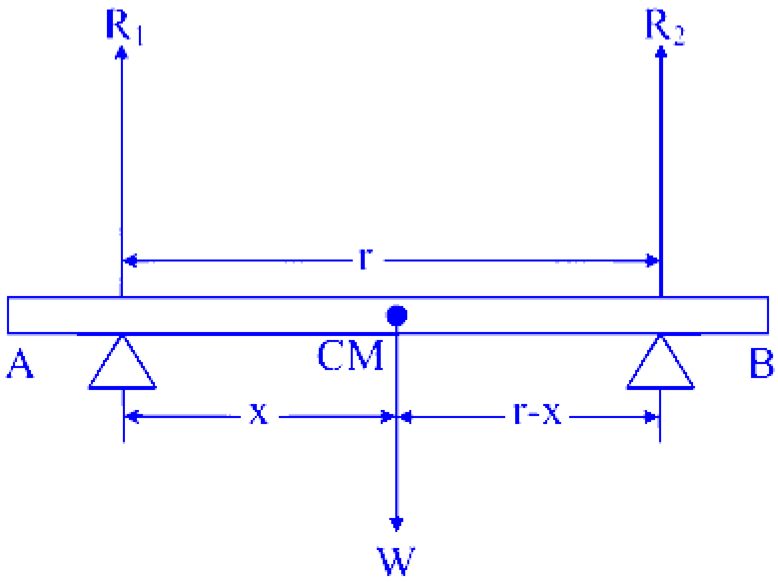
B. $\frac{W \cdot x}{r}$

C. $\frac{W \cdot (r-x)}{x}$

D. $\frac{W \cdot (r-x)}{r}$

Answer: D

Solution:



For equilibrium,

$$N_1 r = W(r-x)$$

$$\therefore \quad N_1 = \frac{W(r-x)}{r}$$

Question11

In the system of two particles of masses ' m_1 ' and ' m_2 ', the first particle is moved by a distance 'd' towards the centre of mass. To keep the centre of mass unchanged, the second particle will have to be moved by a distance

MHT CET 2024 9th May Morning Shift

Options:

A. $\frac{\mathrm{m}_2}{\mathrm{m}_1}$ d, towards the centre of mass.

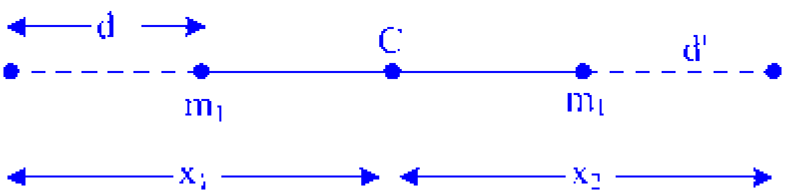
B. $\frac{\mathrm{m}_1}{\mathrm{m}_2}$ d, away from the centre of mass.

C. $\frac{\mathrm{m}_1}{\mathrm{m}_2}$ d, towards the centre of mass.

D. $\frac{\mathrm{m}_2}{\mathrm{m}_1}$ d, away from the centre of mass.

Answer: C

Solution:



$$m_1 x_1 = m_2 x_2 \quad \text{.... (i)}$$

$$m_1 (x_1 - d) = m_2 (x_2 - d') \quad \text{.... (ii)}$$

$$\therefore \quad m_1 x_1 - m_1 d = m_2 x_2 - m_2 d'$$

$$m_1 d = m_2 d' \quad \text{.... [From (i)]}$$

$$\therefore \quad d' = \frac{m_1}{m_2} d$$

Question12

In projectile motion two particles of masses m_1 and m_2 have velocities $\vec{V}_1$, and $\vec{V}_2$ respectively at time $t=0$. Their velocities become $\overline{V_1'}$ and $\overrightarrow{V_2'}$ at time 2 t while still moving in air. The value of $\left[\left(m_1 \overrightarrow{V_1'}+m_2 \overrightarrow{V_2'}\right)-\left(m_1 \vec{V}_1+m_2 \vec{V}_2\right)\right]$ is ($\mathrm{g}=$ acceleration due to gravity)

MHT CET 2024 3rd May Evening Shift

Options:

A. zero

B. $\frac{1}{2}\left(\mathrm{~m}_1+\mathrm{m}_2\right) \mathrm{gt}$

C. $\left(m_1+m_2\right) g t$

D. $2\left(m_1+m_2\right) g t$

Answer: D

Solution:

Considering m_1 and m_2 together as system. The only external force acting on the system is

$$\mathrm{F}_{\text{ext}}=\left(\mathrm{m}_1+\mathrm{m}_2\right) \mathrm{g}$$

$$\frac{\Delta P}{\Delta t}=\frac{\left[\left(m_1 \overline{V_1}+m_2 \overline{V_2'}\right)-\left(m_1 \overline{V_1}+m_2 \overline{V_2}\right)\right]}{2 \mathrm{t}-0}$$

$$\because \quad \mathrm{F}_{\text{ext}}=\frac{\Delta \mathrm{P}}{\Delta \mathrm{t}}$$

$$\therefore \quad\left(\mathrm{m}_1+\mathrm{m}_2\right) \mathrm{g}=\frac{\left[\left(\mathrm{m}_1 \overline{\mathrm{V}_1'}+\mathrm{m}_2 \overline{\mathrm{V}_2'}\right)-\left(\mathrm{m}_1 \overrightarrow{\mathrm{V}}_1+\mathrm{m}_2 \overline{\mathrm{V}_2}\right)\right]}{2 \mathrm{t}}$$

$$\therefore \quad\left[\left(\mathrm{m}_1 \overline{\mathrm{V}_1'}+\mathrm{m}_2 \overline{\mathrm{V}_2'}\right)-\left(\mathrm{m}_1 \overline{\mathrm{V}}_1+\mathrm{m}_2 \overline{\mathrm{V}_2}\right)\right]=2\left(\mathrm{~m}_1+\mathrm{m}_2\right) \mathrm{gt}$$

Question13

A meter scale is supported on a wedge at its centre of gravity. A body of weight ' w ' is suspended from the 20 cm mark and another weight of 25 gram is suspended from 74 cm mark balances it and the meter scale remains perfectly horizontal. Neglecting the weight of the meter scale, the weight of the body is

MHT CET 2024 2nd May Evening Shift

Options:

A. 33 gram wt.

B. 30 gram wt.

C. 20 gram wt.

D. 15 gram wt.

Answer: C

Solution:

$\mathrm{W}_1 \times l_1=\mathrm{W}_2 \times l_2$
$\Rightarrow \mathrm{w} \times 30=25 \times 24=20$ gram wt

Question14

A person with machine gun can fire 50 g bullets with a velocity of $240 \mathrm{~m} / \mathrm{s}$. A $60 \mathrm{~kg}$ tiger moves towards him with a velocity of $12 \mathrm{~m} / \mathrm{s}$. In order to stop the tiger in track, the number of bullets the person fires towards the tiger is

MHT CET 2023 14th May Morning Shift

Options:

A. 50

B. 60

C. 70

D. 80

Answer: B

Solution:

In order to stop the tiger, the momentum of the bullets fired must be equal to the momentum of the tiger.

$$\therefore \quad \mathrm{MV} = \mathrm{nmv}$$
$$\therefore \quad \mathrm{n} = \frac{\mathrm{MV}}{\mathrm{mv}} = \frac{60 \times 12}{50 \times 10^{-3} \times 240}$$
$$\therefore \quad \mathrm{n} = 60$$

Question15

A simple spring has length l and force constant K. It is cut in to two springs of length l_1 and l_2 such that $l_1 = nl_2$(n is an integer). The force constant of spring of length l_1 is

MHT CET 2023 13th May Evening Shift

Options:

A. $K(1+n)$

B. $\frac{K(n+1)}{n}$

C. K

D. $\frac{K}{(n+1)}$

Answer: B

Solution:

Let, two parts of the springs have spring constants K_1 and K_2, respectively.

$$\because \quad \begin{aligned} l_1 &= nI_2 \\ k_2 &= nK_1 \end{aligned}$$

Now, before cutting into two parts l_1 and I_2, we have springs in series.

$$\text{i.e.,} \quad \frac{1}{K} = \frac{1}{K_1} + \frac{1}{K_2}$$

$$\Rightarrow \quad \frac{1}{K} = \frac{1}{K_1} + \frac{1}{nK_1}$$

$$\Rightarrow \quad \frac{1}{K} = \frac{n+1}{nK_1}$$

$$\Rightarrow \quad K = \frac{nK_1}{(n+1)}$$

$$\Rightarrow \quad K_1 = \frac{K(n+1)}{n}$$

Question16

A particle of mass 'm' moving east ward with a speed 'v' collides with another particle of same mass moving north-ward with same speed 'v'. The two particles coalesce after collision. The new particle of mass '$2 \mathrm{~m}$' will move in north east direction with a speed (in m / s)

MHT CET 2023 12th May Morning Shift

Options:

A. V

B. 2 V

C. $\frac{\mathrm{V}}{2}$

D. $\frac{\mathrm{V}}{\sqrt{2}}$

Answer: D

Solution:

Momentum of particle moving towards east

$\overrightarrow{\mathrm{p}_1} = \mathrm{mv} \hat{\mathrm{i}}$

Momentum of particle moving towards North

$\overrightarrow{\mathrm{p}_2} = \mathrm{mv}\hat{\mathrm{j}}$

Momentum after collision,

$\vec{p} = 2m\left(v_x\hat{i} + v_y\hat{j}\right)$

Applying momentum conservation,

$$\begin{aligned} & \overrightarrow{p_1} + \overrightarrow{p_2} = \vec{p} \\ & mv\hat{i} + mv\hat{j} = 2m\left(v_x\hat{i} + v_y\hat{j}\right) \\ \therefore \quad & 2mv_x = mv \\ & v_x = \frac{v}{2} \end{aligned}$$

Similarly, $\mathrm{v_y} = \frac{\mathrm{v}}{2}$

$v_R = \sqrt{v_x^2 + v_y^2} = \sqrt{\left(\frac{v}{2}\right)^2 + \left(\frac{v}{2}\right)^2} = \frac{v}{\sqrt{2}}$

Question17

A ball kept at $20 \mathrm{~m}$ height falls freely in vertically downward direction and hits the ground. The coefficient of restitution is 0.4. Velocity of the ball first rebound is $\left[\mathrm{g} = 10 \mathrm{~ms}^{-2}\right]$

MHT CET 2023 11th May Evening Shift

Options:

A. $4 \mathrm{~ms}^{-1}$

B. $8 \mathrm{~ms}^{-1}$

C. $12 \mathrm{~ms}^{-1}$

D. $16 \mathrm{~ms}^{-1}$

Answer: B

Solution:

$$v^2 = 0 + 2gh \quad \ldots . (\because v^2 - u^2 = 2gh)$$
$$v^2 = 2 \times 10 \times 20 = 400$$
$$\therefore \quad v = 20 \mathrm{~m/s}$$
$$e = \frac{u}{v}$$

$\therefore$ The velocity of the body after the first rebound is

$\mathrm{u} = 0.4 \times 20$
$\mathrm{u} = 8 \mathrm{~m/s}$

Question18

A mass 'M' moving with velocity 'V' along X-axis collides and sticks to another mass 2M which is moving along Y-axis with velocity '3 V '. The velocity of the combination after collision is

MHT CET 2023 10th May Evening Shift

Options:

A. $\frac{V}{3} \hat{i} + 2V \hat{j}$

B. $\frac{V}{2} \hat{i} + V \hat{j}$

C. $\frac{V}{3} \hat{i} - 2V \hat{j}$

D. $\frac{V}{2} \hat{i} - V \hat{j}$

Answer: A

Solution:

From law of conservation of linear momentum,

$$M v \hat{i} + 2M(3v \hat{j}) = 3M \vec{v}$$
$$v \hat{i} + 6v \hat{j} = 3\vec{v}$$
$$\vec{v} = \frac{v}{3} \hat{i} + 2v \hat{j}$$

Question19

Consider the following statements A and B. Identify the correct choice in the given answers.

A. In an inelastic collision, there is no loss in kinetic energy during collision.

B. During a collision, the linear momentum of the entire system of particles is conserved if there is no external force acting on the system.

MHT CET 2023 9th May Evening Shift

Options:

A. Both A and B are wrong.

B. Both A and B are correct.

C. A is wrong and B is correct.

D. A is correct and B is wrong.

Answer: C

Solution:

In elastic collision, there is a loss in kinetic energy. However, momentum is conserved if there is no external force acting on the system.

Question20

A body falls on a surface of coefficient of restitution 0.6 from a height of $1 \mathrm{~m}$. Then the body rebounds to a height of

MHT CET 2023 9th May Morning Shift

Options:

A. 1 m

B. 0.36 m

C. 0.4 m

D. 0.6 m

Answer: B

Solution:

As the body falls from a height

$$u = 0$$
$$v^2 = u^2 + 2gh$$
$$\therefore \quad v^2 = 2 \times 9.8 \times 1 = 19.6$$
$$\therefore \quad v = \sqrt{19.6}\ \mathrm{m/s}$$

Coefficient of restitution $e = \frac{v}{u}$

$$e = \frac{\text{Velocity after collision } (v_f)}{\text{Velocity before collision } (v_b)}$$
$$\therefore \quad v_f = e \times v_b$$
$$v_f = 0.6 \times \sqrt{19.6}\ \mathrm{m/s}$$

After the body rebounds,

$$v^2 = u^2 - 2gh$$
$$\Rightarrow u^2 = 2gh$$
$$\therefore \quad h = u^2/2g$$

Here, $u = v_f$

$$\therefore \quad h = \frac{(0.6 \times \sqrt{19.6})^2}{2 \times 9.8}$$
$$= 0.36\ \mathrm{m}$$

Question21

Two massless springs of spring constant K_1 and K_2 are connected one after the other forming a single chain, suspended vertically and certain mass is attached to the free end. If 'e_1' and 'e_2' are their

respective extensions and 'f' is their stretching force, the total extension produced is

MHT CET 2022 11th August Evening Shift

Options:

A. $f\left(\frac{1}{K_1}+\frac{1}{K_2}\right)$

B. $f\left(\frac{1}{K_1}-\frac{1}{K_2}\right)$

C. $f\left(K_1+K_2\right)$

D. $f\left(K_1-K_2\right)$

Answer: A

Solution:

For a spring $F=Kx$

$$\therefore x=\frac{F}{K}$$
$$\therefore x_1=\frac{F}{K_1} \text{ and } x_2=\frac{F}{K_2}$$
$$\text{or } e_1=\frac{F}{K_1} \text{ and } e_2=\frac{F}{K_2}$$

$$\therefore e_1+e_2=F\left(\frac{1}{K_1}+\frac{1}{K_2}\right)$$

Note: The springs are connected in series.

$\therefore$ The effective spring constant $K=\frac{K_1 K_2}{K_1+K_2}$

$\therefore$ Total extension

$$e=\frac{F}{K}=\frac{F(K_1+K_2)}{K_1 K_2}=\frac{F}{K_2}+\frac{F}{K_1}$$

Question22

A wooden black of mass 'm' moves with velocity 'V' and collides with another block of mass '4 m', which is at rest. After collision the

block of mass 'm' comes to rest. The coefficient of restitution will be

MHT CET 2021 23th September Morning Shift

Options:

A. 0.7

B. 0.25

C. 0.4

D. 0.5

Answer: B

Solution:

To determine the coefficient of restitution, let's analyze the given problem using the principles of momentum conservation and the definition of the coefficient of restitution.

First, we note the initial conditions:

- Mass of the moving block: m
- Velocity of the moving block: V
- Mass of the block at rest: $4 \mathrm{~m}$
- Velocity of the block at rest: 0

After the collision:

- The block of mass m comes to rest, so its final velocity is 0.
- Let V_2 be the final velocity of the block with mass $4 \mathrm{~m}$ after the collision.

By the law of conservation of linear momentum, the total momentum before and after the collision must be equal:

$$\mathrm{m} \cdot \mathrm{V}+4 \mathrm{~m} \cdot 0=\mathrm{m} \cdot 0+4 \mathrm{~m} \cdot V_2$$

This simplifies to:

$$\mathrm{V}=4 V_2 \Longrightarrow V_2=\frac{\mathrm{V}}{4}$$

Next, we use the coefficient of restitution (e), which is defined as the relative speed of separation divided by the relative speed of approach. Mathematically, for a one-dimensional collision:

$$e=\frac{\text{Relative speed after collision}}{\text{Relative speed before collision}}$$

Before the collision, the relative speed of approach is:

$$\mathrm{V}-0=\mathrm{V}$$

After the collision, the relative speed of separation is:

$0-\left(\frac{V}{4}\right)=-\frac{V}{4}$

Taking magnitudes (since speeds are always positive):

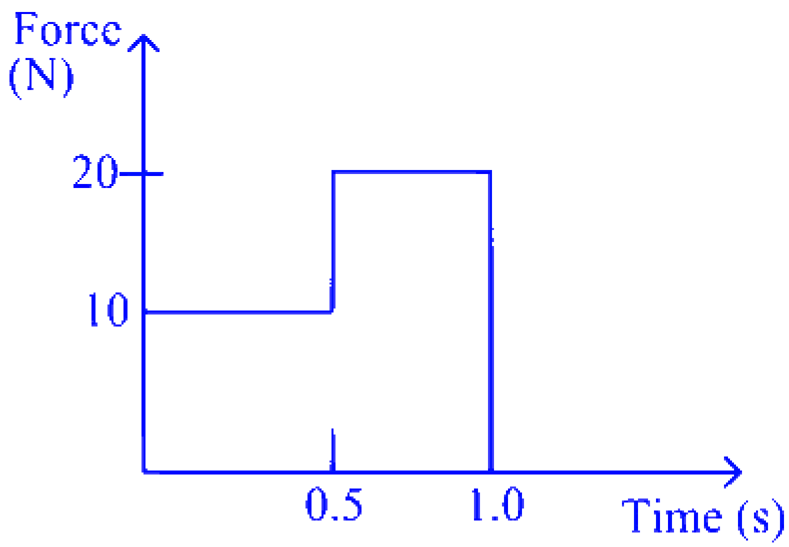
$e=\frac{\left|-\frac{V}{4}\right|}{V}=\frac{\frac{V}{4}}{V}=\frac{1}{4}=0.25$

Thus, the coefficient of restitution for this collision is:

Answer: Option B (0.25)

Question23

Force is applied to a body of mass $2\ \mathrm{kg}$ at rest on a frictionless horizontal surface as shown in the force against time $(F-t)$ graph. The speed of the body after 1 second is



MHT CET 2021 22th September Evening Shift

Options:

A. 7.5 m/s

B. 12.5 m/s

C. 10 m/s

D. 15 m/s

Answer: A

Solution:

Area under the $F - t$ graph gives change in momentum. Since the body is initially at rest, it gives the momentum of the body after 1 second.

$$\begin{aligned} \text{Area } &= 10 \times 0.5 + 20 \times 0.5 \\ &= 5 + 10 = 15 \text{ N} - \text{s} \end{aligned}$$

$$\therefore mV = 15 \text{ N} - \text{s}$$

$$V = \frac{15}{m} = \frac{15}{3} = 7.5 \text{ m/s}$$

Question24

A molecule of mass 'm' moving with velocity 'v' makes 5 elastic collisions with a wall of container per second. The change in momentum of the wall per second in 5 collisions will be

MHT CET 2021 21th September Evening Shift

Options:

A. 10 mv

B. 5 mv

C. $\frac{1}{5}$ mv

D. $\frac{1}{10}$ mv

Answer: A

Solution:

Change in momentum in each collision is [mv − (− mv)] = 2mv

Hence change in momentum in 5 collisions is 5 × 2 mV = 10 mV

Question25

A particle of mass 'm' collides with another stationary particle of mass 'M'. A particle of mass 'm' stops just after collision. The coefficient of restitution is

MHT CET 2021 21th September Morning Shift

Options:

A. $\frac{M}{m}$

B. $\frac{m+M}{M}$

C. $\frac{M-m}{M+m}$

D. $\frac{\mathrm{m}}{\mathrm{M}}$

Answer: D

Solution:

Let v be the velocity of mass m and v′ be the velocity of mass M after collision. By law of conservation of momentum

$$\mathrm{mv} = \mathrm{Mv}'$$

$$\therefore \frac{\mathrm{v}'}{\mathrm{v}} = \frac{\mathrm{m}}{\mathrm{M}}$$

$$\text{Coefficient of restitutions} = \frac{\text{Relative velocity after collision}}{\text{Re lative velocity before collision}} = \frac{\mathrm{v}'}{\mathrm{v}}$$

Question26

Two masses 'm_{a}' and '$\mathrm{m_b}$' moving with velocities 'v_{a}' and 'v_{b}' opposite directions collide elastically. Alter the collision 'm_a' and 'm_b' move with velocities and 'v_{b}' and 'v_a' respectively, then the ratio $\mathrm{m_a} : \mathrm{m_b}$ is

MHT CET 2021 20th September Evening Shift

Options:

A. $\frac{v_a+v_b}{v_a-v_b}$

B. $\frac{1}{2}$

C. 1

D. $\frac{v_a-v_b}{v_a+v_b}$

Answer: C

Solution:

When two bodies of equal masses collide elastically, they exchange their velocities. Since the two masses are exchanging their velocities, their masses must be equal.

Hence, $\frac{\mathrm{m_a}}{\mathrm{m_b}}=1$

Question27

In system of two particles of masses m_1 and m_2, the first particle is moved by a distance d towards the centre of mass. To keep the centre of mass unchanged, the second particle will have to be moved by a distance

MHT CET 2020 19th October Evening Shift

Options:

A. $\frac{m_2}{m_1}d$, towards the centre of mass

B. $\frac{m_1}{m_2}d$, away from the centre of mass

C. $\frac{m_1}{m_2}d$, towards the centre of mass

D. $\frac{m_2}{m_1}d$, away from the centre of mass

Answer: C

Solution:

Let x_1 and x_2 be the position of masses m_1 and m_2, respectively.

The position of centre of mass is

$x_{\mathrm{CM}}=\frac{x_1 m_1+x_2 m_2}{m_1+m_2}$

If Δx_1 and Δx_2 be the changes in positions, then change in the position of centre of mass,

$\Delta x_{\mathrm{CM}}=\frac{\Delta x_1 m_1+\Delta x_2 m_2}{m_1+m_2}$

Given that, the centre of mass remains unchanged e., $\Delta x_{CM}=0$ and $\Delta x_1=d$

$\Rightarrow \quad 0=\frac{d m_1+m_2 \Delta x_2}{m_1+m_2}$

or $\Delta x_2=-\frac{m_1}{m_2} d$

Here, negative sign shows that the second particle should be moved towards the centre of mass.

Question28

N number of balls of mass m kg moving along positive direction of X - axis, strike a wall per second and return elastically. The velocity of each ball is $u \mathrm{~m/s}$. The force exerted on the wall by the balls in newton, is

MHT CET 2020 19th October Evening Shift

Options:

A. 0

B. $2 m N u$

C. $\frac{m N u}{2}$

D. $m N u$

Answer: B

Solution:

The change in momentum of one ball,

$\Delta p = mu - (-mu) = 2mu$

The force exerted on the wall by N balls,

$$\begin{aligned} F &= \frac{\text{Change in momentum for } N \text{ balls}}{\text{Total time } (t)} \\ &= \frac{2m\text{Nu}}{1} \quad (\because t = 1s) \\ &= 2m\text{Nu} \end{aligned}$$

Question29

A batsman hits a ball of mass 0.2 kg straight towards the bowler without changing its initial speed of $6 \mathrm{~m/s}$. What is the impulse imparted to the ball?

MHT CET 2020 16th October Evening Shift

Options:

A. 3.2 N-s

B. 1.6 N-s

C. 4 N-s

D. 2.4 N-s

Answer: D

Solution:

The impulse is equals to change in linear momentum.

$$\begin{aligned} \text{Change in momentum } &= m(v-u) \\ &= 0.2(-6-6) = -2.4 \end{aligned}$$

The negative sign shows the direction of impulse is from batsman to bowler.

Question30

A bullet of mass m moving with velocity v is fired into a wooden block of mass M, If the bullet remains embedded in the block, the final velocity of the system is

MHT CET 2020 16th October Morning Shift

Options:

A. $\frac{m+M}{m}$

B. $\frac{M+m}{mv}$

C. $\frac{mv}{m+M}$

D. $\frac{v}{m(M+m)}$

Answer: C

Solution:

When a bullet of mass m is fired into a wooden block of mass M, and the bullet becomes embedded within the block, this scenario is governed by the law of conservation of momentum. According to the law of conservation of momentum, the total momentum of a system remains constant if no external forces act on the system. The formula for momentum is given by $p = m \cdot v$, where m is the mass and v is the velocity.

Before the collision, the momentum of the bullet is $m \cdot v$ (since it is moving) and the momentum of the block is 0 (since it is stationary). Therefore, the total initial momentum of the system is:

$$p_{\text{initial}} = m \cdot v + 0 = m \cdot v$$

After the collision, the bullet and the block move together as a single body with a combined mass of $M + m$ and a final velocity of v_f. Thus, the total final momentum of the system is:

$$p_{\text{final}} = (M + m) \cdot v_f$$

By conserving momentum (setting the total initial momentum equal to the total final momentum), we can find the final velocity:

$$m \cdot v = (M + m) \cdot v_f$$

To solve for v_f, we can rearrange the equation:

$$v_f = \frac{m \cdot v}{M+m}$$

So, the final velocity of the bullet-block system is $\frac{m \cdot v}{M+m}$.

Therefore, the correct option is:

Option C: $\frac{mv}{m+M}$

Question31

A block of mass ' m ' moving on a frictionless surface at speed ' v ' collides elastically with a block of same mass, initially at rest. Now the first block moves at an angle ' θ ' with its initial direction and has speed ' v_1 '. The speed of the second block after collision is

MHT CET 2019 2nd May Evening Shift

Options:

A. $\sqrt{v_1^2 - v^2}$

B. $\sqrt{v^2 - v_1^2}$

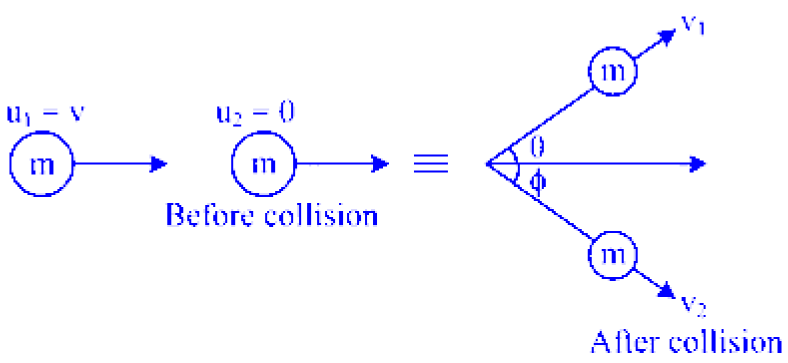
C. $\sqrt{v^2 + v_1^2}$

D. $\sqrt{v - v_1}$

Answer: B

Solution:

The situation can be shown as



Applying law of conservation of kinetic energy, KE (before collision) $=$ KE (after collision)

$$\frac{1}{2} m v^2+\frac{1}{2} m(0)^2=\frac{1}{2} m v_1^2+\frac{1}{2} m v_2^2$$

$$\Rightarrow \quad v^2=v_1^2+v_2^2 \Rightarrow v_2=\sqrt{v^2-v_1^2}$$

Thus, the velocity of second block after collision is $\sqrt{v^2-v_1^2}$.
