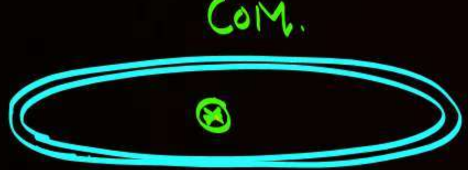
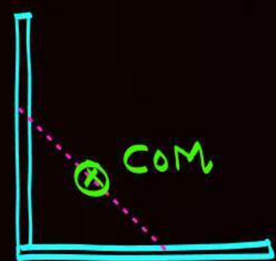
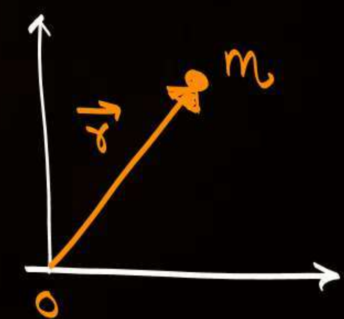
CENTRE OF MASS

(*) Point in space where whole Mass of the body Can be assumed to be Concentrated.





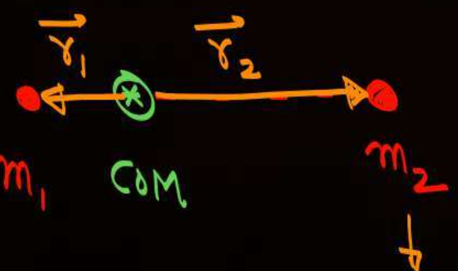
(*) Mass Moment.



Mass Moment wrt O ⇒

$$\boxed{\vec{Z} = (m)(\vec{r})}$$

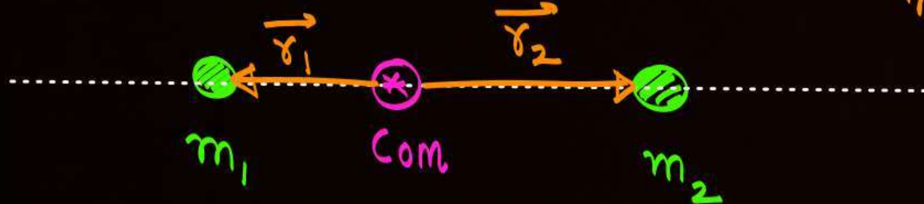
(*)



$m_1 > m_2$

COM :- It is a point in a space about which Net Mass Moment of all particles Sums out to be Zero.

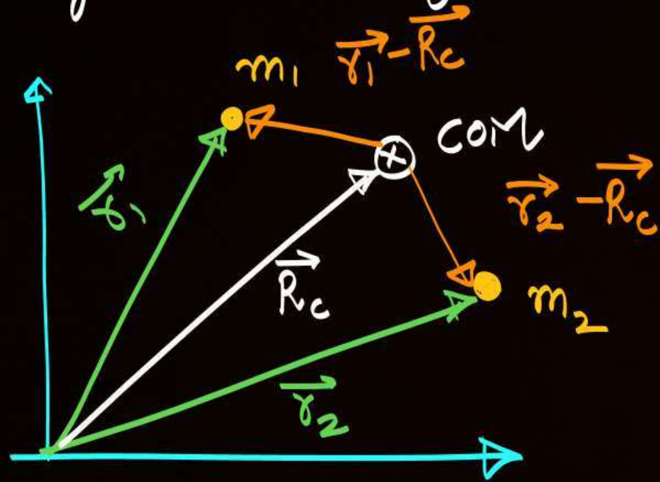
$m_1 > m_2$



$$\boxed{m_1\vec{r_1} + m_2\vec{r_2} = 0}$$

about COM

COM of two particle System.



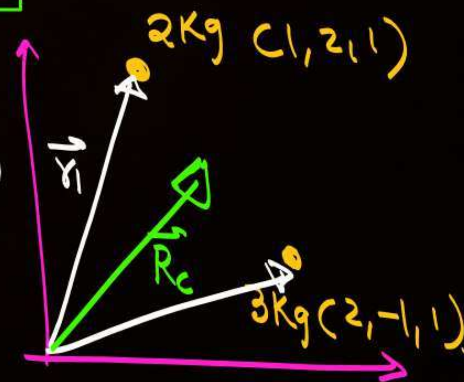
$\boxed{R_c = \text{Position Vector of COM}}$

about COM

$$m_1(\vec{r_1} - \vec{R_c}) + m_2(\vec{r_2} - \vec{R_c}) = 0$$

$$\boxed{\frac{m_1\vec{r_1} + m_2\vec{r_2}}{m_1 + m_2} = \vec{R_c}}$$

$$\vec{R}_{com} = \frac{2(\hat{i} + 2\hat{j} + \hat{k}) + 3(2\hat{i} - \hat{j} + \hat{k})}{5}.$$

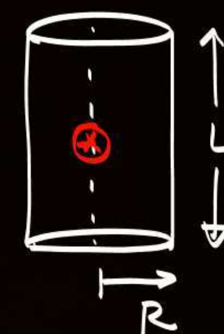


Imp points.

1. $\boxed{\text{Regular uniform}}$ bodies :- Centre of Mass lies at Geometrical Centre.

M, L

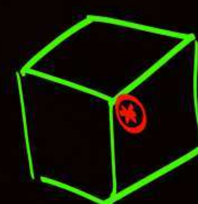
Sphere M, R.



disc M, R

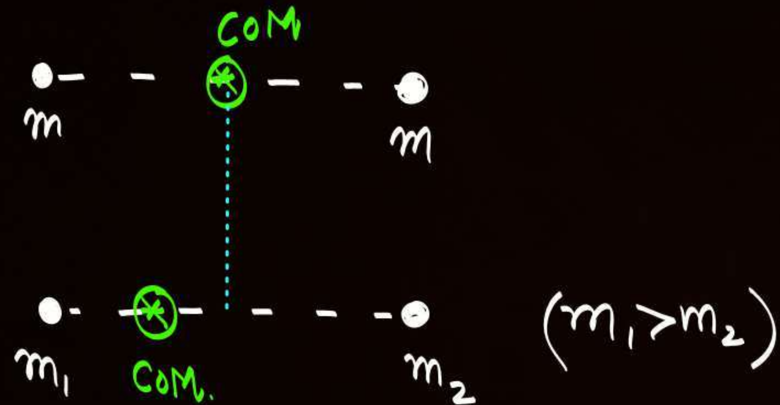
Rectangular plate (L × B)

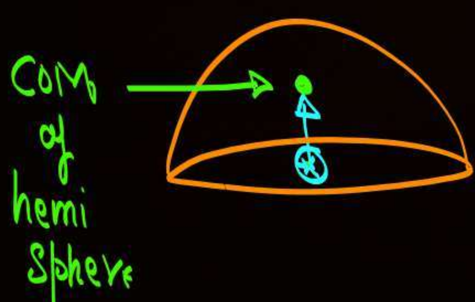
Ring M, R.

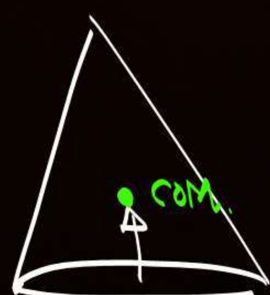


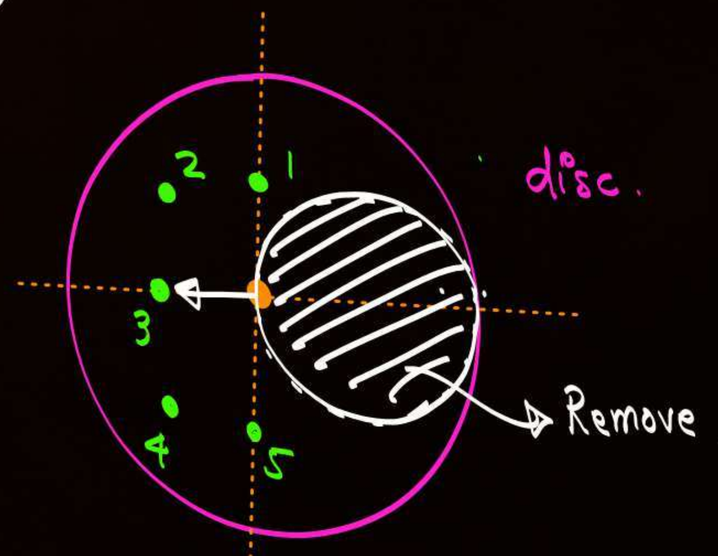
Cuboid (L × B × H).

⊛ Centre of Mass always towards Heavier Mass.



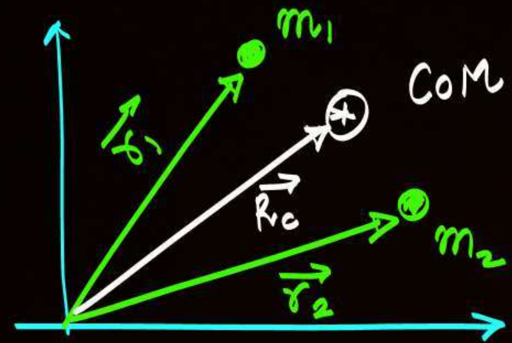




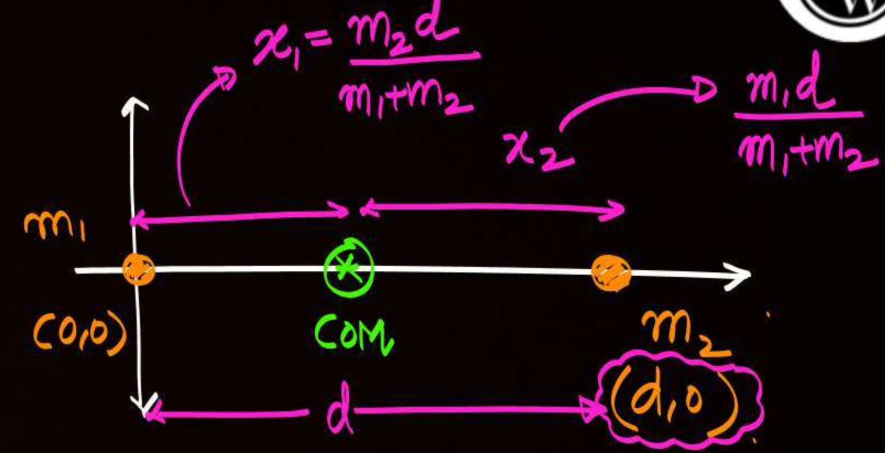


COM will shift to point 3.

*



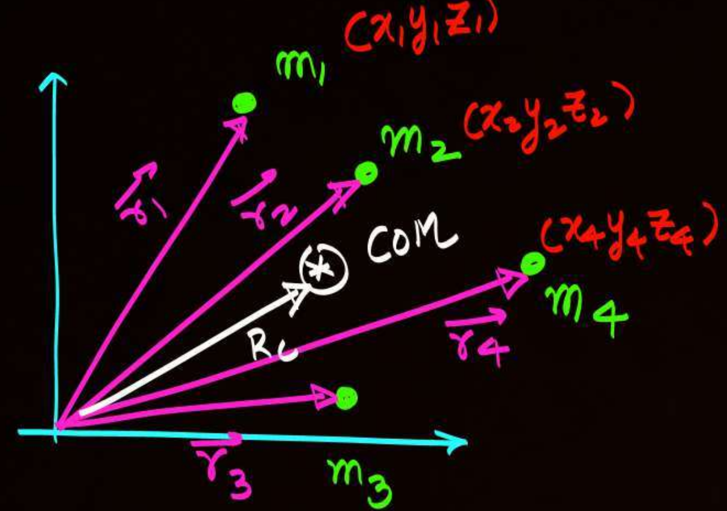
$$\boxed{\vec{R}_c = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1+m_2}}$$



$$\vec{R}_{com} = \frac{m_1(0\hat{i}+0\hat{j}) + m_2(d\hat{i}+0\hat{j})}{m_1+m_2}$$

$$\boxed{\vec{R}_{com} = \frac{m_2 d}{m_1+m_2}}$$

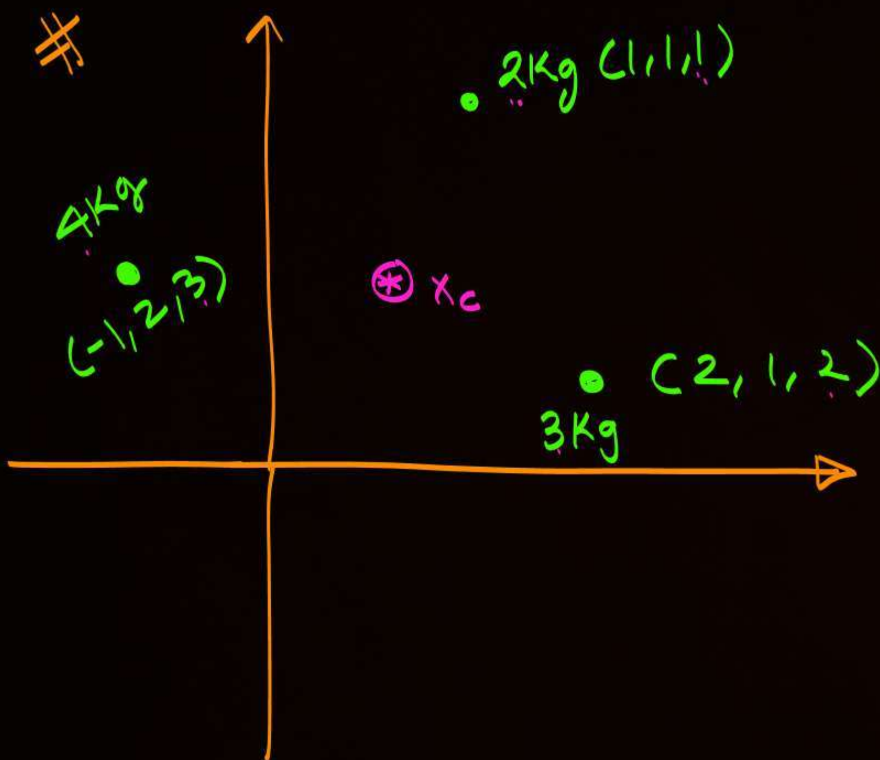
⊛



$$\vec{R_c} = \frac{m_1\vec{r_1} + m_2\vec{r_2} + \cdots\cdots m_n\vec{r_n}}{m_1 + m_2 + \cdots\cdots m_n}$$

$$\boxed{\vec{R_c} = \frac{\sum m_i\vec{r_i}}{\sum m_i}}$$

$$\boxed{X_{com} = \frac{\sum m_i x_i}{\sum m_i} \qquad Y_{com} = \frac{\sum m_i y_i}{\sum m_i} \qquad Z_{com} = \frac{\sum m_i z_i}{\sum m_i}}$$



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

$$X_c = \frac{2\times1 + 3\times2 + 4(-1)}{2+4+3}$$

$$Y_c = \frac{2\times1 + 3\times1 + 4\times2}{2+4+3}$$

$$Z_c = \frac{2\times1 + 3\times2 + 4\times3}{2+4+3}$$

5. Centre of Mass of Continuous $\boxed{\text{Distribution of Mass}}$

discrete Mass $\Rightarrow$ Point mass

• M

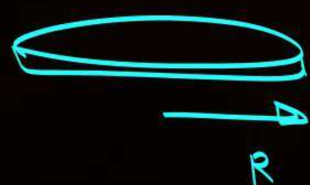
Continous bodies $\Rightarrow$ Mass is distributed.

⊛ Rod

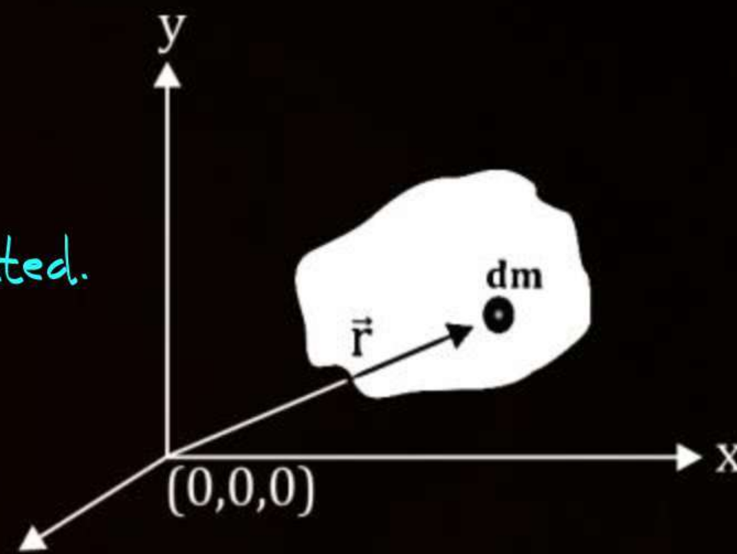
M

⊛

M



disc



Notes

discrete Masses

$$X_c = \frac{\sum m_i x_i}{\sum m_i}$$

$$Y_c = \frac{\sum m_i y_i}{\sum m_i}$$

m = mass of particle.

x = x Coordinate of particle.

y = y Coordinate of particle.

Continous bodies. (Rod, Ring, disc, sphere, Cone)

$$X_c = \frac{\int x\, dm}{\int dm}$$

x = x Coordinate of Element.

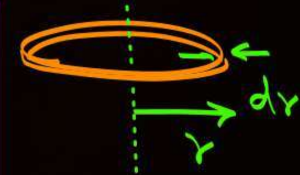
$\boxed{dm \rightarrow \text{mass of Element}}$

Rod: $dm = \lambda dx$

disc: $dm = \sigma dA$

Sphere: $dm = \rho dV$

* uniform $\lambda = \frac{M}{L}$
* Non-uniform λ = Given

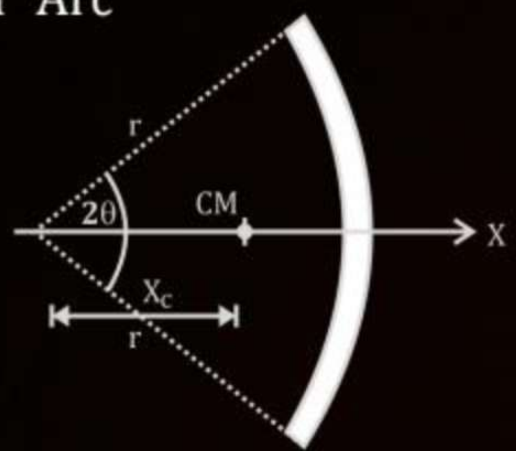


$dA = 2\pi r dr$.

$\boxed{dV = 4\pi r^2 dr}$

❖ **Centre of mass of some uniform symmetric bodies are**

(i) Circular Arc

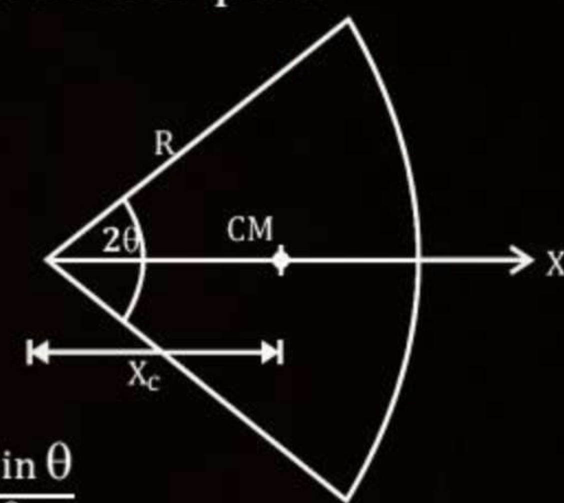


$$x_c = \frac{r \sin \theta}{\theta}$$

Note: Here θ is in radians.

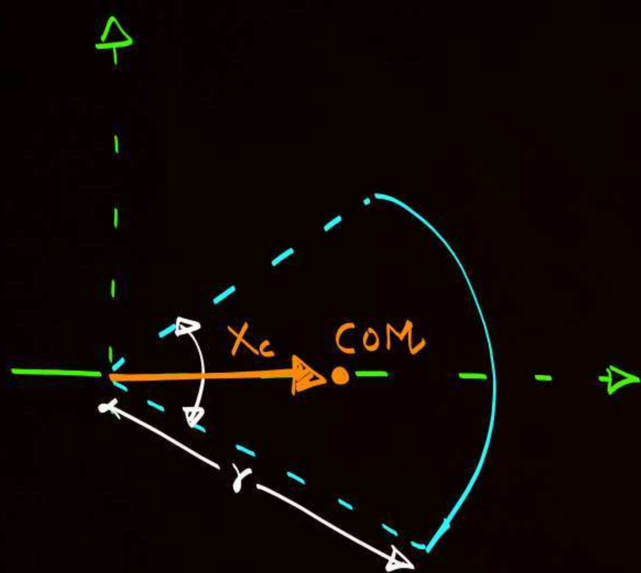
2θ = Total Angle

(ii) Sector of a circular plate



$$x_c = \frac{2r \sin \theta}{3\theta}$$

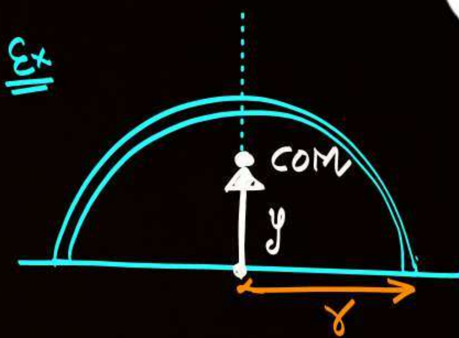
Arc



Total Angle = 2θ

$$X_c = \frac{r\sin\theta}{\theta}$$

Ex



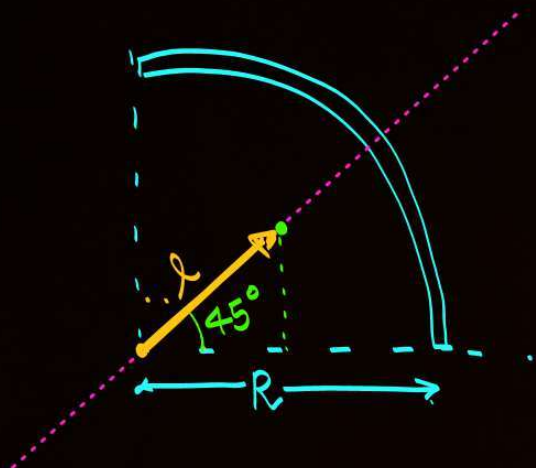
$2\theta = \pi$

$\theta = \frac{\pi}{2}$

$$y = \frac{r\sin(\pi/2)}{\pi/2}$$

$$\boxed{y = \frac{2r}{\pi}}$$

Coordinate of COM = ?



$$2\theta = \frac{\pi}{2}$$

$$\boxed{\theta = \frac{\pi}{4}}$$

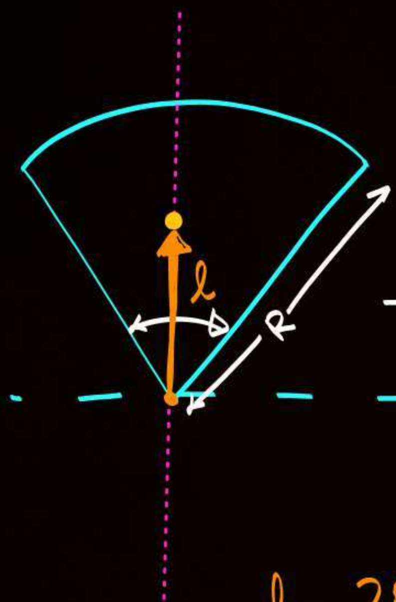
$$l = \frac{R\sin\theta}{\theta} = \frac{R\sin(\pi/4)}{(\pi/4)} = \frac{4R}{\pi} \times \frac{1}{\sqrt{2}}$$

$$\boxed{l = \frac{2\sqrt{2}R}{\pi}}$$

$$\text{Coordinate} = (l\cos 45, l\sin 45)$$

$$= \left(\frac{2R}{\pi}, \frac{2R}{\pi}\right).$$

#

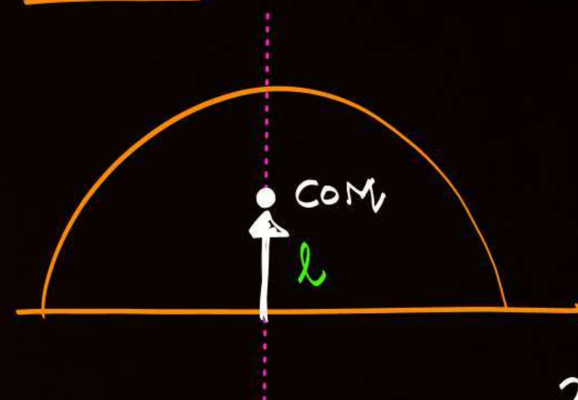


disc.

Total Angle $= 2\theta$.

$$l = \frac{2R\sin\theta}{3\theta}$$

Semi disc.

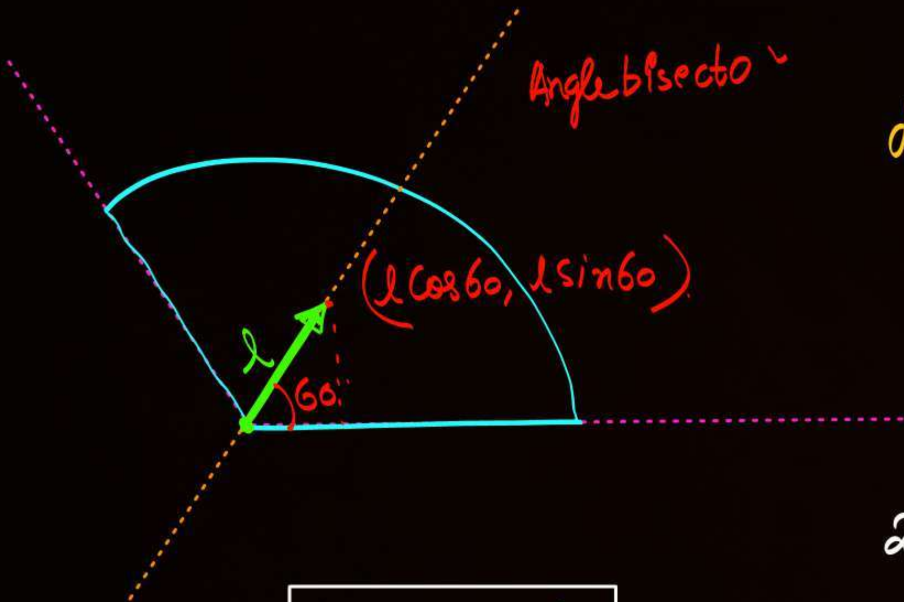


$$2\theta = \pi$$

$$\theta = \frac{\pi}{2}$$

$$l = \frac{2R\sin\theta}{3\theta}$$

$$= \frac{2R\sin(\pi/2)}{3(\pi/2)} = \frac{4R}{3\pi}$$



disc, M,

Radius = R

$\theta = 120^\circ$

Coordinate of COM.

2θ = Total Angle = $\frac{2\pi}{3}$

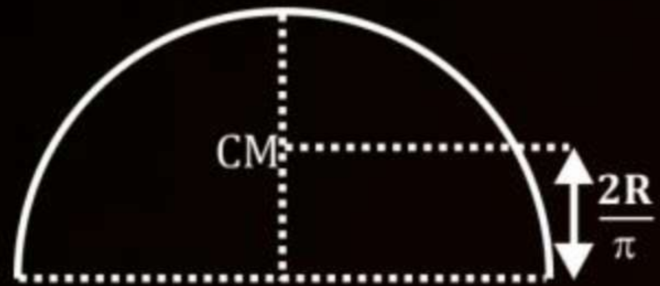
$$\boxed{l = \frac{2R\sin\theta}{3\theta}}$$

$$\boxed{\theta = \frac{\pi}{3}}$$

$$l = \frac{2R\sin(\pi/3)}{3(\pi/3)} = \frac{2R\sqrt{3}}{\pi\ 2} = \frac{R\sqrt{3}}{\pi}$$

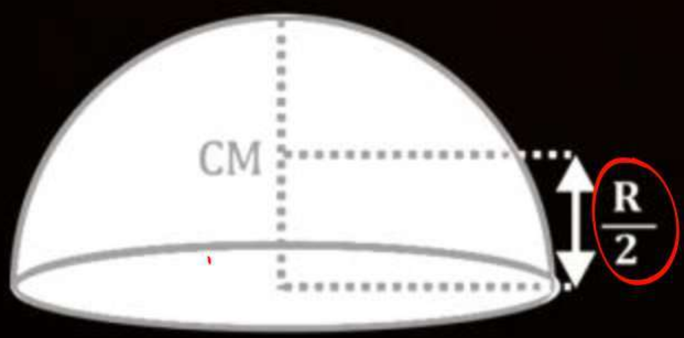
❖ Centre of mass of some uniform symmetric bodies are

(i) Semicircular ring of radius R

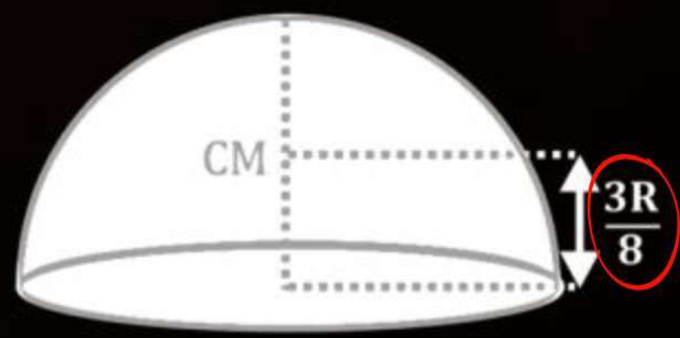


(ii) Semicircular disc

(iii) Hemispherical shell



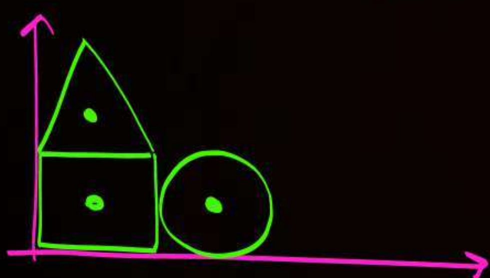
(iv) Solid hemisphere



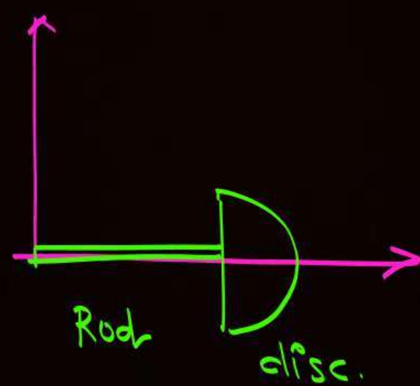
6. Additive Systems and Negative Systems

When bodies are Combined to form System = Additive.

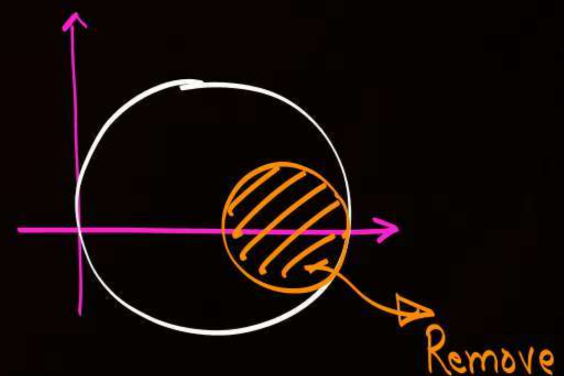
When body is Removed to form a System = Negative.

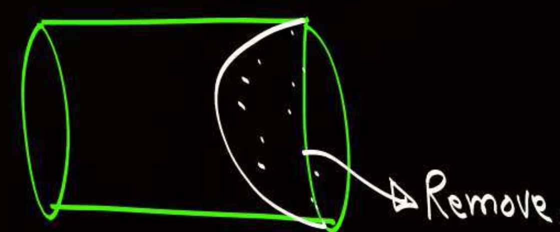


Additive System.



Additive System.



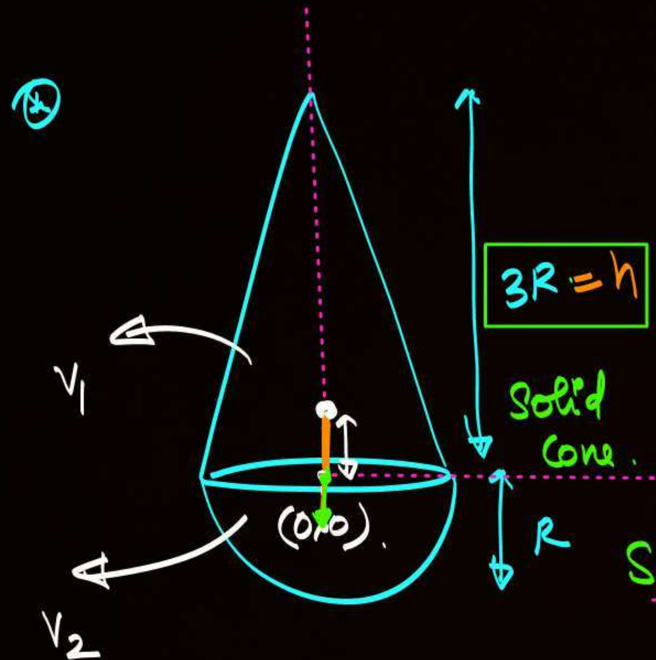


Additive System

mass are Given $\quad X_c = \dfrac{m_1x_1 + m_2x_2}{m_1+m_2}$, $Y_c = \dfrac{m_1y_1 + m_2y_2}{m_1+m_2}$

Area are Given $\quad X_c = \dfrac{A_1x_1 + A_2x_2}{A_1+A_2}$ $\quad Y_c = \dfrac{A_1y_1 + A_2y_2}{A_1+A_2}$

Volume Given $\quad X_c = \dfrac{V_1x_1 + V_2x_2}{V_1+V_2}$ $\quad Y_c = \dfrac{V_1y_1 + V_2y_2}{V_1+V_2}$



Additive.

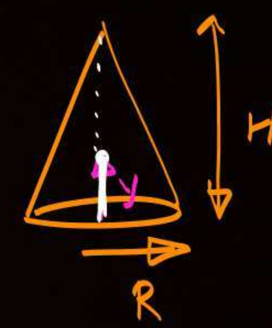
$$y_{com} = \frac{V_1 y_1 + V_2 y_2}{V_1 + V_2}$$

Solid hemisphere.

$$V_1 = \frac{1}{3}\pi R^2 (3R) = \pi R^3 \qquad \left(0, \frac{H}{4}\right) = \left(0, \frac{3R}{4}\right)$$

$$V_2 = \frac{2}{3}\pi R^3 = \frac{2}{3}\pi R^3 \qquad \left(0, -\frac{3R}{8}\right) = \left(0, -\frac{3R}{8}\right).$$

Com



Solid $y = \frac{H}{4}$

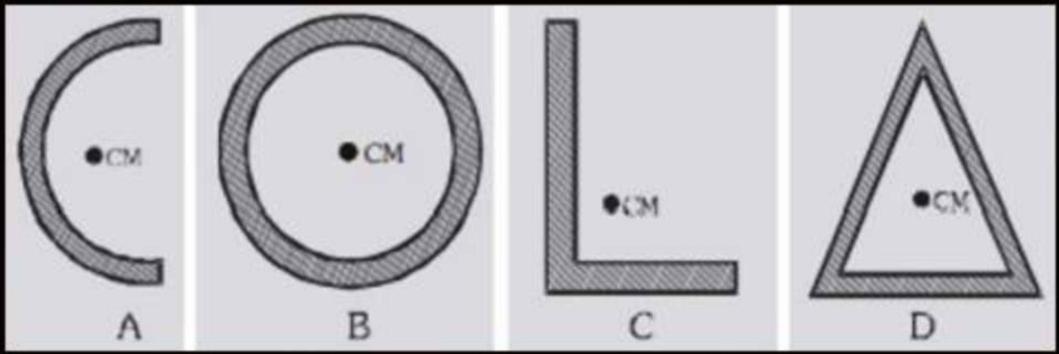
Hollow $y = \frac{H}{3}$.

Negative System.

Area problems $\Rightarrow$ $X_c = \dfrac{A_1x_1 - A_2x_2}{A_1 - A_2}$, $Y_c = \dfrac{A_1y_1 - A_2y_2}{A_1 - A_2}$

Volume problem = $X_c = \dfrac{V_1x_1 - V_2x_2}{V_1 - V_2}$ $Y_c = \dfrac{V_1y_1 - V_2y_2}{V_1 - V_2}$.

Important points



- There may or may not be any mass present physically at the centre of mass (See figure A, B, C, D)
- Centre of mass may be inside or outside a body (See figure A, B, C, D)
- Position of centre of mass depends on the shape of the body. (See figure A, B, C, D)
- For a given shape_ it depends on the distribution of mass within the body and is closer to massive portion

Question 1

Two bodies of mass 1 kg and 3 kg have position vectors $\hat{\imath} + 2\hat{\jmath} + \hat{k}$ and $-3\hat{\imath} - 2\hat{\jmath} + \hat{k}$ respectively. The magnitude of position vector of centre of mass of this system will be similar to the magnitude of vector : [JEE (Main)-2022]

(A) Ans $\hat{\imath} + 2\hat{\jmath} + \hat{k}$ $|A| = \sqrt{1^2+2^2+1^2} = \sqrt{6}$

(B) $-3\hat{\imath} - 2\hat{\jmath} + \hat{k}$

(C) $-2\hat{\jmath} + \hat{k}$

(D) $-2\hat{\imath} - \hat{\jmath} + 2\hat{k}$

1 Kg $(\hat{i}+2\hat{j}+\hat{k})$

3 Kg $(-3\hat{i}-2\hat{j}+\hat{k})$

$$\vec{R}_c = \frac{(\hat{i}+2\hat{j}+\hat{k})+(-9\hat{i}-6\hat{j}+3\hat{k})}{4}$$

$$= \frac{-8\hat{i}-4\hat{j}+4\hat{k}}{4} = -2\hat{i}-\hat{j}+\hat{k}$$

$$|R| = \sqrt{2^2+1^2+1^2} = \sqrt{6}$$

Question 2

Three point particles of masses 1.0 kg, 1.5 kg and 2.5 kg are placed at three corners of a right angle triangle of sides 4.0 cm, 3.0 cm and 5.0 cm as shown in the figure. The center of mass of the system is **JEE Main 2020 - 7 January (Morning)**

At a point:

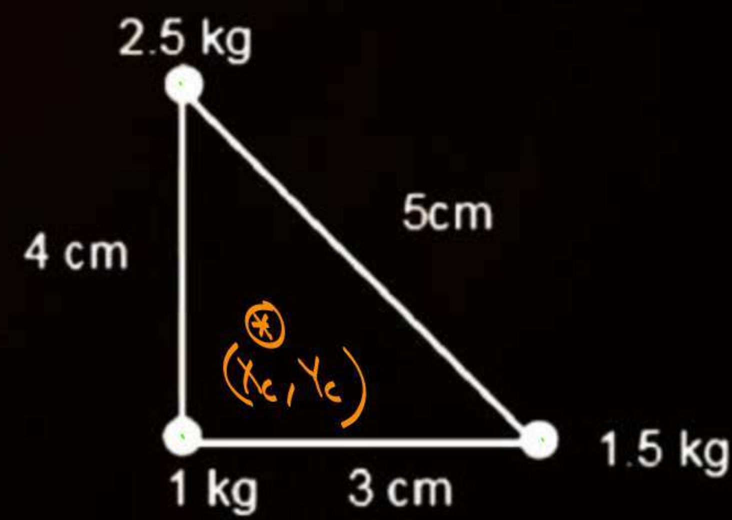
A 0.6 cm to the right and 2 cm above 1 kg mass

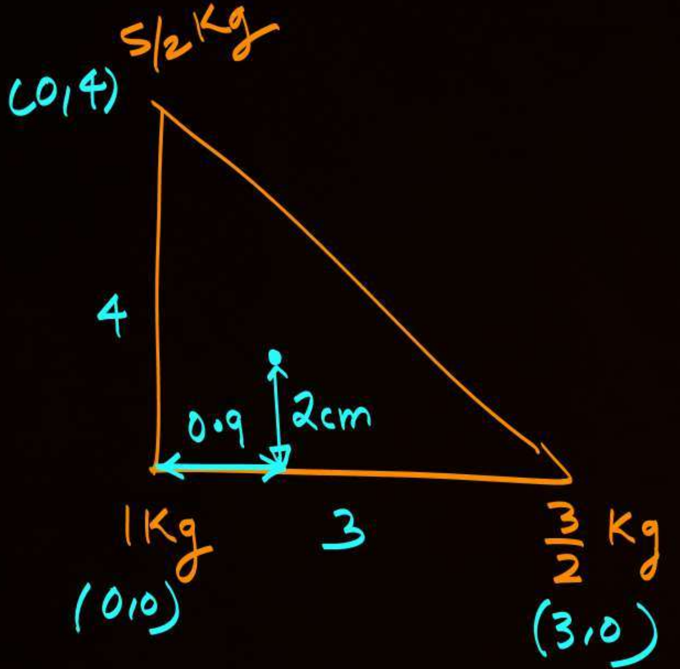
B 0.9 cm to the right and 2 cm above 1 kg mass

Ans

C 0.9 cm to the left and 2 cm above 1 kg mass

D 0.9 cm to the right and 1.5 cm above 1 kg mass





$$x_c = \frac{1\times 0 + \frac{3}{2}\times 3 + \frac{5}{2}\times 0}{5}$$

$$= 0.9 \text{ cm}$$

$$Y_c = \frac{1\times 0 + \frac{3}{2}\times 0 + \frac{4\times 5}{2}}{5}$$

$$= 2 \text{ cm}$$

* Location of COM doesnot depend on Coordinate System.
* Coordinate of COM depends on Coordinate axis.

Question 3

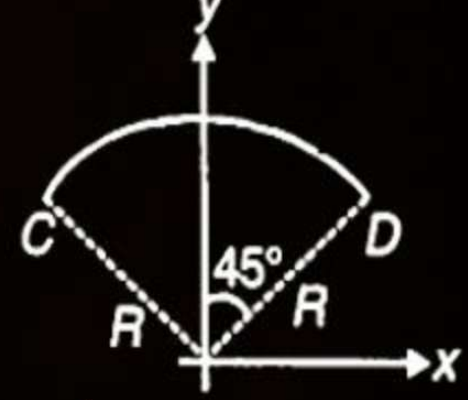
A circular arc CD of thin wire frame of radius R and mass M with center at origin makes an angle of $90°$ at the origin. The y-coordinate center of mass of the arc lies at

A $\frac{\sqrt{2}R}{\pi}$

B $\frac{R}{2\pi}$

C $\frac{2R}{\pi}$

D $\frac{2\sqrt{2}R}{\pi}$ Ans



$2\theta = \pi/2$

$\theta = \pi/4$

Question 4

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

A. $a/10$ Ans

B. $a/8$

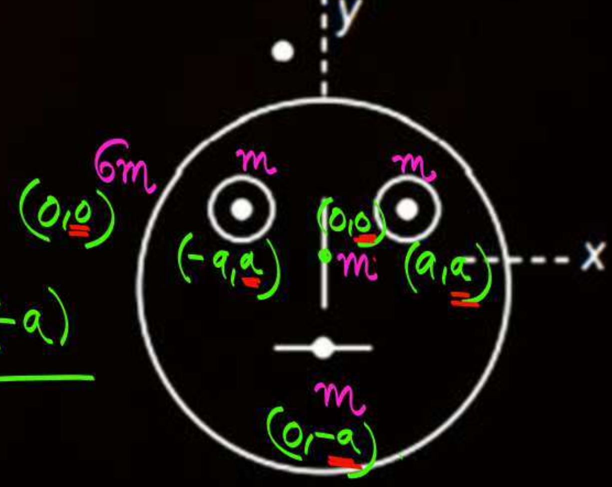
C. $a/12$

D. $a/3$

Additive

$$Y_c = \frac{m_1y_1 + m_2y_2 - - m_ny_n}{m_1 + m_2 - - - m_n}$$

$$= \frac{6m(0) + m(a) + m(0) + m(a) + m(-a)}{6m + 4m}$$



Question 5

Sheet.

Find the coordinates of centre of mass of the lamina, shown in figure

JEE Main 2020 - 8 January (Morning)

A 0.75, 1.75

B 0.75, 1.5

C 0.5, 1.75

D 0.5, 1.5

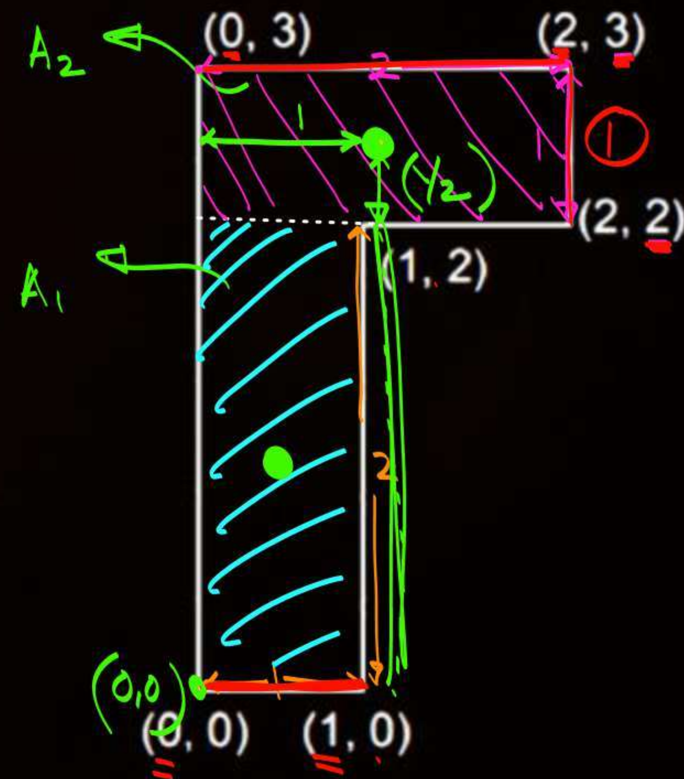
Additive System.

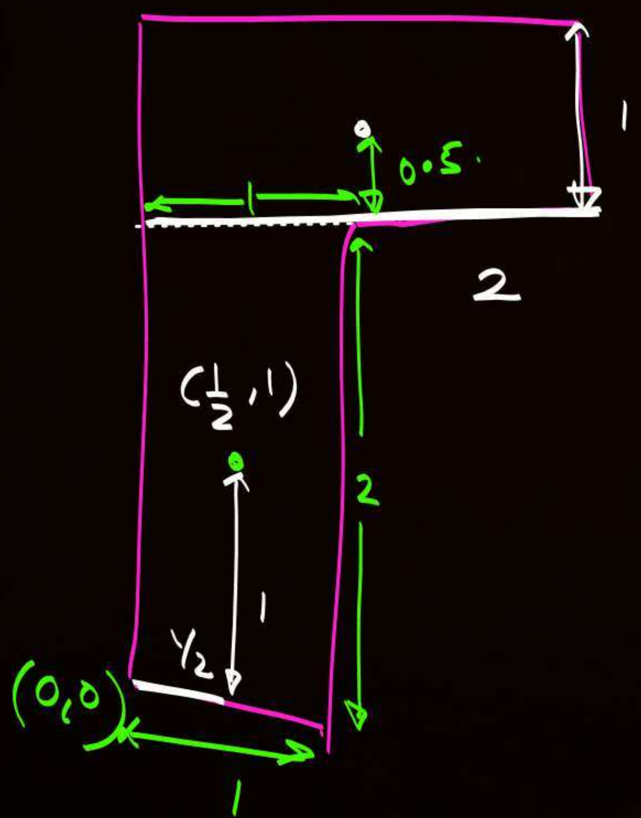
$A_1 = 1 \times 2 = 2$. $\left(\frac{1}{2}, 1\right)$

$A_2 = 2 \times 1 = 2$. $(1, 2.5)$

$$X_c = \frac{A_1 x_1 + A_2 x_2}{A_1 + A_2} = \frac{2 \times \frac{1}{2} + 2 \times 1}{4} =$$

$$Y_c = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2} = \frac{2 \times 1 + 2 \times 2.5}{4} =$$





1
0.5
1
2
(1/2, 1)
2
1
1/2
(0,0)
1

Question 6

A circular hole of radius $\left(\frac{a}{2}\right)$ is $\boxed{\text{cut}}$ out of a circular disc of radius 'a' shown in figure. The centroid of the remaining circular portion with respect to point 'O' will be :

24 Feb (Shift 2) - Single Correct 2021

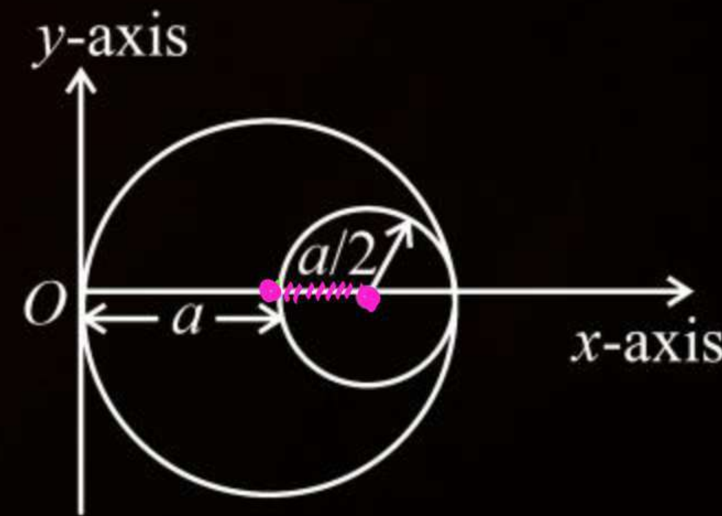
$A_1 = A_{bigger}$ $(a, 0)$

$= \pi a^2$

$A_2 = A_{smaller}$ $\left(\frac{3a}{2}, 0\right)$

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

$= \frac{\pi a^2}{4}$



A. $\frac{10}{11}a$

B. $\frac{2}{3}a$

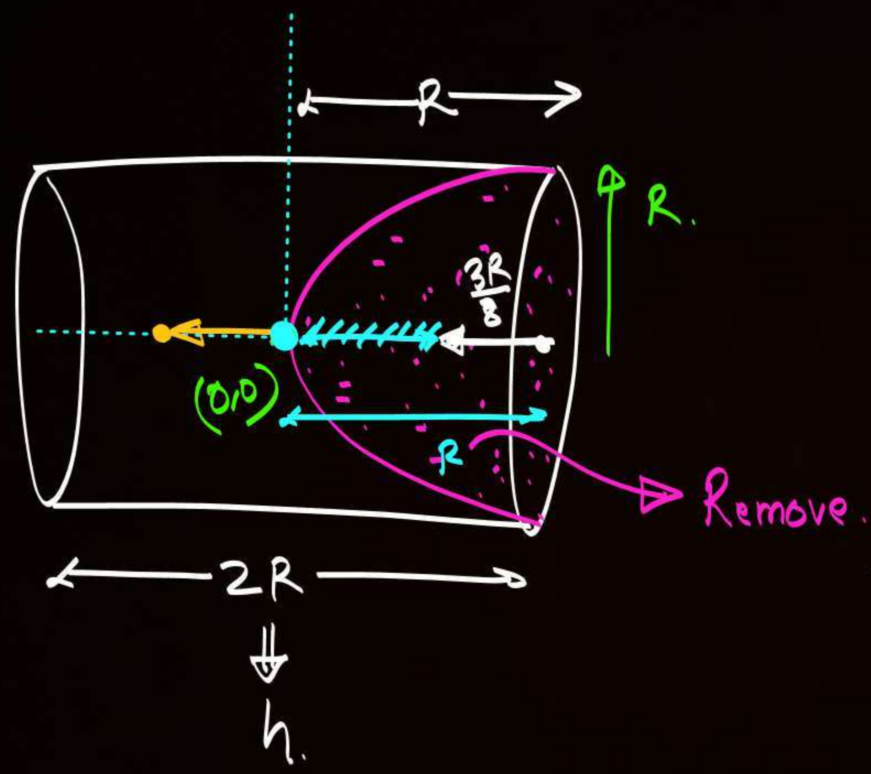
C. $\frac{1}{6}a$

D. $\frac{5}{6}a$

$$x_c = \frac{A_{bigger}\, x_{bigger} - A_{smaller}\, x_{smaller}}{A_{big} - A_{small}}.$$

$$x_c = \frac{\pi a^2 (a) - \frac{\pi a^2}{4}\left(\frac{3a}{2}\right)}{\pi a^2 - \frac{\pi a^2}{4}} = \_$$

#



Find Coordinate of com of Remaining part.

Negative (Volume).

$V_1 \text{ (bigger)} = \pi R^2 (2R)$ $\quad (0, 0)$

$V_2 \text{ (smaller)} = \frac{2}{3}\pi R^3$ $\quad \left(R - \frac{3R}{8}, 0\right)$

Question 7

A rod of length L has $\boxed{\text{non-uniform linear}}$ mass density given by $\rho(x) = a + b\left(\frac{x}{L}\right)^2$, where a and b are constants and $0 \le x \le L$. The value of sc for the centre of mass of the rod is at :

JEE Main 2020 - 9 January (Evening)

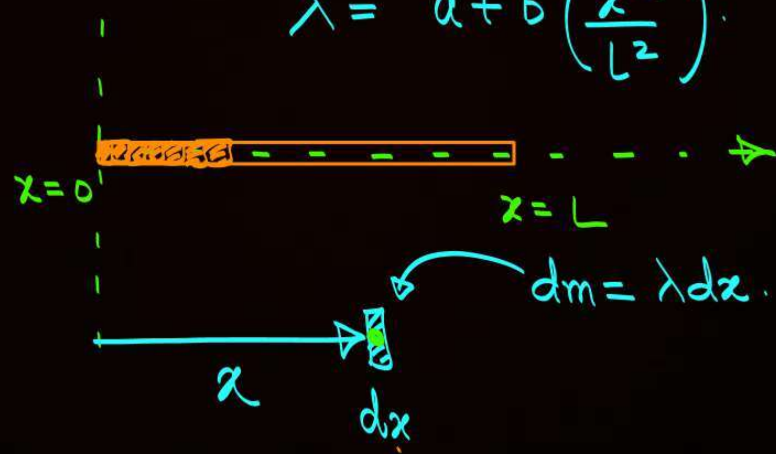
A $\frac{4}{3}\left(\frac{a+b}{2a+3b}\right)L$

B $\frac{3}{4}\left(\frac{2a+b}{3a+b}\right)$

C $\frac{3}{2}\left(\frac{2a+b}{3a+b}\right)L$

D $\frac{3}{2}\left(\frac{a+b}{2a+b}\right)L$

$\lambda = a + b\left(\frac{x^2}{L^2}\right)$



$dm = \lambda dx = \left(a + \frac{bx^2}{L^2}\right)dx$

$$X_{com} = \frac{\int x\,dm}{\int dm} = \frac{\int_0^L x\left(a + \frac{bx^2}{L^2}\right) dx}{\int_0^L \left(a + \frac{bx^2}{L^2}\right) dx}$$

$dx \rightarrow$ Variable.

$$\boxed{X = \frac{\int_0^L ax\,dx + \int_0^L \frac{bx^3}{L^2} dx}{\int_0^L a\,dx + \int_0^L \frac{bx^2\,dx}{L^2}}}$$

Question

HW

Three particles of masses 50 g, 100 g and 150 g are placed at the vertices of an equilateral triangle of side 1 m (as shown in the figure). The (x, y) coordinates of the centre of mass will be

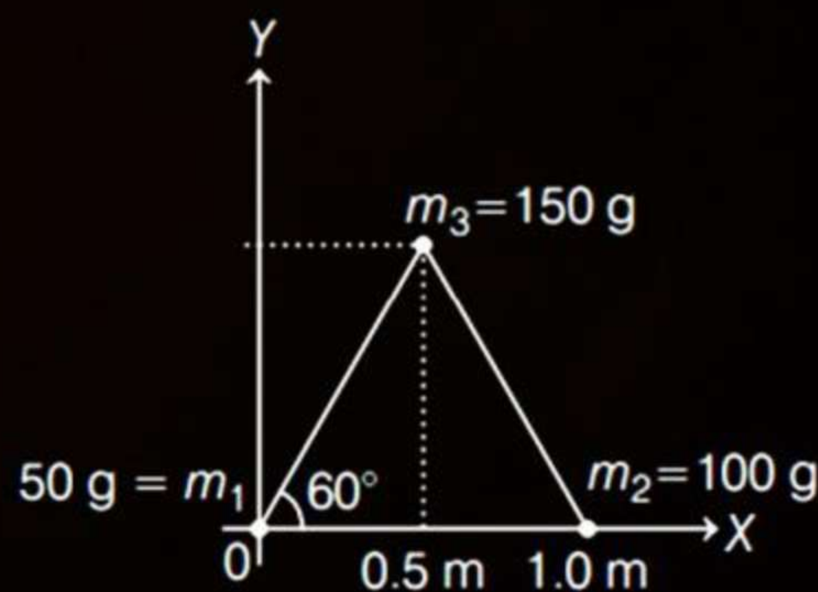
(2019 Main, 12 April II)

A $\left(\frac{\sqrt{3}}{4}m, \frac{5}{12}m\right)$

B $\left(\frac{7}{12}m, \frac{\sqrt{3}}{8}m\right)$

C $\left(\frac{7}{12}m, \frac{\sqrt{3}}{4}m\right)$

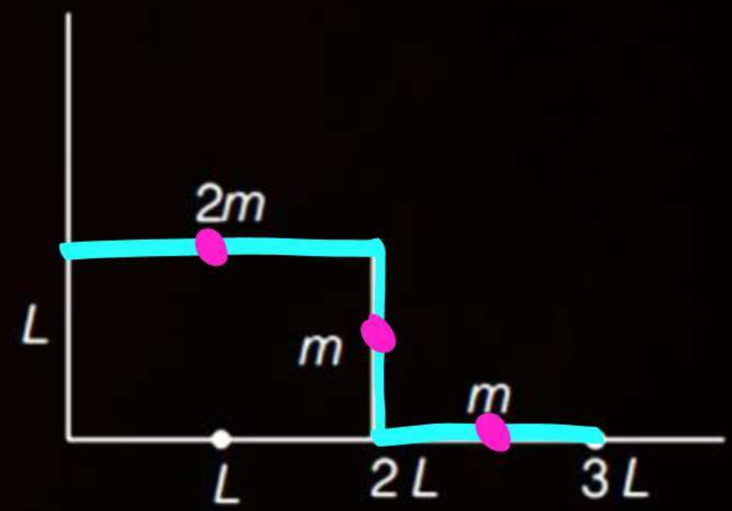
D $\left(\frac{\sqrt{3}}{8}m, \frac{7}{12}m\right)$



Question

HW

The position vector of the centre of mass r_{cm} of an asymmetric uniform bar of negligible area of cross-section as shown in figure is **(2019 Main, 12 Jan I)**



A $r = \frac{13}{8} L\,\hat{x} + \frac{5}{8} L\,\hat{y}$

B $r = \frac{11}{8} L\,\hat{x} + \frac{3}{8} L\,\hat{y}$

C $r = \frac{3}{8} L\,\hat{x} + \frac{11}{8} L\,\hat{y}$

D $r = \frac{8}{8} L\,\hat{x} + \frac{13}{8} L\,\hat{y}$

Question

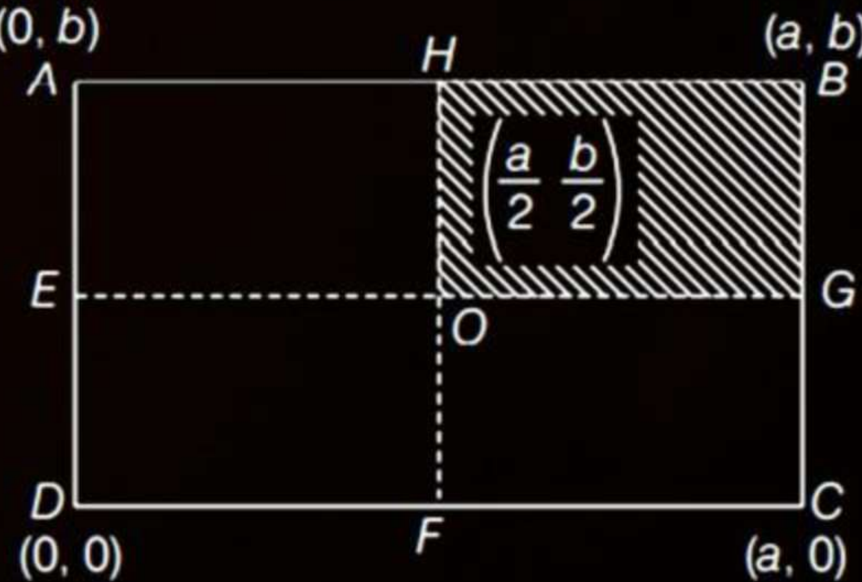
A uniform rectangular thin sheet *ABCD* of mass M has length a and breadth b, as shown in the figure. If the shaded portion *HBGO* is cut-off, the coordinates of the centre of mass of the remaining portion will be **(2019 Main, 8 April II)**

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

B $\left(\frac{5a}{12}, \frac{5b}{12}\right)$

C $\left(\frac{3a}{4}, \frac{3b}{4}\right)$

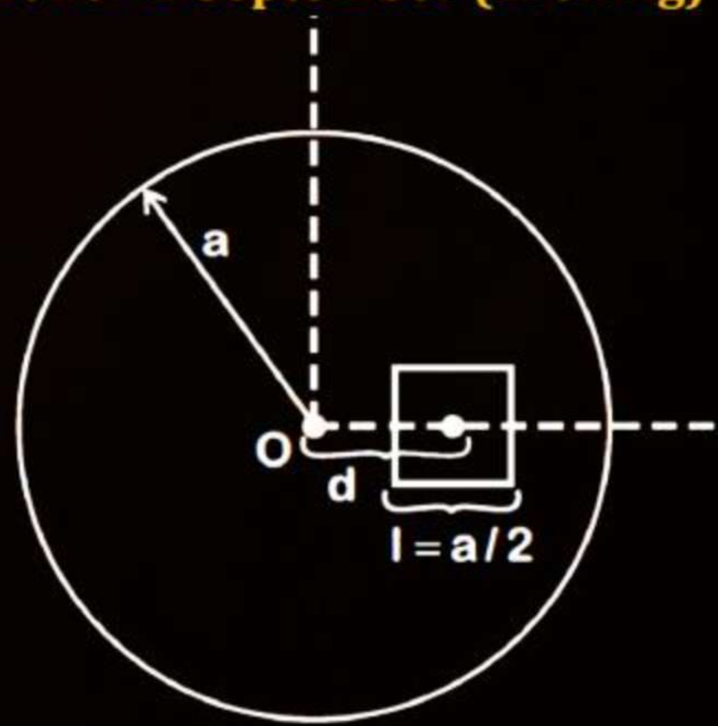
D $\left(\frac{5a}{3}, \frac{5b}{3}\right)$



Question

A square shaped hole of side $I = a/2$ is carved out at a distance $d = a/2$ from the centre 'O' of a uniform circular disk of radius a. If the distance of the centre of mass of the remaining portion from O is $-a/x$, value of x (to the nearest integer) is

JEE Main 2020 - 2 September (Evening)



Question

HW

A rod of length L has non-uniform linear mass density given by $\rho(x) = a + b\left(\frac{x}{L}\right)^2$, where a and b are constants and $0 \le x \le L$. The value of x for the centre of mass of the rod is at

[JEE (Main)-2020]

A $\frac{3}{2}\left(\frac{a+b}{2a+b}\right)L$

B $\frac{4}{2}\left(\frac{a+b}{2a+3b}\right)L$

C $\frac{3}{2}\left(\frac{2a+b}{3a+b}\right)L$

D $\frac{3}{4}\left(\frac{2a+b}{3a+b}\right)L$

Question HW

The distance of centre of mass from end A of a one dimensional rod (AB) having mass density $\rho = \rho_0\left(1 - \frac{x^2}{L^2}\right)$ kg/m and length L (in meter) is $\frac{3L}{\alpha}$ m. The value of α is ____.
(where x is the distance from end A)

[JEE (Main)-2022]

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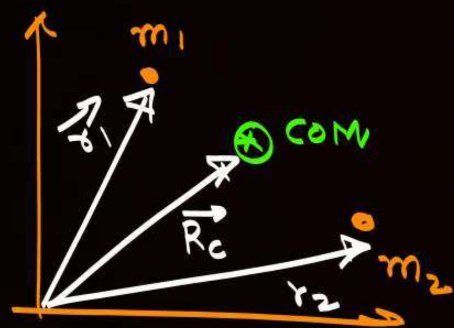
MOTION OF CENTRE OF MASS

❖ **Shifting of com**



$$\vec{R_c} = \frac{m_1\vec{r_1} + m_2\vec{r_2}}{m_1+m_2}$$

If Particles are displaced.

Shift in m_1

$$\boxed{\vec{\Delta R}_{com} = \frac{m_1\vec{\Delta R_1} + m_2(\vec{\Delta R_2})}{m_1+m_2}}$$

Shift in m_2 Particle.

Shift of COM.

If particles has Velocity $\vec{v}_1$ & $\vec{v}_2$

$$\vec{V}_{com} = \frac{d}{dt}\vec{\Delta R}_{com} = \frac{d}{dt}\left(\frac{m_1\vec{\Delta R}_1 + m_2\vec{\Delta R}_2}{m_1+m_2}\right)$$

$$\boxed{\vec{V}_{com} = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1+m_2}}$$

diff wrt time

$$\boxed{\vec{a}_{com} = \frac{m_1\vec{a}_1 + m_2\vec{a}_2}{m_1+m_2}}$$

Question 8

Two blocks of masses 10 kg and 30 kg are placed on the same straight line with coordinates $(0, 0)$cm and $(x, 0)$cm respectively. The block of 10 kg is moved on the same line through a distance of 6 cm towards the other block. The distance through which the block of 30 kg must be moved to keep the position of centre of mass of the system unchanged is

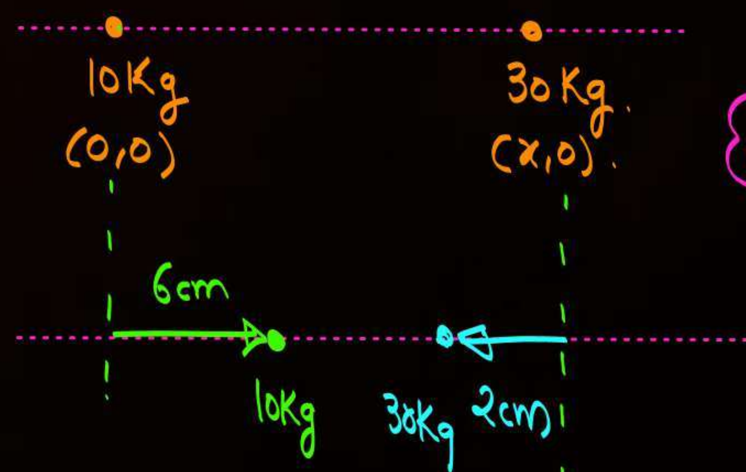
[JEE (Main)-2022]

A 4 cm towards the 10 kg block

B 2 cm away from the 10 kg block

C 2 cm towards the 10 kg block Ans

D 4 cm away from the 10 kg block



$\Delta \vec{R}_{com} = 0$

$$\Delta\vec{R}_{com} = \frac{m_1\Delta\vec{R}_1 + m_2\Delta\vec{R}_2}{m_1+m_2}$$

as per Question

$$0 = \frac{10(6\hat{i}) + 30(\Delta\vec{R})}{10+30}$$

$$-60\hat{i} = 30\,\Delta R$$

$$\Delta R = -2\hat{i}$$

Question 9

H-W

Consider a system having two masses m_1 and m_2 in which first mass is pushed towards the centre of mass by a distance a. The distance by which the second mass should be moved to keep the centre of mass at same position is :-

A $\frac{m_1}{m_2}a$

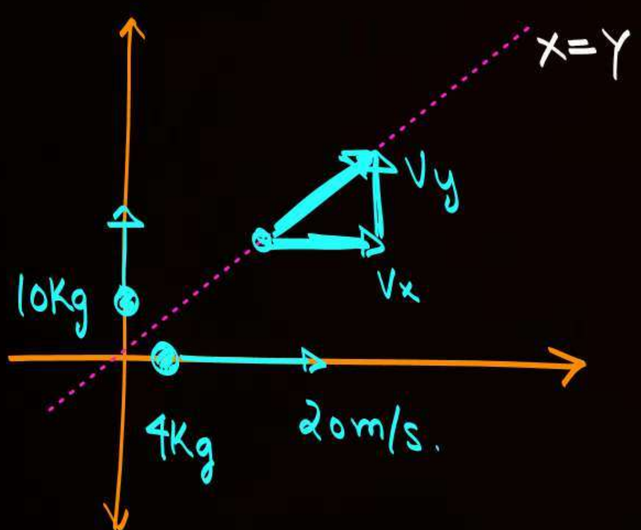
B $\frac{m_1}{(m_1+m_2)}a$

C $\frac{m_2}{m_1}a$

D $\left(\frac{m_2}{m_1+m_2}\right)a$

Question 10

A body of mass 4 kg moves along $+X$ direction at speed 20 m/s. Find the speed with which a 10 kg mass should move along $+Y$ direction such that their centre of mass travels along line $x = y$. Assume both particle starts at the same time from origin.



$$\vec{V}_{com} = \frac{m_1\vec{v_1} + m_2\vec{v_2}}{m_1+m_2}$$

$$\vec{V}_{com} = \frac{4\times 20\hat{i} + 10v\hat{j}}{10+4}$$

$$\vec{V}_{com} = \underbrace{\left(\frac{4\times 20}{14}\right)}_{V_x}\hat{i} + \underbrace{\left(\frac{10v}{14}\right)}_{V_y}\hat{j}$$

for Particle to Move on x=Y line

$V_x = V_y$

$$\frac{4\times 2\cancel{0}}{\cancel{14}} = \frac{\cancel{10}v}{\cancel{14}}$$

$v = 8$ Ans

Question 11

Two blocks of masses 10 kg and 4 kg are connected by a spring of negligible mass and placed on frictionless horizontal surface. An impulse gives a velocity of 14 m/s to the heavier block in the direction of the lighter block. The velocity of the centre of mass if

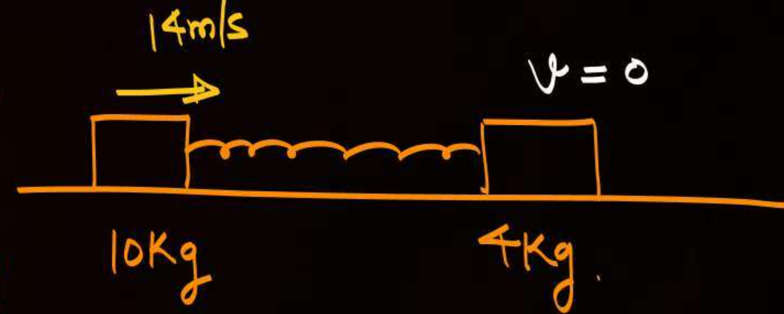
A 30 m/s

B 20 m/s

C 10 m/s Ans

D 5 m/s

Spring ⇒ Anter Pantar.



$$V_{com} = \frac{10\times 14\hat{i} + 4\times 0}{10+4}$$

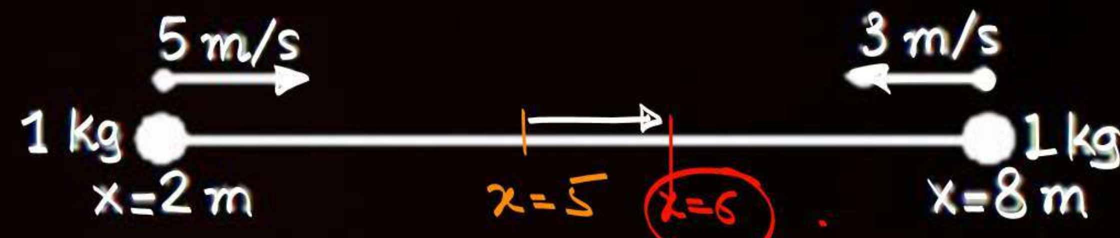
$$= 10\hat{i}$$

Question 12

The figure shows the positions and velocities of two particles. It the particles move under the mutual attraction of each other, then the position of centre of mass at $t = 1$ s is :-

$\{F_{ext} = 0\}$

$\boxed{\vec{P_i} = \vec{P_f}}$



A $x = 5$ m

B $x = 6$ m Ans

C $x = 3$ m

D $x = 2$ m

$\vec{V}_{com} = \dfrac{1\times5\hat{i} + 1\times(-3\hat{i})}{2} = 1\,m/s\,\hat{i}$ // In Each sec it will travel 1m.

Initially. $X_{com} \Rightarrow \dfrac{m_1x_1 + m_2x_2}{m_1+m_2} = \dfrac{1\times2\hat{i} + 1\times8\hat{i}}{2} = 5\hat{i}$ //

In 1 sec COM will move by 1m.

Newton's 2nd Law

$$f_{ext} = \frac{dP}{dt}$$

$$0 = \frac{d\vec{P}}{dt} \Rightarrow \vec{P} = \text{Conserved.}$$

→ Initially = Finally
Rest   Rest

→ Initially = finally
v = move   v = Move.

Question

Two particles A and B initially at rest, move towards each other under their mutual force of attraction. At the instant when the speed of A is v and the speed of B is $2v$. the speed of the centre of mass of the system is:

A $3v$

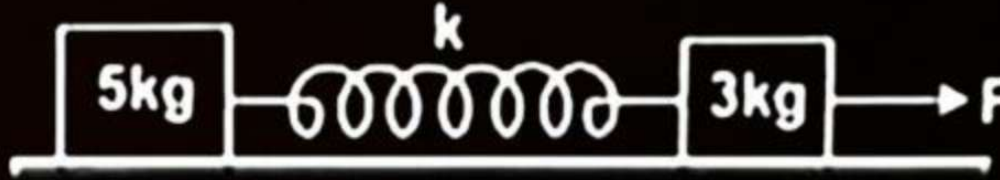
B v

C $1.5v$

D zero

Question 13

Two blocks of masses 3 kg and 5 kg are connected by an ideal spring and placed on a smooth surface as shown. A force of 40 N is applied on 3 kg block and it is observed that at an instant acceleration of 3 kg mass is 2 m/s. Find acceleration of 5 kg mass at this instant.



Question 14

Two bodies of masses m and $2m$, are connected to the ends of a massless cord and allowed to move as shown in figure. The pulley is massless and frictionless. Calculate the acceleration oi the centre of mass.

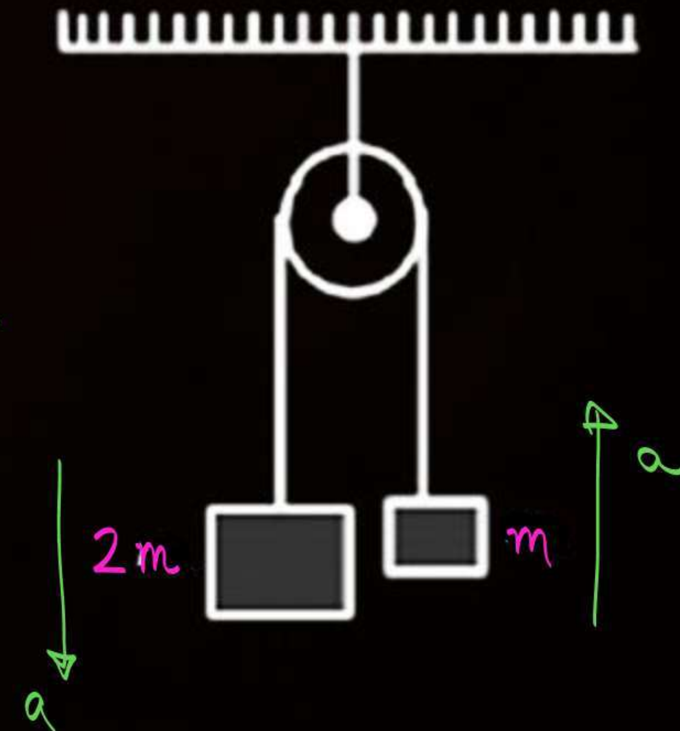
$$\boxed{\vec{a}_{com} = \frac{m_1\vec{a_1} + m_2\vec{a_2}}{m_1+m_2}}$$

$$\vec{a}_{com} = \frac{2m\left(\frac{g}{3}\,-\hat{j}\right) + m\left(\frac{g}{3}\right)\hat{j}}{3m}$$

$$= \left(\frac{-\frac{2mg}{3} + \frac{mg}{3}}{3m}\right)\hat{j} = -\frac{g}{9}\hat{j}$$

$$a = \frac{2mg - mg}{3m}$$

$$\boxed{a = \frac{g}{3}}$$



Question 15

Four particles A, B, C an D with masses $m_A = m$, $m_B = 2m$, $m_C = 3m$ and $m_D = 4m$ are at the corners of a square. They have accelerations of equal magnitude with directions as shown. The acceleration of the centre of mass of mass of the particles (in ms^{-2}) is

(2019 Mian, 8 April I)

A $\frac{a}{5}(\hat{\imath} - \hat{\jmath})$ Ans

B $a(\hat{\imath} - \hat{\jmath})$

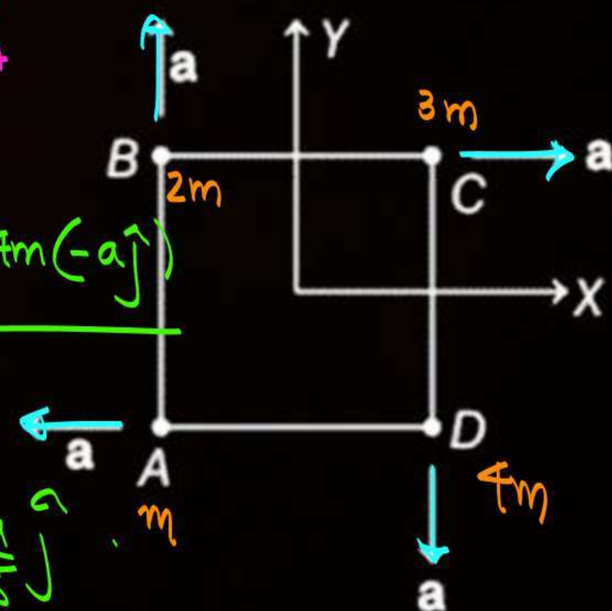
C Zero

D $\frac{a}{5}(\hat{\imath} + \hat{\jmath})$

$$\vec{a}_{com} = \frac{m_1\vec{a}_1 + m_2\vec{a}_2 + m_3\vec{a}_3 + m_4\vec{a}_4}{m_1 + m_2 + m_3 + m_4}$$

$$\vec{a}_{com} = \frac{m(-a\hat{i}) + 2m(a\hat{j}) + 3m(a\hat{i}) + 4m(-a\hat{j})}{m + 2m + 3m + 4m}$$

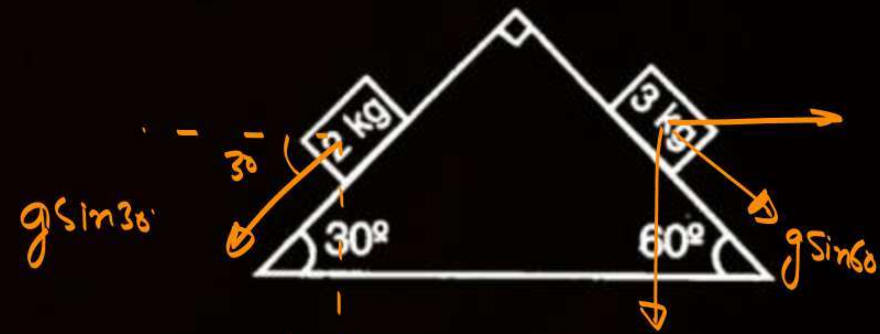
$$= \frac{2ma\hat{i} - 2ma\hat{j}}{10m} = \frac{a}{5}\hat{i} - \frac{a}{5}\hat{j}$$



Question

HW

Figure shows a fixed wedge on which two blocks of masses 2 kg and 3 kg are placed on its smooth inclined surfaces. When the two blocks are released from rest, the x −component of the acceleration of center of mass of the two blocks



A $\frac{\sqrt{3}g}{20}$

B $\frac{g}{20}$

C $\frac{\sqrt{3}g}{10}$

D $\frac{g}{10}$

$$\boxed{\vec{a}_{com} = \frac{m_1\vec{a}_1 + m_2\vec{a}_2}{m_1+m_2}}$$

Break → till → 8:20 PM

Collisions from - 9:30.

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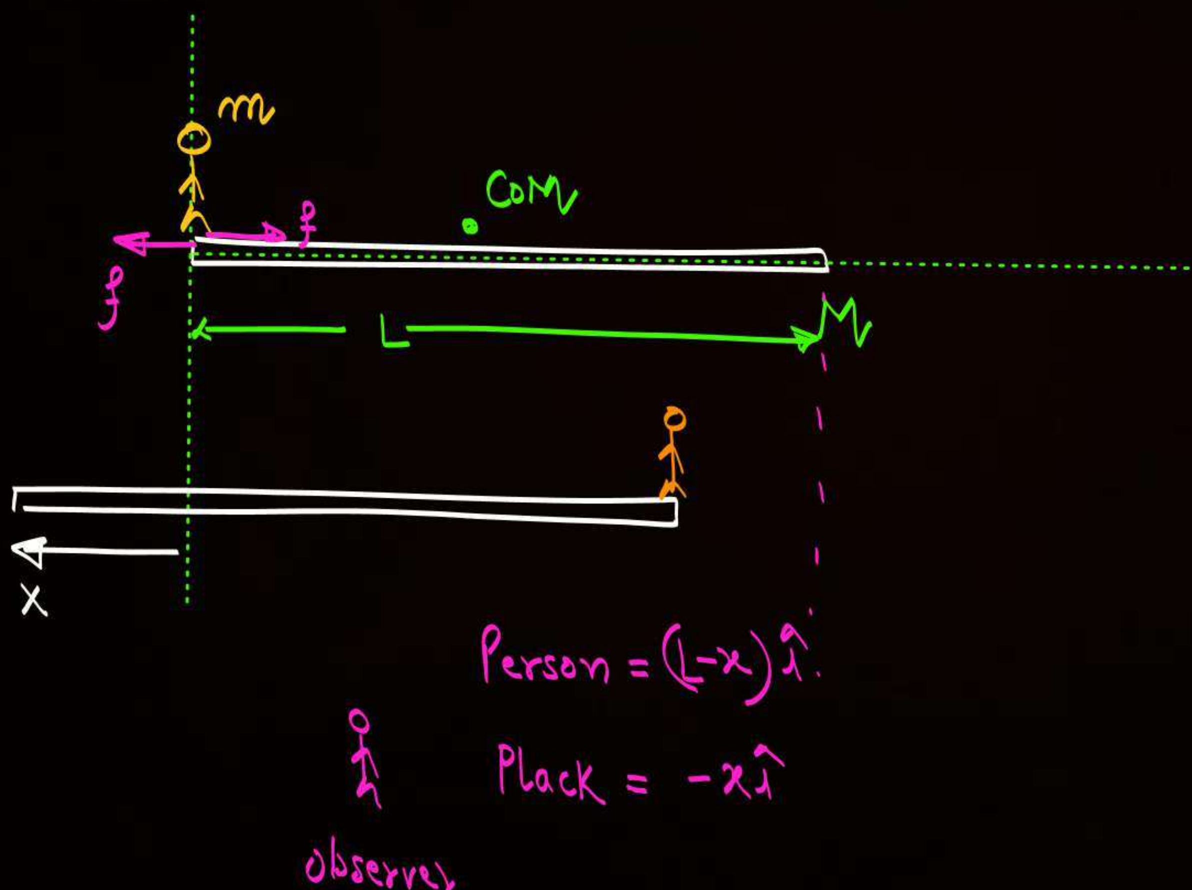
Motion of person on Planck or boat



When Person Move to another end

Shift of boat = ?

along x axis $F_{net\,system} = 0$

$\vec{P}_{i\,sys\,x} = \vec{P}_{f\,system\,x}$

$\vec{\Delta R}_{com\,x} = 0$

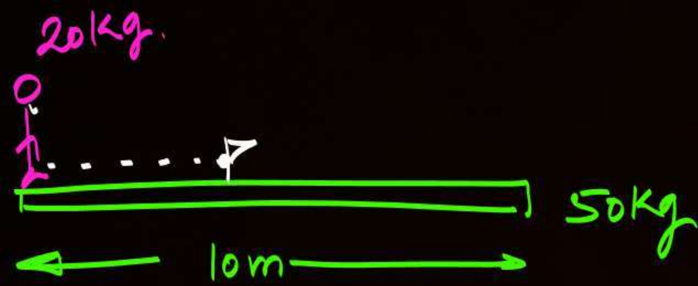
$$\Delta R_{com\,x} = 0 = \frac{m(l-x)\hat{i} - Mx\hat{i}}{M+m}$$

$$ml - mx - Mx = 0$$

$$\boxed{x = \frac{ml}{M+m}}$$

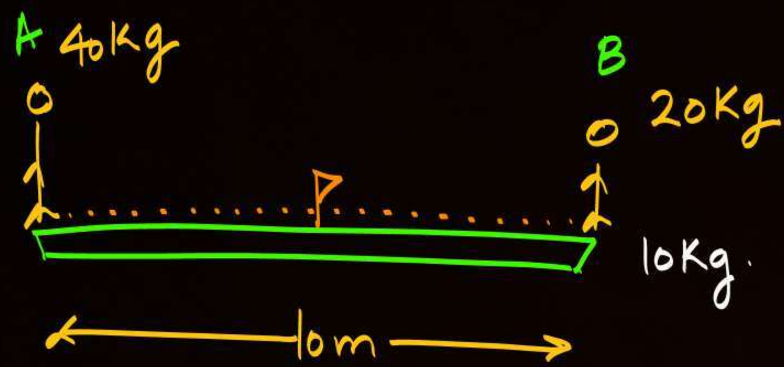
$$\boxed{x_{\text{shift of boat/planck}} = \frac{m_{\text{person move}}(\text{length travelled along x as by person})}{M_{\text{Total}}}}$$

(*)



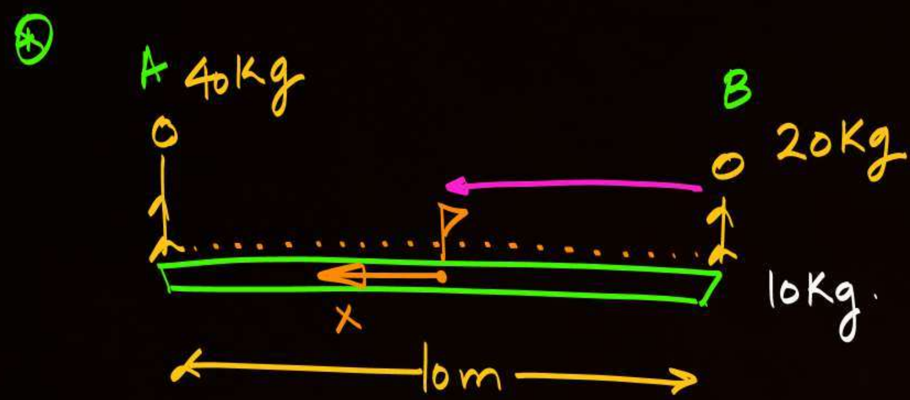
Move to Centre of boat.

Shift of boat = $x_{\text{shift boat}} = \dfrac{20(5)}{50+20}$.



a) Shift of boat when A moves to Meet B = $x_{shift} = \frac{40(10)}{40+20+10} \cdot (-\hat{i})$.

b) Shift of boat when both moves to meet at Centre.



$A = (5-x)\hat{i}$

Observer $B = -(5+x)\hat{i}$

$\text{Boat} = -x\hat{i}.$

along x $F_{net\,x} = 0.$

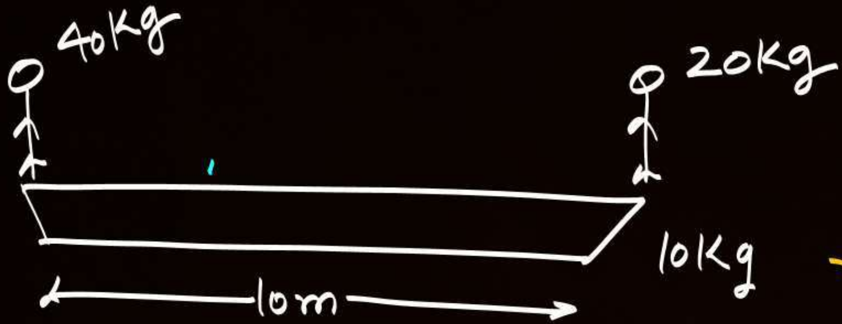
$$\Delta R_{com} = \frac{40(5-x)\hat{i} - 20(5+x)\hat{i} - 10x\hat{i}}{40+20+10}$$

$0 = 200 - 40x - 100 - 20x - 10x$

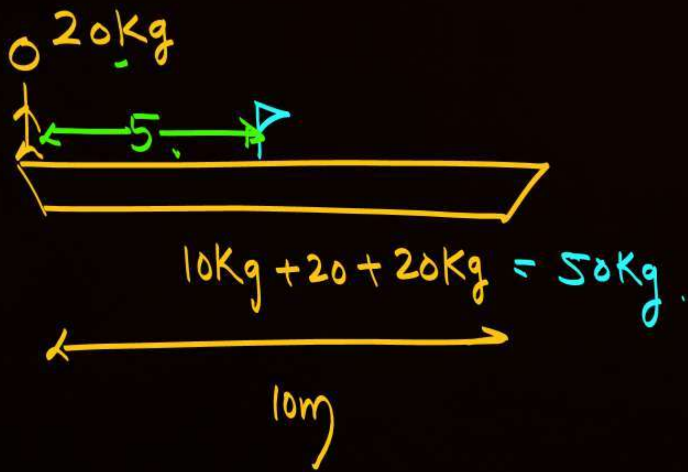
$70x = 100$

$x = \frac{10}{7}$

Easy

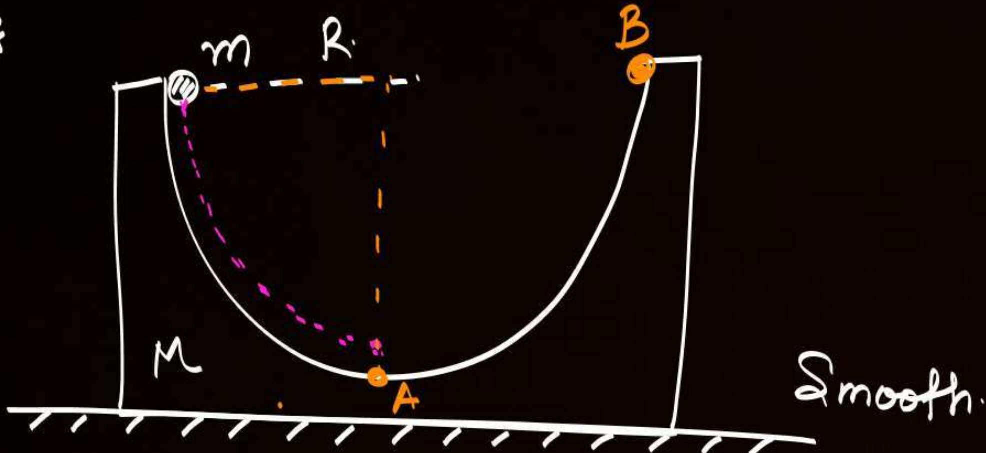


Make Person & boat problem



$$x = \frac{20(5)}{50+20} = \frac{100}{70} = \frac{10}{7}"$$

#



Shift of wedge along x
when m moves to A

(ii) moves to B.

along Y $F_{net} \neq 0$

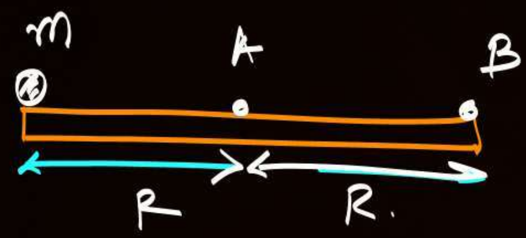
com will shift.

along x $F_{ext(x)} = 0$

$\Delta R_{com} = 0$

a) $$\boxed{x_{planck} = \frac{m(R)}{M+m}}$$

b) $$x_{planck} = \frac{m(2R)}{M+m}.$$



Shift of planck when it Reaches A = $x_{shift} = \frac{m(R)}{M+m}$.

$$x_{shift} = \frac{m(2R)}{M+m}$$

Question 16

HW

Two men of masses 40 kg and 20 kg are standing on a boat of mass 100 kg. Length of boat is 20 m. Neglect the friction between water and boat. Find the displacement of the boat when both person reach at middle of boat

A. 5/4 m, towards right

B. 5/4 m, towards left

C. 5/8 m, towards right

D. 5/8 m, towards left

Question 17

Hw

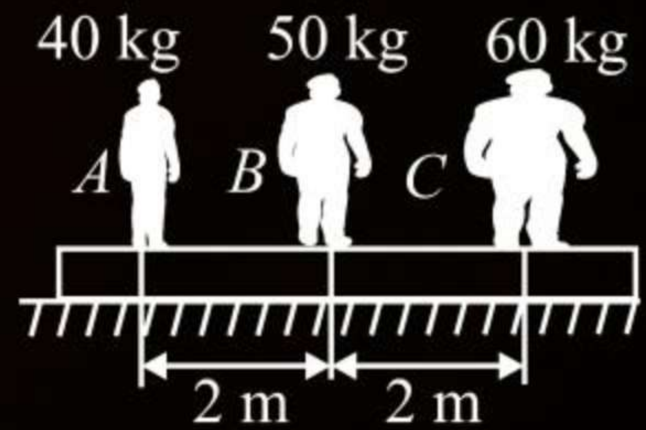
Three men A, B and C of masses 40 kg, 50 kg and 60 kg are standing on a plank of mass 90 kg, which is kept on a smooth horizontal plane. If A and C exchange their positions then mass B will shift

A 1/3 m towards left

B 1/3 m towards right

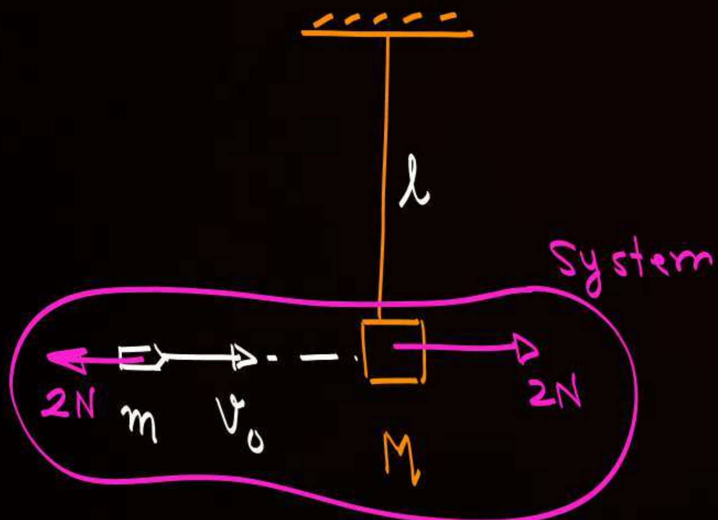
C will not move w.r.t. ground

D 5/3 m towards left



Conservation of Linear Momentum

Block-Bullet System :



Case-1. bullet Stuck in Wood.

for bullet & Wood ⇒ System.

f will be along x

f_{net} along $x = 0$

$$\vec{P}_{i\,sy_x} = \vec{P}_{f\,system_x}$$

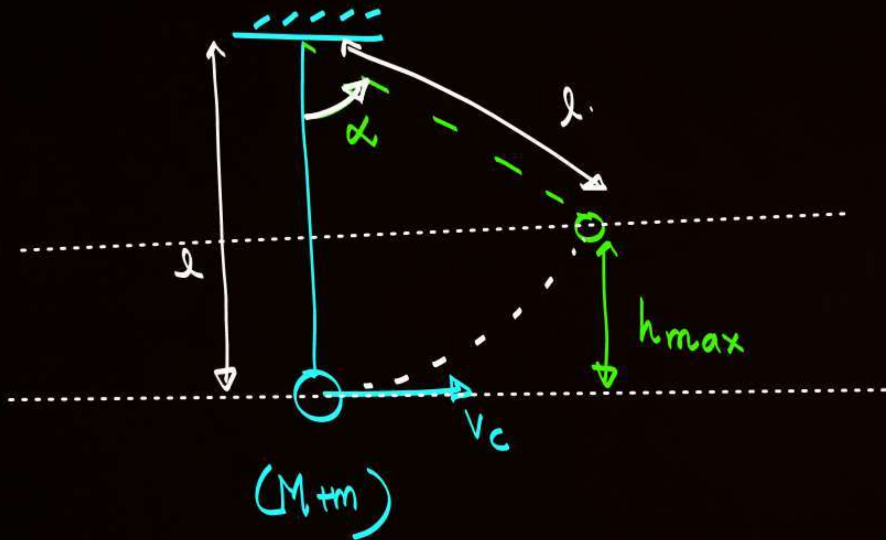
$$mv_0 = (M+m)V_c$$

$$\boxed{V_c = \frac{mv_0}{M+m}}$$

Concept.

$$f_{net} = 0 = \frac{d\vec{P}}{dt}$$

$\vec{P}$ = Conserved



$$E_i = E_f$$

$$\frac{1}{2}(M+m)v_c^2 = (M+m)g\,h_{max}$$

$$h_{max} = \underline{\qquad\qquad}$$

$l - l\cos\alpha = h_{max}$

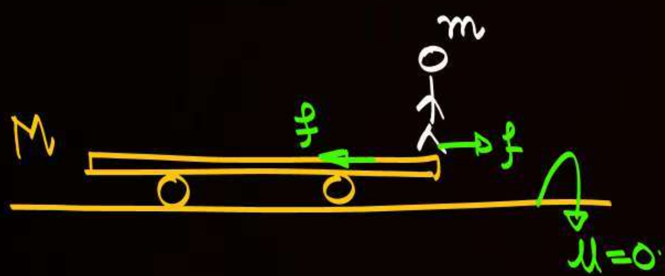
$$l(1-\cos\alpha) = h_{max}$$

$$\alpha = \underline{\qquad\qquad}.$$

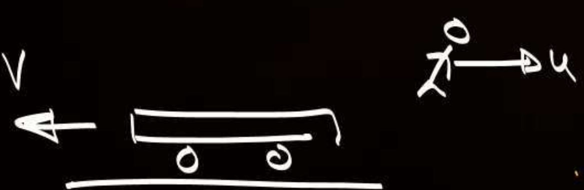
Initially at Rest

Recoil of gun/ Jumping From Cart

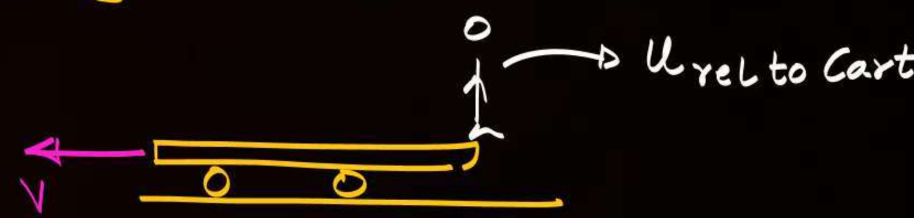
Person Jumps wrt ground

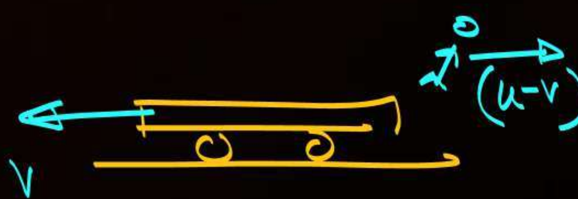


Person jumps with u relative to ground.



Person Jumps wrt Cart.





$$\vec{v}_{pc} = \vec{v}_p - \vec{v}_c$$

$$+u = \vec{v}_{p/g} - (-v)$$

$$\boxed{u - v = \vec{v}_{p/g}}$$

$$\vec{P}_{i\,system\,x} = 0$$

$$\vec{F}_{ext\,system} = 0$$

$$\vec{P}_{f\,system\,x} = 0$$

$$0 = mu\hat{i} + M(-V)\hat{i}$$

$$\boxed{V_{recoil} = \frac{m u_{ground}}{M}}$$

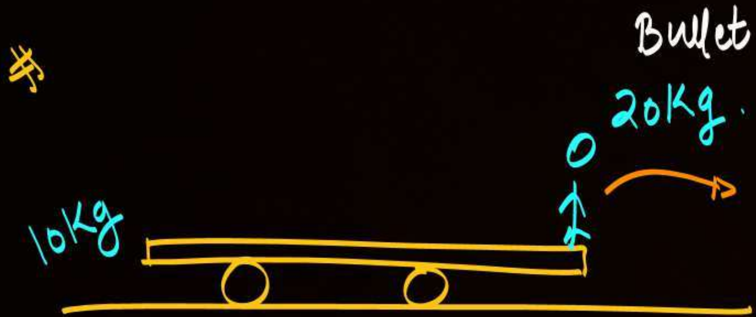
$$V_{recoil} = \frac{m_{bullet}\, u_{ground}}{M_{gun}}.$$

$$F_{ext\,x} = 0$$

$$\vec{P}_{ix} = \vec{P}_{fx}$$

$$0 = m(u-v)\hat{i} - Mv\hat{i}$$

$$\boxed{V_{recoil} = \frac{m u_{rel}}{M+m}}$$



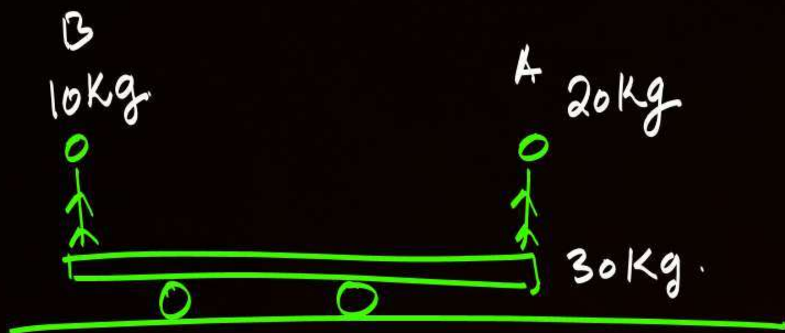
Recoil velocity of Cart

$v_{P/ground} = 5\,m/s$

$v_{P\,Cart} = 5\,m/s.$

$$v_{recoil} = \frac{2\cancel{0}(5)}{1\cancel{0}} = 10\,m/s.$$

$$v_{recoil} = \frac{20(5)}{10+20} = \frac{2\cancel{0}\times 5}{3\cancel{0}} = \frac{10}{3}\,m/s.$$

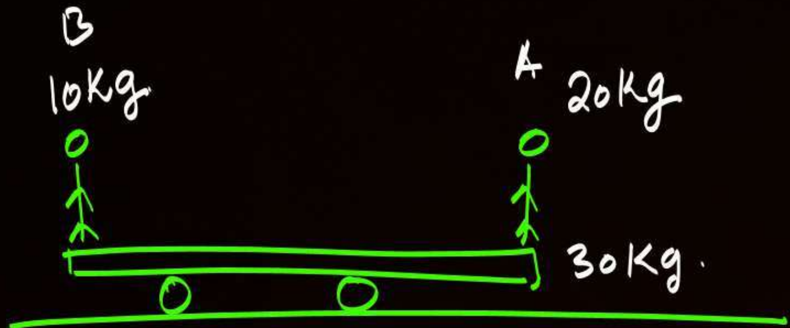


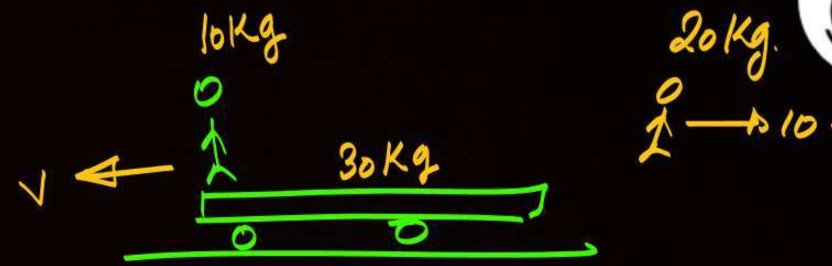
Case. 1 A jumps with $\boxed{\text{10m/s wrt ground}}$ towards Right

then

B jumps with $\boxed{\text{20m/s wrt Cart}}$ towards Right.

$v_{recoil} = ?$





Case.1 A jumps with $\boxed{\text{10m/s wrt ground}}$ towards Right

$$F_{ext} = 0$$

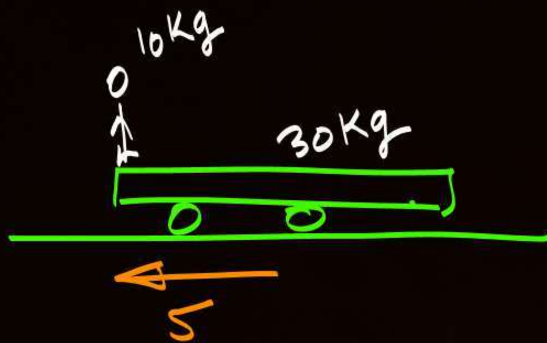
$$\bar{P}_{ix} = \bar{P}_{fx}$$

$$0 = 20 \times 10\hat{i} + (40(-v\hat{i}))$$

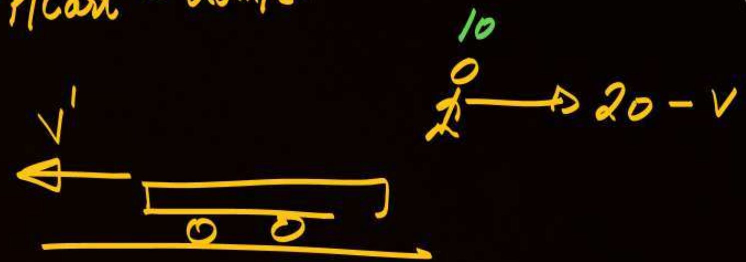
$$\frac{200}{40} = v = 5\ m/s.$$

Step.-2

Initial.



$v_{p/cart} = 20\,m/s.$



$\vec{P}_{ix} = 40(-5)\hat{i}$

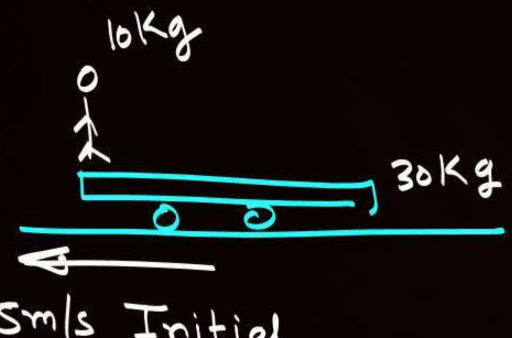
$\vec{P}_{fx} = 10(20-v')\hat{i} - 30v'$

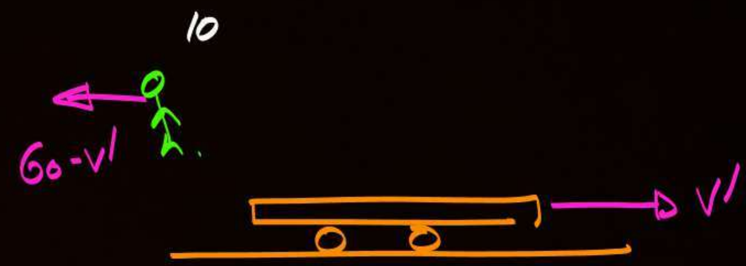
$-200 = 200 - 10v' - 30v'$

$-400 = -40v'$

$\boxed{v' = 10}$ (+ve) dir is Same as assumed.

What if B jumps with 60 m/s relative to Cart towards Left.





$$\vec{F}_{ext_x} = 0$$

$$\vec{P}_{ix} = \vec{P}_{fx}$$

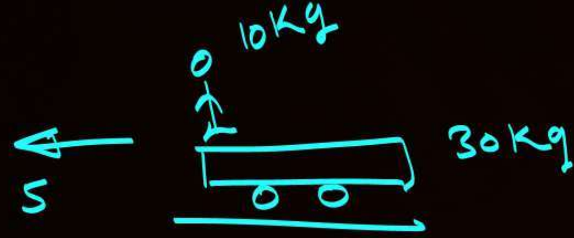
$$40(-5)\hat{i} = -10(60 - v')\hat{i} + 30v'$$

$$-200 = -600 + 10v' + 30v'$$

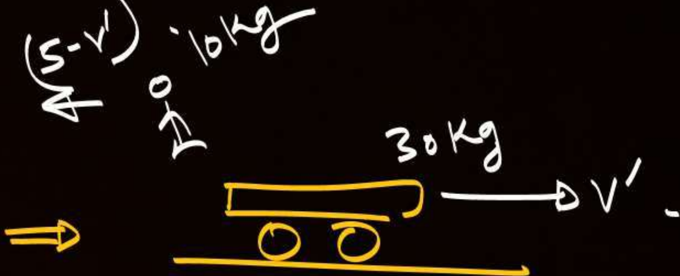
$$v' = +10\,m/s$$

direction Correct.

What if B jumps with 5 m/s relative to Cart towards Left.



$\Rightarrow$

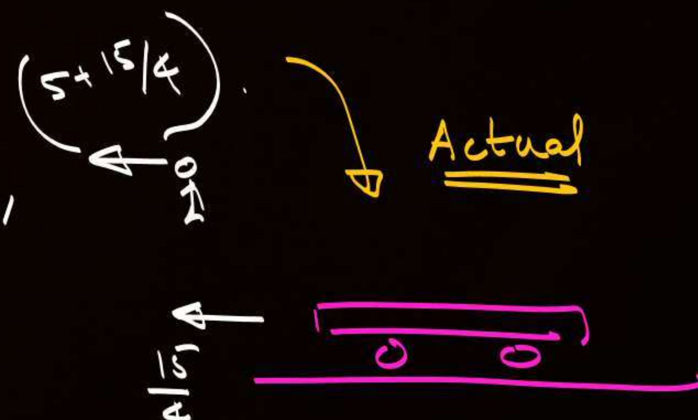


$\bar{P}_{ix} = \bar{P}_{fx}$

$40(-5) = -10(5-v') + 30v'$

$-200 = -50 + 10v' + 30v'$

$\frac{-15\cancel{0}}{4\cancel{0}} = v' = (-ve)$



Explosion of bomb :-

$|\vec{p}_2|$ $|\vec{p}_1|$

$f_{ext} = 0$

$$\boxed{\vec{p}_i = \vec{p}_f}$$

\# If we assume bomb is at Rest.

$$\vec{p}_i = \vec{p}_f$$

$$0 = m_1 u_1 - m_2 u_2$$

$$\boxed{m_1 u_1 = m_2 u_2} \;(*)$$

$$\boxed{(*)\quad |\vec{p}_1| = |\vec{p}_2|}$$

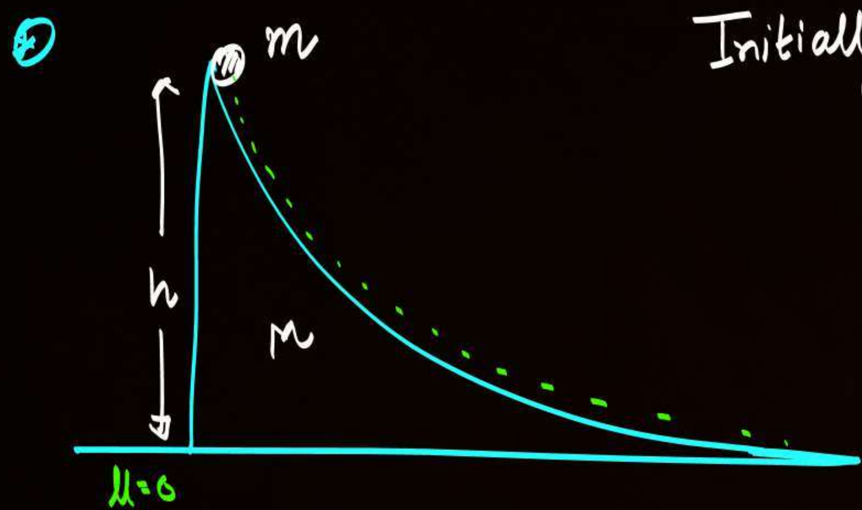
$\boxed{\text{Energy of Explosion}} = \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$

$$= \frac{p^2}{2m_1} + \frac{p^2}{2m_2}$$

$$\text{Energy} = \frac{p^2}{2}\left[\frac{1}{m_1} + \frac{1}{m_2}\right]$$

$$\text{Energy} = \frac{p^2}{2(\mu)}$$

$$\boxed{\mu = \frac{m_1 m_2}{m_1 + m_2}}$$ Reduced Mass.



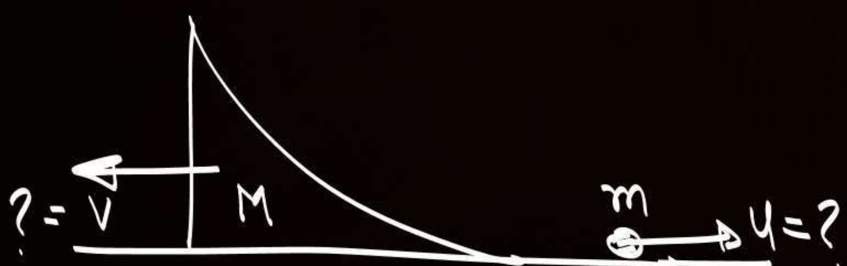
Initially System at Rest.

find Velocity of Each after Separating out

$$\Sigma f_{ext\,x} = 0$$

$$m\underline{\underline{u}} = M\underline{\underline{V}} = P$$

$$mgh = \frac{P^2}{2\mu}$$



$$mgh = \frac{M^2V^2}{2\mu} \qquad mgh = \frac{m^2u^2}{2\mu}$$

$V = \_\_\_\_$ $\qquad$ $u = \_\_\_\_$.

Question 18

A bullet of mass m moving vertically upwards with a velocity u hits a hanging block of mass "m" and gets embedded in it. The height to which block will rise after collision

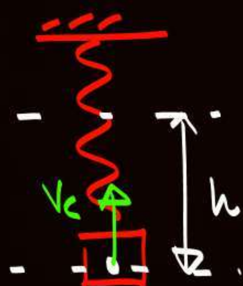
A $\frac{u^2}{2g}$

B $\frac{u^2}{g}$

C $\frac{u^2}{8g}$

D $\frac{u^2}{4g}$

String → non Impulsive → Slack.



$mu = (m+m)V_c$

$V_c =$ ____.

$h = \frac{V_c^2}{2g}$

(*) gravitational force

⇓

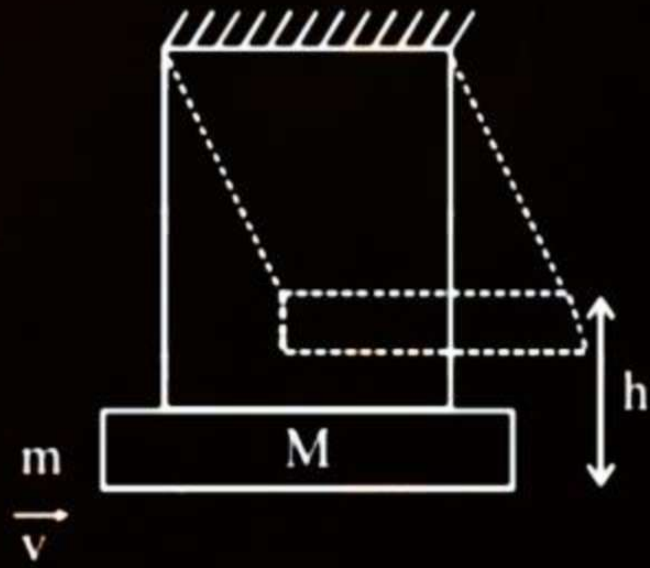
Non-Impulsive

Question

HW

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

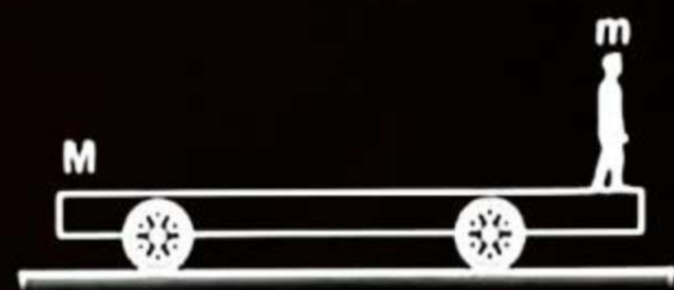
16 March (Shift 2) - Single Correct; JEE Main 2021 (March)



Question 19

HCV

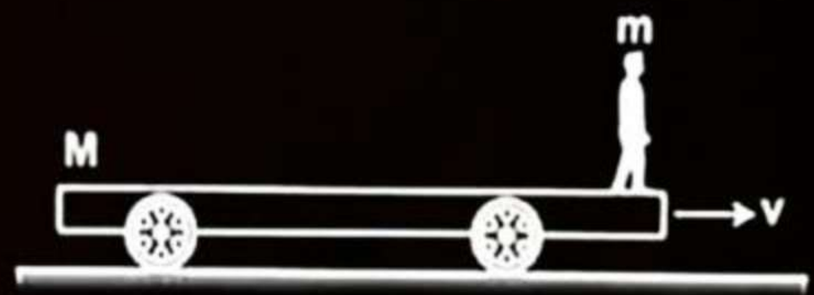
A flat car of mass M is at rest on a frictionless floor with a child of mass m standing at the edge. If child jumps off from the car toward right with initial velocity u, with respect to car, find the velocity of car after the jump.



Question 20

HCV

A flat car of mass M with a child of mass m is moving at speed v_1. The child jumps in the direction of motion of car with a velocity u with respect to car. Find the final velocities of the child and that of car after jump.



Question 21

A body of mass M at rest explodes into three pieces, in the ratio of masses 1 : 1 : 2. Two smaller pieces fly off perpendicular to each other with velocities of 30 ms^{-1} and 40 ms^{-1} respectively. The velocity of the third piece will be [JEE (Main)-2022]

A 15 ms^{-1}

B 25 ms^{-1}

C 35 ms^{-1}

D 50 ms^{-1}

Bomb → Rest

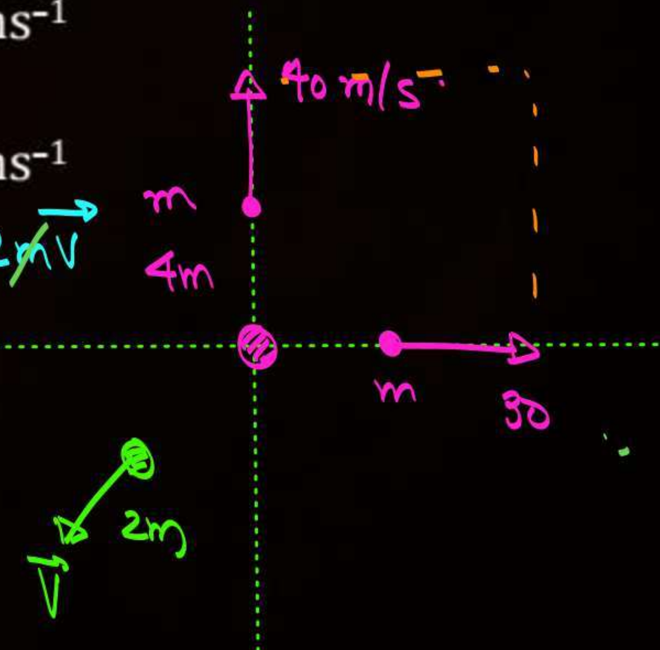
$\vec{P}_{system} = 0$

$\vec{F}_{ext} = 0$

$\vec{P}_{system\,f} = 0$

$0 = 30\cancel{m}\hat{i} + 40\cancel{m}\hat{j} + 2\cancel{m}\vec{V}$

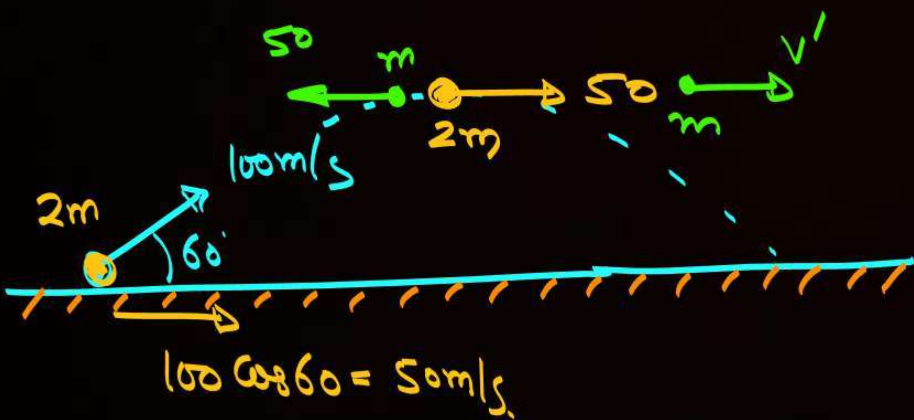
$\boxed{-15\hat{i} - 20\hat{j} = \vec{V}}$



Question 22

banduk.

A shell is fired from a canon with a speed of 100 m/s at 60° with horizontal. At the highest point of its trajectory, the shell explodes into two equal fragments. One of these moves along horizontal backward direction at 50 m/s, find the speed of other fragment at the time of explosion.



At point point $f_{ext}=0$

gravitional

⇓

Non Impulsi

⇓

$\vec{P}$ change nahi Karega

$$\vec{P}_{ix} = \vec{P}_{fx}$$

$$2m(50)\hat{i} = m(-50\hat{i}) + m\vec{v}$$

$$100m\hat{i} + 50m\hat{i} = m\vec{v}$$

$$\boxed{150\hat{i} = \vec{v}}$$

Question 23

HCV WET

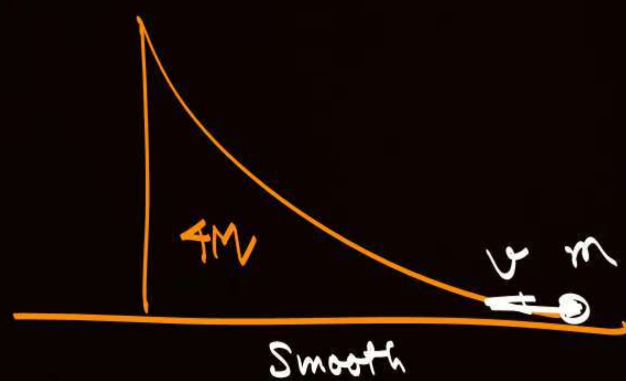
A wedge of mass $M = 4$ m lies on a frictionless plane. A particles of mass m approaches the wedge with speed v. There is no friction between the particle and the plane or between the particle and the wedge. The maximum height climbed by the particle on the wedge is given by **2019 Main, 9 April II**

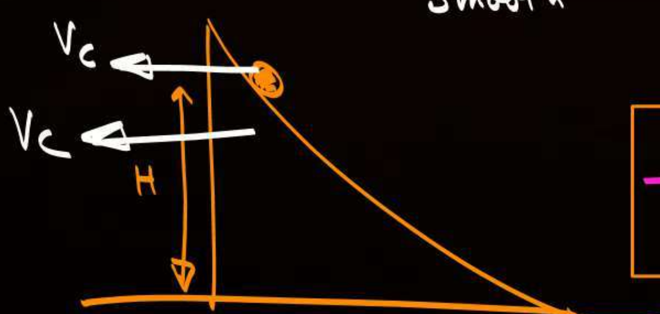
A $\frac{2v^2}{7g}$

B $\frac{v^2}{g}$

C $\frac{2v^2}{5g}$

D $\frac{v^2}{2g}$





$F_{ext\,x} = 0$

$\vec{P}_{ix} = \vec{P}_{fx}$

$mv\hat{i} = (4m+m)V_c\hat{i}$

$\boxed{\frac{v}{5} = V_c}$

$$\boxed{-mgH = \frac{1}{2}(4m+m)V_c^2 - \frac{1}{2}mv^2}$$

Question

A man of 60 kg is running on the road and suddenly jumps into a stationary trolly car of mass 120 kg. Then, the trolly car starts moving with velocity 2 ms^{-1}. The velocity of the running man was ____ ms^{-1}, when he jumps into the car. [JEE (Main)-2022]

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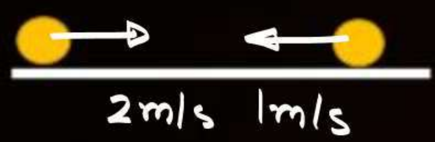
COLLISION

- Velocities of approach



$|v_{rel\ of\ app}| = 3$

$|v_{rel\ of\ app}| = 3$

- Velocities of Separation

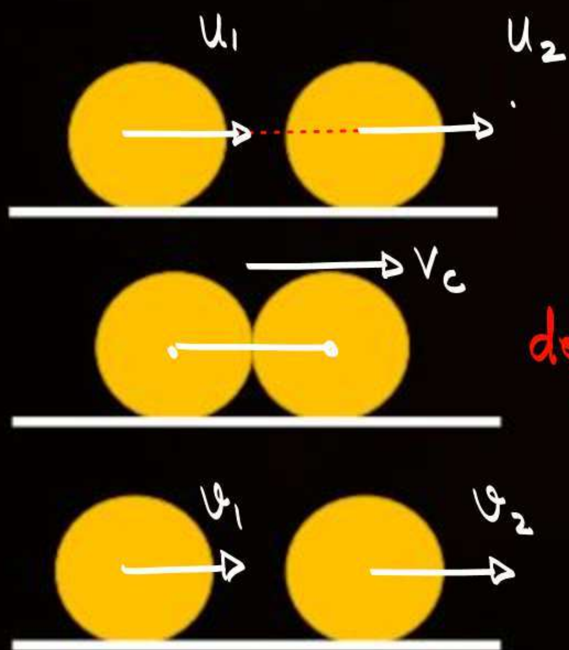
$v_{rel\ sep} = 4$

$|v_{rel\ sep}| = 10m/s$

COLLISION

$u_1 > u_2$

- Line of Impact



$v_2 > v_1$

❖ Coefficient of Restitution

Materials
→ Perfectly Elastic
→ Inelastic
→ Perfectly Inelastic.

deformation "bond break, compress".

at Max Comp both moves with common speed.

Note: Coefficient of restitution is always calculated using velocities along LOI.

$$\text{Coefficient of Restitution} = e = \frac{v_{rel\,sep}}{v_{rel\,app.}} = \frac{v_2 - v_1}{u_1 - u_2}$$

$e = 1$

Perfectly Elastic

$0 < e < 1$

In-elastic.

$e = 0$

Perfectly Inelastic

$v_{rel\,sep} = 0$

along LoI both moves with v_{common}.

LoI

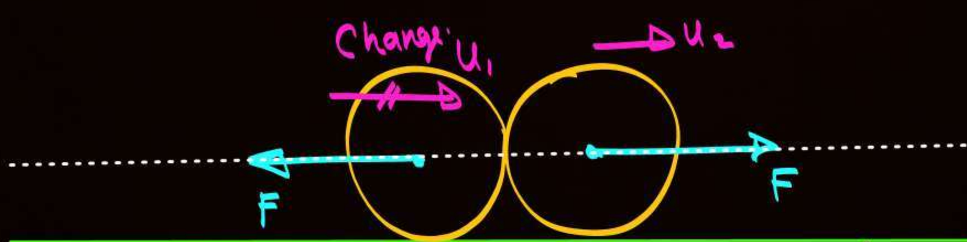
along LoI, Individual bodies ka $\vec{P}$ change hoga.

⊛ for System of both bodies

$f \Rightarrow$ Internal.

$\boxed{\vec{P_i} = \vec{P_f} \text{ along LoI}}$

for any collision.



Line of Impact.

along LoI $\vec{P}$ of body (1) changes = ($\overset{\checkmark}{J}$ / F) (No $\vec{P}$ = Conservation for body 1 along LoI)

" " $\vec{P}$ " body (2) changes = ($\overset{\checkmark}{J}$ / F) (" " " " " " " 2 " ")

Collisions Type and Equations

Before Collision

$u_1 > u_2$

approach.

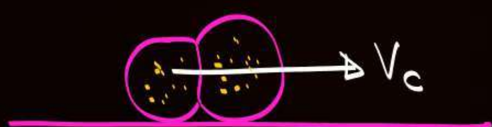
$|v_{approach}| = u_1 - u_2$

$\vec{P}_i = m_1\vec{u}_1 + m_2\vec{u}_2$

$KE_i = \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$

At time of Collision

Max deformation



$\vec{P}_{at} = (m_1 + m_2)V_c$

$\vec{P}_i = \vec{P}_{at}$

$F_{ext\ system} = 0$.

$KE_{at} = \frac{1}{2}(m_1+m_2)V_c^2$.

$\boxed{\text{PE Stored in body} = KE_i - KE_{at}}$

$e = 1$

$m_1 \to v_1 \quad m_2 \to v_2$

$\vec{P}_f = m_1\vec{v}_1 + m_2\vec{v}_2$

$KE_f = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$

$\boxed{\vec{P}_i = \vec{P}_{at} = \vec{P}_f}$

$KE_i \neq KE_{at}$

$\boxed{KE_i = KE_f}$

$e = 0$

$\to V_c \quad P_f = (m_1+m_2)V_c$

$\boxed{\vec{P}_i = \vec{P}_{at} = \vec{P}_f}$

Loss of Energy =

Break till → 11:00 PM

Collision → Theory
+
PYQ's

Velocities after collisions and loss of energy

$\boxed{0 < e < 1}$

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

$\Rightarrow v_2 - v_1 = e(u_1 - u_2)$

$\vec{v}_2 = \vec{v}_1 + e(\vec{u}_1 - \vec{u}_2$

all type of Collisions.

$$\boxed{m_1\vec{u}_1 + m_2\vec{v}_2 = m_1\vec{v}_1 + m_2\vec{v}_2}$$

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2\left[v_1 + e(u_1 - u_2)\right]$$

general

$$\boxed{v_1 = \frac{(m_1 - em_2)u_1 + (1+e)m_2u_2}{m_1+m_2}}$$

$$\boxed{v_2 = \frac{(m_2 - em_1)u_2 + (1+e)m_1u_1}{m_1+m_2}}$$

$$\boxed{\text{Loss of KE} = \frac{1}{2}\frac{m_1m_2}{m_1+m_2}(u_1-u_2)^2(1-e^2)}$$

"$e=0$"

$$\boxed{v_1 = \frac{m_1u_1 + m_2u_2}{m_1+m_2}}$$

$$\boxed{v_2 = \frac{m_2u_2 + m_1u_1}{m_1+m_2}}$$

$$\boxed{\text{Loss} = \frac{1}{2}\frac{m_1m_2}{m_1+m_2}(u_1-u_2)^2}$$

COLLISION

1. For e=1 Find final velocities and Max Potential energy stored
2. For e = ½ Find final Velocities and loss of energy
3. For e=0 Find final velocities and Loss of energy

Sol

$\vec{P}_i = \vec{P}_f \quad = \boxed{1\times 6 + 3\times 2 = 1\times v_1 + 2v_2}$

$\boxed{12 = v_1 + 2v_2}$

$e = 1 = \dfrac{v_2 - v_1}{3}$

$\boxed{3 = v_2 - v_1}$

$12 = \cancel{v_1} + 2v_2$

$3 = v_2 - \cancel{v_1}$

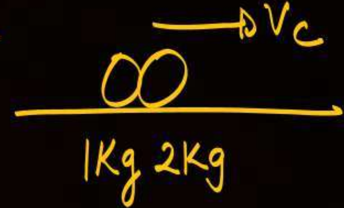
$15 = 3v_2 \quad v_2 = 5$

$\boxed{v_1 = 2}$ Ans.

COLLISION

1. For e=1 Find final velocities and Max Potential energy stored
2. For e = ½ Find final Velocities and loss of energy
3. For e=0 Find final velocities and Loss of energy

Q01 Max PE.



$$1\times6 + 2\times3 = 3V_c$$

$$12 = 3V_c$$

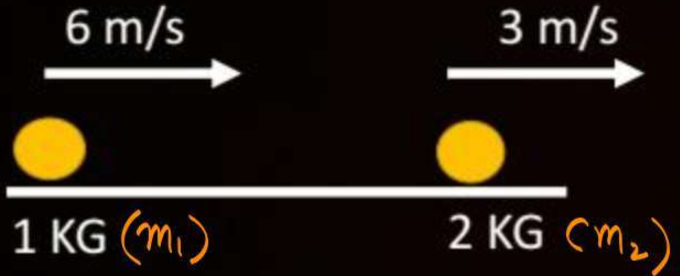
$$V_c = 4$$

$$KE_i = \frac{1}{2}\times1\times6^2 + \frac{1}{2}\times2\times3^2$$

$$KE_{at} = \frac{1}{2}(1+2)4^2$$

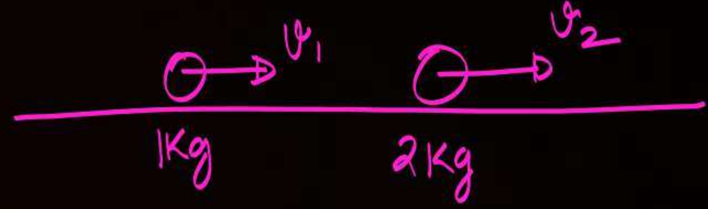
$$\Delta K = PE$$

COLLISION



1. For e=1 Find final velocities and Max Potential energy stored
2. For e = ½ Find final Velocities and loss of energy
3. For e=0 Find final velocities and Loss of energy

Q.2 $e = 1/2$.



$$\boxed{1\times 6 + 2\times 3 = v_1 + 2v_2}$$

$$e = \frac{1}{2} = \frac{v_2 - v_1}{3} \Rightarrow \boxed{3 = 2v_2 - 2v_1}$$

$v_1 =$ ___

$v_2 =$ ___

* $KE_i = \frac{1}{2}\times 1\times 6^2 + \frac{1}{2}\times 2\times 3^2$.
* $KE_f = \frac{1}{2}\times 1\times v_1^2 + \frac{1}{2}\times 2\times v_2^2$

ΔK = Loss.

COLLISION

1. For e=1 Find final velocities and Max Potential energy stored
2. For e = ½ Find final Velocities and loss of energy
3. For e=0 Find final velocities and Loss of energy

$$\boxed{1\times 6 + 2\times 3 = 1\times v_1 + 2v_2}$$

$$e = 0 = \frac{v_2 - v_1}{3} \Rightarrow v_2 = v_1$$

$$12 = 3v_1$$

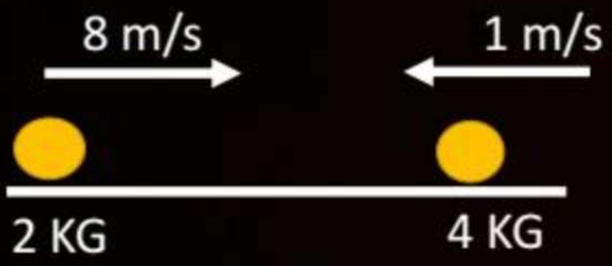
$v_1 = 4$ Common Velocity.

$$KE_i = \frac{1}{2}\times 1\times 6^2 + \frac{1}{2}\times 2\times 3^2$$

$$KE_f = \frac{1}{2}(1+2)4^2$$

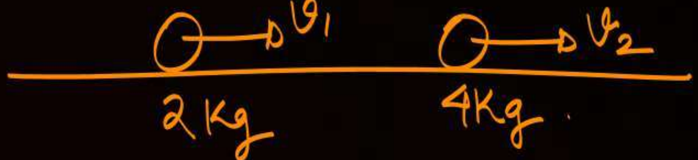
$\Delta K = \text{Loss}$

COLLISION



[redacted]

2. For e = ½ Find final Velocities and loss of energy



$\vec{P_i} = \vec{P_f}$

$2 \times 8 - 1 \times 4 = 2v_1 + 4v_2$

$\boxed{12 = 2v_1 + 4v_2} \Rightarrow \boxed{6 = v_1 + 2v_2}$ — 1

$e = \frac{1}{2} = \frac{v_2 - v_1}{9}$

$\boxed{9 = 2v_2 - 2v_1}$ — 2

$v_1 =$ ____

$v_2 =$ ____

$6 = v_1 + \cancel{2v_2}$

$9 = \cancel{2v_2} - 2v_1$

$-\quad - \quad +$

$-3 = 3v_1$

$v_1 = -1$

after collision 2kg (-ve) dir with 1m/s.

$v_2 = \_\_\_\_$.

$KE_i = \frac{1}{2} \times 2 \times 8^2 + \frac{1}{2} \times 4 \times 1^2$

$KE_f = \frac{1}{2} \times 2 \times 1^2 + \frac{1}{2} \times 4 \times v_2^2$

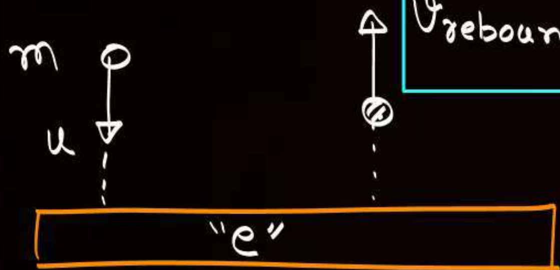
$\Delta K = \text{Loss}$

Bouncing of Ball

(*) JEE Mains + Adv.

$$\boxed{v_{rebound} = e\, v_{hitting\ \perp\ to\ Surface}}$$

(1)



(2) heavy body at Rest. ($u_2 = 0,\ v_2 = 0$)

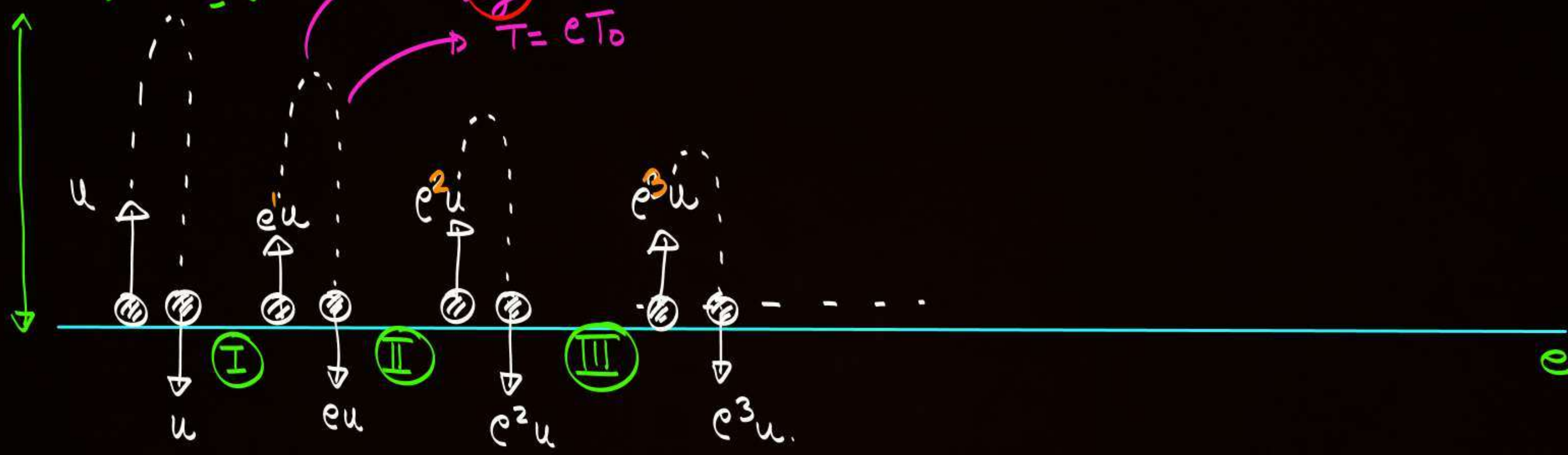
$$e = \frac{\cancel{v_2}^{\,0} - v_1}{u_1 - \cancel{u_2}^{\,0}}$$

$$e = \frac{-v_1}{u_1} \Rightarrow v_1 = -e u_1$$

$H_{0}max = \frac{u^2}{2g}$, $T_0 = \frac{2u}{g}$

$H_1 = \frac{e^2 u^2}{2g} = e^2 H_0$

$T = eT_0$

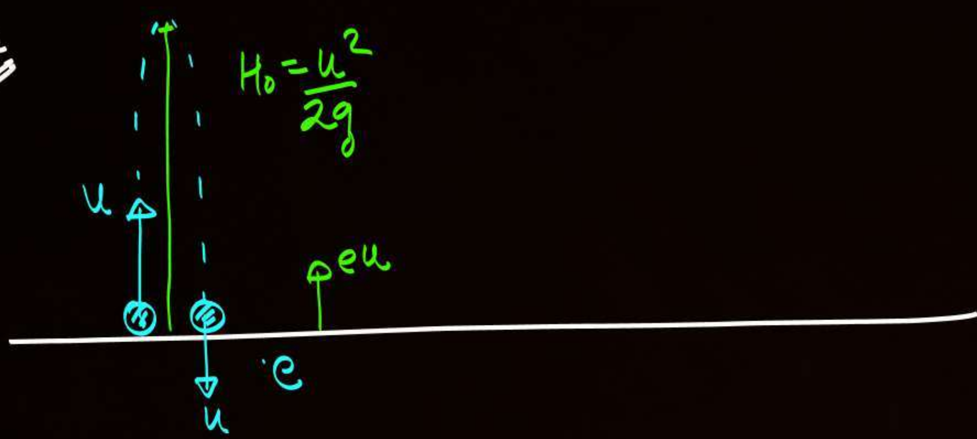


Velocity after n^{th} Collision = $v_{rebound} = e^n u$.

Height after n^{th} Collision = $e^{2n} H_0$

Time after n^{th} Collision = $e^n T_0$

Que

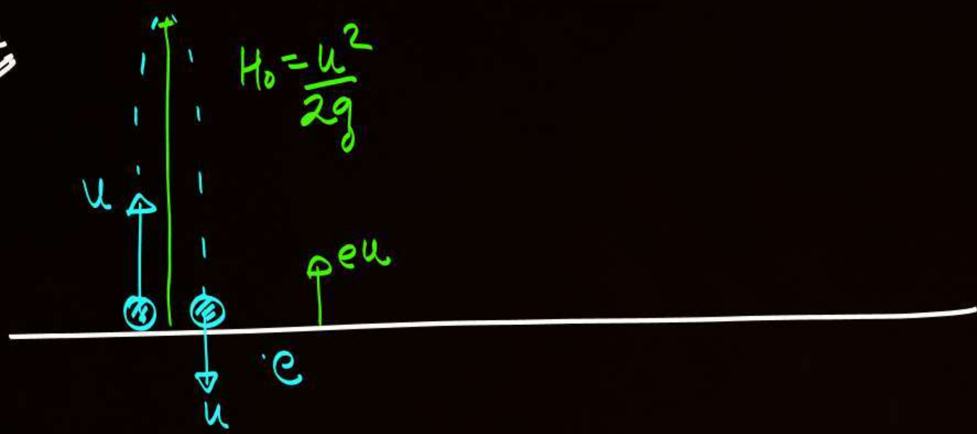


⊛ Find Total distance travelled by body =

$$\text{distance} = \cancel{2}\left[\frac{u^2}{\cancel{2}g}\right] + \cancel{2}\left[\frac{e^2u^2}{\cancel{2}g}\right] + \cancel{2}\left[\frac{e^4u^2}{\cancel{2}g}\right] + \cancel{2}\left[\frac{e^6u^2}{\cancel{2}g}\right] + \text{------}$$

$$= \frac{u^2}{g}\left[1 + e^2 + e^4 + e^6 + \text{----} \infty\right] = \frac{u^2}{g}\left(\frac{1}{1-e^2}\right) \text{ Ans.}$$

Que



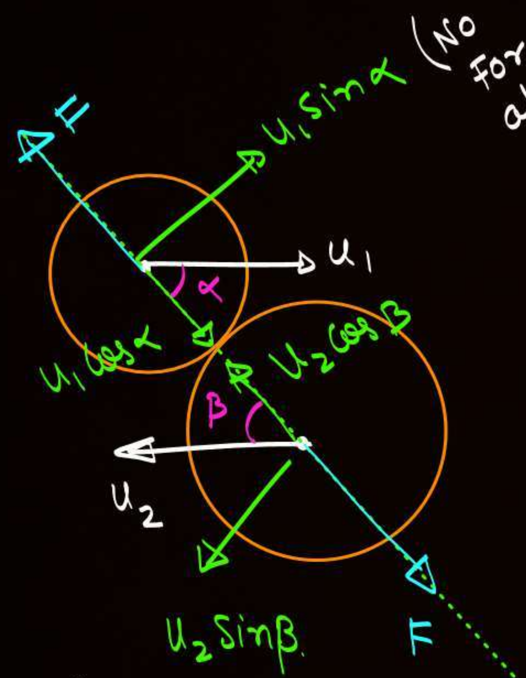
Avg speed $= \frac{\text{Total dis}}{\text{Total time}}$

(*) Find Total time.

$$T = \frac{2u}{g} + \frac{2eu}{g} + \frac{2e^2u}{g} + \frac{2e^3u}{g} + \cdots$$

$$= \frac{2u}{g}\left[1 + e + e^2 + e^3 + \cdots\right] = \frac{2u}{g}\left[\frac{1}{1-e}\right]$$

⊛ Oblique Collision. Velocities make angle with LoI



LoI (Line along which force will Act).

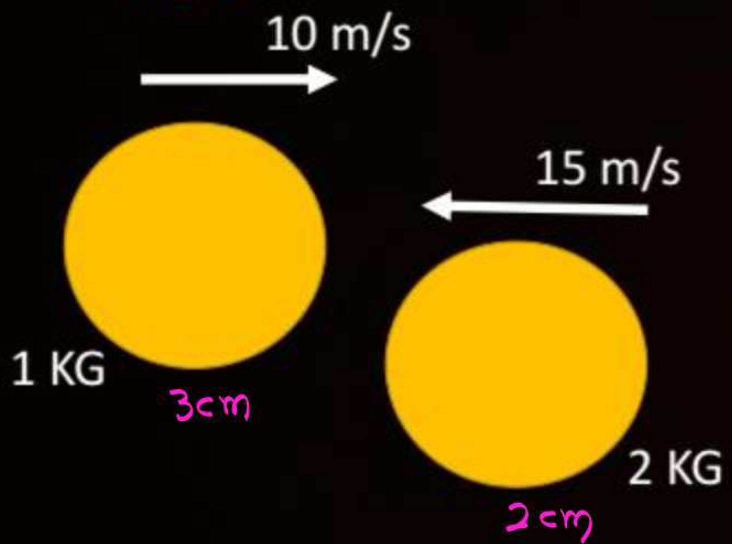
(No Force along this)

⊛ along LoI $\vec{P}_{system}$ Conserve = (T/F) ✓

along LoI $P_{\text{Individual bodies}}$ Conserve (T/F) ✓

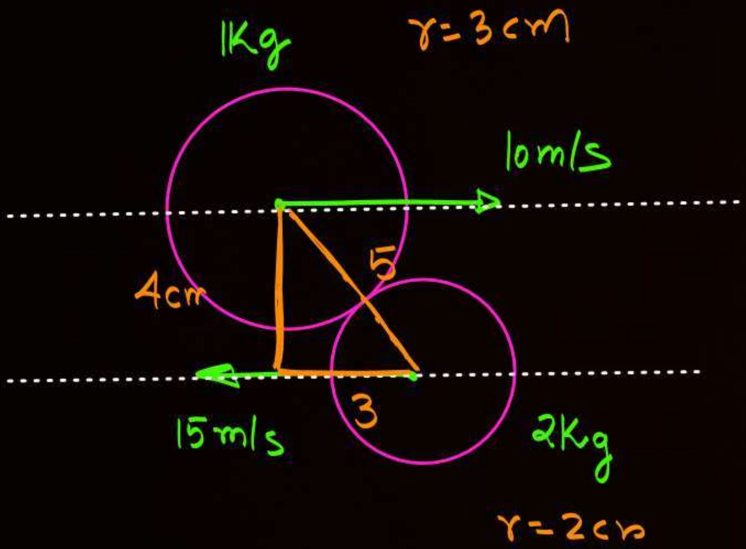
⊛ $\perp$ to LoI Momentum will be Conserved for Individual bodies (T/F) ✓

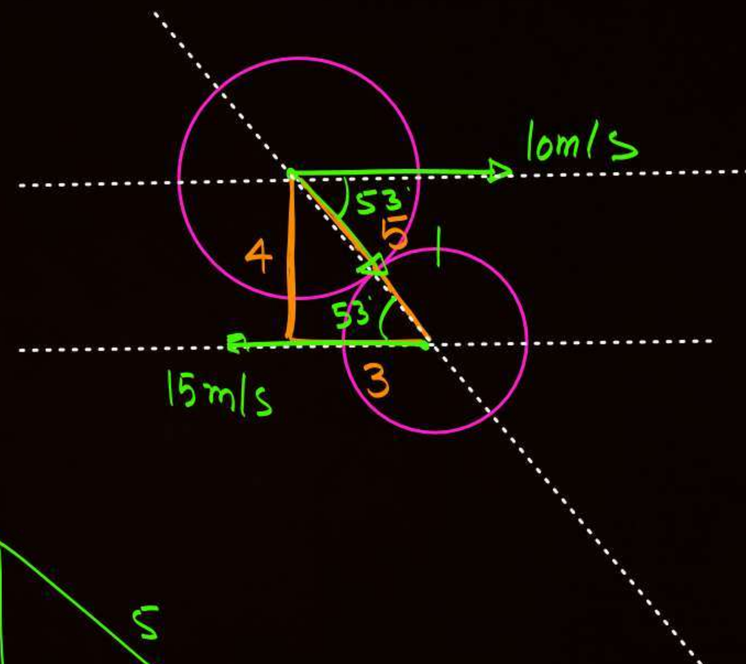
Oblique Collisions

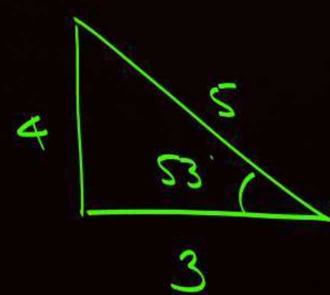


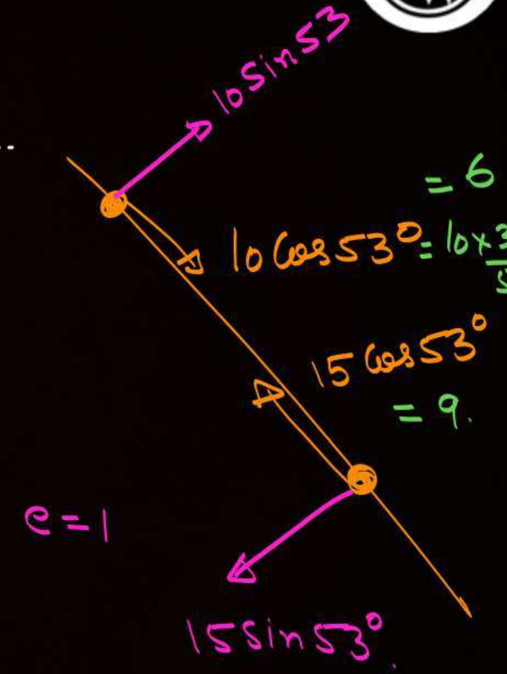
Radius of spheres is 3 cm and 2 cm
Find the final velocities if impact (⊥ distance between velocity is called Impact Parameter)
Parameter is 4 cm
Consider e = 1 and e = 0

(H.W)

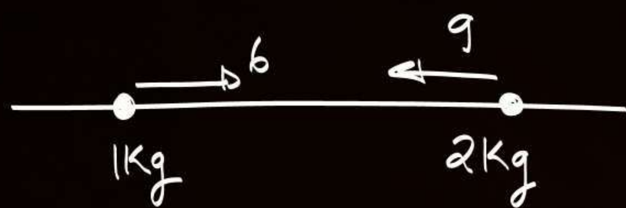

1Kg
r = 3cm
10m/s
4cm
5
3
15m/s
2Kg
r = 2cm

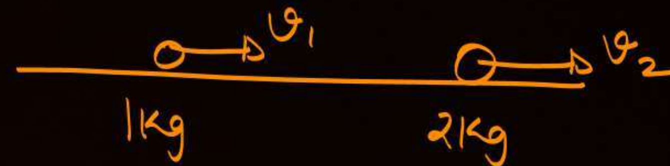

10m/s
53°
5
1
4
53°
15m/s
3


4
5
53°
3


10 sin 53
= 6
10 cos 53° = 10 × 3/5
15 cos 53°
= 9.
e = 1
15 sin 53°.

$e = 1$





$\vec{P}$ conserved System along LOI

$$\boxed{1\times 6 - 2\times 9 = 1\times v_1 + 2\times v_2}$$

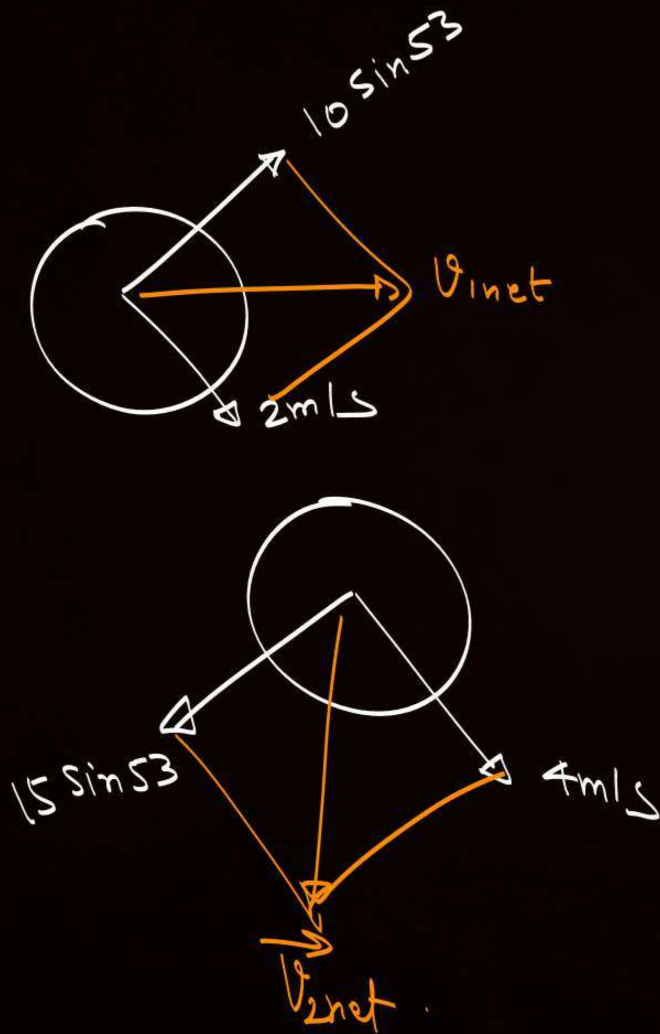
assume

$v_1 = 2\,m/s$

$v_2 = 4\,m/s.$

$$e = 1 = \frac{v_2 - v_1}{15}$$

$$v_2 - v_1 = 15$$



Oblique

① Resolve velocities along & ⊥ to LoI

⊛ along LoI

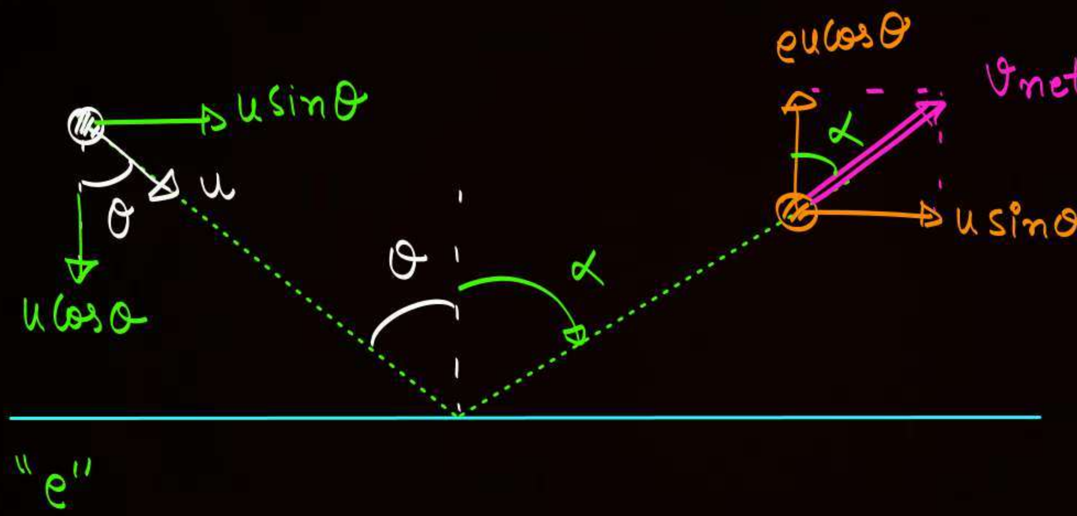
$$\vec{P_i} = \vec{P_f}$$

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

⊛ ⊥ velocities same.

⊛ Solve & get Result.

Oblique Collisions on horizontal ground



$$v_{net} = \sqrt{u^2 \sin^2\theta + e^2 u^2 \cos^2\theta}$$

$$\tan\alpha = \frac{u\sin\theta}{eu\cos\theta}$$

$$\boxed{\tan\alpha = \frac{\tan\theta}{e}}$$

$e = 0$ $\quad \boxed{v = u\sin\theta}$

$\alpha = \pi/2$

$e = 1$ $\quad v_{net} = u$

$\alpha = \theta$

Projectile Collision from ground

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Question 24

A body of mass 2 kg makes an elastic collision with a second body at rest and continues to move in the original direction but with one-fourth of its original speed. What is the mass of the second body? **(2019 Main, 9 April I)**

(A) 1.5 kg

(B) 1.2 kg Ans

(C) 1.8 kg

(D) 1.0 kg

$e = 1$

u; 2 kg; $m = ?$, $u_2 = 0$; 2 kg, $\frac{u}{4}$

Method:

$\bar{P}_i = \bar{P}_f$

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

$v_1 = \frac{(m_1 - m_2)u_1 + \cancel{2m_2u_2}}{m_1 + m_2}$ (0)

$\frac{\cancel{u}}{4} = \frac{(2-m)\cancel{u}}{2+m}$

$2+m = 4(2-m)$

$2+m = 8-4m$

$m = \frac{6}{5} = 1.2$

Question 25

Two small particles of equal masses start moving in opposite directions from a point A in a horizontal circular orbit. Their tangential velocities are v and $2v$ respectively, as shown in the figure. Between collisions, the particles move with constant speeds. After making how many elastic collisions, other than that at A, these two particles will again reach the point A? $e=1$ (2009) Adv

A 4

B 3

C 2

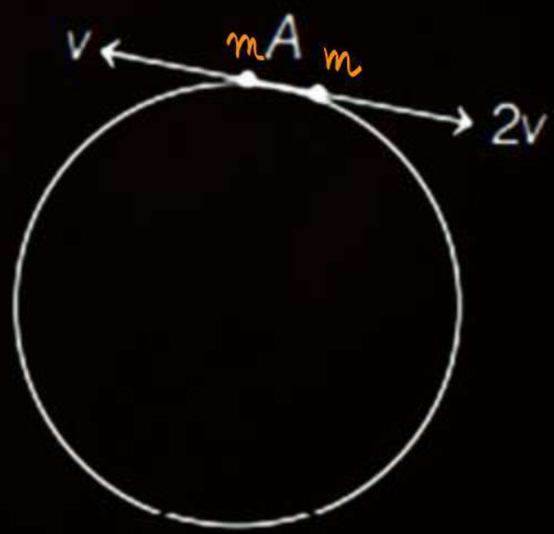
D 1

#

$\boxed{\text{for Same mass } e=1 \quad \text{Velocities} \Rightarrow \text{Exchange.}}$

$$v_1 = \frac{(\cancel{m_1} - \cancel{m_2})\cancel{u_2} + 2m_2u_2}{m_1+m_2}$$

$v_1 = u_2$ ||ly $v_2 = u_1$



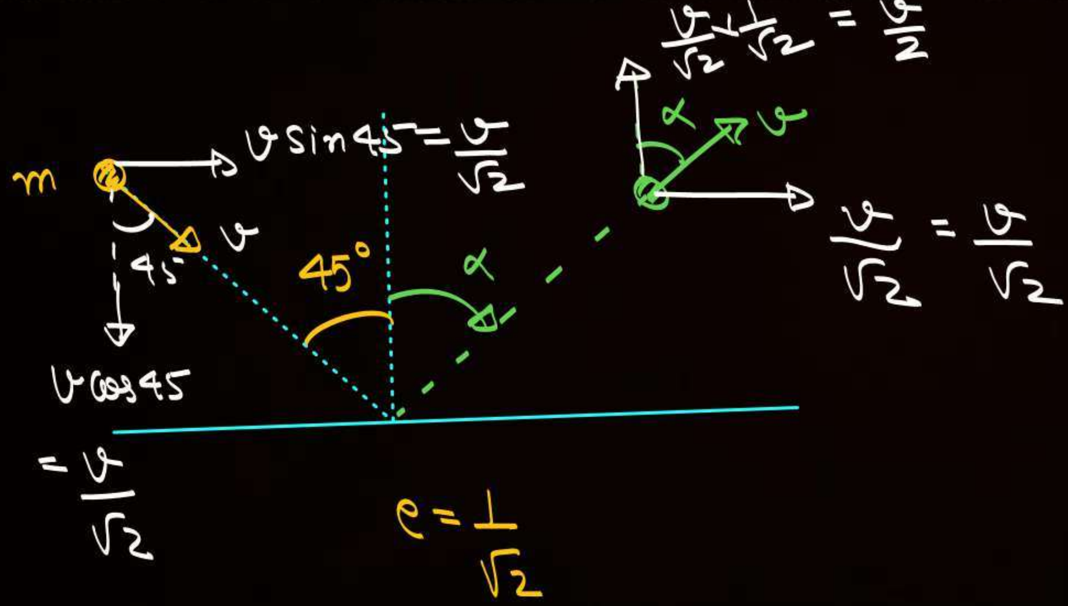
Velocity ⇒ Exchange.

As per Question we dont have to count Collision at A

Ans = 2

Question 26

A ball of mass m hits a floor with a speed v making an angle of incidence $\theta = 45°$ with the normal to the floor. If the coefficient of restitution is $e = 1/\sqrt{2}$, find the speed of the reflected ball and the angle of reflection. [[redacted] 2005]



$$v_{net} = \sqrt{\left(\frac{v}{2}\right)^2 + \left(\frac{v}{\sqrt2}\right)^2}$$

$$\tan\alpha = \frac{P}{B} = \frac{v}{\sqrt2} \times \frac{2}{v}$$

$$\boxed{\alpha = \tan^{-1}(\sqrt2)}$$

Question 27

(*) Oblique Collision (point masses) $\vec{P}_{xi} = \vec{P}_{fx}$

$\vec{P}_{iy} = \vec{P}_{fy}$.

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

$\hookrightarrow |v| = \frac{u}{2}\sqrt{2} = \frac{u}{\sqrt{2}}$

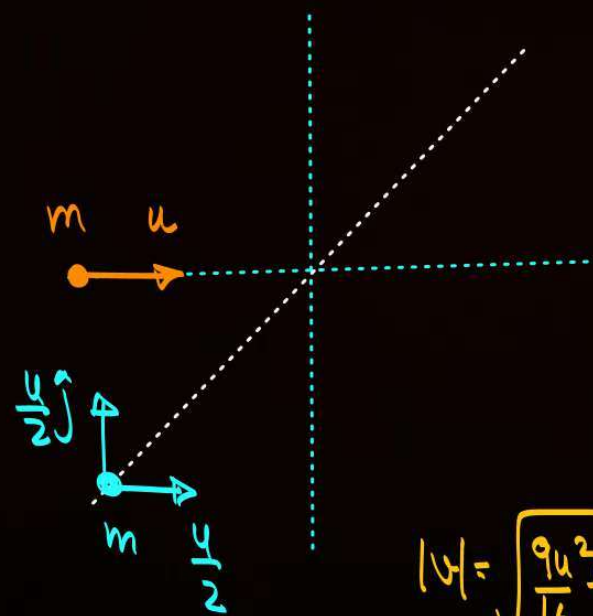
JEE Main 2020 - 9 January (Morning)

A $\frac{mv^2}{8}$

B $\frac{5mv^2}{8}$

C $\frac{mv^2}{4}$

D $\frac{3mv^2}{8}$



$KE_i = \frac{1}{2}mu^2 + \frac{1}{2}m\left(\frac{u}{\sqrt{2}}\right)^2$

Collision $\vec{P}_{system_i} = \vec{P}_{system_f}$ (2D).

$\cancel{m}u\hat{i} + \frac{\cancel{m}u}{2}\hat{i} + \frac{\cancel{m}u}{2}\hat{j} = 2\cancel{m}\vec{V}$.

$\frac{3u}{2}\hat{i} + \frac{u}{2}\hat{j} = 2\vec{V}$

$\frac{3u}{4}\hat{i} + \frac{u}{4}\hat{j} = \vec{V}$

$|v| = \sqrt{\frac{9u^2}{16} + \frac{u^2}{16}}$

$= \frac{u\sqrt{10}}{4}$

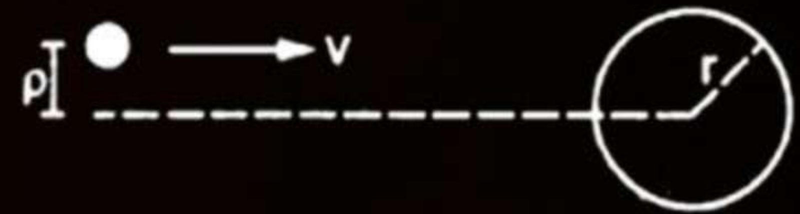
$$KE_i = \frac{1}{2}mu^2 + \frac{1}{2}m\left(\frac{u}{\sqrt{2}}\right)^2$$

$$KE_f = \frac{1}{2}(2m)\left(\frac{u\sqrt{10}}{4}\right)^2$$

$$Loss = \checkmark$$

Question 28

A small particle travelling with a velocity v collides elastically with a spherical body of equal mass and of radius r initially kept at rest. The centre of this spherical body is located a distance $\rho(< r)$ away from the direction of motion of the particles (figure). Find the final velocities of the two particles.



Question 29

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

A $\frac{1}{2}$

B $\frac{1}{3}$

C $\frac{2}{3}$

D $\frac{3}{4}$

Question 30

A small ball on a frictionless horizontal surface moves towards right with a velocity v. It collides with the wall and returns back and continues to and fro motion. If the average speed for first to and fro motion of the ball is $\left(\frac{2}{3}\right)v$, then the coefficient of restitution of impact is

(A) 0.5 Ans

(B) 0.8

(C) 0.25

(D) 0.75

Avg speed = $\frac{\text{Total dist}}{\text{Total time}}$

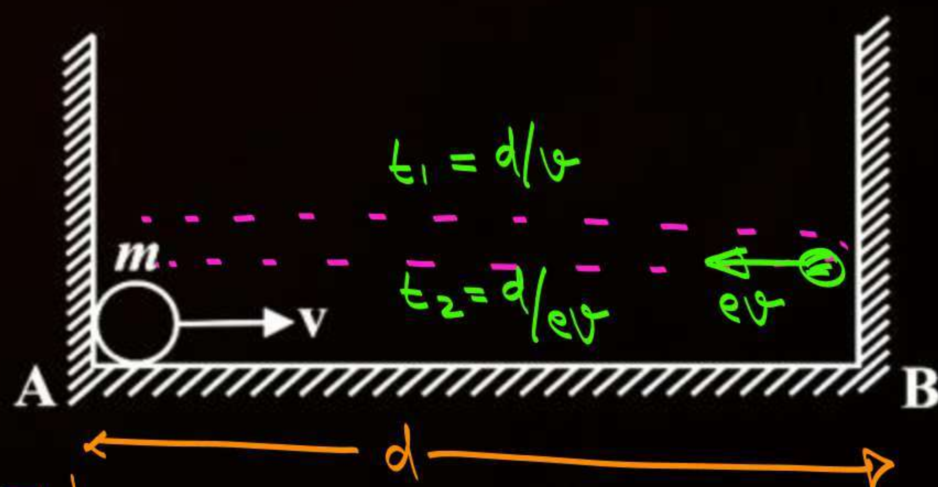
$$\frac{2v}{3} = \frac{2\cancel{d}}{\frac{\cancel{d}}{v} + \frac{\cancel{d}}{ev}}$$

$$\frac{\cancel{2}\cancel{v}}{3} = \frac{\cancel{2}\cancel{v}e}{(e+1)}$$

$3e = e + 1$

$2e = 1$

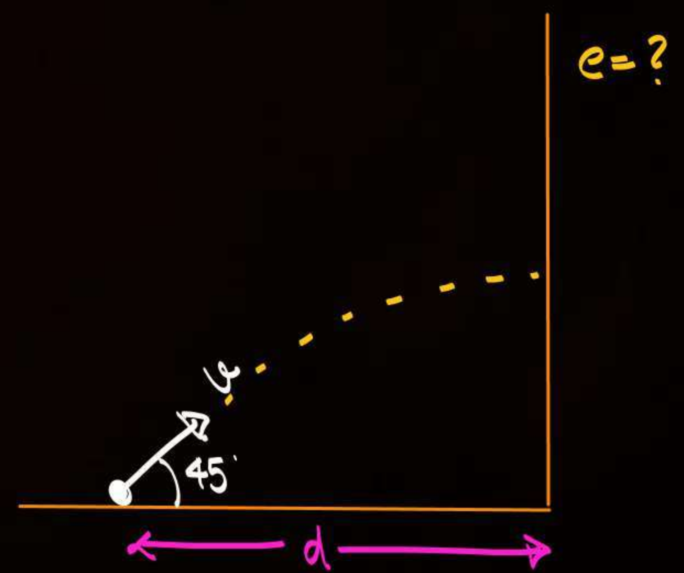
$e = 0.5$



Question 31

(Proj + Collision)

A girl throws a ball with initial velocity v at an inclination of 45°. The ball strikes a smooth vertical wall at a horizontal distance d from the girl and after rebounding returns to her hand. What is the coefficient of restitution between the wall and the ball?

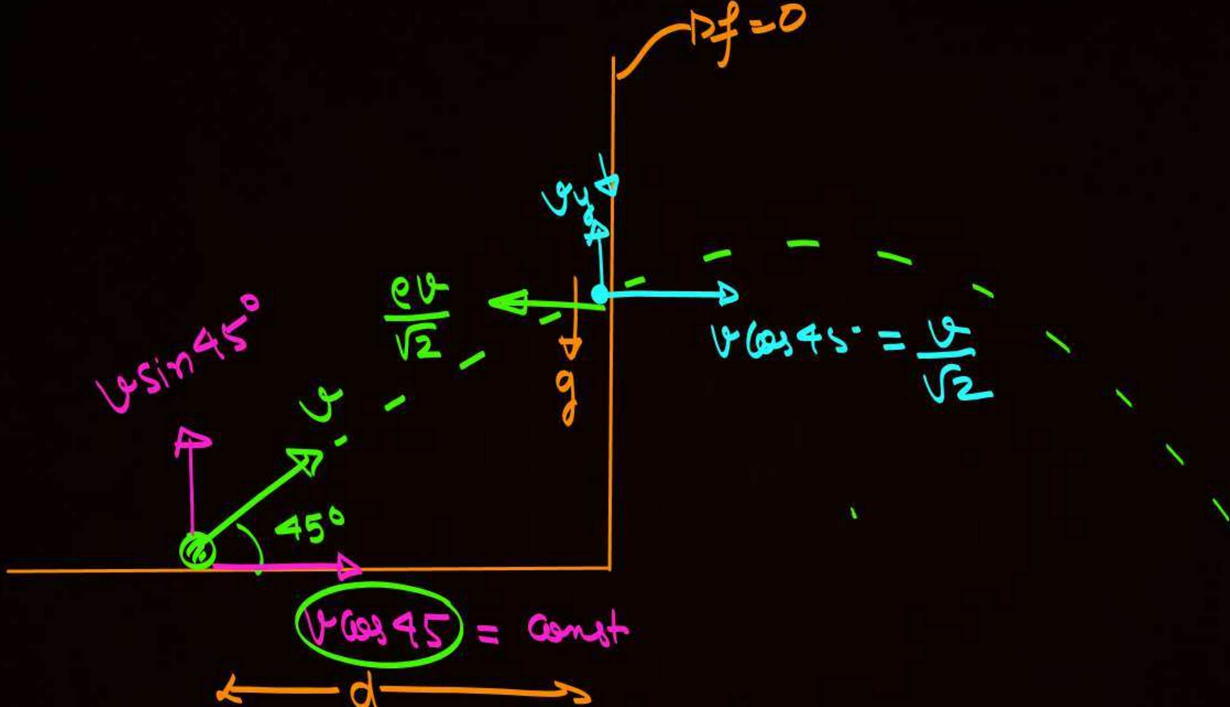


A $v^2 - gd$

B $\dfrac{gd}{v^2 - gd}$

C $\dfrac{gd}{v^2}$

D $\dfrac{v^2}{gd}$



Total time of flight (Same | change)

Vertical velocity → only gravity chang

$$T = \frac{2u_y}{a_y}$$

$$\frac{d}{v\cos45} + \frac{d}{ev\cos45} = T = \frac{\sqrt{2}v}{g}$$

e = ____

$$t_{\text{jate samay}} + t_{\text{aate}} = \frac{\sqrt{2}v}{g}$$

$$T = \frac{\sqrt{2}v}{g} = T = \frac{2u\sin45}{g}$$

Question 32

A body of mass m_1 moving with an unknown velocity of $v_1\hat{\imath}$, undergoes a collinear collision with a body of mass m_2 moving with a velocity $v_2\hat{\imath}$,. After collision m_1 and m_2 move with velocities of $v_3\hat{\imath}$ and $v_4\hat{\imath}$, respectively.

If $m_2 = 0.5\, m_1$ and $v_3 = 0.5\, v_1$, then $\underline{\underline{v_1}}$ is (2019 Mam, 8 April II)

A $v_4 + v_2$

B $v_4 - v_2/4$

C $v_4 - v_2/2$

D $v_4 - v_2$ Ans

$m_1 \xrightarrow{} v_1$ $\quad m_2 \left(\frac{m_1}{2}\right) \xrightarrow{} v_2$ $\quad m_1 \xrightarrow{} v_3 \left(\frac{v_1}{2}\right)$ $\quad m_2 \left(\frac{m_1}{2}\right) \xrightarrow{} v_4$

$\vec{P_i} = \vec{P_f}$ whatever may be e.

$\cancel{m_1} v_1 + \frac{\cancel{m_1}}{2} v_2 = \cancel{m_1} \frac{v_1}{2} + \frac{\cancel{m_1}}{2} v_4 \Rightarrow \frac{v_1}{2} = \frac{v_4}{2} - \frac{v_2}{2} \Rightarrow \boxed{v_1 = v_4 - v_2}$ Ans

Question 33

An α-particle of mass m suffers one-dimensional elastic collision with a nucleus at rest of unknown mass. It is scattered directly backwards losing 64% of its initial kinetic energy. The mass of the nucleus is (2019)

A. 1.5 m

B. 4 m

C. 3.5 m

D. 2 m

Question 34

A ball with a speed of 9 m/s collides with another identical ball at rest. After the collision, the direction of each ball makes an angle of 30° with the original direction. The ratio of velocities of the balls after collision is $x : y$, where x is

24 Feb (Shift I) Numerical

Question 35

Two identical blocks A and B each of mass m resting on the smooth horizontal floor are connected by a light spring of natural length L and spring constant K. A third block C of mass m moving with a speed v along the line joining A and B collides with A. The maximum compression in the spring is **JEE Main 2021 (March)**

A $\sqrt{\frac{M}{2K}}$

B $\sqrt{\frac{mv}{2K}}$

C $\sqrt{\frac{mv}{K}}$

D $\sqrt{\frac{m}{2K}}$

Question 36

An object of mass m_1 collides with another object of mass m_2, which is at rest. After the collision the objects move with equal speeds in opposite direction. The ratio of the masses $m_2 : m_1$ is:

18 March (Shift 2); JEE Main 2021

A $3:1$

B $2:1$

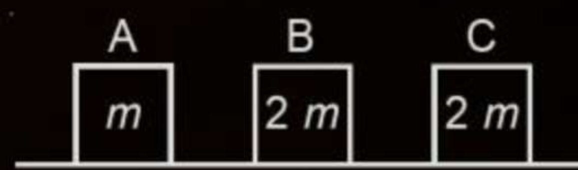
C $1:2$

D $1:1$

Question 37

Three objects A, B and C are kept in a straight line on a frictionless horizontal surface. The masses of A, B and C are m, 2 m and 2 m respectively. A moves towards B with a speed of 9 m/s and makes an elastic collision with it. Thereafter B makes a completely inelastic collision with C. All motions occur along same straight line. The final speed of C is

[JEE (Main)-2021]



A 6 m/s

B 4 m/s

C 9 m/s

D 3 m/s

Question 37

Three blocks A, B and C are lying on a smooth horizontal surface as shown in the figure. A and B have equal masses m while C has mass M. Block A is given an initial speed v towards B due to which it collides with B perfectly inelastically. The combined mass collides with C. also perfectly inelastically $\frac{5}{6}$th of the initial kinetic energy is lost in whole process. What is value of M/m? **(2019 Main, 9 Jan I)**

A 4

B 2

C 3

D 5

Question 38

A particle of mass m is projected with a speed u from the ground at an angle $\theta = \pi/3$ w.r.t. horizontal (x-axis). When it has reached its maximum height, it collides completely in-elastically with another particle of the same mass and velocity $u\hat{i}$. The horizontal distance covered by the combined mass before reaching the ground is :

A $\frac{3\sqrt{3}}{8}\frac{u^2}{g}$

B $2\sqrt{2}\frac{u^2}{g}$

C $\frac{5}{8}\frac{u^2}{g}$

D $\frac{3\sqrt{2}}{4}\frac{u^2}{g}$

Question 39

A particle of mass m with an initial velocity $u\hat{i}$ collides perfectly elastically with a mass 3m at rest. It moves with a velocity $v\hat{j}$ after collision, then, v is given by

JEE Main 2020 - 2 September (Morning)

A $v = \frac{1}{\sqrt{6}}u$

B $v = \frac{u}{\sqrt{3}}$

C $v = \sqrt{\frac{2}{3}}u$

D $v = \frac{u}{\sqrt{2}}$

Question 40

Statement-1 : Two particles moving in the same direction do not lose all their energy in a completely inelastic collision.

Statement-2 : Principle of conservation of momentum holds true for all kinds of collisions.

[AIEEE-2010]

A. Statement-1 is true, Statement-2 is false

B. Statement-1 is true, Statement-2 is true; Statement-2 is the correct explanation of Statement-1

C. Statement-1 is true, Statement-2 is true; Statement-2 is the not the correct explanation of Statement-1

D. Statement-1 is false, Statement-2 is true

Question 41

As per the given figure, two blocks each of mass 250 g are connected to a spring of spring constant $2 \mathrm{Nm}^{-1}$. If both are given velocity v in opposite directions, then maximum elongation of the spring is:

[JEE (Main)-2022]

A $\frac{v}{2\sqrt{2}}$

B $\frac{v}{2}$

C $\frac{v}{4}$

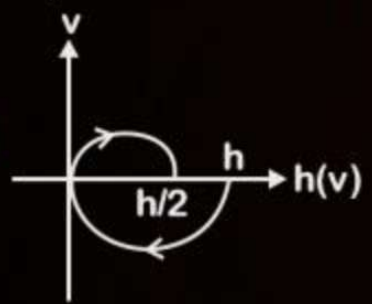
D $\frac{v}{\sqrt{2}}$

Question 42

A tennis ball is released from a height h and after freely falling on a wooden floor it rebounds and reaches height $\frac{h}{2}$. The velocity versus height of the ball during its motion may be represented graphically by(graph are drawn schematically and on not to scale)

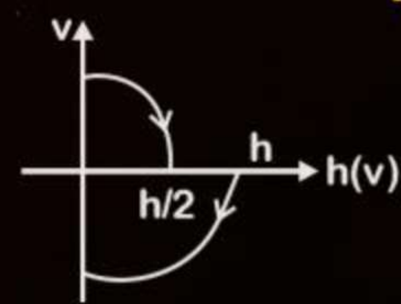
[JEE (Main)-2020] Adv

A

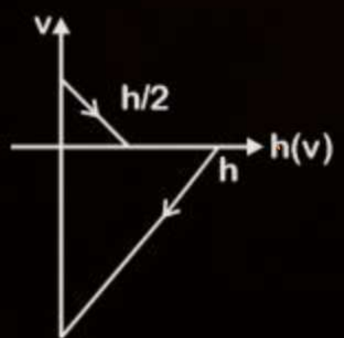


Ans

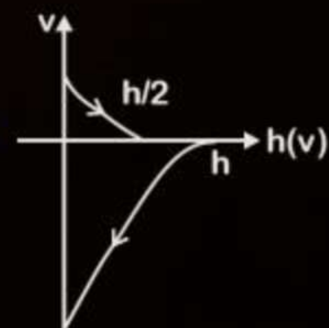
B



C



D



Question 43

A particle of mass m moving in the x direction with speed $2v$ is hit by another particle of mass $2m$ moving in the y direction with speed v. If the collision is perfectly inelastic, the percentage loss in the energy during the collision is close to

[JEE (Main)-2015]

A. 44%

B. 50%

C. 56%

D. 62%

Question 44

A block moving horizontally on a smooth surface with a speed of 40 m/s splits into two parts with masses in the ratio of 1 : 2. If the smaller part moves at 60 m/s in the same direction, then the fractional change in kinetic energy is: **[JEE (Main)-2021]**

A 1/3

B 2/3

C 1/4

D 1/8

Question 45

Two billiard balls of mass 0.05 kg each moving in opposite directions with $10\ \text{ms}^{-1}$ collide and rebound with the same speed. If the time duration of contact is $t = 0.005$ s, then what is the force exerted on the ball due to each other?

[JEE (Main)-2022]

A 100 N

B 200 N

C 300 N

D 400 N

Question 46

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

A. $\sqrt{\frac{2}{3}}mu^2$

B. $\frac{3}{4}mu^2$

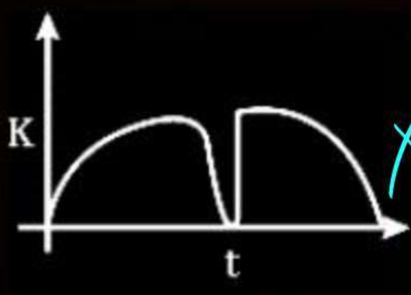
C. $\frac{1}{8}mu^2$

D. $\frac{1}{3}mu^2$

Question 47

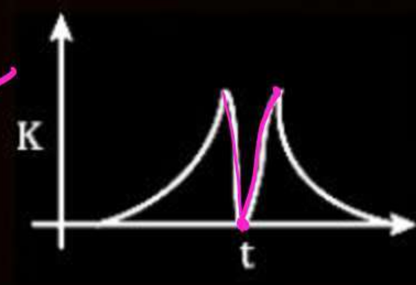
A tennis ball is dropped on a horizontal smooth surface. It bounces back to its original position after hitting the surface. The force on the ball during the collision is proportional to the length of compression of the ball. Which one of the following sketches describes the variation of its kinetic energy K with time t most appropriately? The figures are only illustrative and not to the scale. (2014) Adv.

A

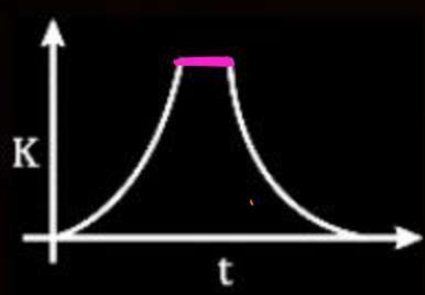


Ans

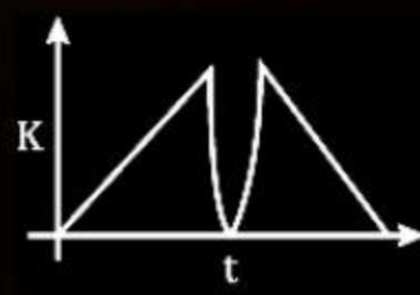
B



C



D



KE as fn(t).

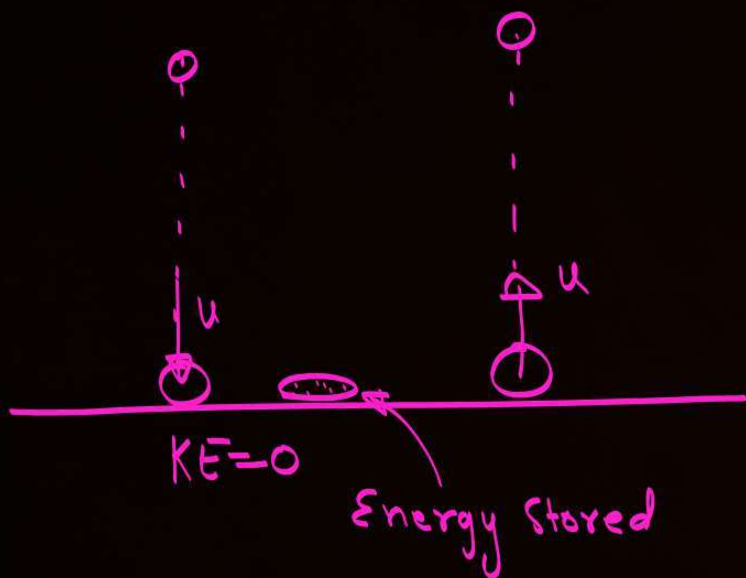
$u = 0$

h

$v = u + at = gt$

$KE = \frac{1}{2}mv^2 = \frac{1}{2}mg^2t^2$

$KE \propto t^2$ Parabola.

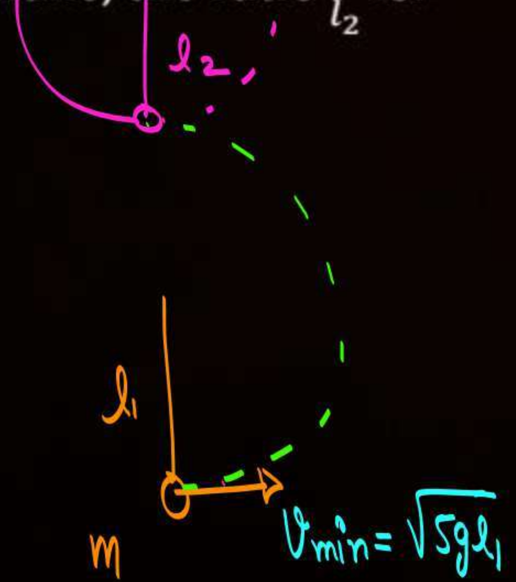

u
u
KE=0
Energy Stored

Question 48

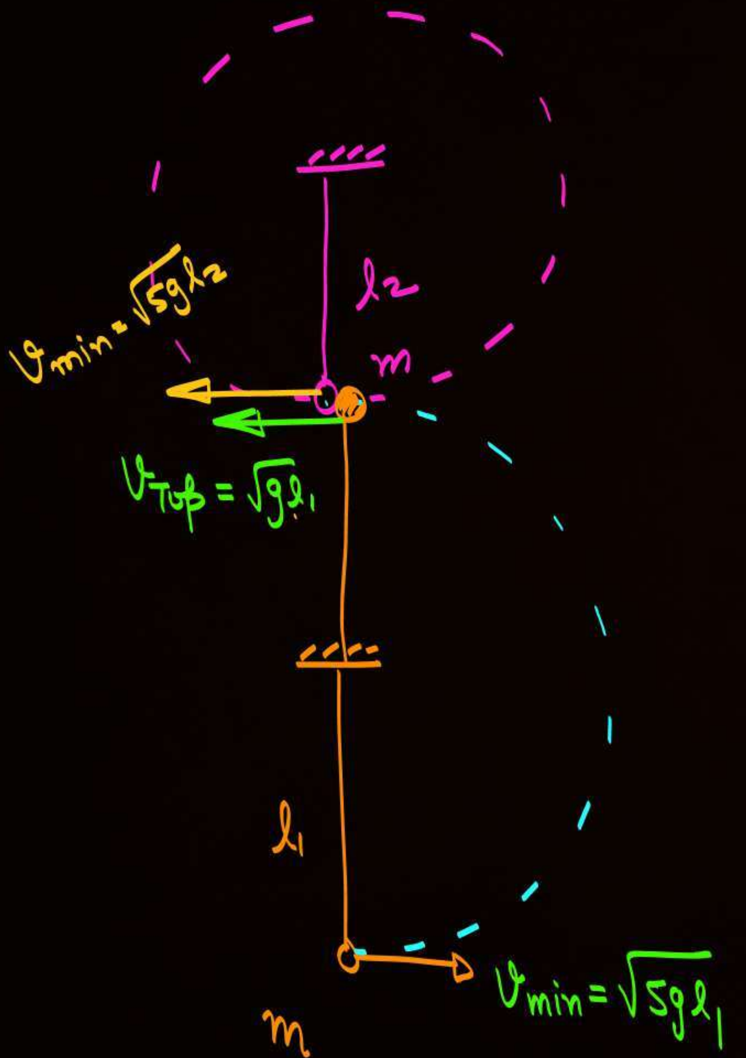
(Vertical Circular + Collisions)

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

Adv



$e = 1$ mass Same velocity Exchange.



mass = Same

$e = 1$

Velocity Exchange

$v_{Top_1} = v_{min}$ for 2

$\sqrt{g l_1} = \sqrt{5 g l_2}$

$l_1 = 5 l_2$

$\frac{l_1}{l_2} = 5$

Question 49

A particle of mass m is projected from the ground with an initial seed u_0 at an angle α with the horizontal. At the highest point of its trajectory, it makes a completely inelastic collision with another identical particle, which was thrown vertically upward from the ground with the same initial speed u_0. The angle that the composite system makes with the horizontal immediately after the collision is:

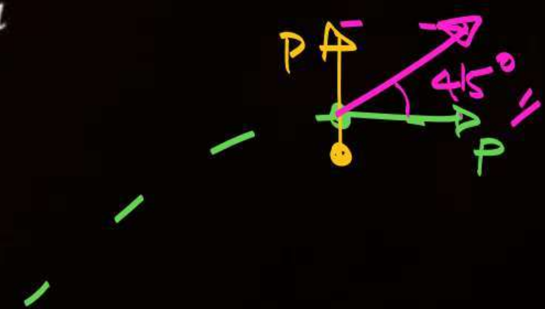
(2013)

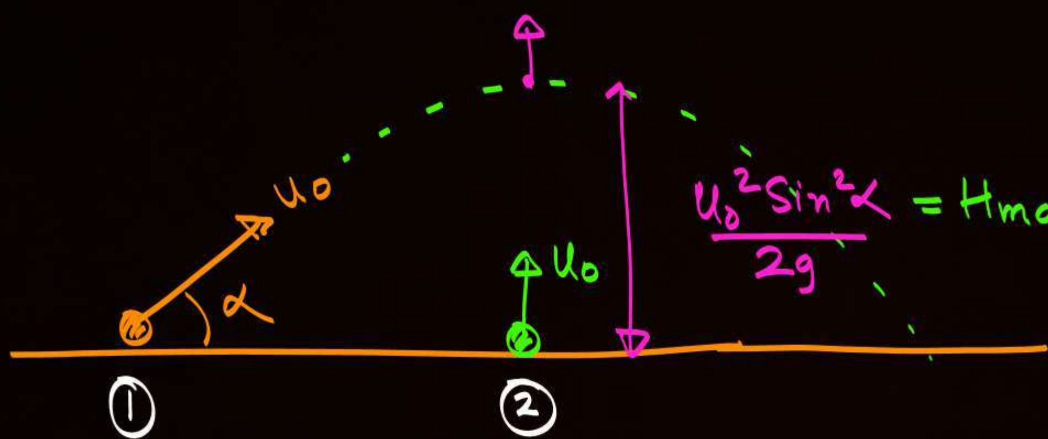
(A) $\frac{\pi}{4}$ Ans

(B) $\frac{\pi}{4}+a$

(C) $\frac{\pi}{4}-a$

(D) $-\frac{\pi}{4}$





$$\frac{u_0^2 \sin^2\alpha}{2g} = H_{max}$$

$$v^2 - u^2 = 2aS$$

$$v = \sqrt{u_0^2 - \cancel{2g}\cdot\frac{u_0^2\sin^2\alpha}{\cancel{2g}}}$$

$$\boxed{v = u_0 \cos\alpha}$$

Particle 1

Top

m $\longrightarrow$ $u_0 \cos\alpha$

$e = 0$

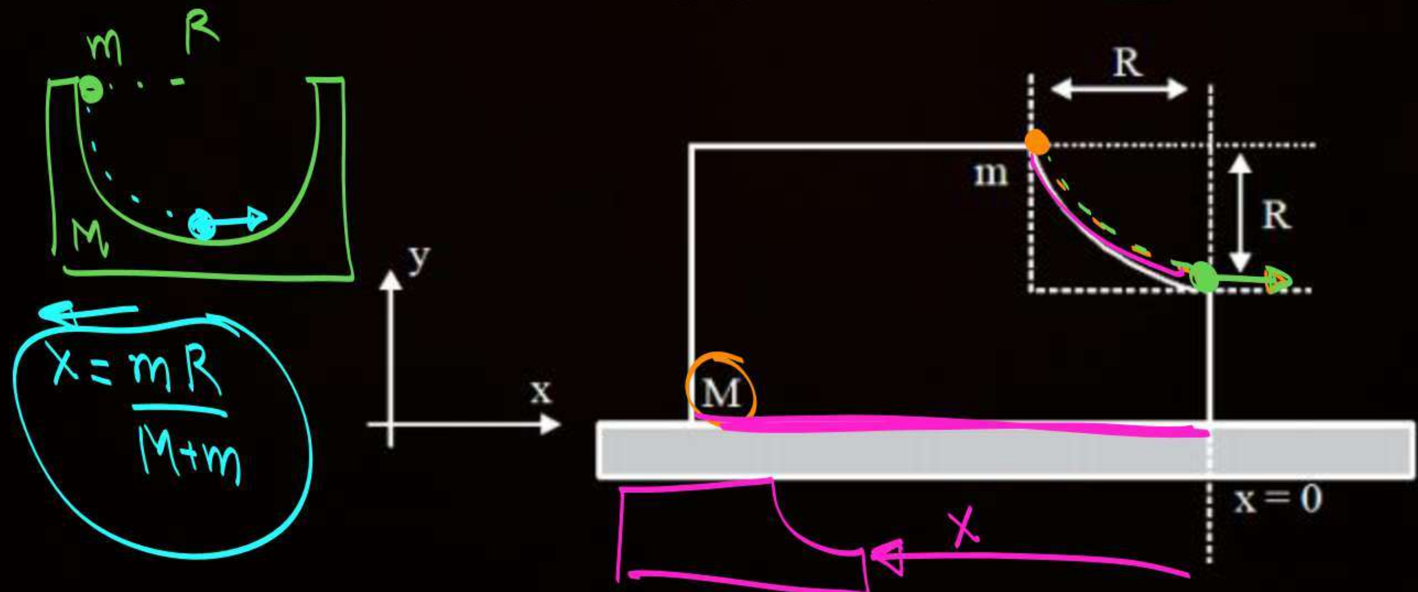
Particle 2

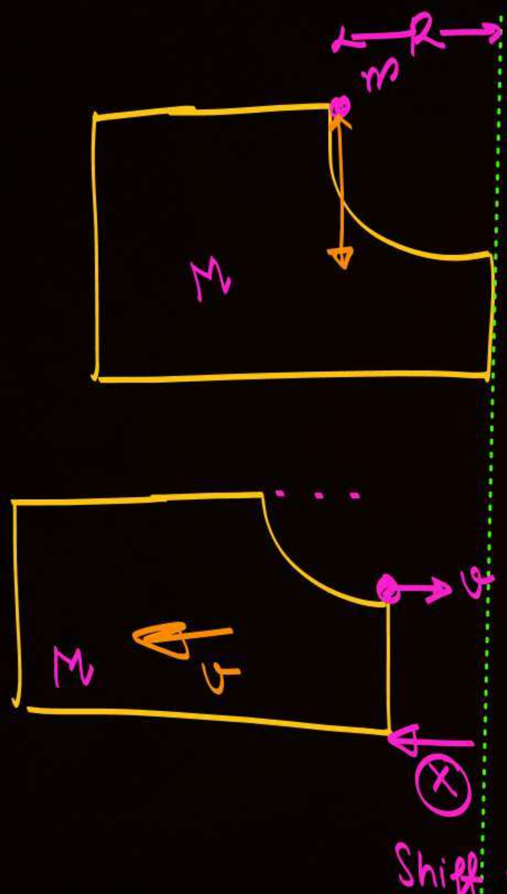
Top

m $\uparrow$ $u_0 \cos\alpha$

Question 50

A block of mass M has a circular cut with a frictionless surface as shown. The block rests on the horizontal frictionless surface of a fixed table. Initially the right edge of the block is at $x = 0$ in a coordinate system fixed to the table. A point mass m is released from rest at the topmost point of the path as shown and its slides down. When the mass loses contact with the block, its position is x and the velocity is v. At the instant, which of the following options is/are correct? **(2017)** Adv





$$mgR = \frac{P^2}{2\mu}$$

$$\boxed{P = mu = Mv}$$

$$\text{Shift} = \frac{mR}{M+m}$$

A The velocity of the point mass m is : $v = \sqrt{\frac{2gR}{1+\frac{m}{M}}}$

Ans

B The x component of displacement of the center of mass of the block M is: $-\frac{mR}{M+m}$

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

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

Explosion

$mgR = \frac{P^2}{2\mu}$

$mgR = \frac{M^2 v^2}{2\left(\frac{mM}{M+m}\right)}$

$mgR = \frac{m^2 u^2}{2\left(\frac{mM}{M+m}\right)}$ $u =$

Question 51

Hw

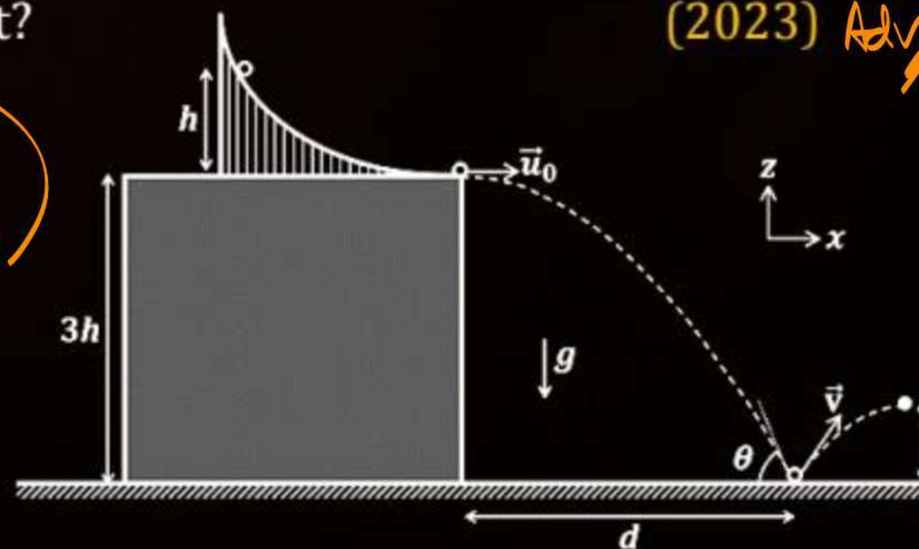
A solid horizontal surface is covered with a thin layer of oil. A rectangular block of mass $m = 0.4$ kg is at rest on this surface. An impulse of 1.0 Ns is applied to the block at time to $t = 0$ so that it starts moving along the x-axis with a velocity $v(t) = v_0 e^{-t/\tau}$, where v_0 is a constant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

Question 52

HW

A slide with a frictionless curved surface, which becomes horizontal at its lower end, is fixed on the terrace of a building of height $3h$ from the ground, as shown in the figure. A spherical ball of mass m is released on the slide from rest at a height h from the top of the terrace. The ball leaves the slide with a velocity $\vec{u}_0 = u_0\hat{x}$ and falls on the ground at a distance d from the building making an angle θ with the horizontal. It bounces off with a velocity $\vec{v}$ and reaches a maximum height h_1. The acceleration due to gravity is g and the coefficient of restitution of the ground is $1/\sqrt{3}$. Which of the following statement(s) is(are) correct? (2023) Adv

(WET, Projectile, Collisions)



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

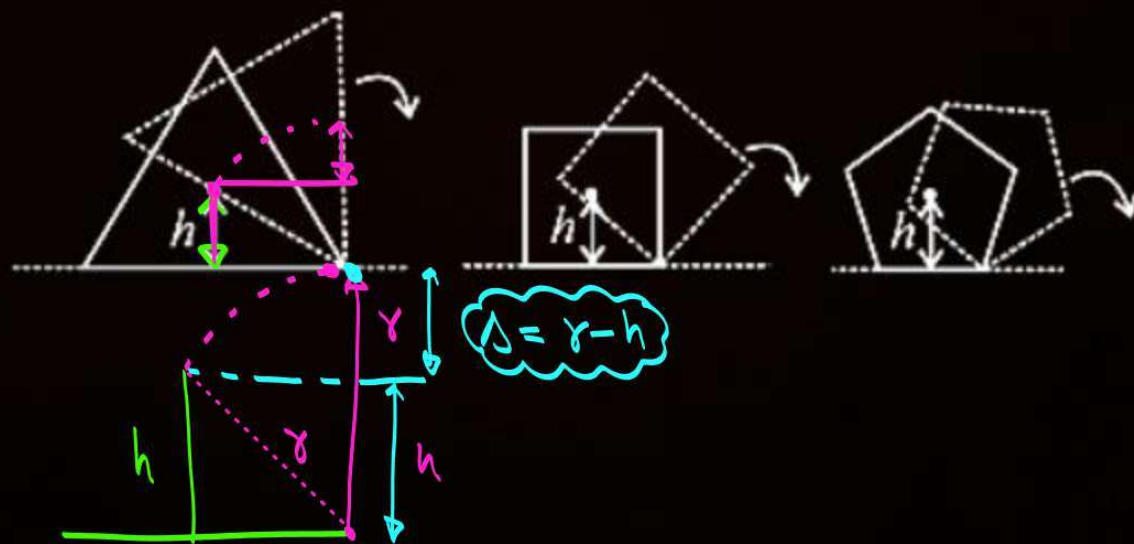
B $\vec{v} = \sqrt{2gh}(\hat{x} - \hat{z})$

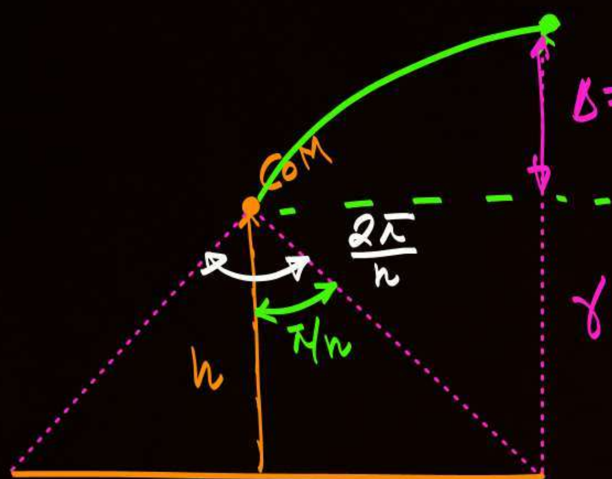
C $\theta = 60^\circ$

D $d/h_1 = 2\sqrt{3}$

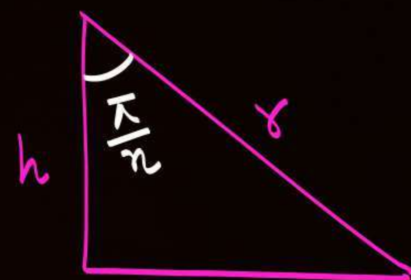
Question 53

Consider regular polygon with number of sides $n = 3,4.\ 5\ ...$ as shown in the figure. The centre of mass of all the polygons is at height h from the ground. They roll on a horizontal surface about the leading vertex without slipping and sliding as depicted. The maximum increase in height of the locus of the center of mass for each polygon is Δ. Then Δ depends on n and h as **(2017)**





$$\Delta = r - h = \frac{h}{\cos(\pi/n)} - h = h\left[\frac{1}{\cos\left(\frac{\pi}{n}\right)} - 1\right]$$



Polygon of n side.

$$\cos\left(\frac{\pi}{n}\right) = \frac{B}{H}$$

$$\cos\left(\frac{\pi}{n}\right) = \frac{h}{r}$$

$$r = \frac{h}{\cos(\pi/n)}$$

A $\Delta = h\sin\left(\frac{2\pi}{n}\right)$

B $\Delta = h\tan^2\left(\frac{\pi}{2n}\right)$

C $\Delta = h\sin^2\left(\frac{\pi}{n}\right)$

D $\Delta = h\left(\frac{1}{\cos\left(\frac{\pi}{n}\right)} - 1\right)$

Ans

Download PDF of class and DPP from PW mobile APP

Homework

- DPP of Centre of mass and collisions


Thank
You