Physicsaholics

DPP – 4

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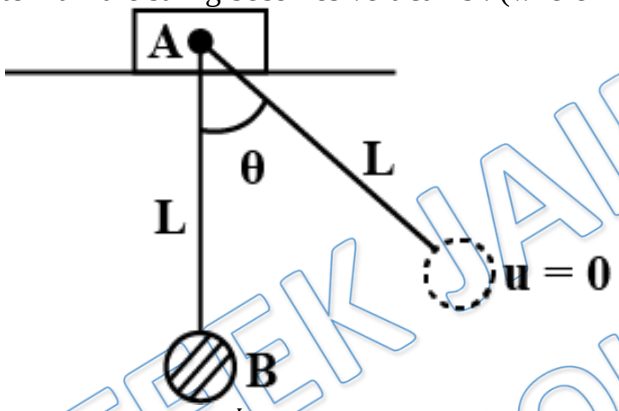
Q 1. The magnitude of vertical displacement of center of mass of A+B (A & B having same mass) system till the string becomes vertical is : (where A is fixed)



(a) zero (b) $\frac{L}{2}(1-\cos\theta)$

(c) $\frac{L}{2}(1-\sin\theta)$ (d) none of these

Q 2. In a gravity free space, a man of mass M standing at a height h above the floor, throws a ball of mass m straight down with a speed u. When the ball reaches the floor, the distance of the man above the floor will be

(a) $h\left(1+\frac{m}{M}\right)$ (b) $h\left(2-\frac{m}{M}\right)$

(c) 2h (d) a function of m, M, h and u

Q 3. A man of 50kg mass is standing in a gravity free space at a height of 10m above the floor. He throws a stone of 0.5kg mass downwards with a speed 2m/s. When the stone reaches the floor, the distance of the man above the floor will be

(a) 9.9 m (b) 10.1 m

(c) 1.0 m (d) 20 m

Q 4. Consider a two particle system with particles having masses m_1 and m_2. If the first particle is pushed towards the center of mass through a distance d, by what distance should the second particle be moved, so as to keep the center of mass at the same position –

(a) $\frac{m_1}{m_2}d$ (b) d

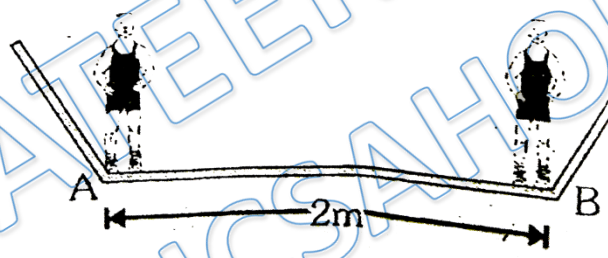
(c) $\frac{m_2}{m_1}d$ (d) $\frac{m_1}{m_1+m_2}d$

Q 5. Two bocks of masses 10 kg and 20 kg are placed on the X-axis. The first mass (10 kg) is moved on the axis by a distance of 2 cm. By what distance should the second mass be moved to keep the position of the center of mass unchanged?
(a) 1 cm (b) 2 cm
(c) 3 cm (d) 4 cm

Q 6. Two blocks of masses 10 kg and 30 kg are placed along a vertical line. The first block (10 kg) is raised through a height of 7 cm. By what distance should the second mass be moved to raise the center of mass by 1 cm?
(a) 1 cm (b) 6 cm
(c) 7 cm (d) 8 cm

Q 7. A boy is standing at the center of a boat which is free to move on water. If the masses of the boy and the boat are M and m respectively and the boy moves a distance of 1 m forward then the movement of the boat is ..... meters
(a) $\frac{Mm}{M+m}$ (b) $\frac{m}{M+m}$
(c) $\frac{M}{M+m}$ (d) $\frac{m}{M-m}$

Q 8. Two persons A and B of weight 80kg and 50kg respectively are standing at opposite ends of a boat of mass 70kg and length 2m at rest. When they interchange their positions then displacement of the center of mass of the boat will be :-



(a) 60cm towards left
(b) 30cm towards right
(c) 30cm towards left
(d) remains stationary

Q 9. A man weighing 80 kg is standing at the center of a flat boat and he is 20 m from the shore. He walks 8 m on the boat towards the shore and then halts. The boat weight 200 kg. How far is he from the shore at the end of this time ?
(a) 11.2 m (b) 13.8 m
(c) 14.3 m (d) 15.4 m

Q 10. A man of 80 kg attempts to jump from the small boat of mass 40 kg on to the shore. He can generate a relative velocity of 6 m/s between him and boat. His velocity towards shore is
(a) 2 m/s (b) 3 m/s
(c) 4 m/s (d) 5 m/s

Q 11. A boy of mass 50kg is standing at one end of a boat of length 9m and mass 400kg. He runs to the other end. The distance through which the center of mass of the boat boy system moves is

(a) 0 m (b) 1 m
(c) 2 m (d) 3 m

Q 12. A 1kg block slides down an inclined plane of mass 3.2kg having inclination 45°. If the inclined plane is fixed and the 1kg block slides without friction, find the acceleration of the center of mass of the system of the block and inclined plane (take g $= 9.8\, m/s^2$)

(a) 2.1 m/s^2 (b) 0.9 m/s^2
(c) 9.8 m/s^2 (d) 1.7 m/s^2

Q 13. A boy of mass 40 kg jumps off a boat with a velocity of 3 m/s w.r.t. ground. With what momentum does the boat move ?

(a) -210 kg-m/s (b) -120 kg-m/s
(c) -125 kg-m/s (d) -215 kg-m/s

Q 14. A bullet is fired from a gun with a velocity 600 m/s. The recoil velocity of the gun is 3 m/s. What is the ratio of the mass of the gun and bullet ?

(a) 100 : 1 (b) 400 : 1
(c) 200 : 1 (d) 300 : 2

Answer Key

Q.1 b	**Q.2 a**	**Q.3 b**	**Q.4 a**	**Q.5 a**
Q.6 a	**Q.7 c**	**Q.8 c**	**Q.9 c**	**Q.10 a**
Q.11 a	**Q.12 d**	**Q.13 b**	**Q.14 c**	

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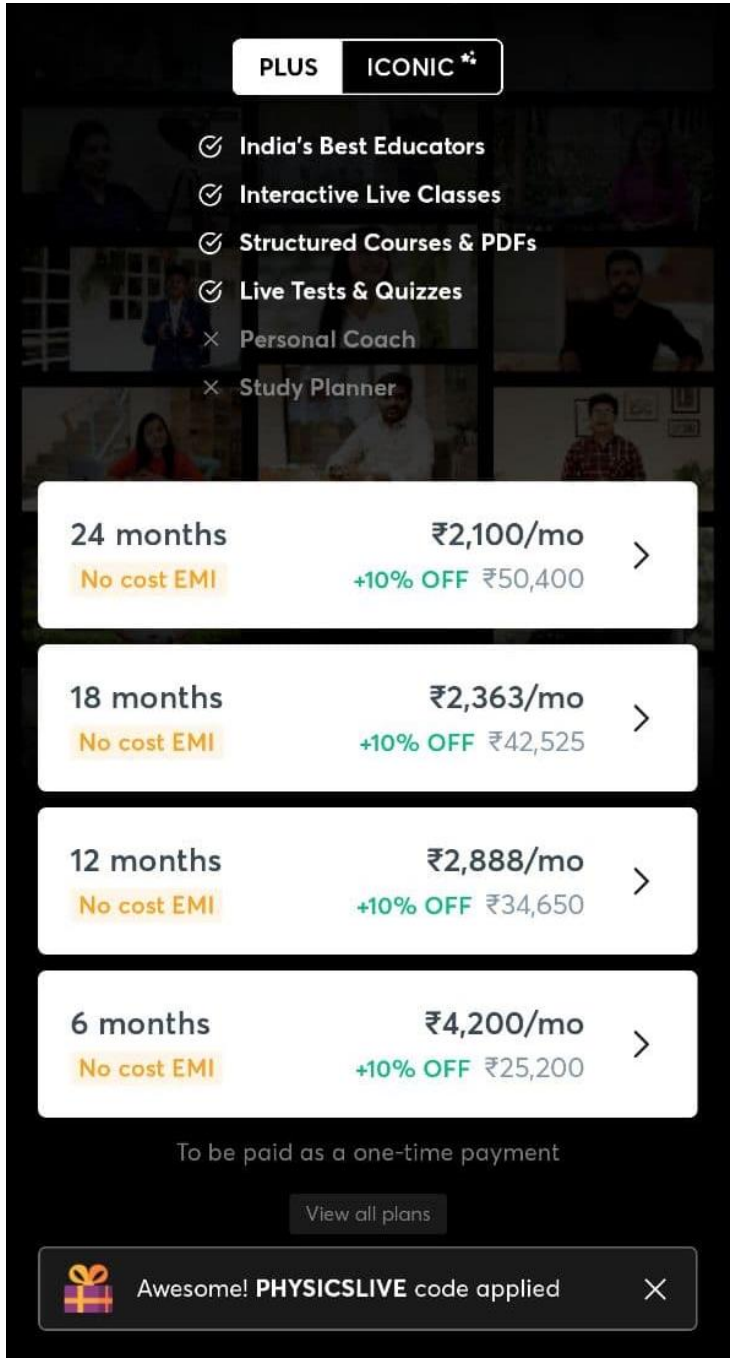
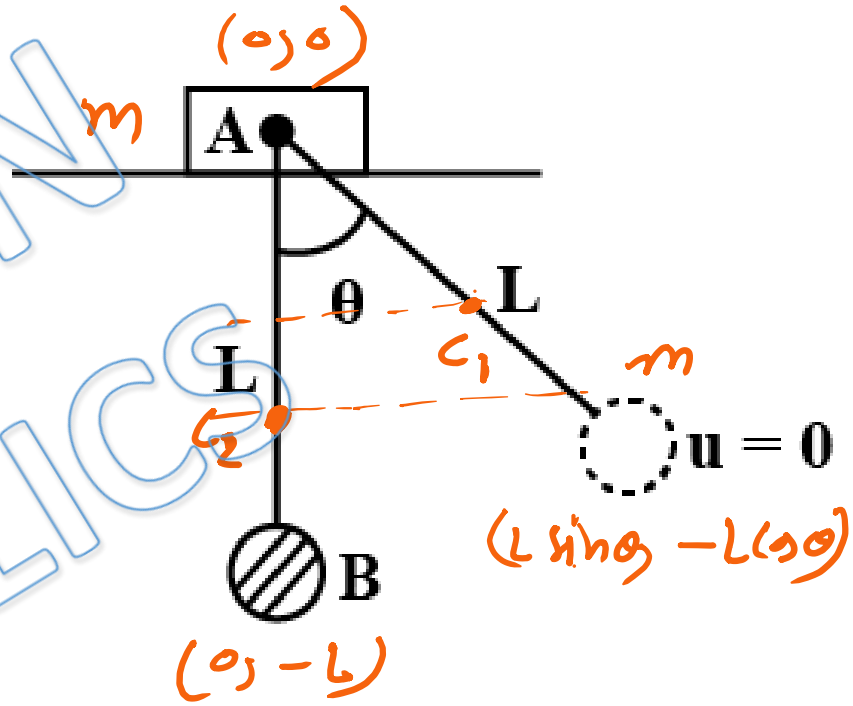


Written Solution

DPP-4 COM: Conservation of Momentum, Shifting of com & Stationary com (Jumping Problems)

By Physicsaholics Team

Solution: 1



C_1 = COM initially.

$$(x_1, y_1) = \left(\frac{m(0) + m(L\sin\theta)}{2m} \;\; \frac{m(0) + m(-L\cos\theta)}{2m} \right)$$

$$(x_1, y_1) = \left(\frac{L\sin\theta}{2} \;;\; -\frac{L\cos\theta}{2} \right)$$

C_2 = COM after

$$(x_2, y_2) = \left(\frac{m(0) + m(0)}{2m} \;;\; \frac{m(0) + m(-L)}{2m} \right)$$

$$(x_2, y_2) = \left[0, -\frac{L}{2} \right]$$

Vertical displacement of COM $= y_2 - y_1 = -\frac{L}{2} - \left[-\frac{L\cos\theta}{2} \right]$

$$d = |y_2 - y_1| = \left| -\frac{L}{2}(1 - \cos\theta) \right| \Rightarrow \boxed{d = \frac{L}{2}(1 - \cos\theta)} \text{ Ans.}$$

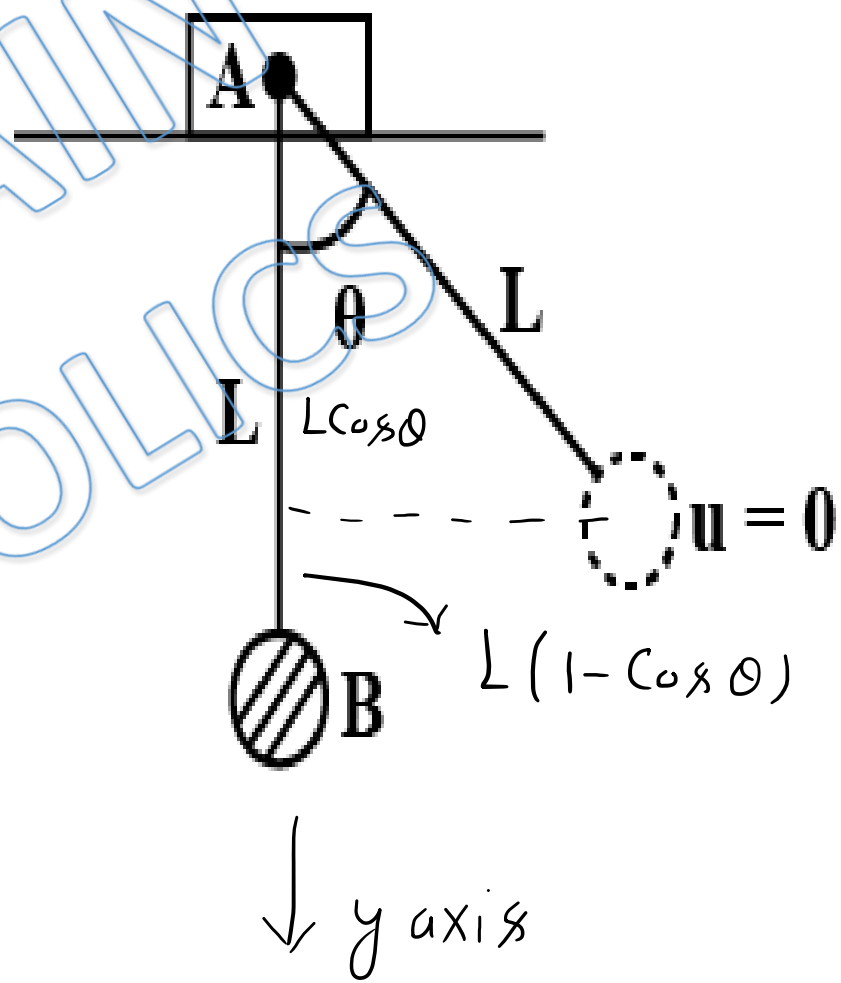
Ans. b

OR

$$\Delta y_{cm} = \frac{m_1 \Delta y_1 + m_2 \Delta y_2}{m_1 + m_2}$$

$$= \frac{m \times 0 + m L (1 - \cos\theta)}{m + m}$$

$$= \frac{L}{2}(1 - \cos\theta)$$



ANS (B)

Solution: 2

as gravity is absent

$F_{ext} = 0$ on system (ball + man)

so, COM will be in rest

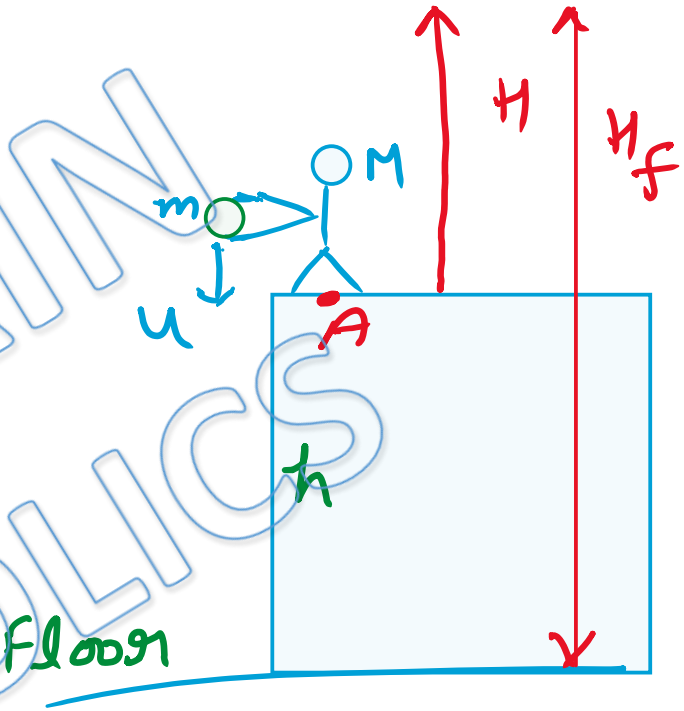
$$\Delta r_{cm} = 0 = \frac{m_1 \Delta r_1 + m_2 \Delta r_2}{m_1 + m_2}$$

$$m_1 \Delta r_1 + m_2 \Delta r_2 = 0$$

$$-mh + MH = 0$$

Let; H = Height achieved by man from A

$$\boxed{H = \frac{m}{M} h} \Rightarrow H_f = h + H \Rightarrow \boxed{H_f = h\left(1 + \frac{m}{M}\right)}$$ Ans.



Ans. a

Solution: 3

as grav is

$F_{ext} = 0$ on system (ball + man)

so, COM will be in rest

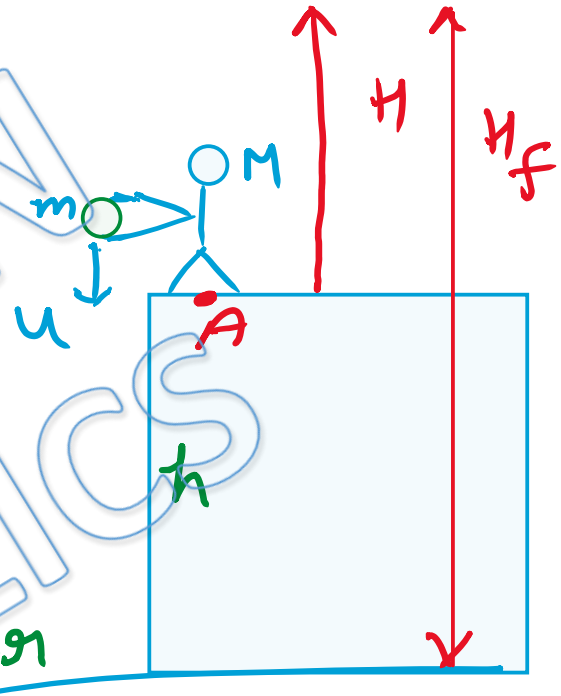
$$\Delta r_{cm} = 0 = \frac{m_1 \Delta r_1 + m_2 \Delta r_2}{m_1 + m_2}$$

$$m_1 \Delta r_1 + m_2 \Delta r_2 = 0$$

$$(0.5)\times(-10) + 5\alpha \times H = 0$$

$$\boxed{H = 0.1\,m}$$

$$H_f = h + H = 10 + 0.1 \Rightarrow \boxed{H_f = 10.1\,m}$$ Ans.



Ans. b

Solution: 4

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

if com is at the same position

then $\Delta x_{cm} = 0 = \frac{m_1 d - m_2 D}{m_1 + m_2}$

$$\boxed{D = \frac{m_1}{m_2} d}$$

$$\boxed{D = \frac{m_1}{m_2} d}$$ (Towards com or m_1) Ans

Ans. a

Solution: 5

$$\Delta x_2 = \frac{m_1}{m_2}\Delta x_1$$

$$\Rightarrow \Delta x_2 = \frac{10}{20} \times 2\,cm$$

$$\boxed{x_2 = 1\,cm}$$ Ans.

Ans. a

Solution: 6

given; $\Delta y_{cm} = 1\,cm$

$$\Delta y_{cm} = \frac{m_1 \Delta y_1 + m_2 \Delta y_2}{m_1 + m_2}$$

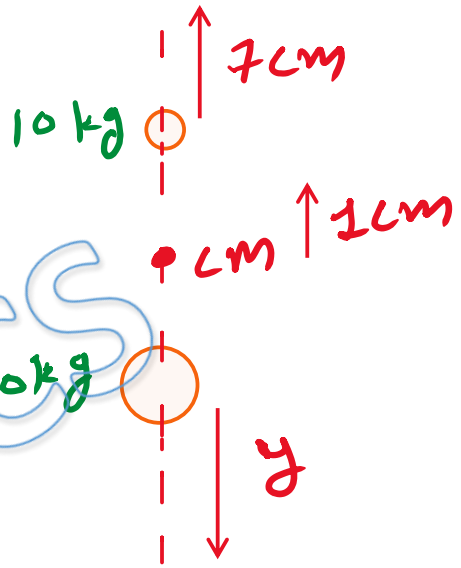
$$1 = \frac{10 \times 7 + 30 \times y}{10 + 30} = \frac{70 + 30y}{40}$$

$$70 + 30y = 40$$

$$30y = -30$$

$$\boxed{y = -1\,cm}$$

$$\boxed{|y| = 1\,cm}$$ Ans.



Ans. a

Solution: 7

man moves 1m w.r.t boat

$\therefore F_{ext} = 0$; [COM will be rest]

Let ; x = displacement of boat

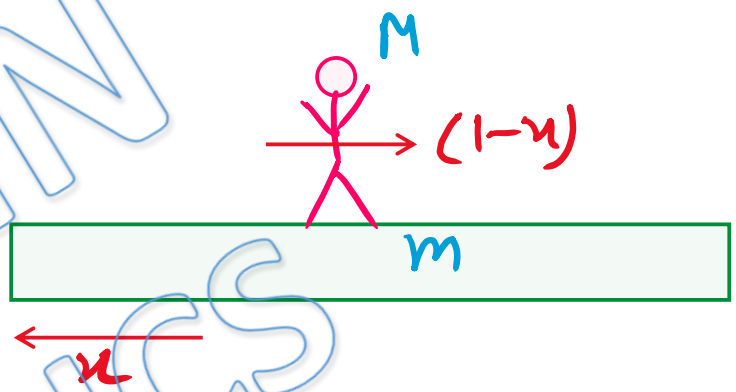
so; $(1-x)$ = displacement of boy

$$m(-x) + M(1-x) = 0$$

$$-mx = -M + Mx$$

$$M = (M+m)x$$

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



Ans. c

Solution: 8

Let, boat moved 'x' in left

$\because F_{net} = 0$ [com will be in rest]

So; distance of A = 2 − x

& distance of B = 2 + x

$$x_{cm} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$$

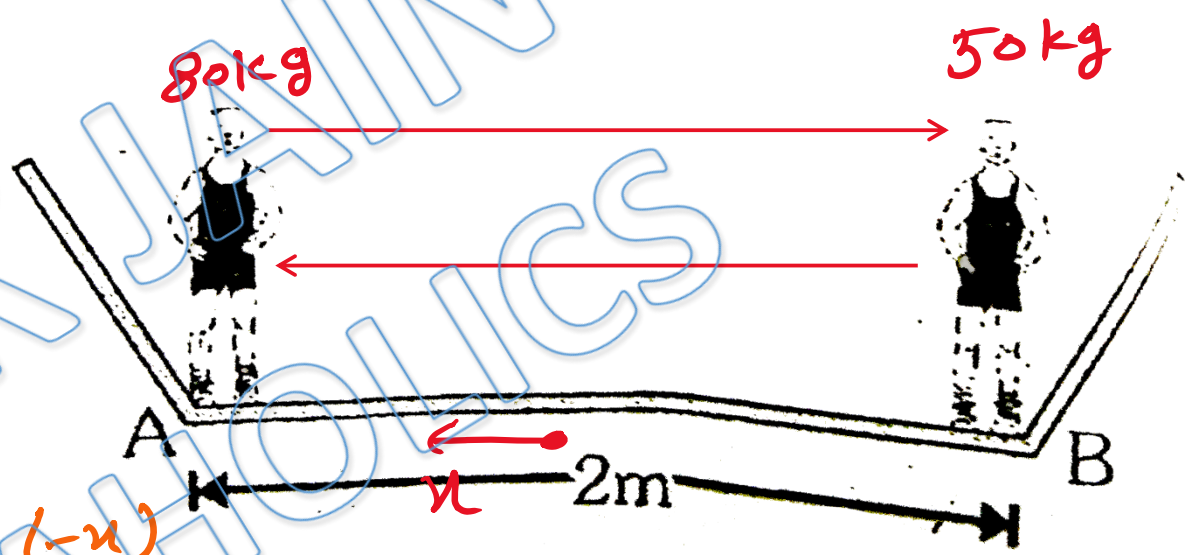
$$0 = \frac{80(2-x) + 50[-(2+x)] + 70(-x)}{80 + 50 + 70}$$

$$80(2-x) - 50(2+x) - 70x = 0$$

$$\Rightarrow 160 - 100 = 80x + 50x + 70x$$

$$200x = 60 \Rightarrow x = \frac{60}{200} = 0.3m \Rightarrow \boxed{x = 30cm}$$ Ans.

towards left

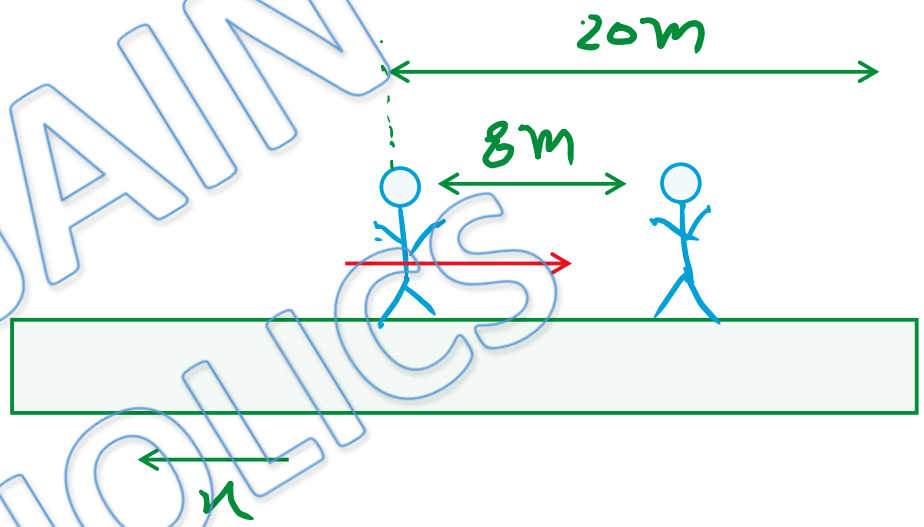


Ans. c

Solution: 9

Let, com of boat displaces 'x'

[$\because F_{net}=0$; com will be in rest]



soj net displacement of man = 8 − x

$$m_1x_1 + m_2x_2 = 0$$

$$80(8-x) + 200(-x) = 0$$

$$640 = 280x$$

$$x = \frac{640}{280}\ m = \frac{64}{28} = 2.3\ m$$

soj displacement of man = 8 − x = 8 − 2.3 = 5.7 m

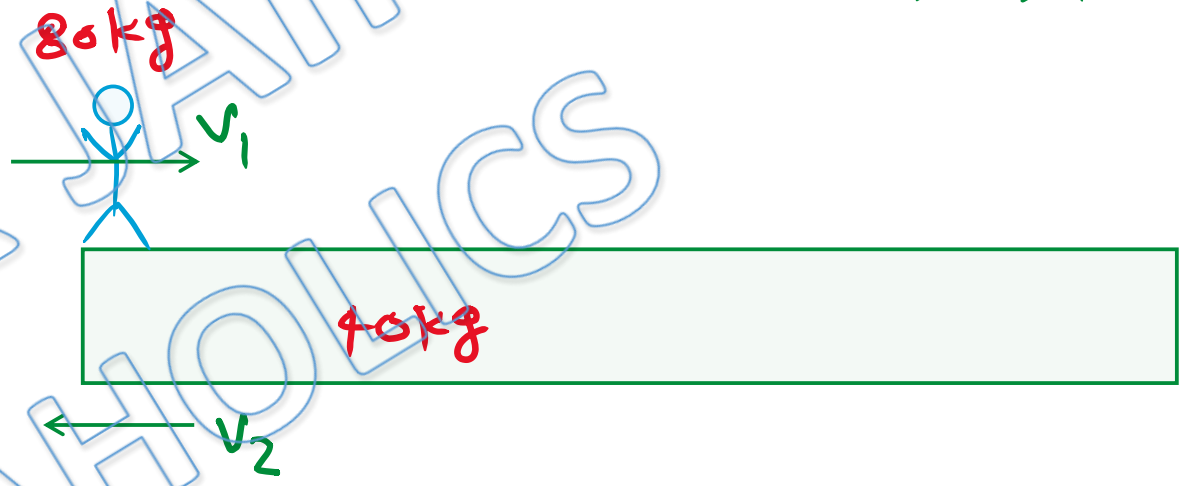
soj distance between shore & man = 20 − 5.7 = 14.3 m

$\boxed{d = 14.3\ m}$ Ans.

Ans. c

Solution: 10

$$\vec{v}_{1/2} = \vec{v}_1 - \vec{v}_2 = 6\,m/s\,\hat{i} \quad \text{— (1)}$$



$\because F_{net} = 0$

& COM is initially in rest

So; $v_{cm} = 0$

$$m_1 v_1 + m_2 v_2 = 0$$

$$80 v_1 + 40(-v_2) = 0$$

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

$$\Rightarrow \vec{v}_2 = -2\vec{v}_1$$

Put in eq^n (1)

$$\vec{v}_1 - (-2\vec{v}_1) = (6\,m/s)\,\hat{i}$$

$$\Rightarrow 3\vec{v}_1 = (6\,m/s)\,\hat{i}$$

$$\boxed{\vec{v}_1 = (2\,m/s)\,\hat{i}}$$

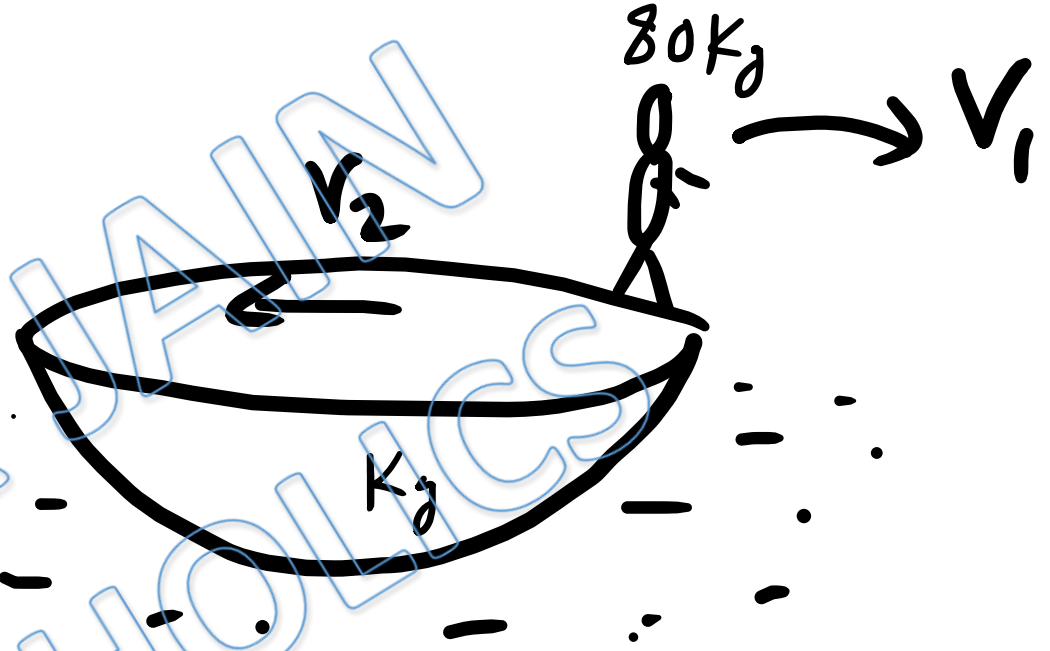
$$\boxed{v_1 = 2\,m/s}$$

Ans. a

OR

$V_1 + V_2 = 6 \quad \text{- - -(i)}$

by Conservation of momentum →



$80V_1 = 40V_2$

$2V_1 = V_2 \quad \text{- - (ii)}$

$V_1 + 2V_1 = 6$

$V_1 = 2 m/Sec$

Ans(a)

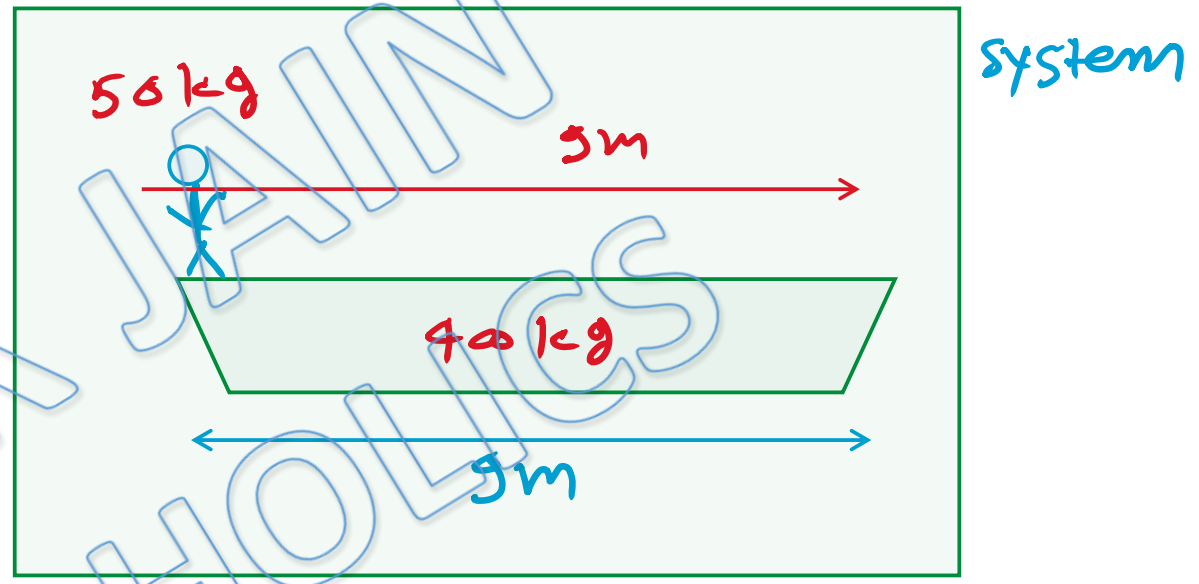
Solution: 11

∵ On system
(Boat + Boy)

$F_{ext} = 0$ and $(a_{cm} = 0)$

So, COM of system will remain stationary

∴ displacement of COM of (Boat + Boy); $\boxed{d = 0}$ Ans.



Ans. a

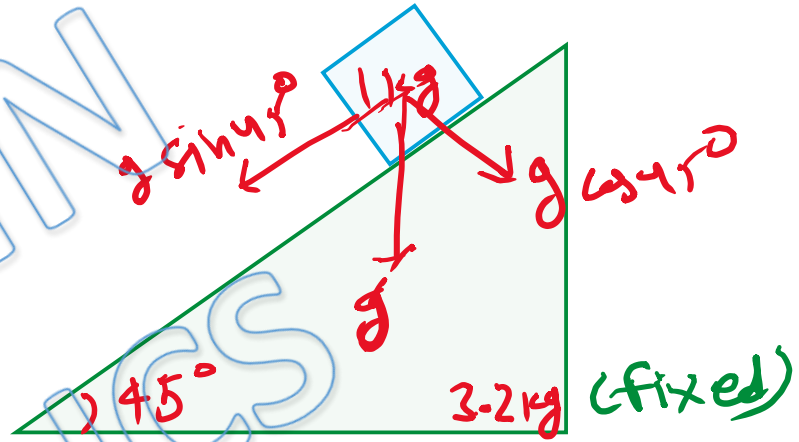
Solution: 12

$$a_{cm} = \frac{m_1 a_1 + m_2 a_2}{m_1 + m_2}$$

$$a_{cm} = \frac{1(g\sin 45^\circ) + (3.2)(0)}{1 + 3.2}$$

$$a_{cm} = \frac{(g/\sqrt{2}) + 0}{4.2} = \frac{9.8}{\sqrt{2} \times 4.2}$$

$$\boxed{a_{cm} = 1.7\ m/s^2}\ \text{Ans}$$



Ans. d

Solution: 13

$F_{ext} = 0$

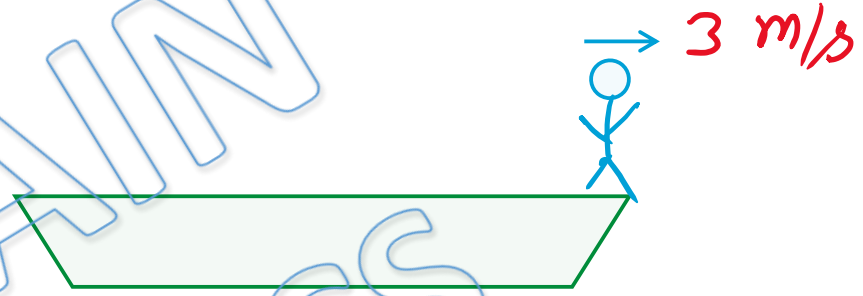
$P_i = P_f$

$0 = m_1 v_1 + P_B$

$P_B = -m_1 v_1$

$P_B = -40 \times 3$

$\boxed{P_B = -120 \text{ kg-m/s}}$ Ans.



Ans. b

Solution: 14

$\therefore F_{ext} = 0$

$P_i = P_f$

$0 = m_B v_B + m_g v_g$

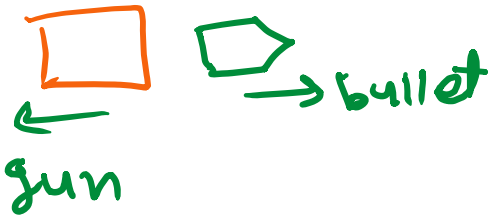
$0 = m_B(600) + m_g(-3)$

$3m_g = 600 m_B$

$$\frac{m_g}{m_B} = \frac{200}{1}$$ Ans.

m_B = mass of bullet

m_g = mass of gun



Ans. c

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