DPP – 3 (COM)

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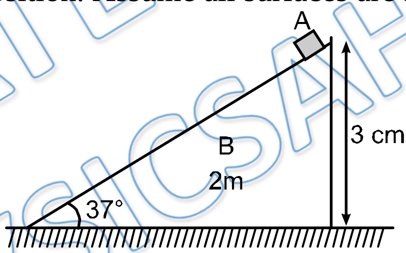
Q 1. A man of mass M stands at one end of a plank of length L which lies at rest on a frictionless surface. The man walks to the other end of the plank. If the mass of plank is M/3, the distance that the plank moves relative to the ground is:
(a) 3L/4 (b) L/4 (c) 4L/5 (d) L/3

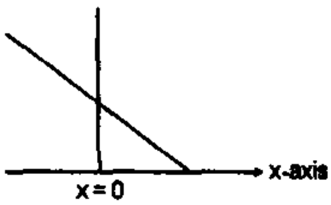
Q 2. The motion of the centre of mass of a system of two particles is unaffected by their internal forces:
(a) irrespective of the actual directions of the internal forces
(b) only if they are along the line joining the particles
(c) only if they are at right angles to the line joining the particles
(d) only if they are obliquely inclined to the line joining the particles.

Q 3. A particle A of mass m is situated at highest point of wedge B of mass 2 m is released from rest. Then distance travelled by wedge B (With respect to ground) when particle A reaches at lowest position. Assume all surfaces are smooth.



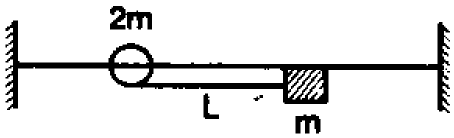
(a) 4/3cm (b) 8/3 cm (c) 2/3 cm (d) none of these

Q 4. A uniform rod of length! is kept vertically on a rough horizontal surface at x =0. It is rotated slightly and released. When the rod finally falls on the horizontal surface, the lower end will remain at:



(a) x = $l/2$ (b) x > $l/2$ (c) x < $l/2$ (d) x = 0

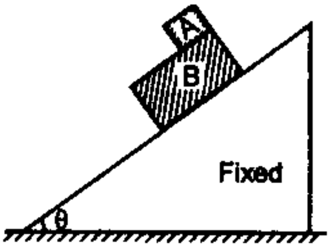
Q 5. A bead can slide on a smooth straight wire and a particle of mass m is attached to the bead by a light string of length L. The particle is held in contact with the wire with the string taut and is then let fall. If the bead has mass 2 m. Then, when the string makes an angle θ with the wire the bead will have slipped a distance:



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

(c) $\frac{L}{3}(1 - \cos\theta)$ (d) $\frac{L}{6}(1 - \cos\theta)$

Q 6. A block A slides over another block B which is placed over a smooth inclined plane as shown in figure. The coefficient of friction between the two blocks A and B is μ. Mass of block B is two times the mass of block A. The acceleration of the centre of mass of two blocks is:



(a) $g\sin\theta$ (b) $\frac{g\sin\theta - \mu g\cos\theta}{3}$

(c) $\frac{g\sin\theta}{3}$ (d) $\frac{2g\sin\theta - \mu g\cos\theta}{3}$

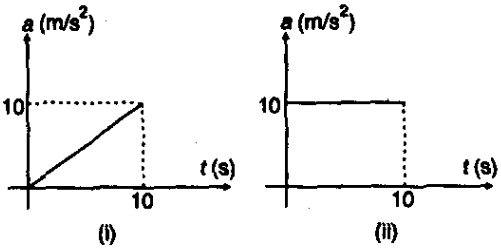
Q 7. Velocity of centre of mass of two particles is v and the sum of the masses of two particles is m. Kinetic energy of the system:
(a) will be equal to $1/2\ mv^2$
(b) will always be less than $1/2\ mv^2$
(c) will be greater than or equal to $1/2\ mv^2$
(d) will always be greater than $1/2\ mv^2$

Q 8. Two particles of equal mass m are projected from the ground with speeds v_1 and v_2 at angles θ_1 and θ_2 as shown in figure. The centre of mass of the two particles:

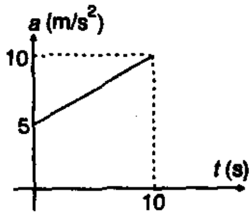
(a) will move in a parabolic path for any values of v_1, v_2, θ_1 and θ_2
(b) can move in a vertical line
(c) can move in a horizontal line
(d) will move in a straight line for any values of v_1, v_2, θ_1 and θ_2

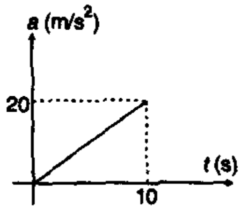
COMPREHENSION

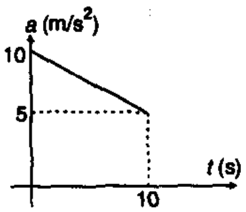
Acceleration of two Identical particles moving in a straight line are as shown in figure.

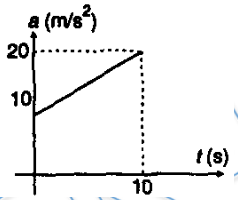


Q 9. The corresponding a-t graph of their centre of mass will be:

(a) 

(b) 

(c) 

(d) 

Q 10. If initial velocity of both the particles was zero. Then velocity of their centre of mass after 10 s will be:

(a) 40 m/s (b) 60 m/s (c) 75 m/s (d) 120 m/s

Q 11. Two particles A and B which are initially at rest move towards each other under the 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 -

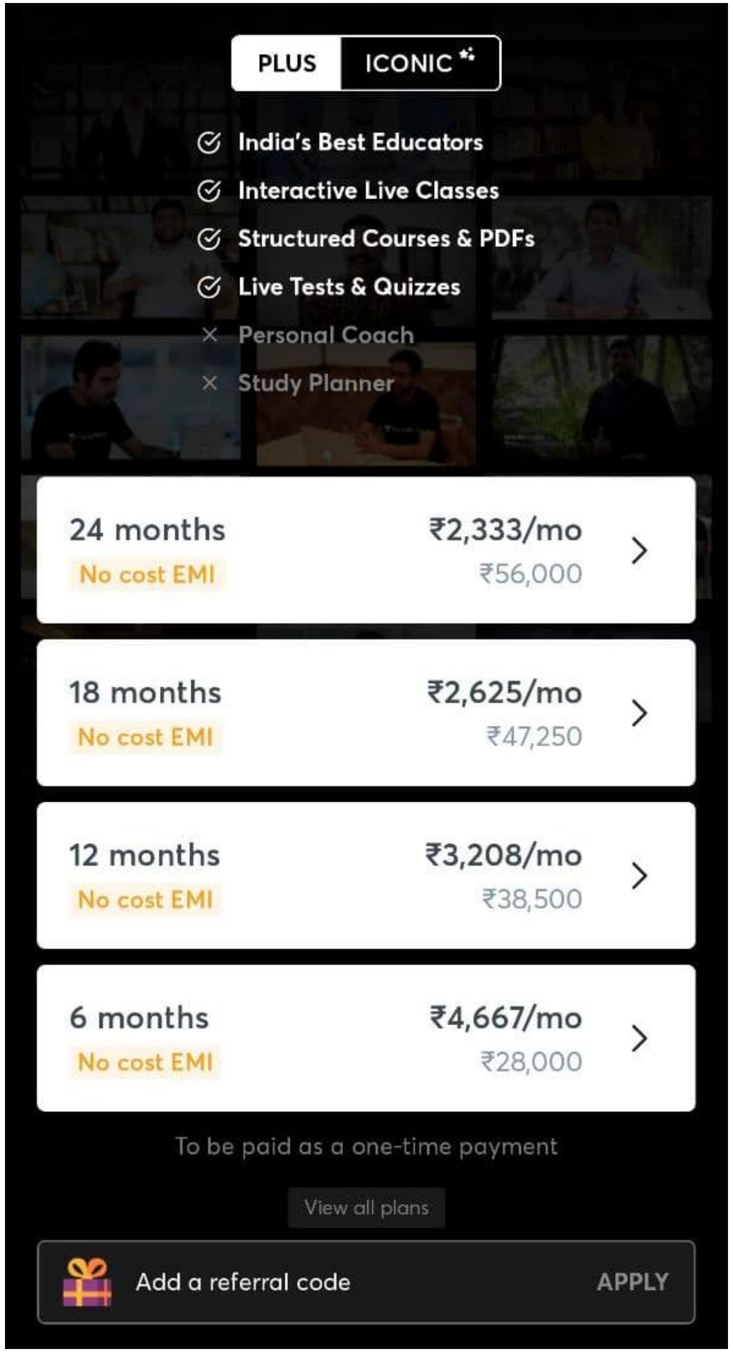
(a) v (b) 1.5v
(c) 3v (d) zero

Q 12. Mark the correct statement

(a) Momentum of system w.r.t. COM of system is always zero.
(b) Net force on system w.r.t. COM of system is always zero.
(c) Among all possible frames kinetic energy of a system has minimum magnitude from COM frame.
(d) Among all possible frames kinetic energy of a system has maximum magnitude from COM frame.

Answer Key

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



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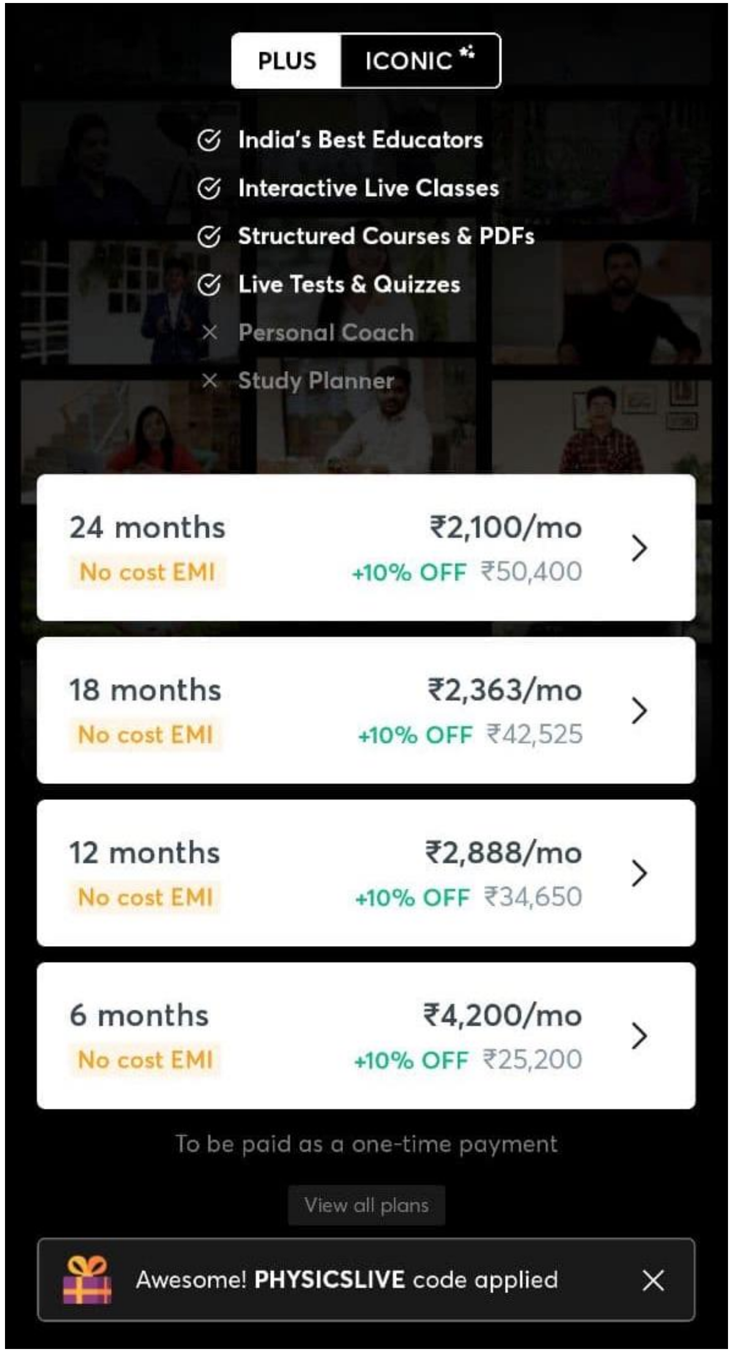

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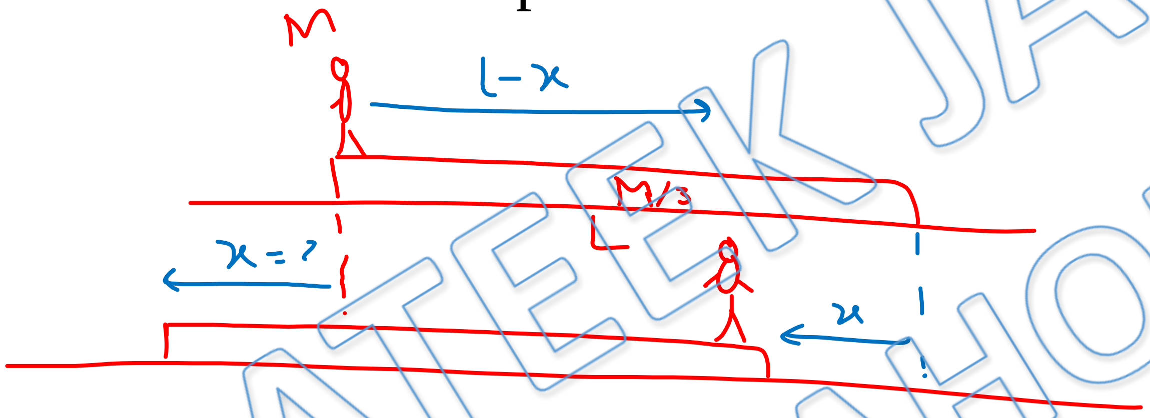
Written Solution

DPP- 3 : Motion of C.O.M.

By Physicsaholics Team

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



(a) 3L/4 (b) L/4 (c) 4L/5 (d) L/3

$\Delta x_{cm} = 0$

$\Rightarrow m_1 \Delta x_1 + m_2 \Delta x_2 = 0$

$\Rightarrow M(L - x) - \frac{M}{3} x = 0$

$\Rightarrow L - x - \frac{x}{3} = 0$

$L = \frac{4x}{3}$

$x = 3L/4$

Q)2 The motion of the centre of mass of a system of two particles is unaffected by their internal forces :

$$\vec{a}_{cm} = \frac{\vec{F}_{net\,ext}}{m}$$

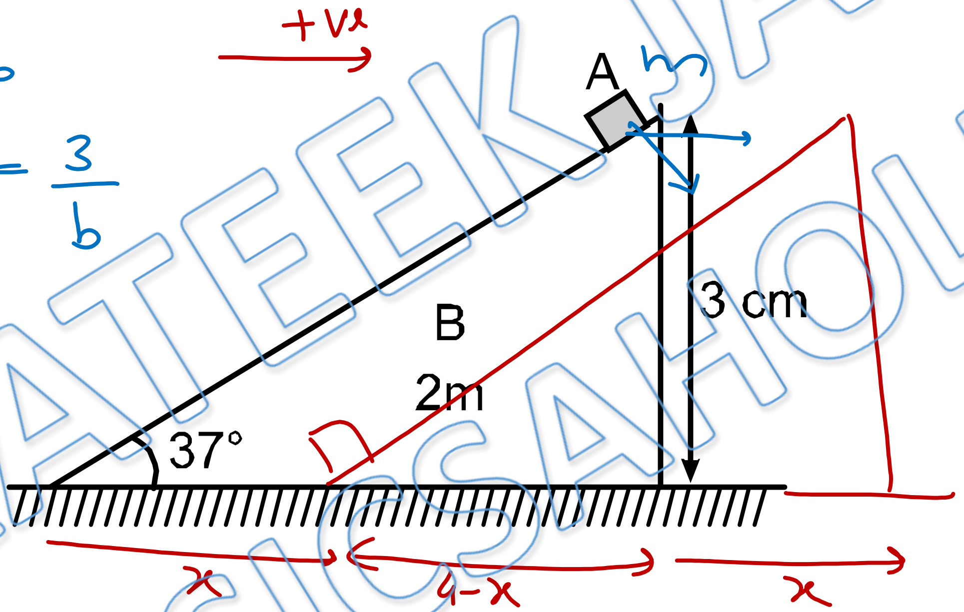
(a) irrespective of the actual directions of the internal forces

(b) only if they are along the line joining the particles

(c) only if they are at right angles to the line joining the particles

(d) only if they are obliquely inclined to the line joining the particles.

Q)3 A particle A of mass m is situated at highest point of wedge B of mass 2 m is released from rest. Then distance travelled by wedge B (With respect to ground) when particle A reaches at lowest position. Assume all surfaces are smooth.



baselength = b

$\tan 37 = \frac{3}{4} = \frac{3}{b}$

$b = 4m$

$\Delta x_{cm} = 0$

$m_1 \Delta x_1 + m_2 \Delta x_2 = 0$

$2m x - m(4-x) = 0$

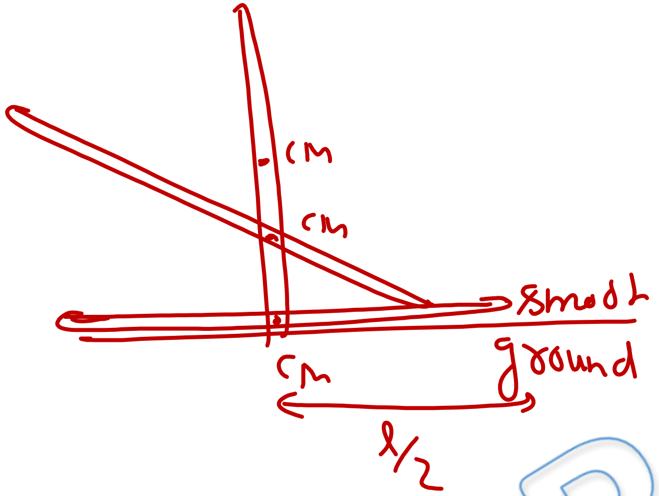
$2x - 4 + x = 0$

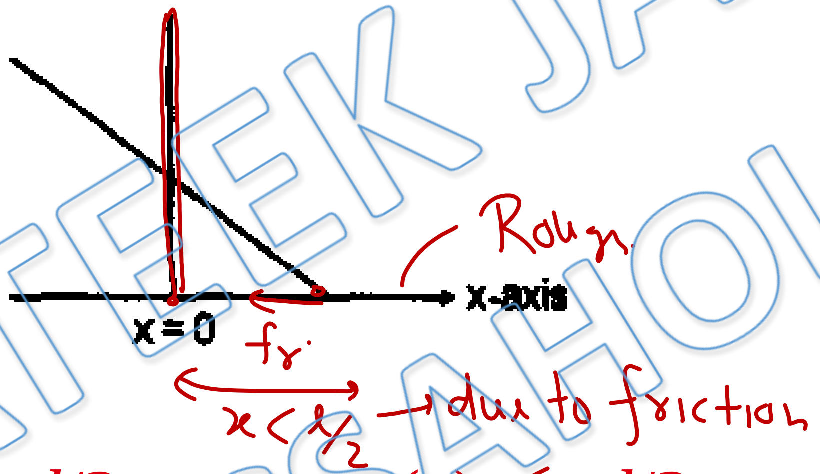
$3x = 4$

$x = 4/3 \, m$

(a) 4/3cm (b) 8/3 cm (c) 2/3 cm (d) none of these

Q)4 A uniform rod of length! is kept vertically on a rough horizontal surface at x =0. It is rotated slightly and released. When the rod finally falls on the horizontal surface, the lower end will remain at:

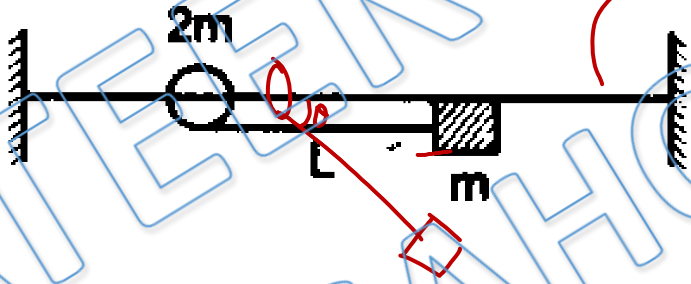


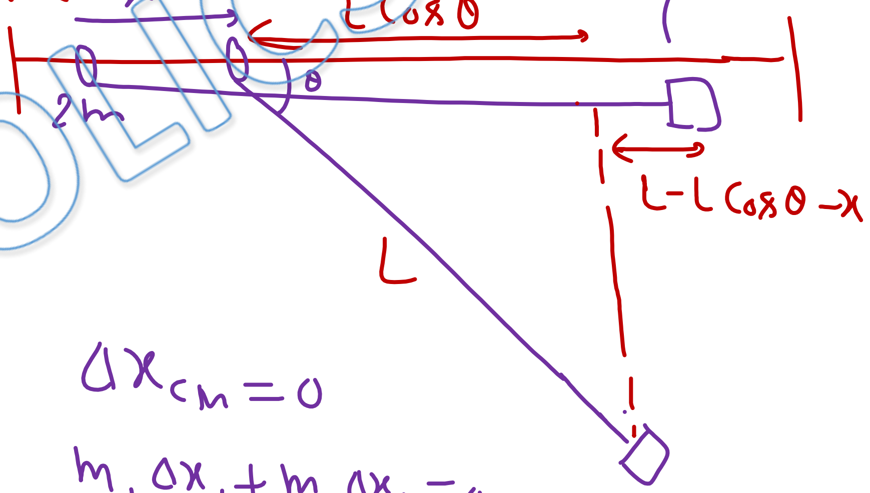


(a) x = *l*/2 (b) x > *l*/2 (c) x < *l*/2 (d) x = 0

Q)5 A bead can slide on a smooth straight wire and a particle of mass m is attached to the bead by a light string of length L. The particle is held in contact with the wire with the string taut and is then let fall. If the bead has mass 2 m. Then, when the string makes an angle θ with the wire the bead will have slipped a distance:

There is no horizontal external force on (wire + string + bead)





(a) $L(1 - \cos\theta)$

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

(c) $\frac{L}{3}(1 - \cos\theta)$

(d) $\frac{L}{6}(1 - \cos\theta)$

$\Delta x_{cm} = 0$

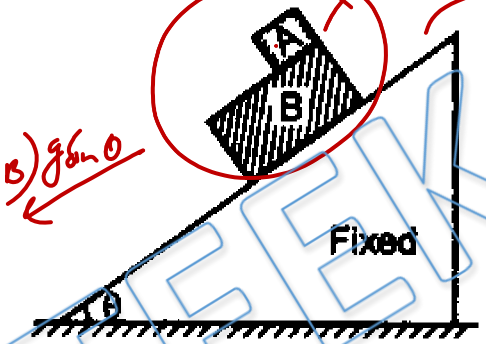
$m_1 \Delta x_1 + m_2 \Delta x_2 = 0$

$2m x - m(L - L\cos\theta - x) = 0$

$2x - L(1 - \cos\theta) + x = 0$

$x = \frac{L}{3}(1 - \cos\theta)$

Q)6 A block A slides over an another block B which is placed over a smooth inclined plane as shown in figure. The coefficient of friction between the two blocks A and B is μ. Mass of block B is two times the mass of block A. The acceleration of the centre of mass of two blocks is:



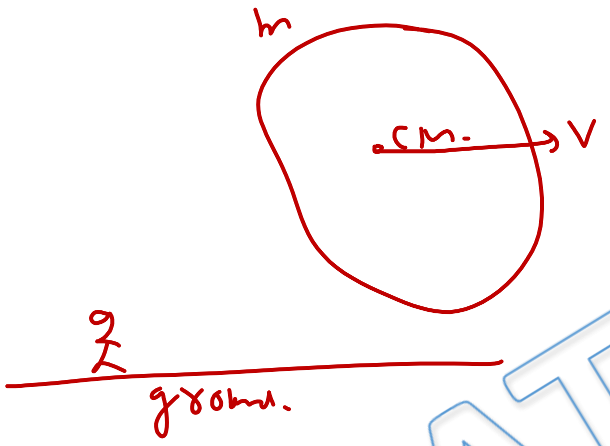
(a) $g \sin \theta$

(b) $\frac{g\sin\theta - \mu g\cos\theta}{3}$

(c) $\frac{g\sin\theta}{3}$

(d) $\frac{2g\sin\theta - \mu g\cos\theta}{3}$

Q)7 Velocity of centre of mass of two particles is v and the sum of the masses of two particles is m. Kinetic energy of the system:



$K = $ (KE if whole mass is at cm & moving with V_{cm}) + (KE of particles w.r.t. cm)

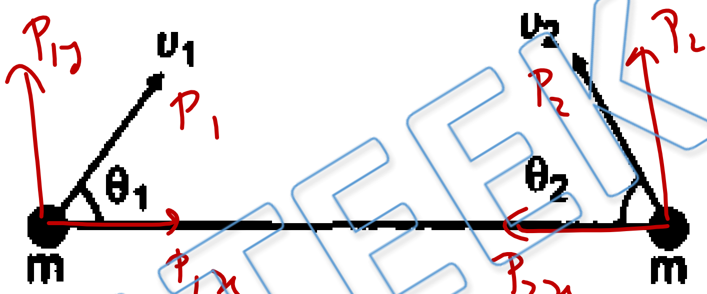
$K = \frac{1}{2} mV^2 + $ (KE of System w.r.t. cm)

(a) will be equal to 1/2 mv^2
(b) will always be less than 1/2 mv^2
(c) will be greater than or equal to 1/2 mv^2 ✓
(d) will always be greater than 1/2 mv^2

Q)8 Two particles of equal mass m are projected from the ground with speeds v_1 and v_2 at angles θ_1 and θ_2 as shown in figure. The centre of mass of the two particles:

$u_x = V_{x\,cm} = \frac{P_{1x} - P_{2x}}{2m}$ → may be zero

$u_y = V_{y\,cm} = \frac{P_{1y} + P_{2y}}{2m}$ → not zero



$a_{cm} = \frac{mg + mg}{2m} = g \downarrow$ → Constant acceleration.

u_{cm}: u_y → non zero; u_x → may be zero

(a) will move in a parabolic path for any values of v_1, v_2, θ_1 and θ_2

(b) can move in a vertical line

(c) can move in a horizontal line

(d) will move in a straight line for any values of v_1, v_2, θ_1 and θ_2

If $u_x = 0 \Rightarrow$ St. line motion

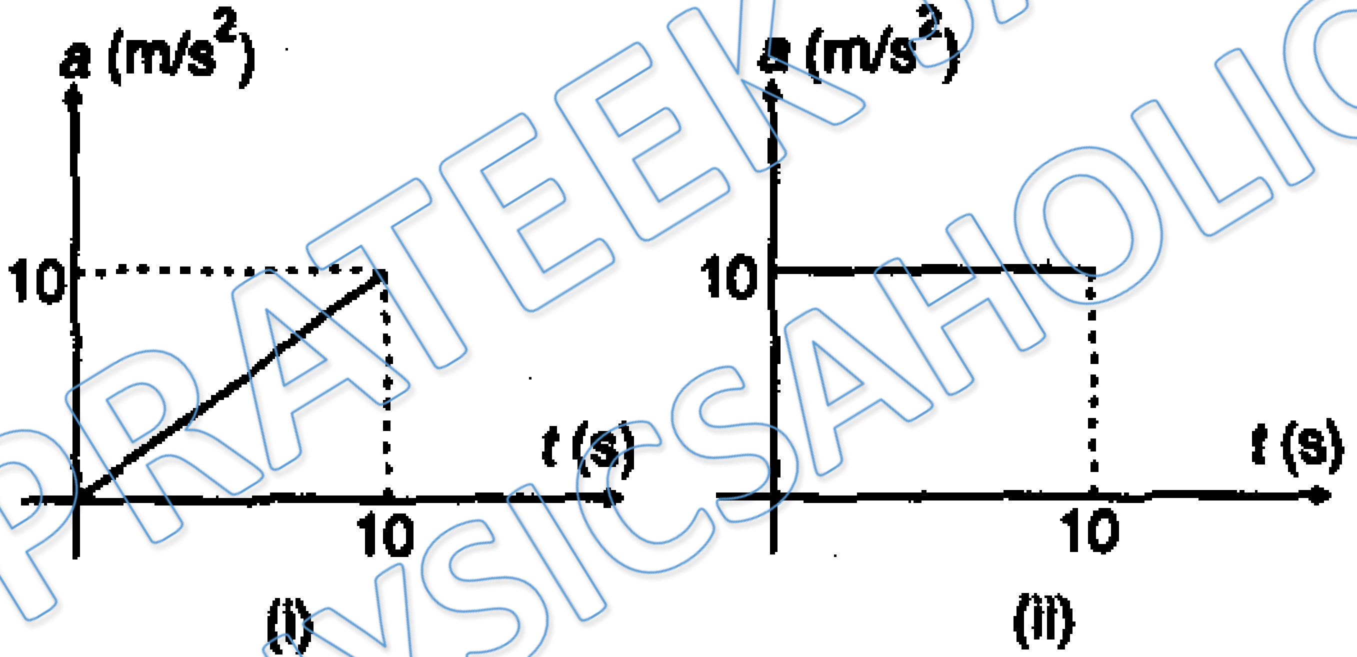
$u_x \neq 0 \Rightarrow$ Parabola

COMPREHENSION

Acceleration of two Identical particles moving in a straight line are as shown in figure.

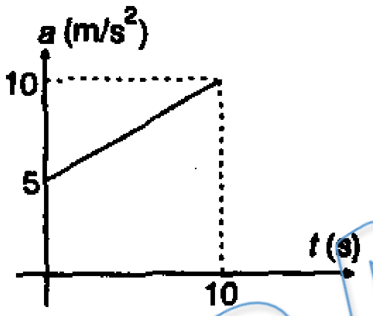
at t=0 $a_{cm} = \frac{m \times 0 + m \times 10}{2m} = 5 \, m/sec^2$

at t=10 $a_{cm} = 10 \, m/sec^2$

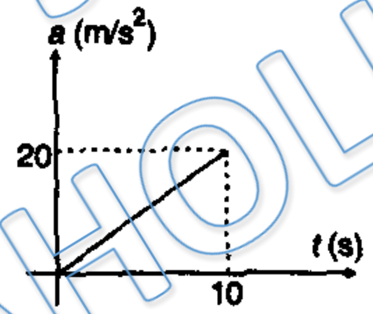


Q)8 The corresponding a-t graph of their centre of mass will be:

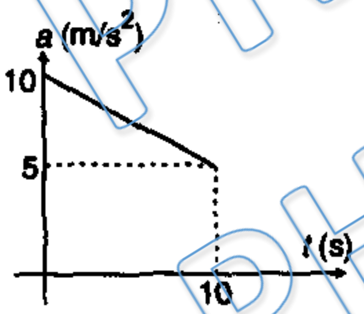
(a)



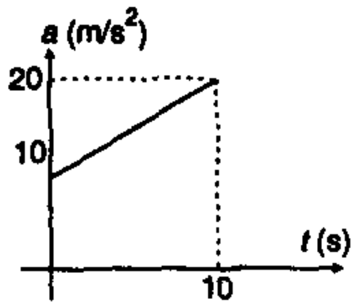
(b)



(c)

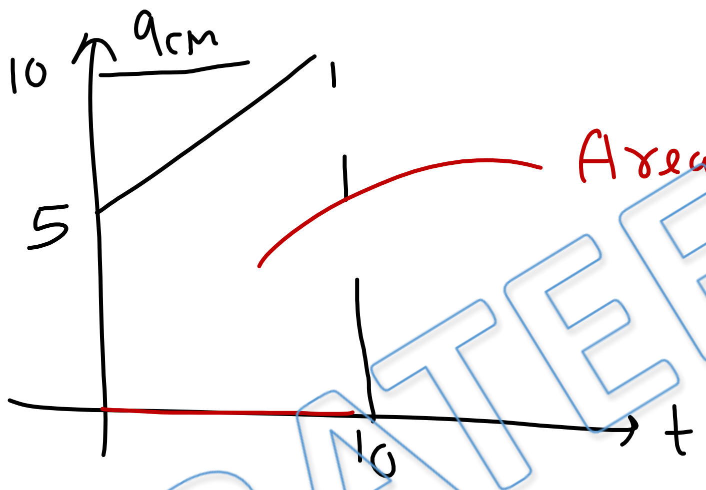


(d)



Q)9 If initial velocity of both the particles was zero. Then velocity of their centre of mass after 10 s will be:

$u_{CM} = 0$



Area $= \frac{1}{2} \times 10 \times 15 = 75 = V_{10} - 0$

$V_{10} = 75$ m/sec

(a) 40 m/s (b) 60 m/s (c) 75 m/s (d) 120 m/s

Q)10 Two particles A and B which are initially at rest move towards each other under the 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) v

(b) 1.5v

(c) 3v

(d) zero

for System of particles

$u_{CM} = 0$

no external force on system

$a_{CM} = 0$

$\Rightarrow V_{CM} = 0$

$$\vec{P}_{system, cm} = M \vec{V}_{cm, cm} = 0$$

Q)11 Mark the correct statement

(a) Momentum of system w.r.t. COM of system is always zero.

(b) Net force on system w.r.t. COM of system is always zero.

(c) Among all possible frames kinetic energy of a system has minimum magnitude from COM frame.

(d) Among all possible frames kinetic energy of a system has maximum magnitude from COM frame.

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