PRAYAS

JEE 2026

Physics

COM and System of particles

Lecture - 09

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Topics to be covered

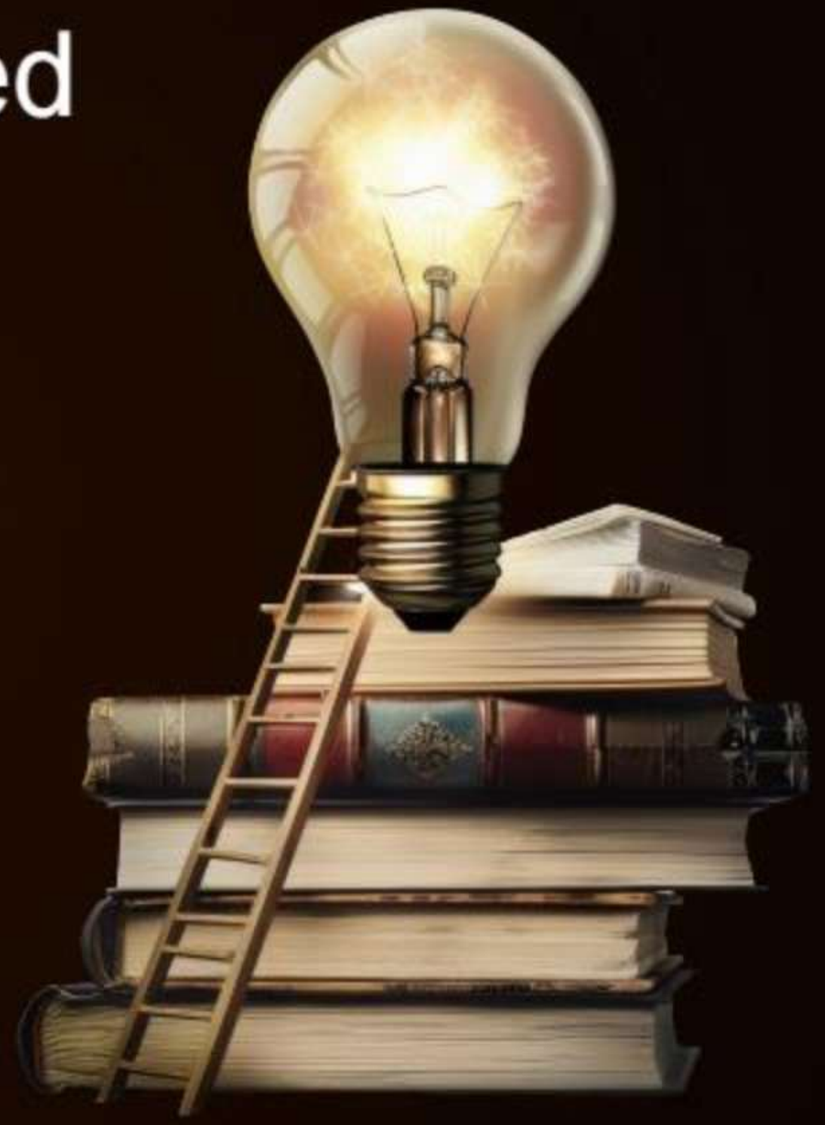
A Momentum and energy Conservation

B

C

D

ATDB.uno



Profile-1 $\longrightarrow$ $\vec{f}_{ext.} = 0 \Rightarrow \vec{P}_f = \vec{P}_i$

Profile-2 $\longrightarrow$ $\vec{f}_{ext.} = 0$ and $\vec{U}_{cm} = 0$ $\Rightarrow (a_{cm} = 0)$ $\longrightarrow$ $\vec{S}_{cm} = 0$ (Com remain at rest)

$m_1\vec{S}_1 + m_2\vec{S}_2 + \dots = 0$

Profile-3 $\longrightarrow$ $f_{ext.} = 0 \Rightarrow \vec{P}_f = \vec{P}_i$

and $W_{NC} = 0 \Rightarrow K_1 + U_1 = K_2 + U_2$

(also if $U_{cm} = 0$

$m_1\vec{a}_1 + m_2\vec{a}_2 + \dots = 0$)

if $f_{ext.})_x = 0 \Rightarrow \vec{P}_f)_x = \vec{P}_i)_x$

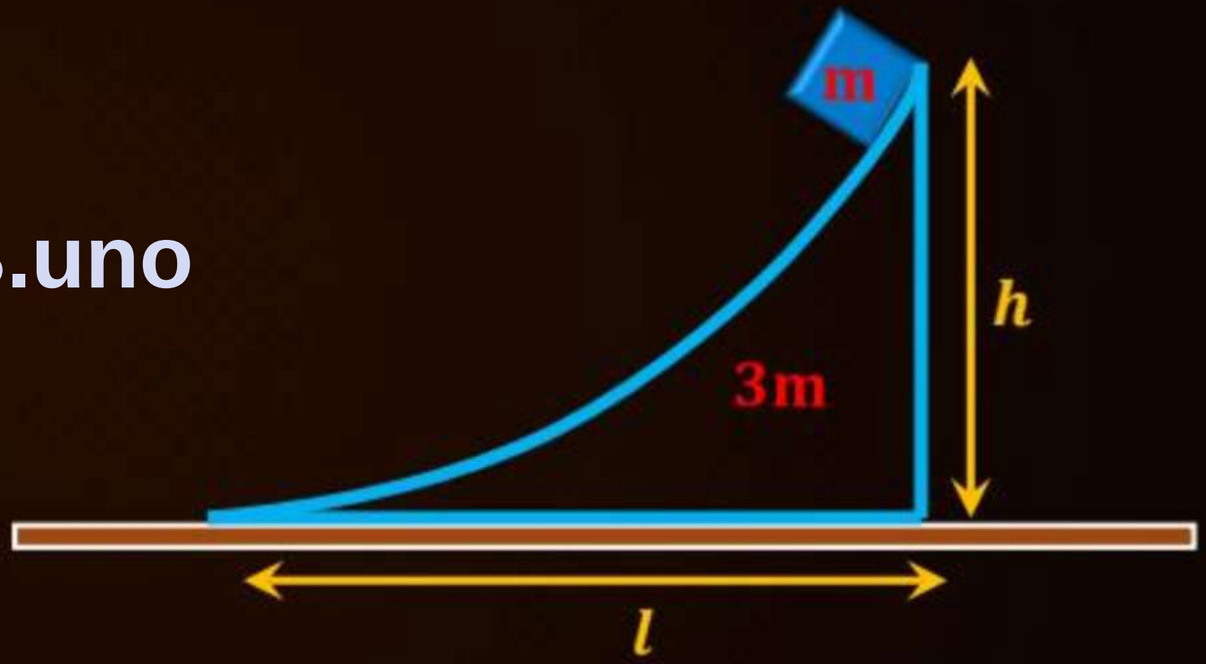
→ net work done by internal forces may or may not zero it can change K.E., U, T.E.

→ net work done by internal Normal, Tension and static friction is always zero

Question

A block of mass m is release from rest on a stationary smooth wedge of mass 3m and height h. wedge is free to move on smooth horizontal surface. When block just land on horizontal surface. find

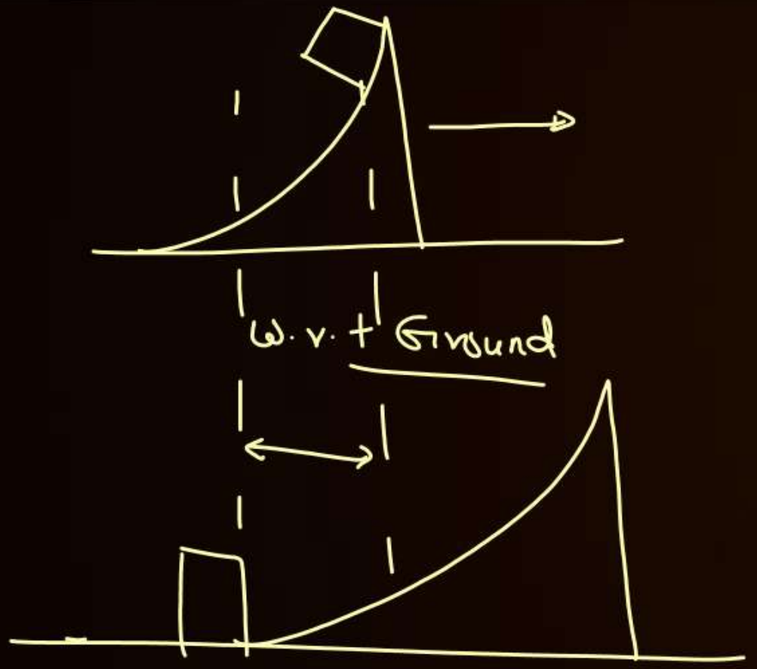
1. Displacement of wedge
2. Speed of block and wedge

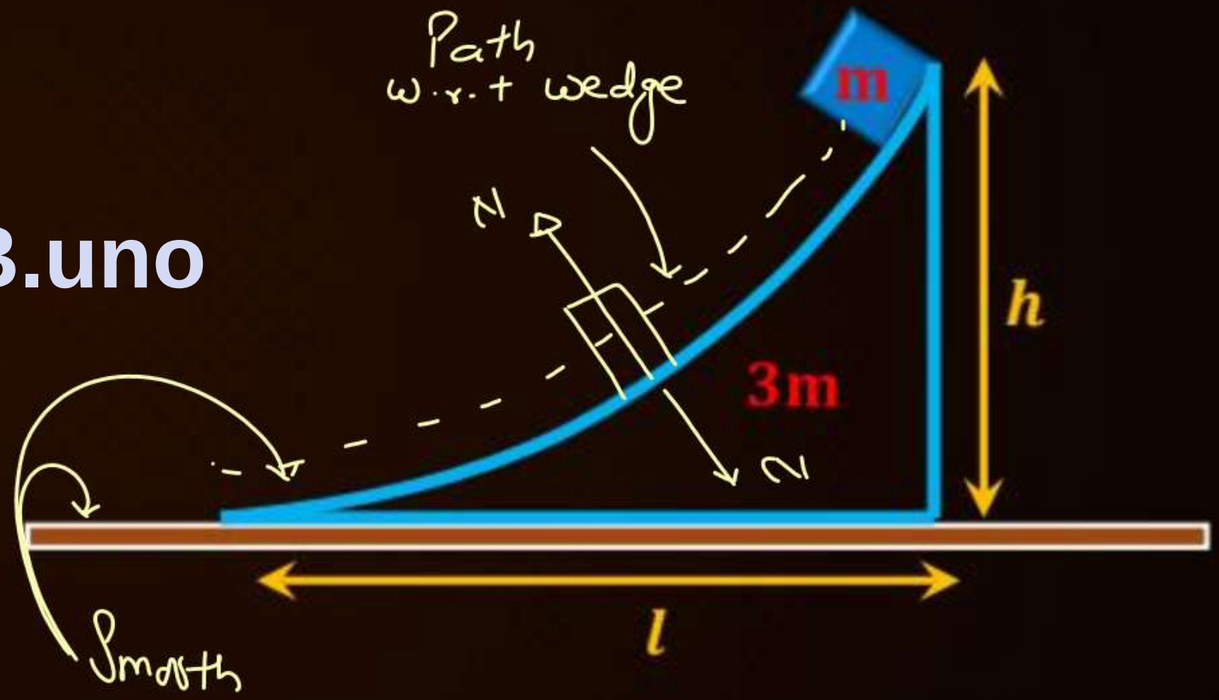


Question – 33

A block of mass m is release from rest on a stationary smooth wedge of mass 3m and height h. wedge is free to move on smooth horizontal surface. When block just land on horizontal surface. find

1. Displacement of wedge
2. Speed of block and wedge





Tools →

1st → $W_{NC} = 0 \Rightarrow K_1 + U_1 = K_2 + U_2$

(Normal, mg)

(block + wedge)

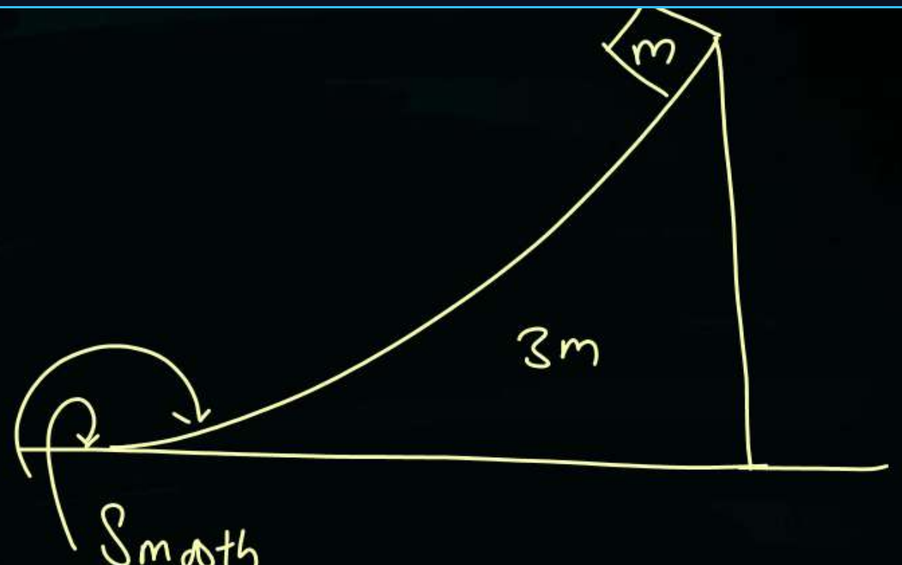
2nd → $f_{ext.} = 0$ yes or no

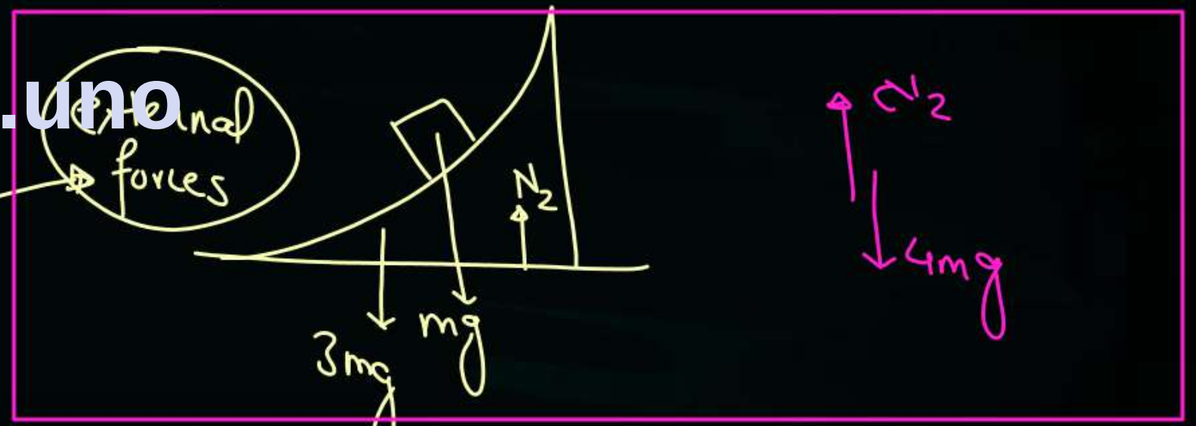
$f_{ext.})_x = 0 \Rightarrow \vec{P}_f)_x = \vec{P}_i)_x$

(block + wedge)

3rd $f_{ext})_x = 0$ and $U_{cm})_x = 0$

$\Rightarrow (m_1\vec{s}_1 + m_2\vec{s}_2 + \cdots)_x = 0$





is $N_2 = 4mg$ valid during motion of block on wedge → No

Why $N_2 \neq 4mg$ during motion of block on wedge

is COM of system move downward or not

→ yes

$\Rightarrow$ net $f_{ext.}$ in y-dirn is not zero

during motion of block on wedge which may be true

(A) $N_2 > 4mg$

(B) $N_2 < 4mg$

(C) $N_2 = 4mg$

Sol^n $U_{cm})_y = 0$ and $V_{cm})_y = 0$ and COM move downward

$\Rightarrow$ COM first accelerat downward then retard

↓ $N_2 < 4mg$

↓ $N_2 > 4mg$

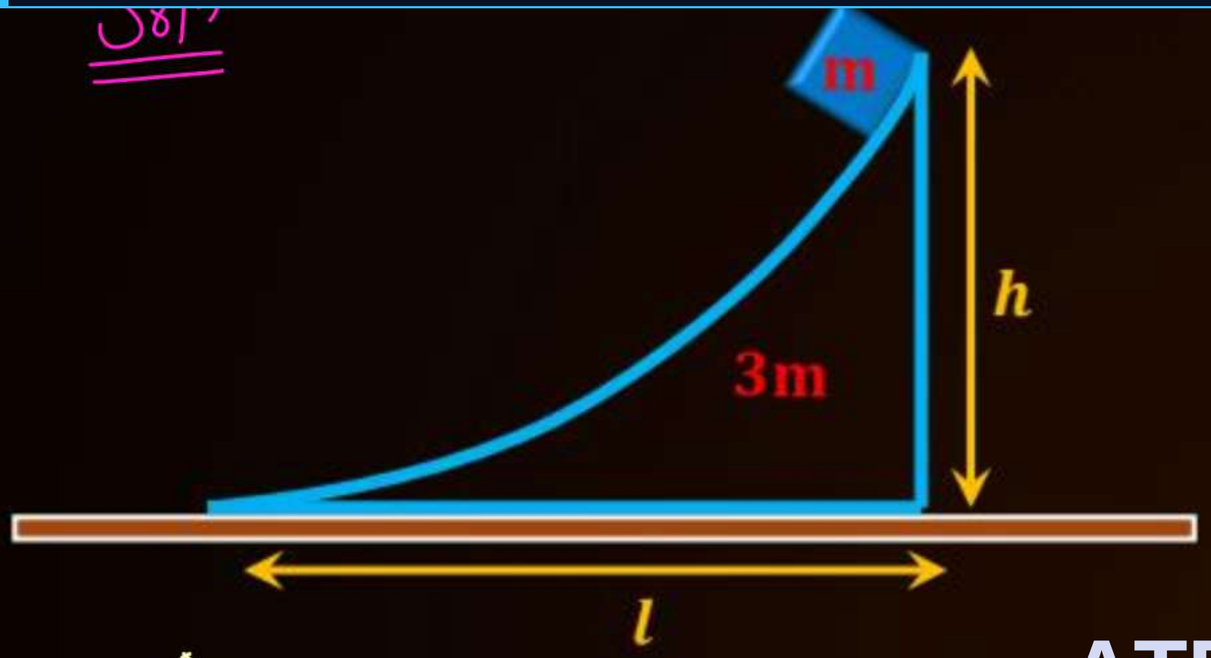
$\longrightarrow S_{cm}$ in y-dir^n $= \dfrac{m(-h)+3m(0)}{4m} = -\dfrac{h}{4}$

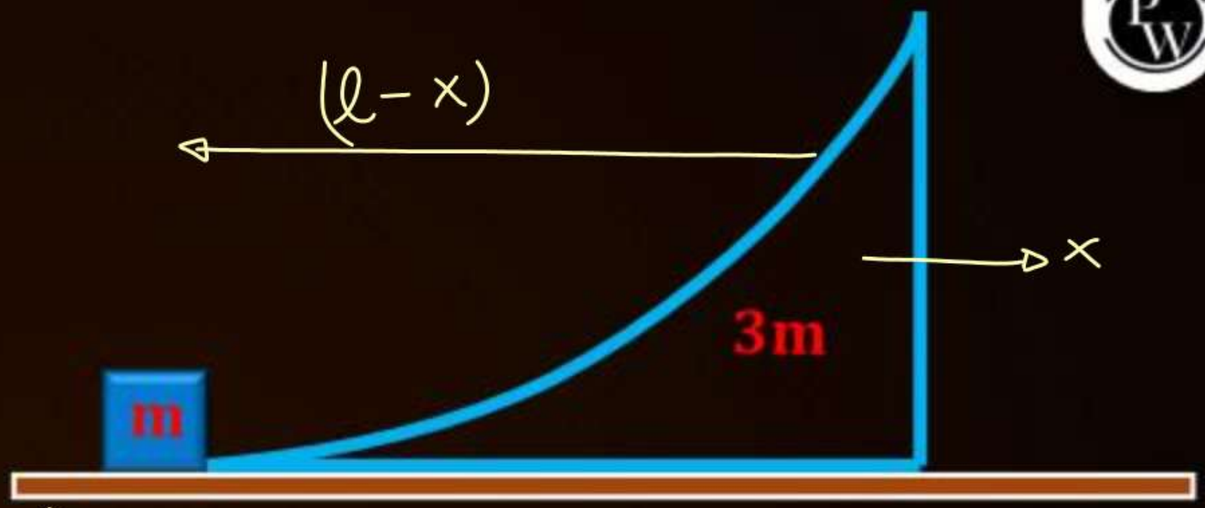
$\longrightarrow$ Path of com $\longrightarrow$ Vertical St. line

X में नहीं चला , y में नीचे आया

$\left(f_{ext.})_x = 0 \Rightarrow a_{cm}|_x = 0\right)$

Sol:



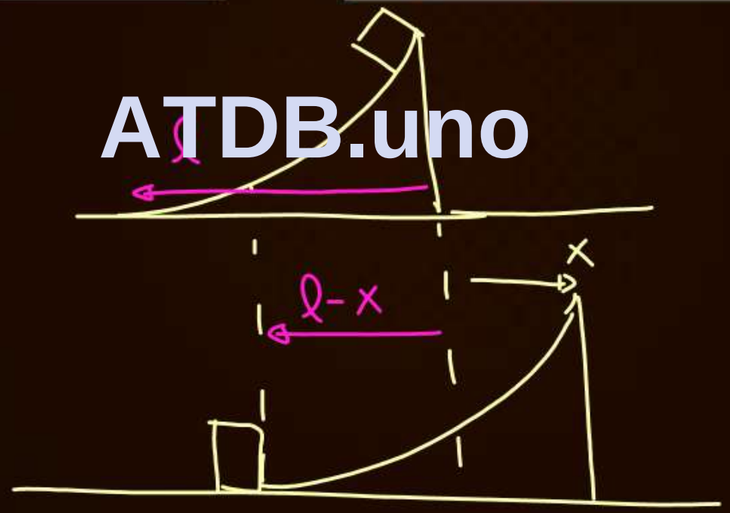


(i) displacement →

$$\left(m_1\vec{s}_1 + m_2\vec{s}_2\right)_x = 0$$

$$-m(l-x) + 3mx = 0$$

$$x = \frac{l}{4}$$



$s_{wedge} = l/4$

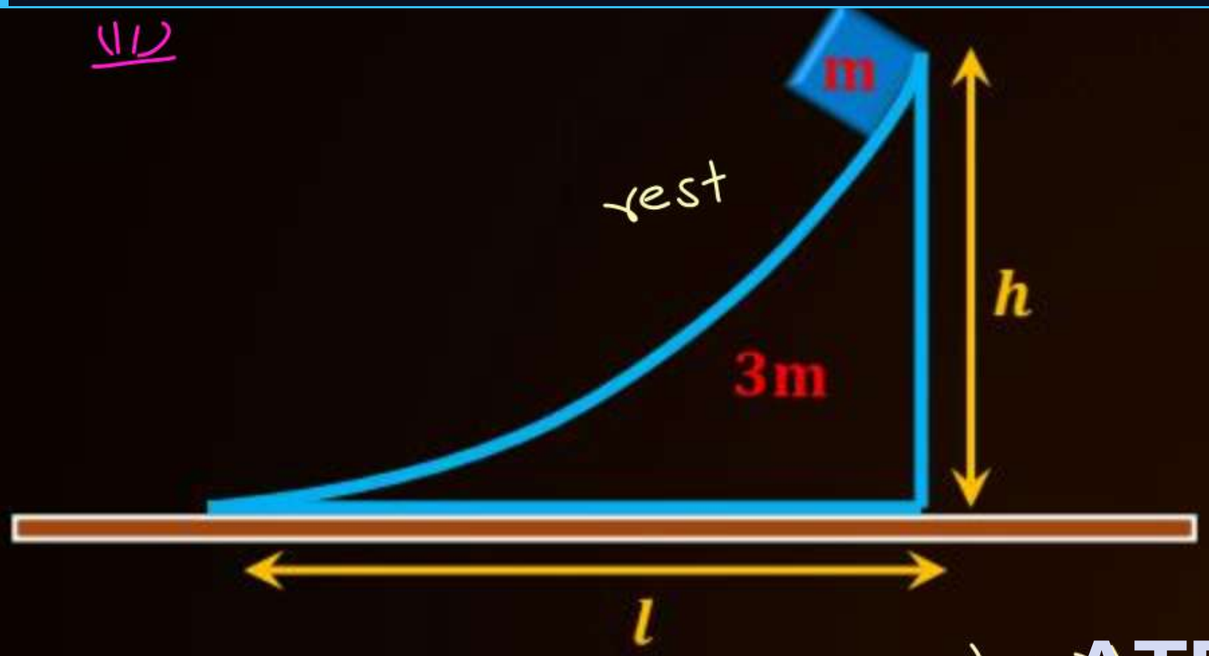
$s_{block} = \frac{3l}{4}$ in $-\hat{i}$ dirn

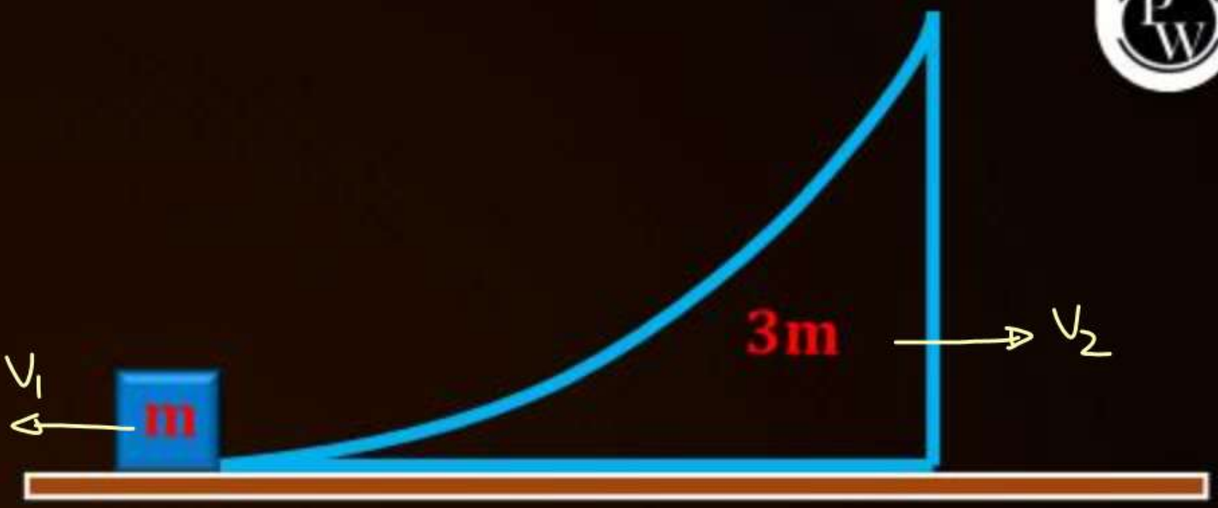
→ $K_1 + U_1 = K_2 + U_2$

→ $(\vec{P}_i)_x = (\vec{P}_f)_x$

→ $m_1\vec{s}_1 + m_2\vec{s}_2 + \ldots = 0$

VII





Speed: $\rightarrow$ $F_{ext.})_x = 0 \Rightarrow \vec{P}_i)_x = \vec{P}_f)_x \Rightarrow 0 = 3mV_2 - mV_1 \Rightarrow V_1 = 3V_2$

$\rightarrow$ $K_1 + U_1 = K_2 + U_2$ (block + wedge)

$$0 + mgh = \frac{1}{2}mV_1^2 + \frac{1}{2}3mV_2^2 = \frac{1}{2}m(3V_2)^2 + \frac{1}{2}3mV_2^2 = 6mV_2^2$$

$$V_2 = \sqrt{\frac{gh}{6}} \quad \text{and} \quad V_1 = 3\sqrt{\frac{gh}{6}}$$

$\rightarrow$ $K_1 + U_1 = K_2 + U_2$

$\rightarrow$ $\vec{P}_i)_x = \vec{P}_f)_x$

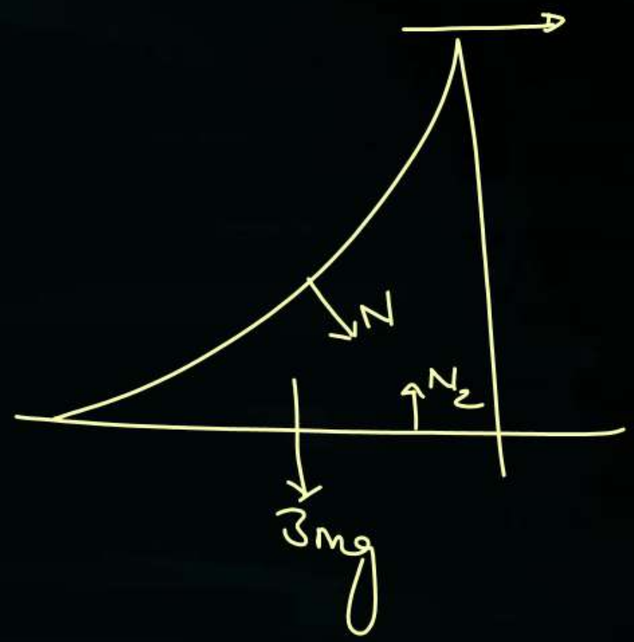
$\rightarrow$ $m_1\vec{v}_1 + m_2\vec{v}_2 + \dots = 0$

Q. Find work done by normal on wedge

$$W_{net} = \Delta K \cdot \text{E} \quad \text{wedge}$$

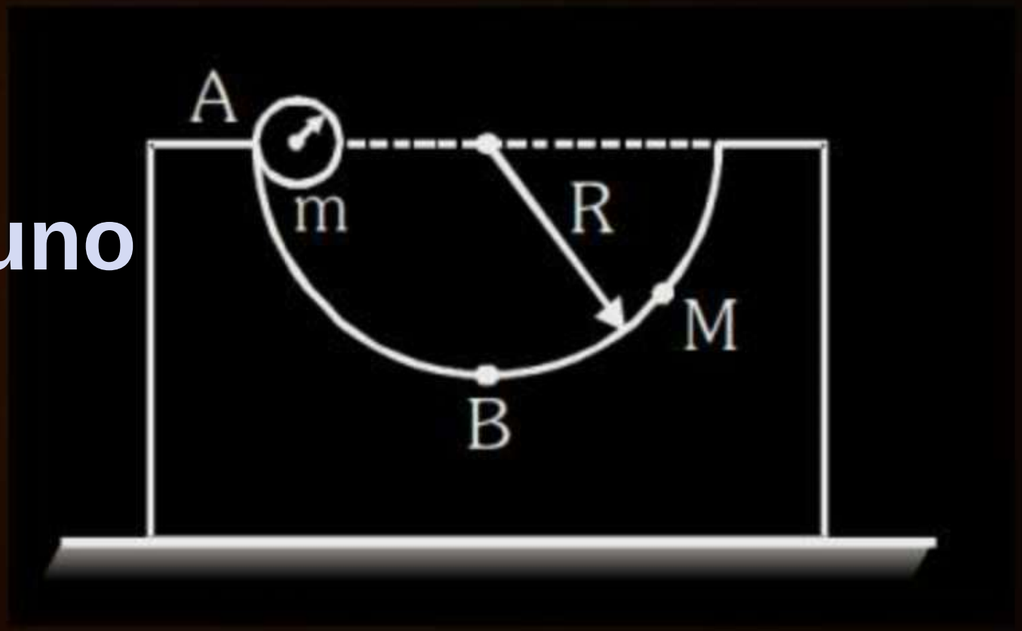
$$\cancel{W_{N_2}}^{\,0} + \cancel{W_{3mg}}^{\,0} + W_N = \frac{1}{2} 3mv_2^2 - 0$$

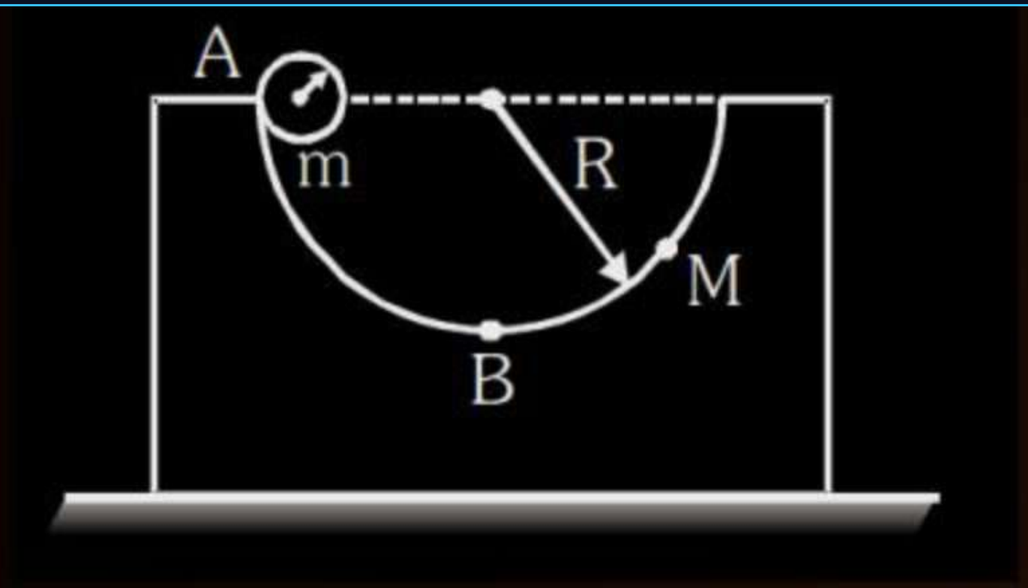
$$W_N = \frac{1}{2} \cdot 3m \cdot \frac{gh}{4} = \frac{mgh}{4}$$

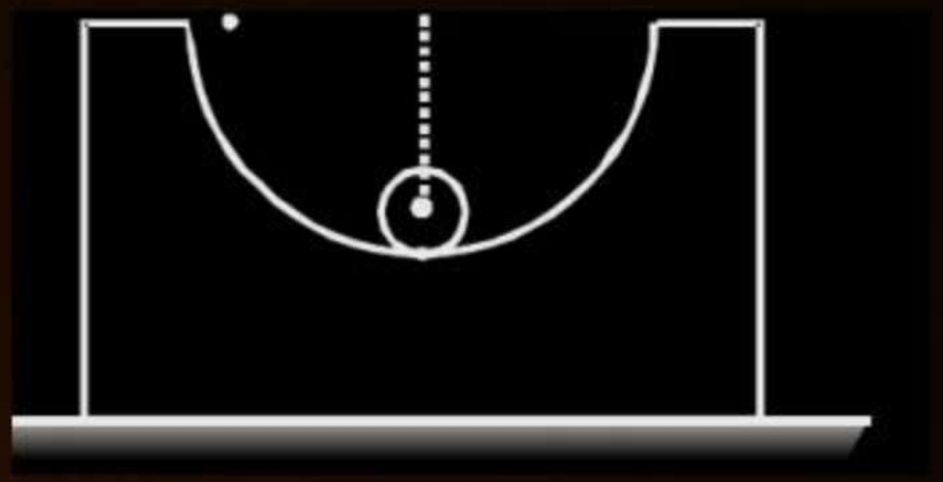


$$W_N \text{ on block} = -W_N\Big)_{\text{wedge}} = -\frac{mgh}{4}$$

A block of mass M with a semicircular track of radius R, rests on a horizontal frictionless surface. A uniform cylinder of radius r and mass m is released from rest at the top point A (see Fig). The cylinder slips on the semicircular frictionless track. How far has the block moved when the cylinder reaches the bottom (point B) of the track ? How fast is the block moving when the cylinder reaches the bottom of the track?







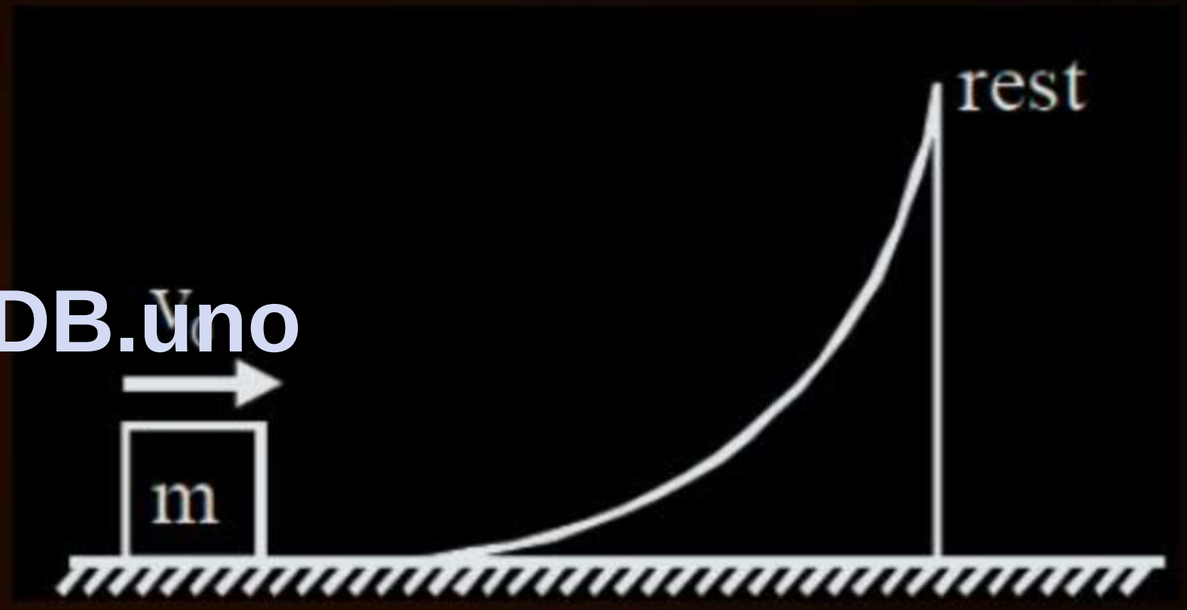
ATDB.uno

Question — S 1

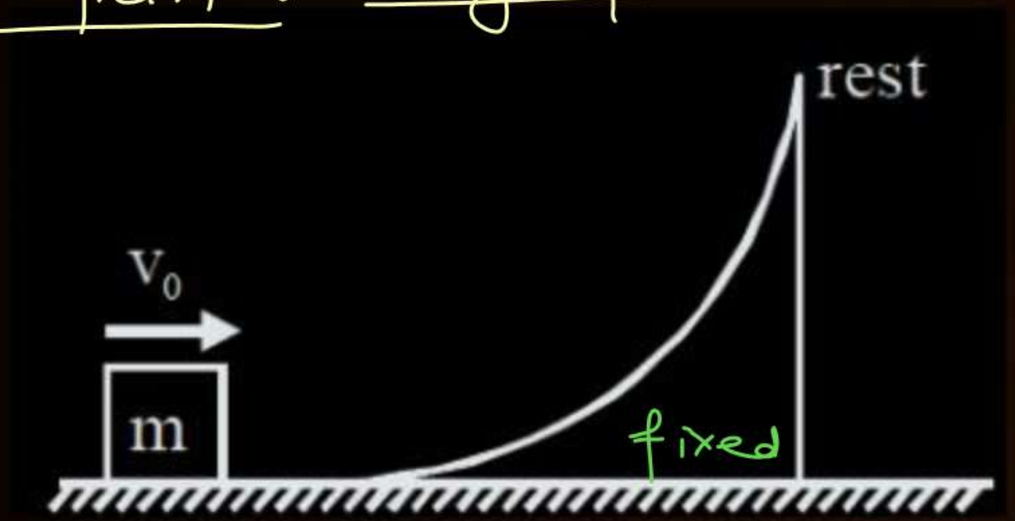
A block of mass m is moving on smooth horizontal surface with speed V_0. Block encounter a smooth wedge as shown. Find maximum height attend by the block if

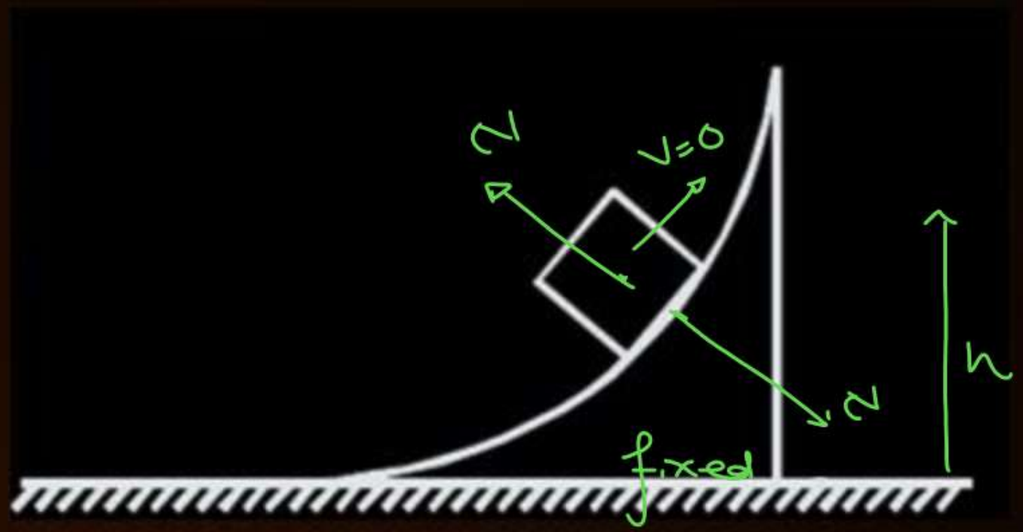
(1) Wedge is fixed

(2) Wedge (mass = 2m) is free to move on horizontal surface



1st part :→ wedge fixed





$\vec{F}_{ext.})_x \neq 0$

$W_{NC} = 0 \Rightarrow K_1 + U_1 = K_2 + U_2$

$\frac{1}{2}mv_0^2 + 0 = 0 + mgh \Rightarrow h = \frac{v_0^2}{2g}$

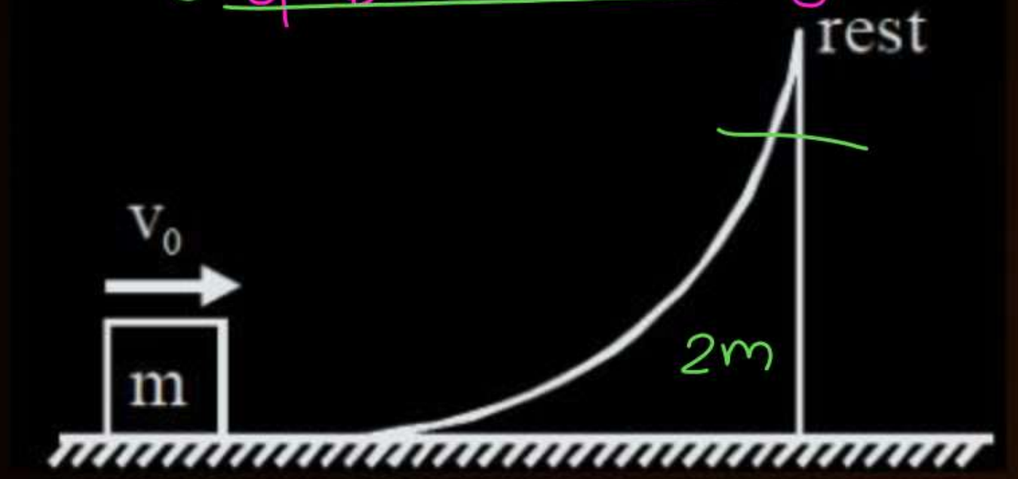
System → (block + wedge)

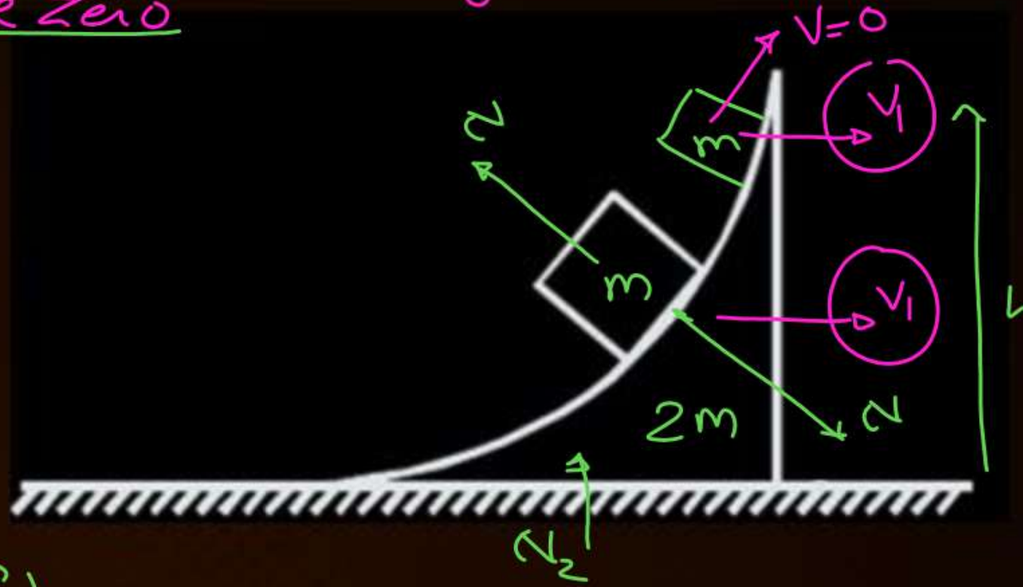
$\vec{F}_{ext.})_x = 0 \Rightarrow \vec{P}_i)_x = \vec{P}_f)_x$ ✗

$K_1 + U_1 = K_2 + U_2$ ✓

$(m_1\vec{v}_1 + m_2\vec{v}_2 + \cdots)_x = 0$ ✗

(2) Wedge is ... of block w.r.t wedge become zero





$\rightarrow (F_{ext})_x = 0$

{ ext. N_2 $mg + 2mg$ }

$\vec{P}_i)_x = \vec{P}_f)_x$

$mV_0 + 2m(0) = mV_1 + 2mV_1$

$V_1 = V_0/3$

$\rightarrow W_{NC} = 0 \Rightarrow K_1 + U_1 = K_2 + U_2$

$\left(\frac{1}{2}mV_0^2 + 0\right) + 0 = \left(\frac{1}{2}2mV_1^2 + \frac{1}{2}mV_1^2\right) + mgh$

$= \frac{1}{2}3m\left(\frac{V_0}{3}\right)^2 + mgh = \frac{mV_0^2}{6} + mgh$

$h = \frac{V_0^2}{3g}$

System → (block + wedge)

$(F_{ext.})_x = 0 \Rightarrow (\vec{P}_i)_x = (\vec{P}_f)_x$ ✓

$K_1 + U_1 = K_2 + U_2$ ✓

$(m_1\vec{v}_1 + m_2\vec{v}_2 + \cdots)_x = 0$ ✗

$(F_{ext})_x = 0$

$(U_{cm})_x \neq 0$