Nishant Jindal

Work is frame dependent quantity

Work done by force F w.r.t trolley frame.

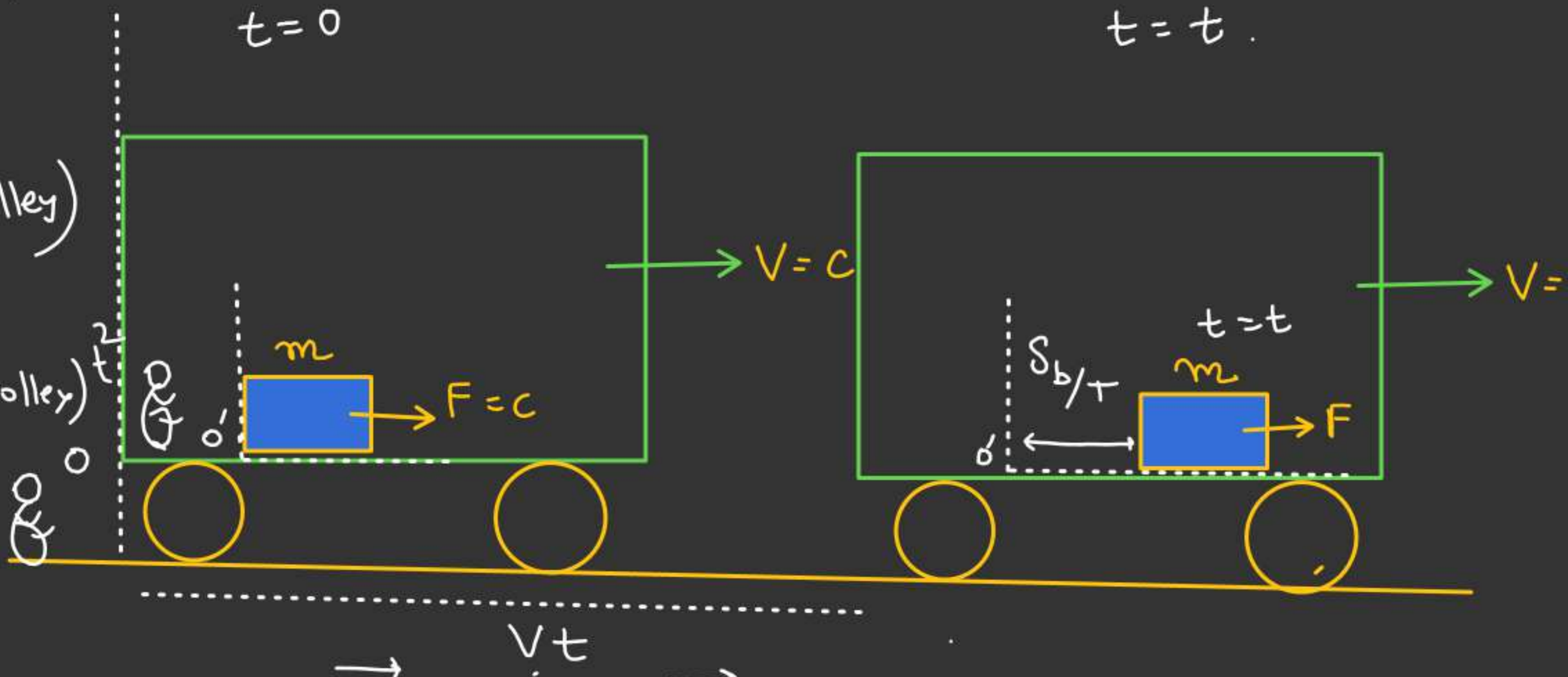
$$W_{F/\text{trolley}} = F\cdot\left(\underline{S_{\text{block/trolley}}}\right)$$

$$\underline{S_{\text{block/trolley}}} = \frac{1}{2}\left(a_{\text{block/trolley}}\right)t^2$$

$$= \frac{1}{2}\left(\frac{F}{m}\right)t^2$$

$$= \underline{\left(\frac{Ft^2}{2m}\right)}$$

$$W_{F/\text{trolley}} = F\cdot\left(\frac{Ft^2}{2m}\right) = \left(\frac{F^2t^2}{2m}\right)$$



$$\vec{S}_{\text{block}/\varepsilon} = \vec{S}_{\text{block/trolley}} + \vec{S}_{\text{trolley}/\varepsilon}$$

$$= \left[\frac{Ft^2}{2m}\hat{i} + (Vt)\hat{i}\right]$$

$$= \left(\frac{Ft^2}{2m} + vt\right)\hat{i}$$

$$W_{F/\varepsilon} = F\left(\frac{Ft^2}{2m} + vt\right)$$

Nishant Jindal

(a) Find work done by

i) gravity ii) Normal reaction

on the block w.r.t ground.

(b) Find work done by ✓

i) gravity ii) Normal reaction

iii) Pseudo w.r.t elivator on the block

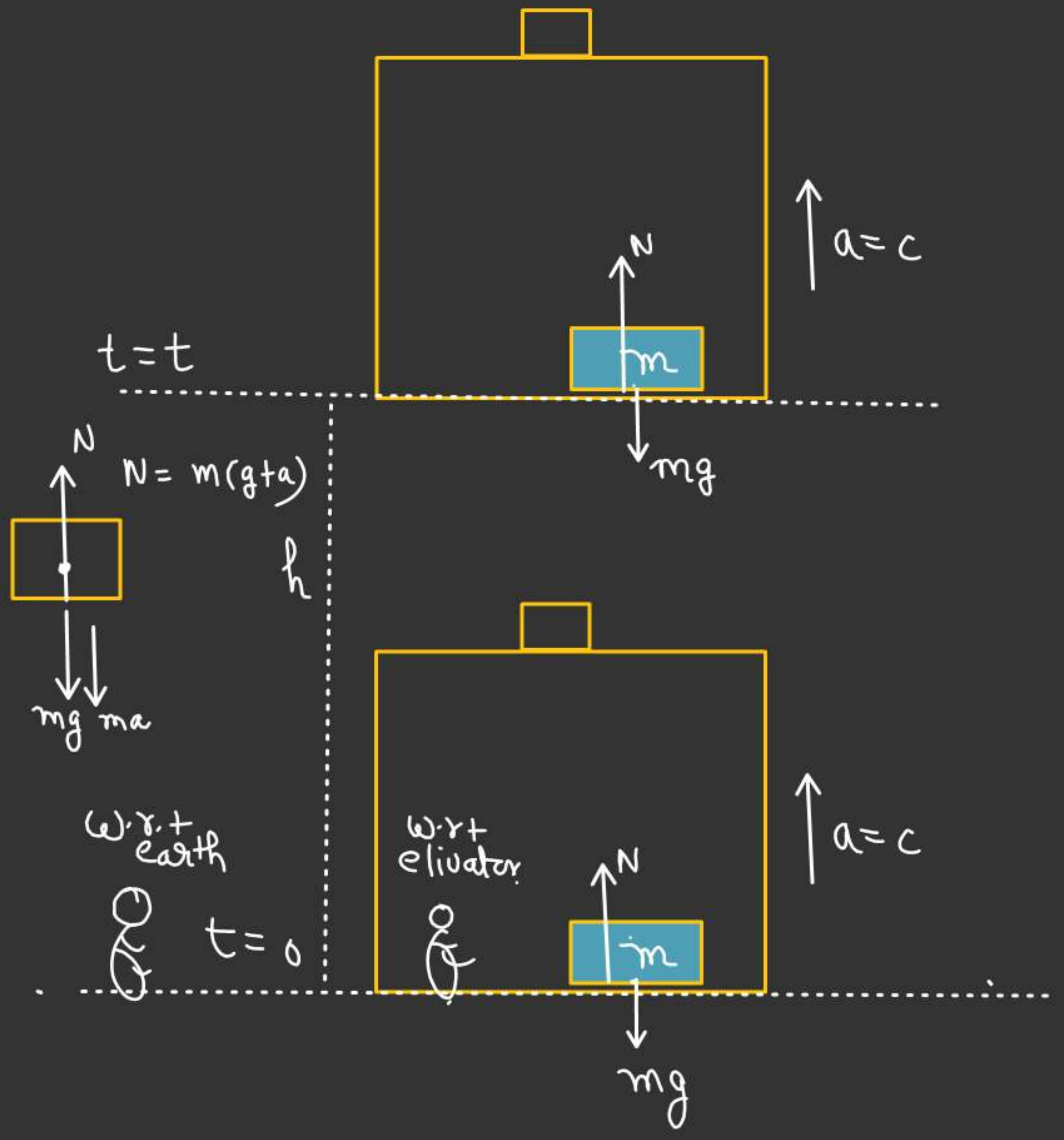
Sol^n W.r.t Earth

$$h = \frac{1}{2}at^2$$

$$W_{mg} = -(mg)(h) = -\left(mg\frac{1}{2}at^2\right) J$$

$$W_N = m(g+a)\frac{1}{2}at^2$$

$$(W_{net}) = W_{mg} + W_N = \left(mg\frac{1}{2}at^2\right)$$



Nishant Jindal

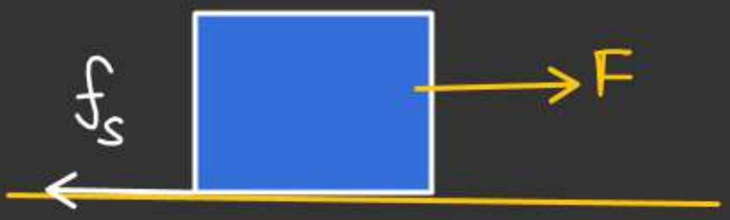
Displacement of block w.r.t Elivator = 0

$$\boxed{\begin{aligned} W_N &= 0 \\ W_{mg} &= 0 \\ W_{pseudo} &= 0 \end{aligned}}$$

Nishant Jindal

Work done by friction

Work done by Static friction



$F = f_s$

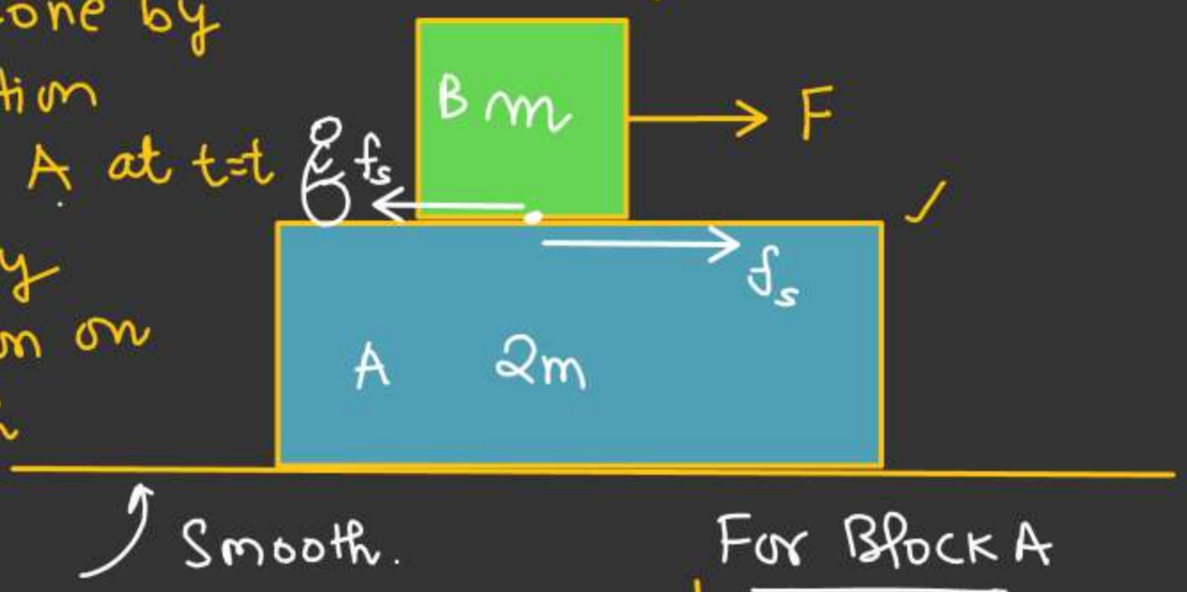
$W_{f_s} = 0.$

$W_F = 0.$

Both the blocks A & B Move together

a) Find work done by Static friction on B w.r.t A at t=t

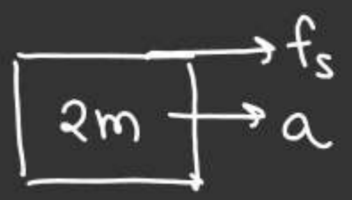
b) Work done by Static friction on B w.r.t earth t = t



$$\left[\left(W_{f_s}\right)_{\substack{\text{on B}\\ \text{w.r.t A}}} = 0\right.$$

$$a = \frac{F}{3m}.$$

For Block A



$f_s = 2ma$

$f_s = 2m\left(\frac{F}{3m}\right)$

$f_s = \frac{2F}{3}$

$$S_{A/E} = S_{B/E} = \frac{1}{2}\left(\frac{F}{3m}\right)t^2$$

$$S_{B/A} = 0.$$

$$\left[\left(W_{f_s}\right)_{\substack{\text{on B}\\ \text{w.r.t}\\ \text{earth}}} = f_s \times S_{B/E} \times \cos\pi\right.$$

$$= -\left(\frac{2F}{3}\right)\left(\frac{F}{6m}t^2\right)$$

$$= -\left(\frac{F^2t^2}{9m}\right) J$$

Nishant Jindal

$$\boxed{\begin{gathered}(W_{f_s})_{net} = 0 \\ (W_{f_s})_{on\ A} = -(W_{f_s})_{on\ B}.\end{gathered}}$$

Nishant Jindal

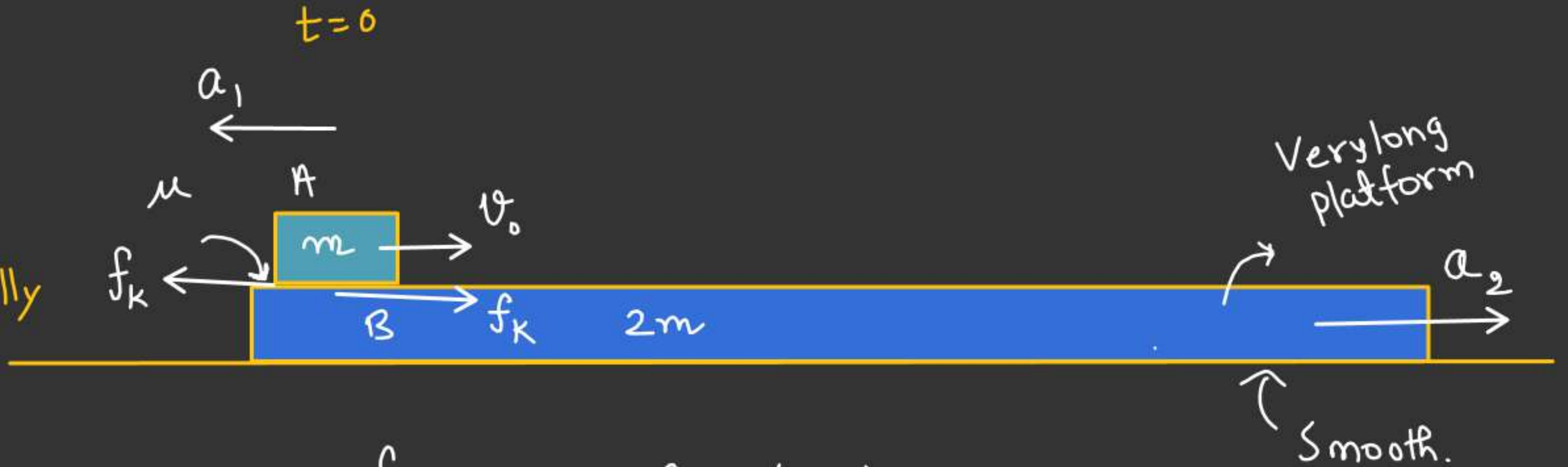
Work done by kinetic friction

Find work done by kinetic friction :-

a) On A w.r.t B.

b) On A w.r.t earth.

Block is projected horizontally on a very a very long platform at $t=0$.



$$a_1 = \frac{f_K}{m} = \frac{\mu mg}{m} = (\mu g)$$

$$a_2 = \frac{f_K}{2m} = \frac{\mu mg}{2m} = \left(\frac{\mu g}{2}\right)$$

f_K retard the motion of block A and acclerate the plank with zero initial velocity.

let, $t=t$ both move with common velocity.

Nishant Jindal

For block

$v = v_0 - a_1 t$

$v = v_0 - \mu g t$

For plank

$v = \frac{\mu g}{2} t$

$v_0 - \mu g t = \frac{\mu g}{2} t$

$v_0 = \frac{3}{2} \mu g t$

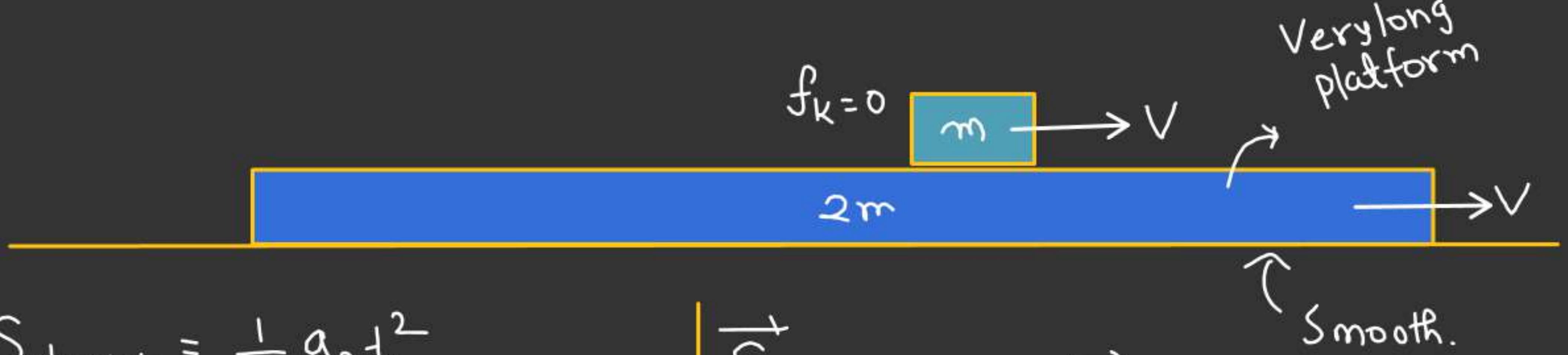
$\left(t = \frac{2v_0}{3\mu g} \right)$ ✓

$S_{block/g} = v_0 t - \frac{1}{2} a_1 t^2$

$= v_0 \left(\frac{2v_0}{3\mu g} \right) - \frac{1}{2} \times \mu g \times \left(\frac{2v_0}{3\mu g} \right)^2$

$= \frac{2v_0}{3\mu g} \left[v_0 - \frac{v_0}{3} \right] = \left(\frac{4v_0^2}{9\mu g} \right) m.$

$t = t.$



$S_{plank/g} = \frac{1}{2} a_2 t^2$

$= \frac{1}{2} \times \left(\frac{\mu g}{2} \right) \times \left(\frac{2v_0}{3\mu g} \right)^2$

$= \left(\frac{v_0^2}{9\mu g} \right)$

$\vec{S}_{block/plank} = \vec{S}_{block/g} - \vec{S}_{plank/g}$

$= \frac{4v_0^2}{9\mu g} \hat{i} - \frac{v_0^2}{9\mu g} \hat{i}$

$= \left(\frac{v_0^2}{3\mu g} \right) \hat{i}$

Nishant Jindal

$$S_{block/E} = \left(\frac{4v_0^2}{9\mu g}\right) \checkmark$$

$$S_{plank/E} = \left(\frac{v_0^2}{9\mu g}\right) \checkmark$$

$$S_{block/plank} = \left(\frac{v_0^2}{3\mu g}\right) \checkmark$$

$$(W_{f_K})_{net} = (W_{f_K})_{\substack{\text{on the}\\ \text{block}\\ \text{w.r.t earth}}} + (W_{f_K})_{\substack{\text{on the}\\ \text{plank w.r.t}\\ \text{earth}}}$$

$$= \left(-\frac{4mv_0^2}{9} + \frac{mv_0^2}{9}\right)$$

$$= (-)\frac{mv_0^2}{3} J$$

$$(W_{f_K})_{\substack{\text{on block}\\ \text{w.r.t plank}}} = f_K \cdot (S_{block/plank}) \cdot \cos\pi$$

$$= -\mu mg \times \left(\frac{v_0^2}{3\mu g}\right)$$

$$= (-)\frac{mv_0^2}{3} \cdot J.$$

$$(W_{f_K})_{\substack{\text{on the}\\ \text{block w.r.t}\\ \text{earth}}} = -(f_K)\,(S_{block/E})$$

$$= -(\mu mg) \times \frac{4v_0^2}{9\mu g}$$

$$= -\frac{4mv_0^2}{9} J$$

$$(W_{f_K})_{\substack{\text{on the}\\ \text{plank}}} = (\mu mg)\left(\frac{v_0^2}{9\mu g}\right) = +\frac{mv_0^2}{9} J$$