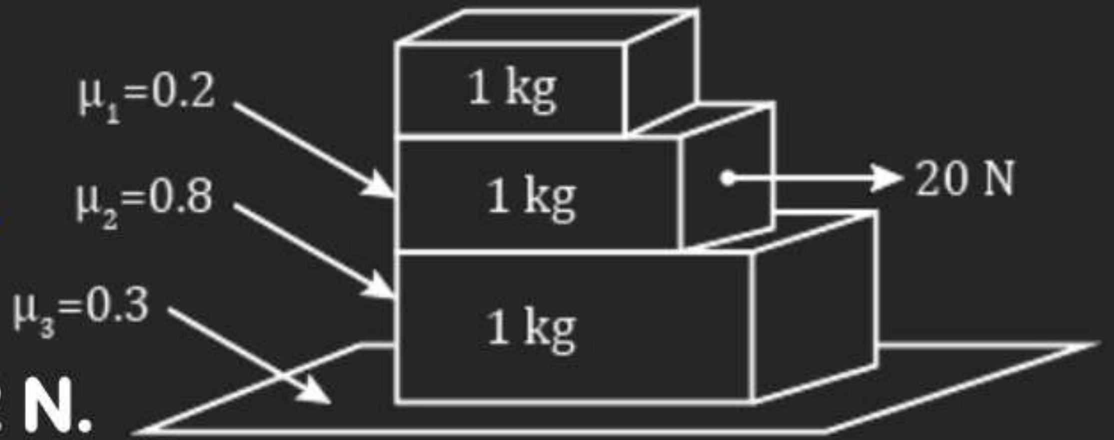
Nishant Jindal

Multiple block system

FRICTION

Q.4 Three large box are kept stationary over one other as shown in figure. A horizontal force 20 N acts on middle block as shown in figure. Then select the correct statement(s).

H-W



(A) Acceleration of lowest block is 4.5 ms^{-2}. ✓

(B) Acceleration of upper most block is 2 ms^{-2}. ✓

X (C) Friction between middle and lower block is 12 N.

(D) Friction between middle and upper block is 2 N. ✓

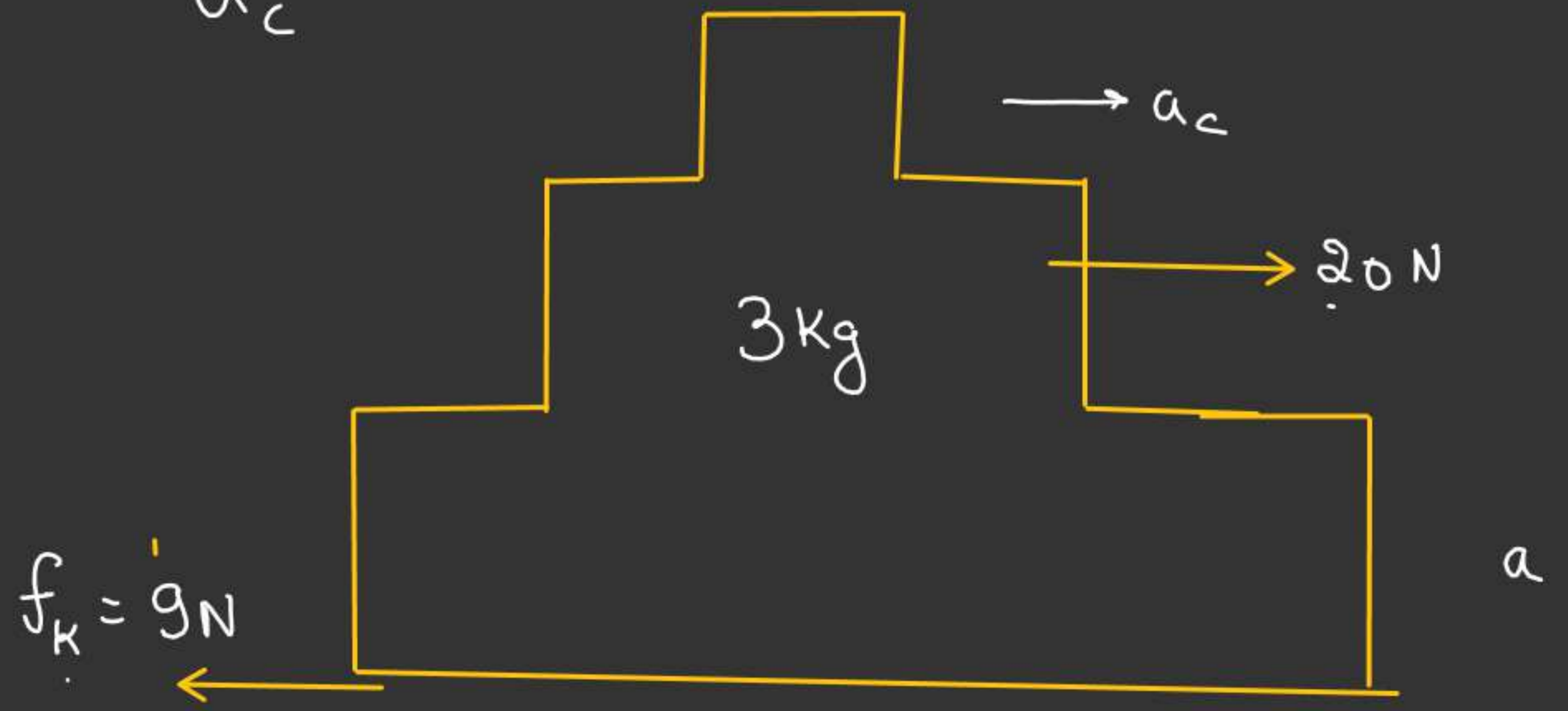
$\boxed{A, B, D}$ Ans.

Nishant Jindal

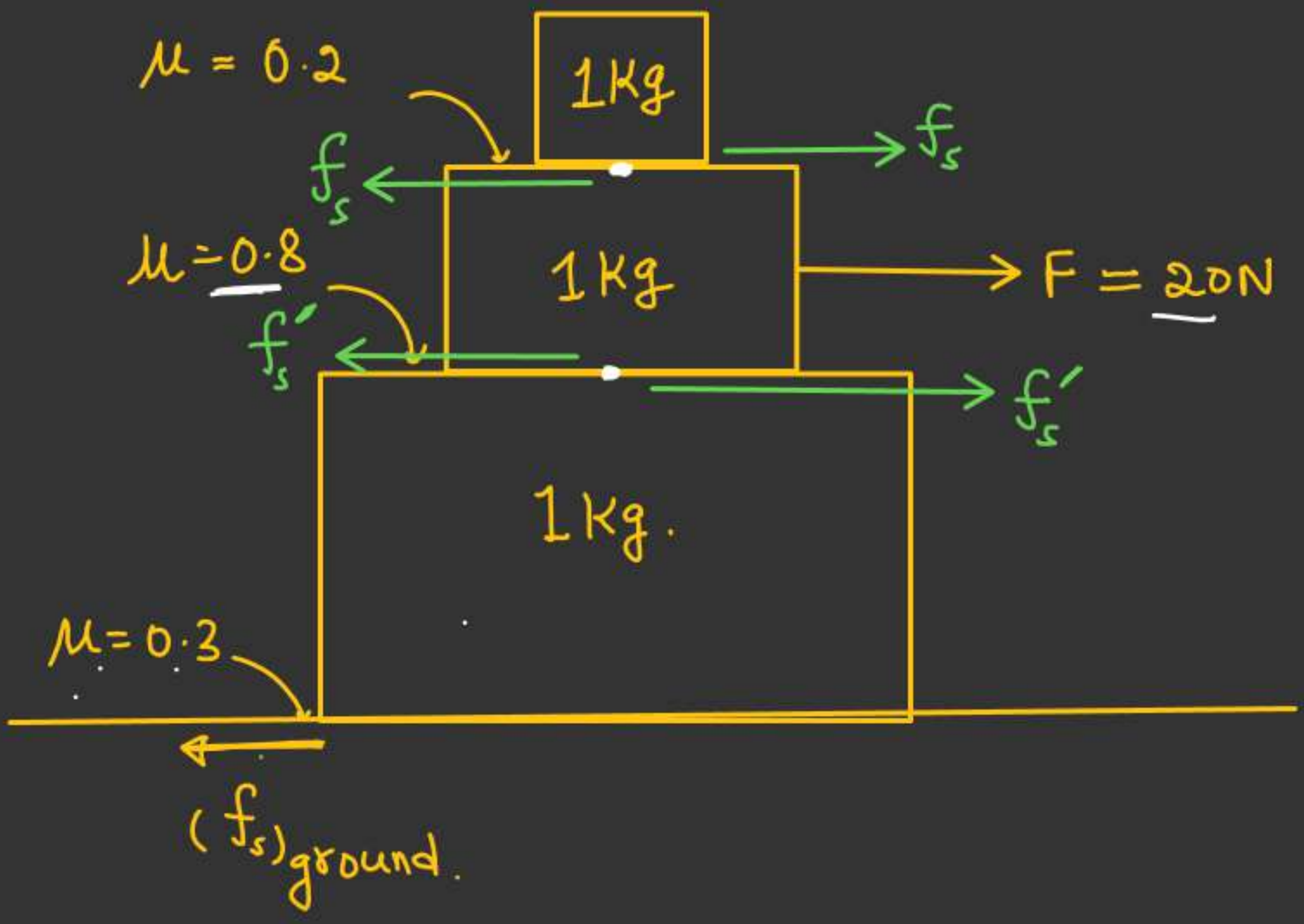
$$\left[(f_s)_{ground}\right]_{max} = \mu \cdot N$$
$$= 0.3 \times 3 \times 10$$
$$= 9N.$$

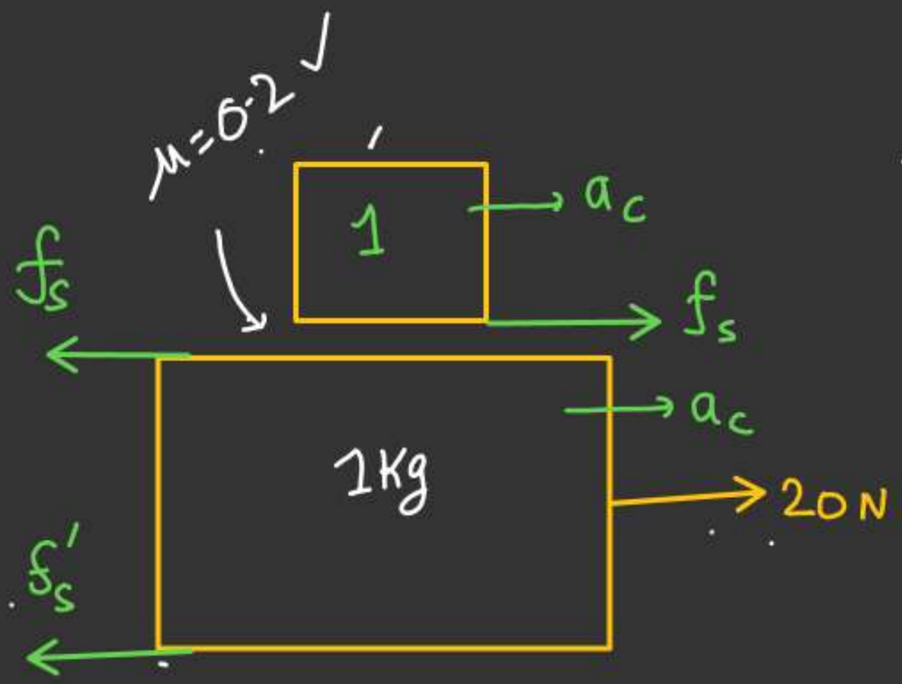
$F > (f_s)_{max}$ of ground.

a_c



$$20 - 9 = 3a_c$$
$$a_c = \frac{11}{3} ms^{-2}$$





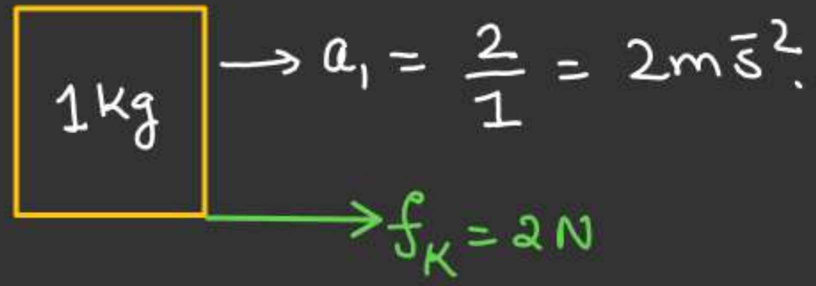
$f_s = 1 \cdot a_c$

$f_s = \frac{11}{3}\,N$

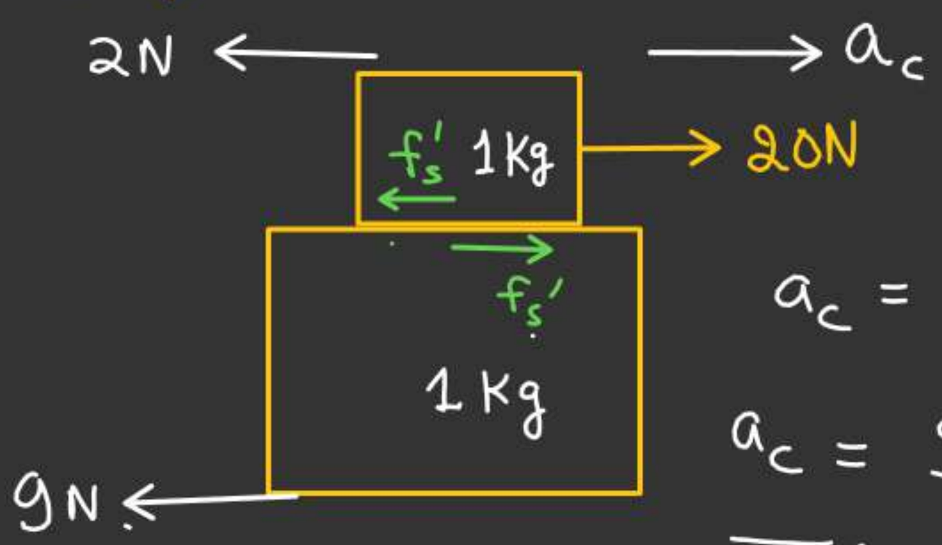
$(f_s)_{max} = 0.2 \times 1 \times 10$

$= 2\,N$

$f_s > (f_s)_{max} \Rightarrow$ Relative Slipping b/w 1 & 2 block.

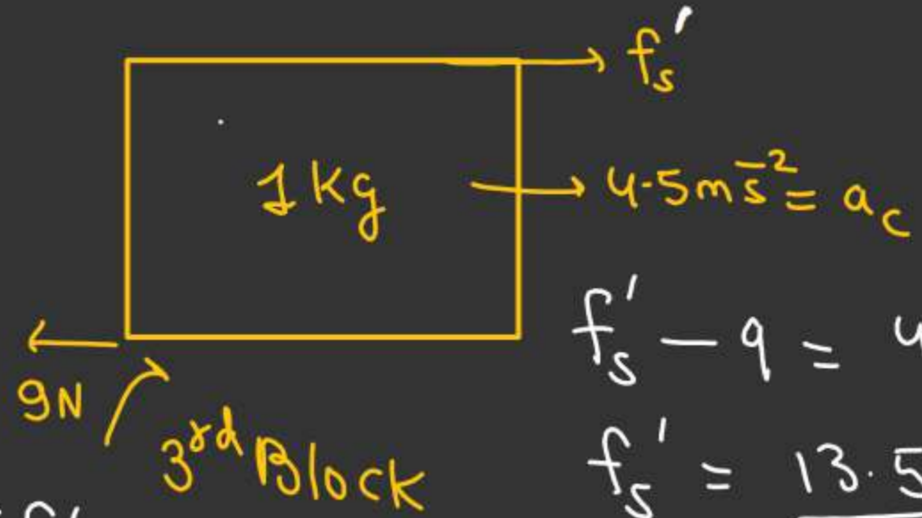


(*) let, 2 & 3 block move together



$a_c = \frac{20 - 11}{2}$

$a_c = \frac{9}{2} = 4.5\,m s^{-2}$



$f_s' - 9 = 4.5$

$f_s' = 13.5\,N$

$(f_s')_{max} =$

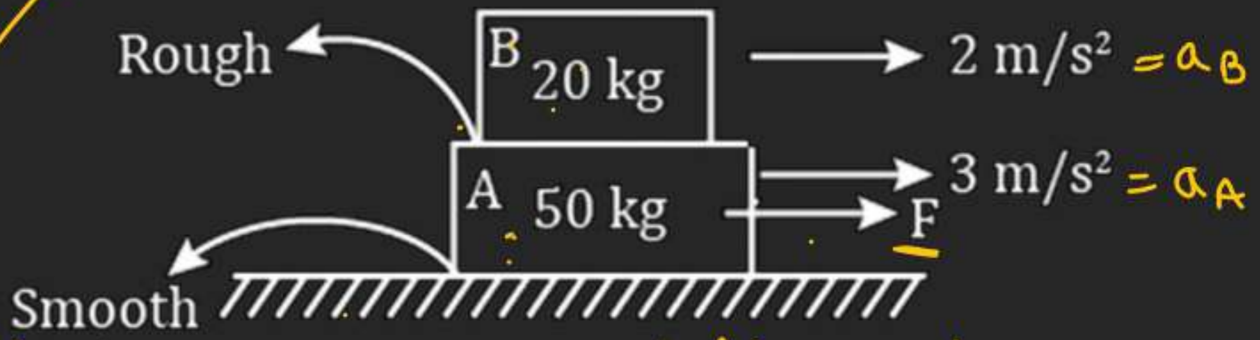
$(f_s') < (f_s')_{max} \Rightarrow$ Assumption is correct

Multiple block system

FRICTION

Q.5 A $20\ \mathrm{kg}$ block is placed on top of $50\ \mathrm{kg}$ block as shown in figure. A horizontal force F acting on A produces an acceleration of $3\ \mathrm{ms}^{-2}$ in A and $2\ \mathrm{ms}^{-2}$ in B as shown in figure. For this situation mark out the correct statement(s).

H.W



(A) The friction force between A and B is $40\ \mathrm{N}$. ✓

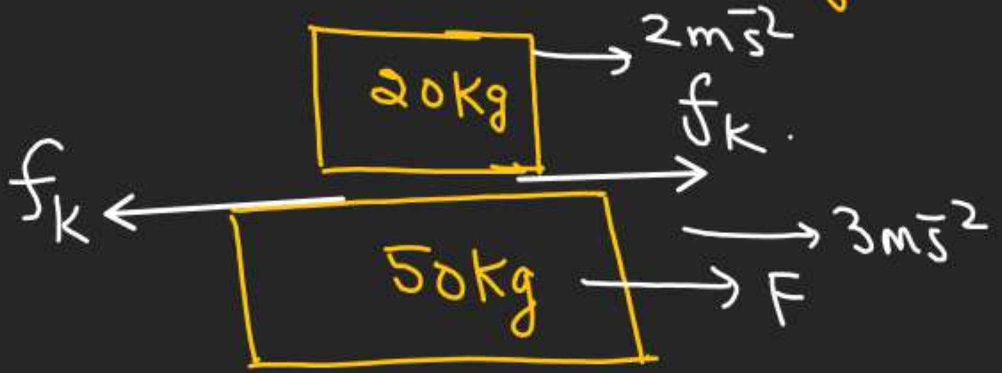
(B) The net force acting on A is $150\ \mathrm{N}$. ✓

(C) The value of F is $190\ \mathrm{N}$. ✓

(D) The value of F is $150\ \mathrm{N}$.

A, B, C ✓

Blocks A and B move with different acclerations, so relative slipping & Kinetic friction acts.



For upper block

$f_K = (2 \times 20) = 40\,N$.

$F - f_K = 50 \times 3$

$F = 150 + 40 = 190\,N$

Multiple block system

FRICTION

Q.1 In the figure, $m_A = 2$ kg and $m_B = 4$ kg. The minimum value of F for which A starts slipping over B is $(g = 10\ ms^{-2})$

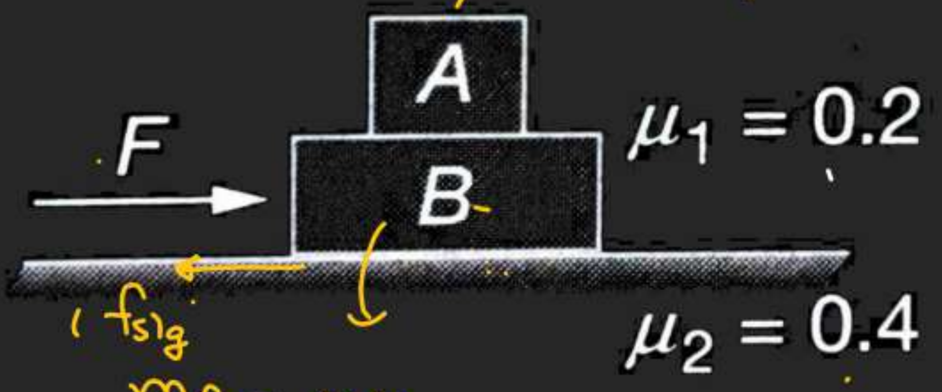
H.W

(A) 24 N

(B) 36 N

(C) 12 N

(D) 20 N

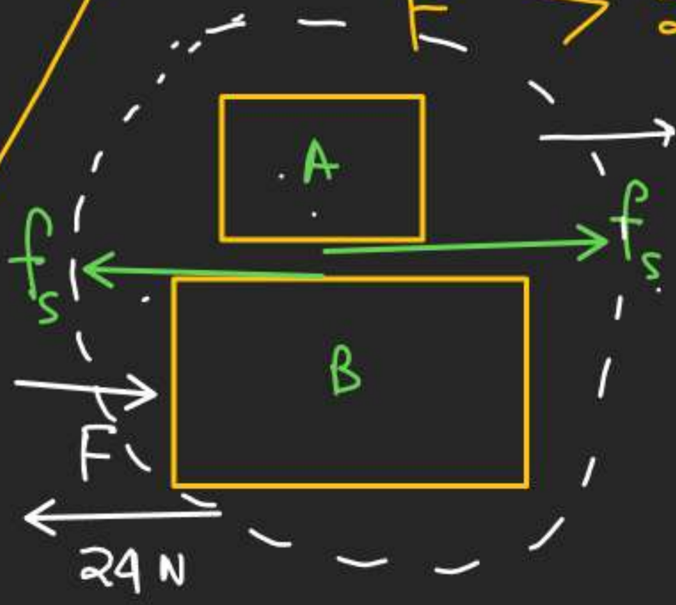


let, Both the blocks move together.

$F > [(f_s)_g]_{max}$

$F > 24\ N$

$[(f_s)_g]_{max} = 0.4 \times 60 = 24N$



$a_c = \left(\frac{F-24}{6}\right)$

$f_s = 2a_c$ (for upper block)

$f_s = 2\left(\frac{F-24}{6}\right) = \left(\frac{F-24}{3}\right)$

$f_s \le (f_s)_{max}$

$\Rightarrow \frac{F-24}{3} \le 0.2 \times 2 \times 10$

$\Rightarrow F \le (24+12)$

$\Rightarrow F \le 36$

For block to move together

$\boxed{24 < F \le 36}$

F_{min} for Slipping start $= 36N$ ✓

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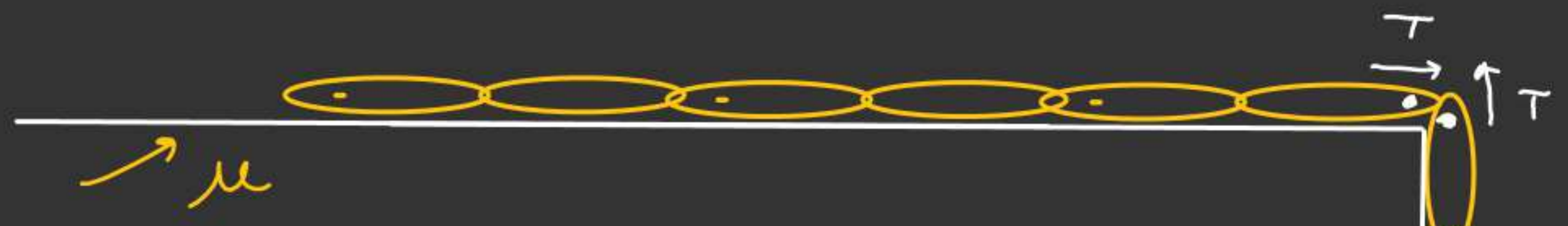
Case of Uniform Chain

Uniform chain.

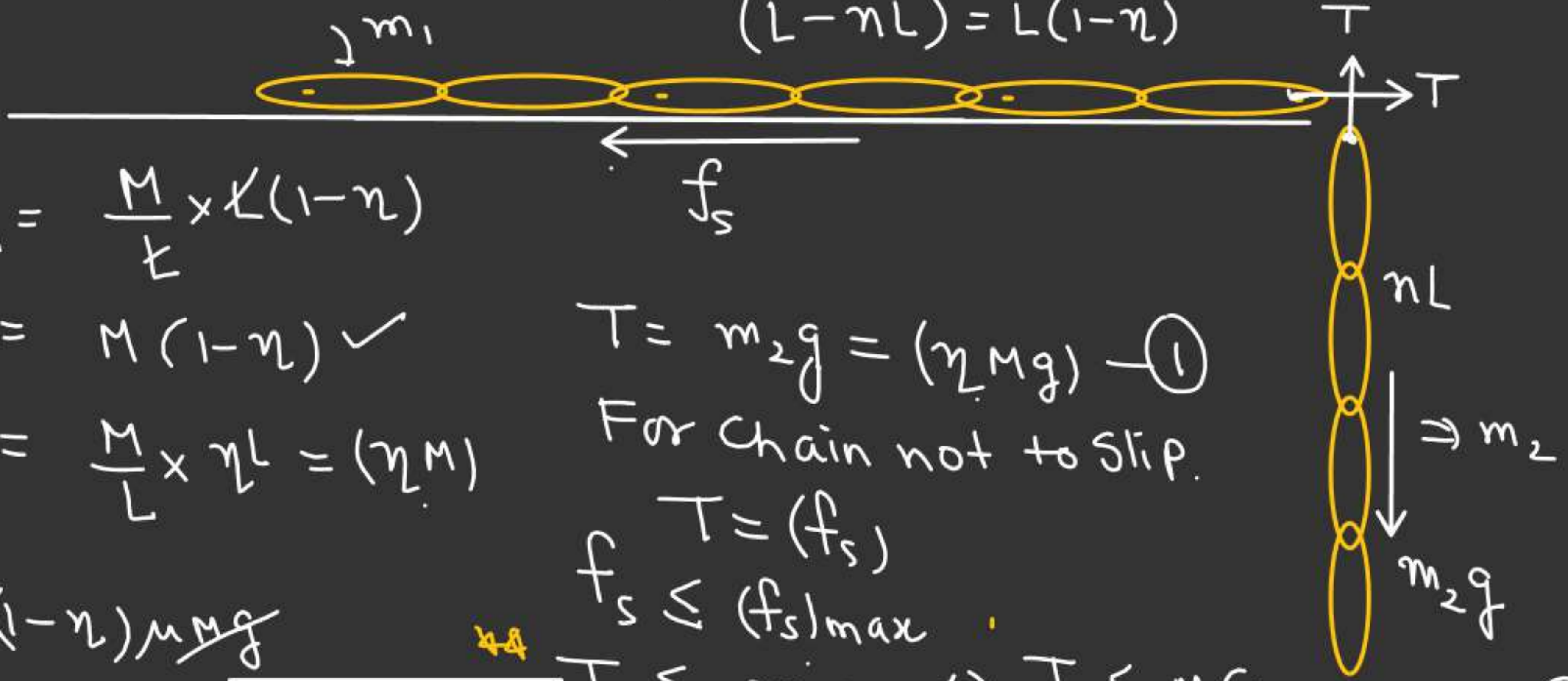
(M, L)

Hanging part $= (\eta L)\ (\eta < 1)$



Find μ_{min} for Chain not to Slip.

$(L - \eta L) = L(1-\eta)$



$$\underline{m_1} = \frac{M}{\cancel{L}} \times \cancel{L}(1-\eta)$$

$$= M(1-\eta) \checkmark$$

$$m_2 = \frac{M}{L} \times \eta L = (\eta M)$$

$T = m_2 g = (\eta M g)$ — ①

For Chain not to Slip.

$T = (f_s)$

$f_s \le (f_s)_{max}$

$T \le m_1 g \mu \Rightarrow T \le M(1-\eta)\mu g$ — ②

From ① & ②

$$\eta \cancel{Mg} \le (1-\eta)\mu \cancel{Mg}$$

$$\mu \ge \frac{\eta}{1-\eta} \Rightarrow \boxed{\mu_{min} = \frac{\eta}{1-\eta}}$$

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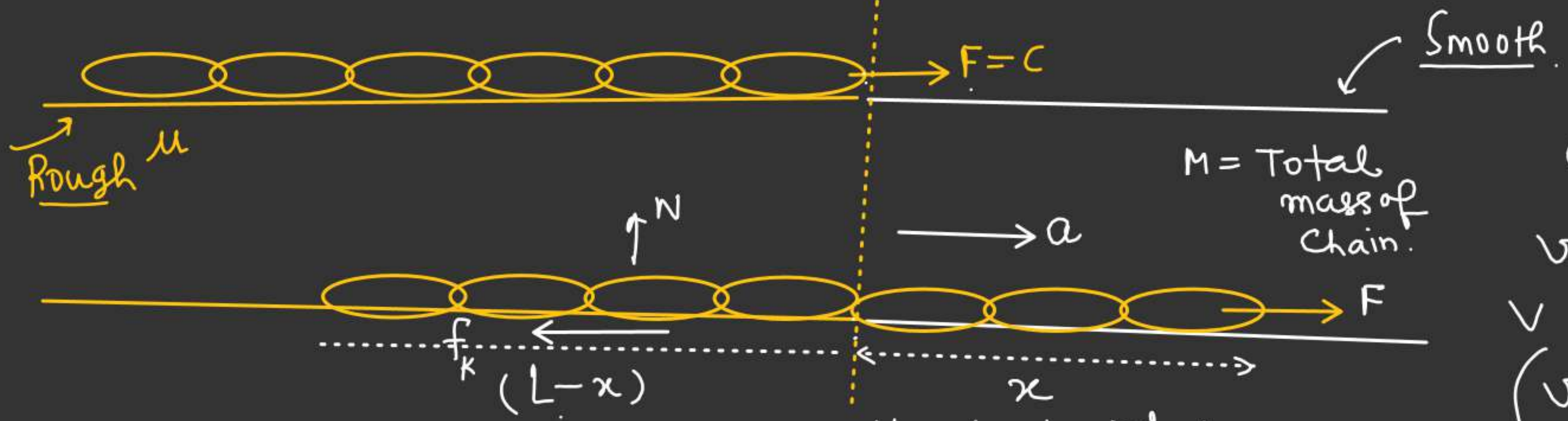
M, L

Find velocity of Chain when whole Chain is on the Smooth Surface.



$$f_k = \mu N$$
$$= \mu (m_{L-x}) g$$
$$f_k = \mu g \frac{M}{L}(L-x)$$

Newton's 2nd Law

$$F - f_k = Ma$$
$$F - \frac{\mu M g}{L}(L-x) = Ma$$
$$\frac{F - \mu M g}{M} + \frac{\mu g}{L} x = a$$
$$\underbrace{\left(\frac{F-\mu Mg}{M}\right)}_{p} + \underbrace{\left(\frac{\mu g}{L}\right)}_{q} x = a$$

$$a = p + qx$$
$$v\frac{dv}{dx} = (p+qx)$$
$$\int_0^V v\,dv = \int_0^L (p+qx)\,dx$$
$$\frac{V^2}{2} = pL + \frac{qL^2}{2}$$
$$V^2 = 2pL + qL^2$$
$$\left(V = \sqrt{2pL+qL^2}\right)$$

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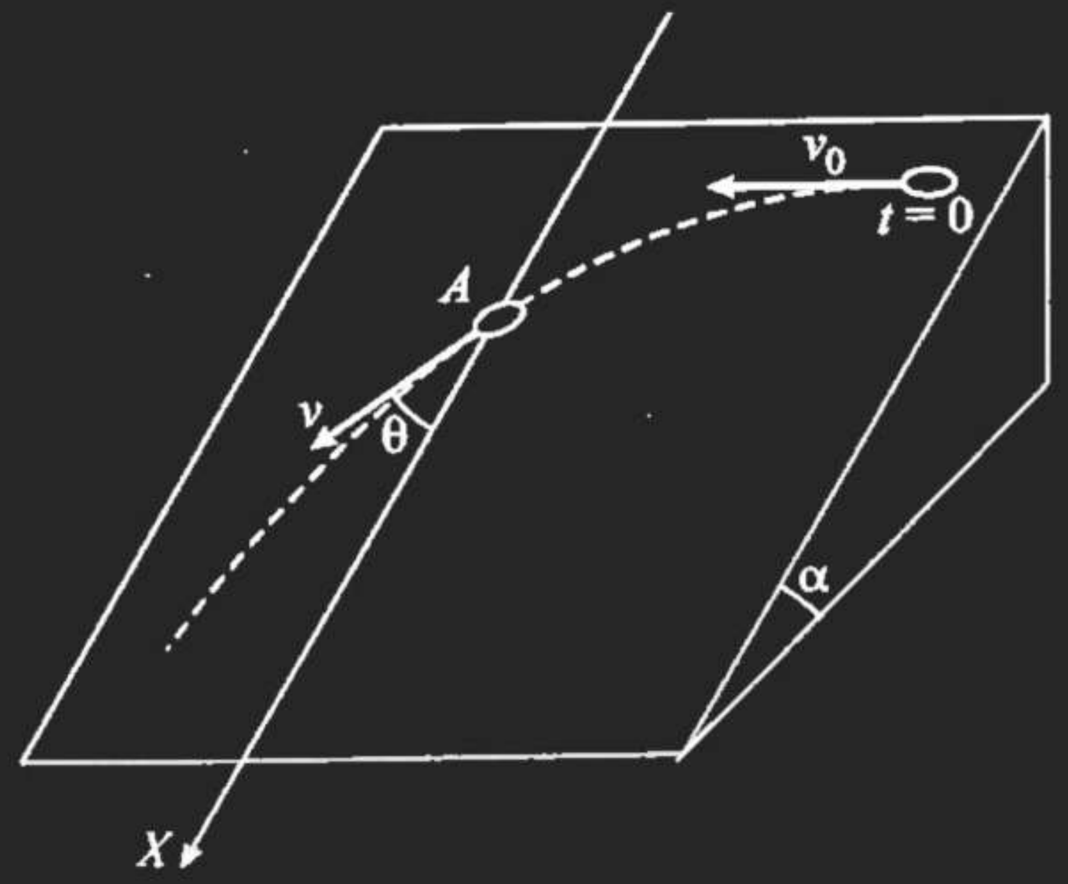
H.W

FRICTION

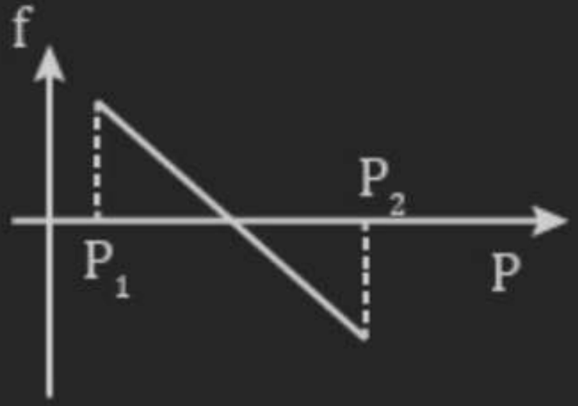
Q.1 A small disc A is placed on an inclined plane forming an angle α with the horizontal and is imparted an initial velocity v_0. Find how the velocity of the disc depends on the angle θ, shown in figure, if the friction coefficient $\mu = \tan\alpha$ and at the initial moment $\theta = \pi/2$.

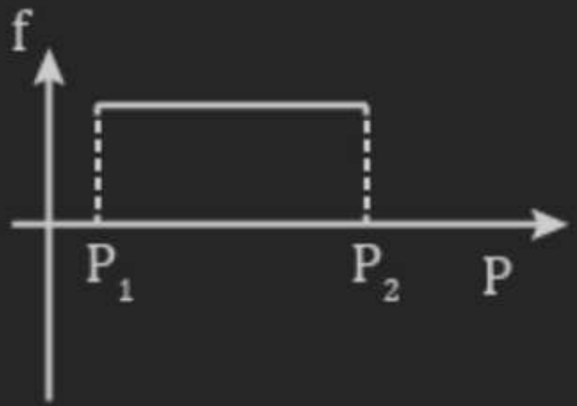


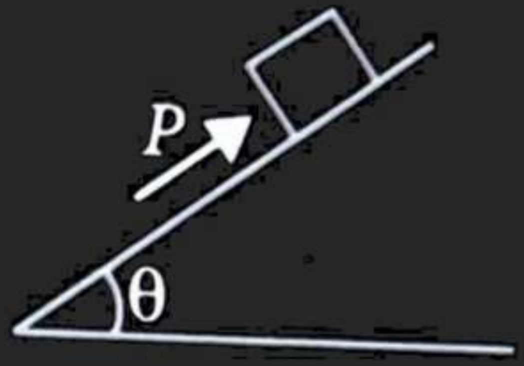
H.W

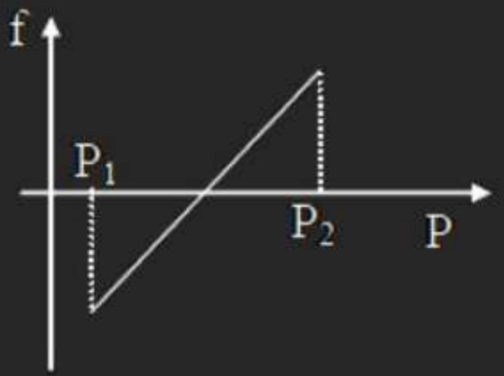
FRICTION

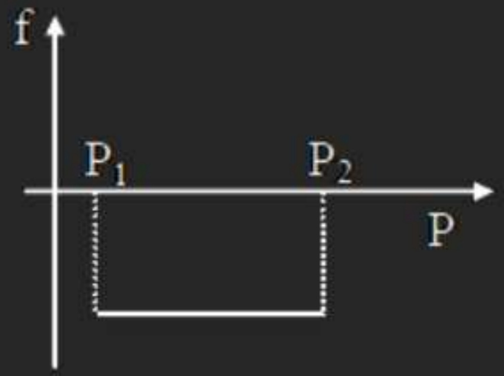
Q.3 A block of mass m is on an inclined plane of angle θ. The coefficient of friction between the block and the plane is μ and $\tan\theta > \mu$. The block is held stationary by applying a force P parallel to the plane. The direction of force pointing up the plane is taken to be positive. As P is varied from $P_1 = mg(\sin\theta - \mu\cos\theta)$ to $P_2 = mg(\sin\theta + \mu\cos\theta)$, the frictional force f versus P graph will look like **(2010)**

(A)


(B)




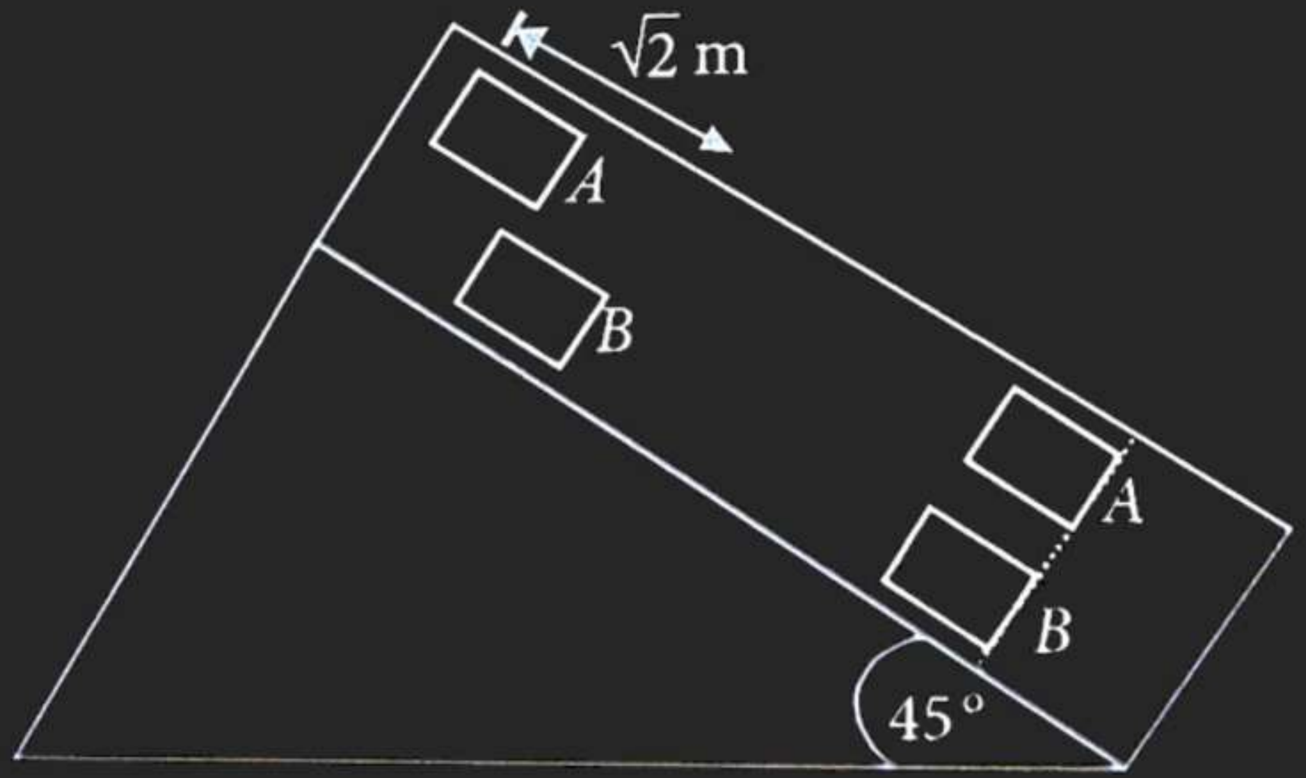
(C)


(D)


FRICTION

H-W

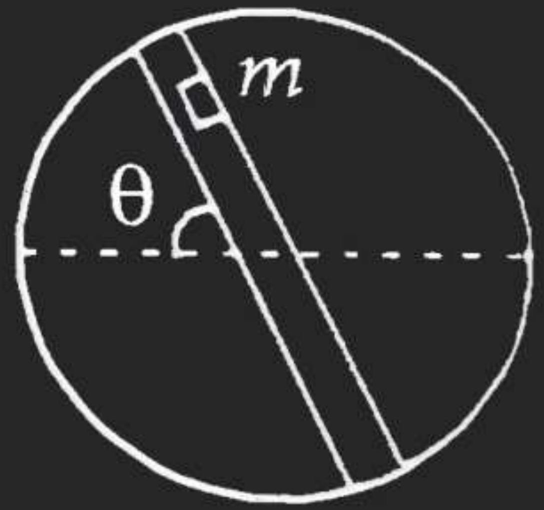
Q.4 Two blocks A and B of equal masses are placed on rough inclined plane as shown in figure. When and where will the two blocks come on the same line on the inclined plane if they are released simultaneously? Initially the block A is $\sqrt{2}$ m behind the block B. Co-efficient of kinetic friction for the blocks A and B are 0.2 and 0.3 respectively $(g = 10\ m/s^2)$. **(2004)**



H.W

FRICTION

Q.5 A circular disc with a groove along its diameter is placed horizontally on a rough surface. A block of mass $1\,\text{kg}$ is placed as shown in the figure. The coefficient of friction between the block and all surfaces of groove and horizontal surface in contact is $2/5$. The disc has an acceleration of $25\,\text{m/s}^2$ towards left. Find the acceleration of the block with respect to disc. Given $\cos\theta = 4/5, \sin\theta = 3/5$. **(2006)**



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H.W

FRICTION

Q.8 The chain is released from rest with the length b of overhanging links just sufficient to initiate motion. The coefficients of static and kinetic friction between the links and the horizontal surface have essentially the same value μ. Determine the velocity v of the chain when the last link leaves the edge Neglect any friction at the corner.