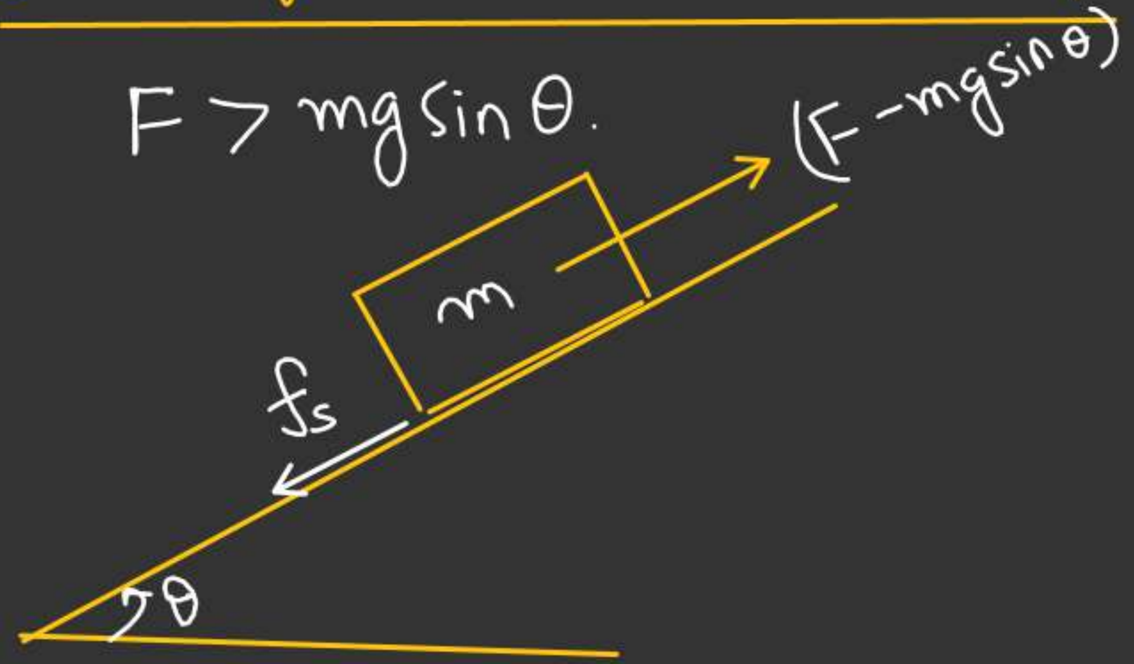
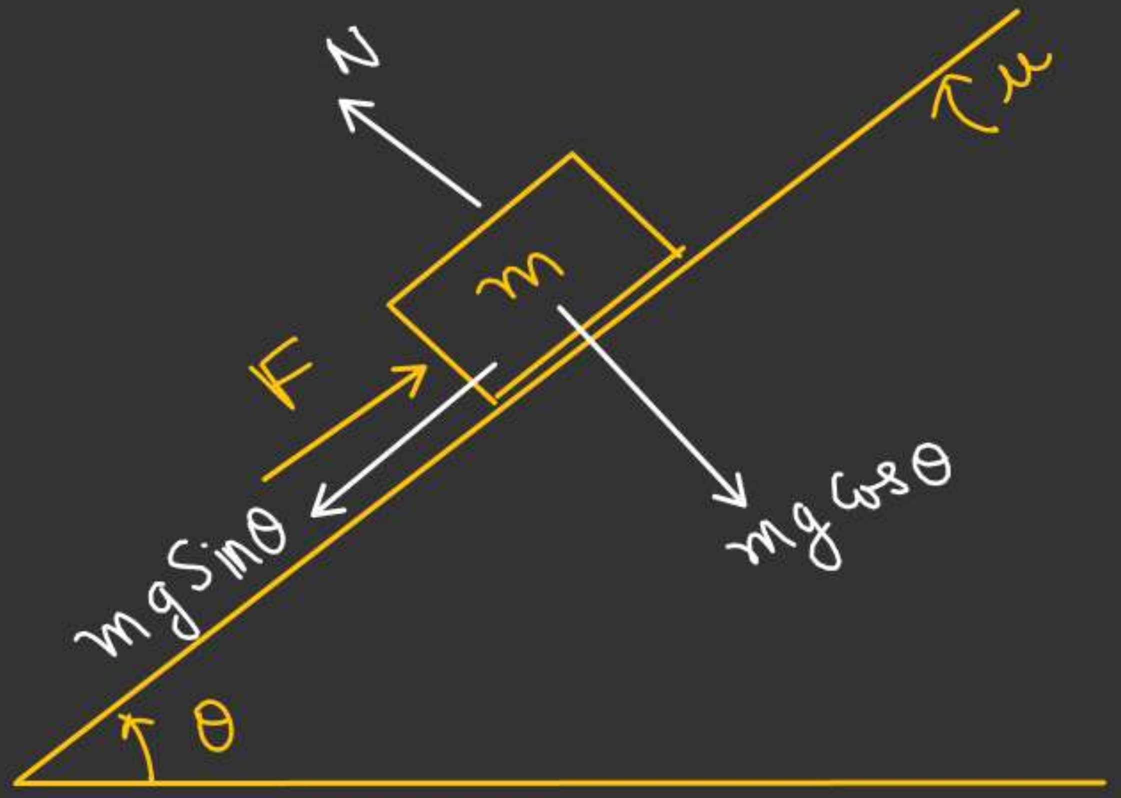
Nishant Jindal

Find F for block not to slip.

$(N = mg\cos\theta)$

Case-1 $F > mg\sin\theta$.





For block not to move

$$f_s = (F - mg\sin\theta)$$

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

$$F - mg\sin\theta \le \mu mg\cos\theta$$

$$F \le mg(\sin\theta + \mu\cos\theta)$$

$$F_{max} = mg(\sin\theta + \mu\cos\theta)$$

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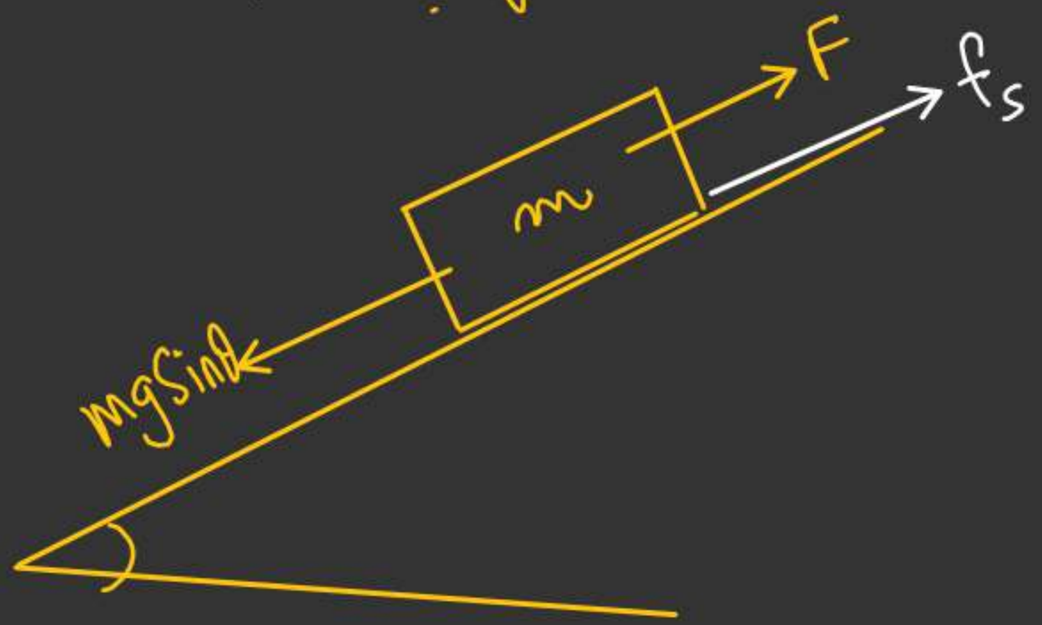
Case-2

$F < mg\sin\theta$



For block not to slip

$$mg\sin\theta = F + f_s$$

$$f_s = (mg\sin\theta - F)$$

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

$$mg\sin\theta - F \le \mu mg\cos\theta$$

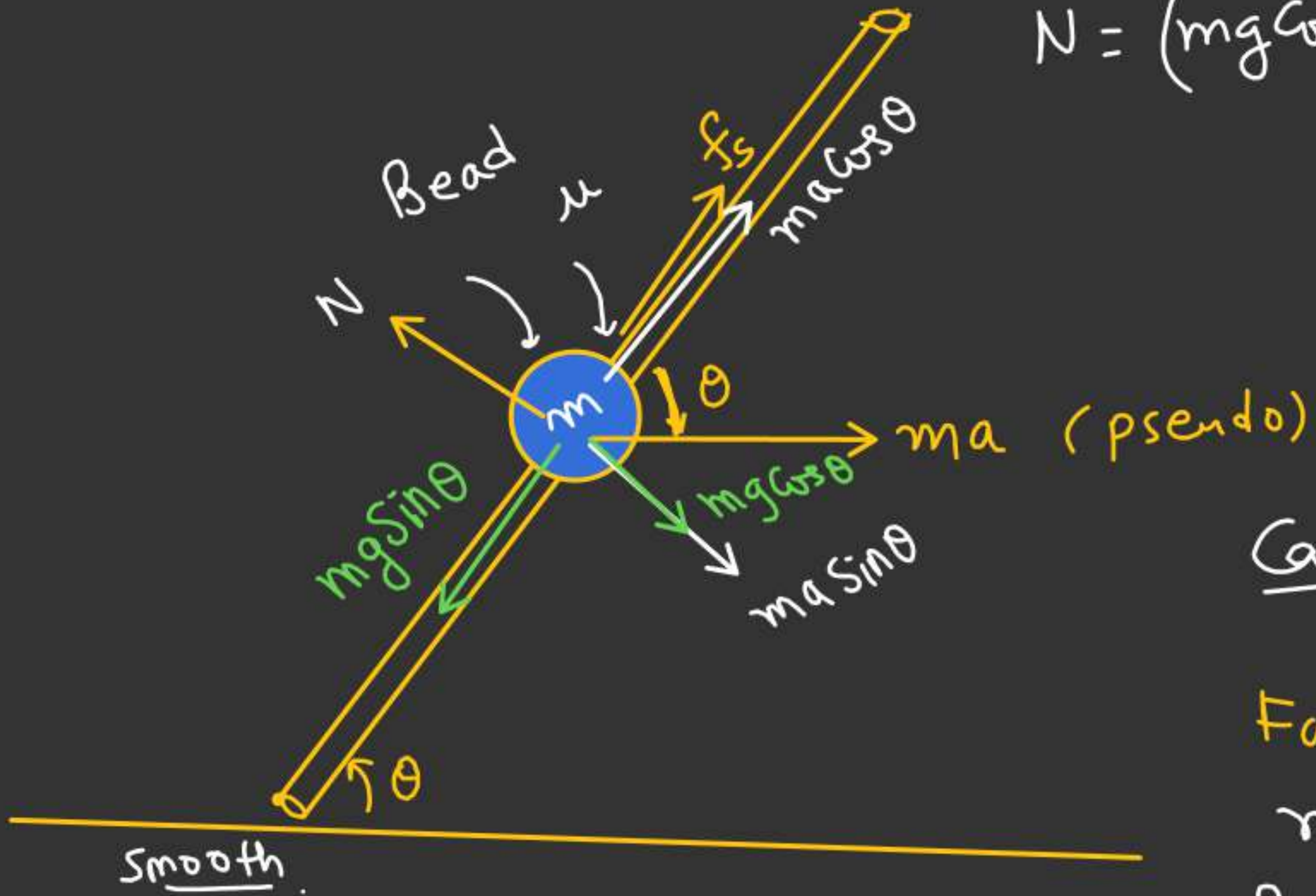
$$mg(\sin\theta - \mu\cos\theta) \le F$$

$$F_{min} = mg(\sin\theta - \mu\cos\theta)$$

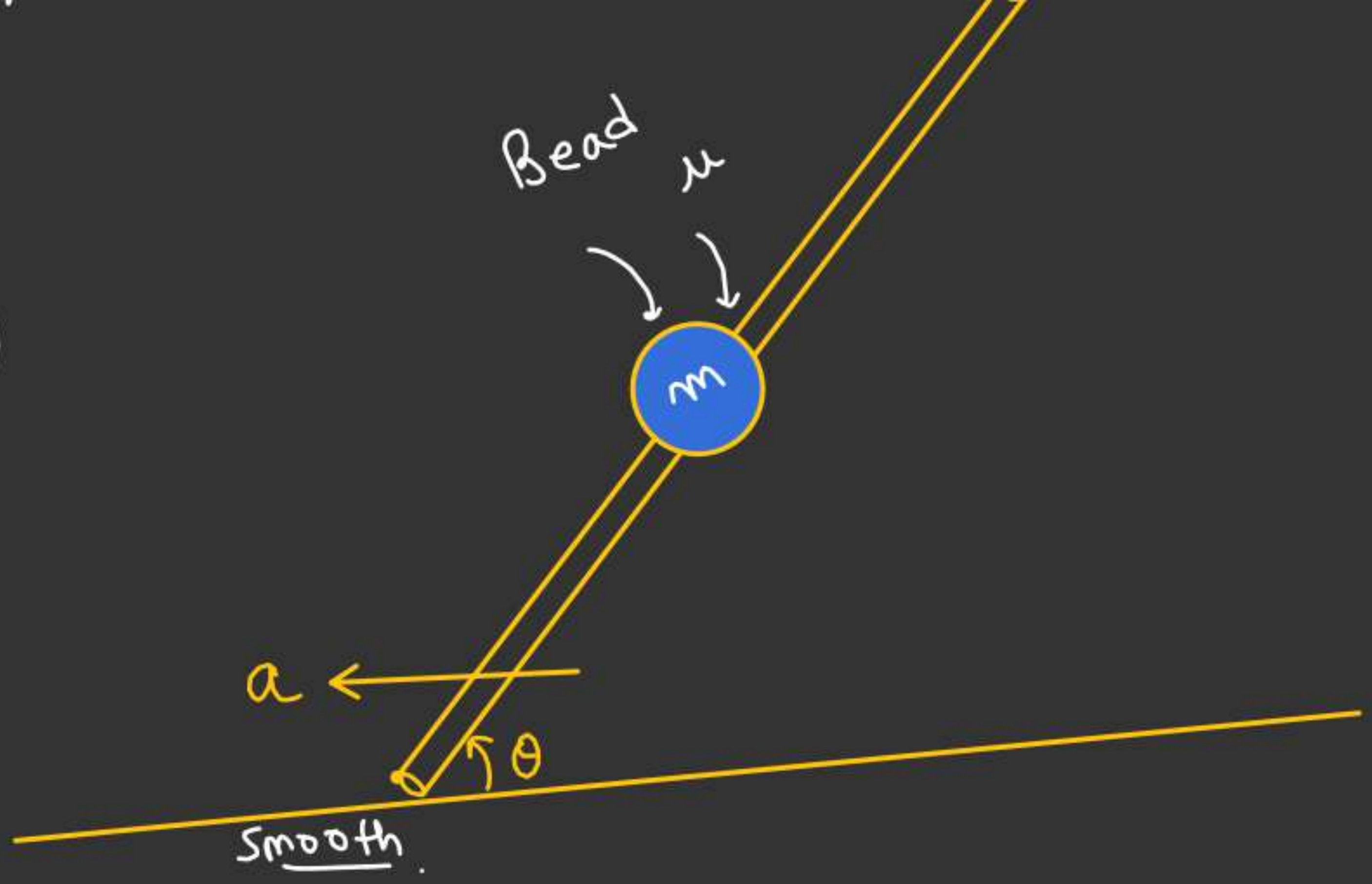
$$\boxed{mg(\sin\theta - \mu\cos\theta) \le F \le mg(\sin\theta + \mu\cos\theta)}$$

Nishant Jindal

Find value of a so that Bead doesn't Slip on the rod. [w.r.t Rod]



$N = (mg\cos\theta + ma\sin\theta)$



Case-1

$mg\sin\theta > ma\cos\theta$

For bead not to slip

$mg\sin\theta = ma\cos\theta + f_s$

$f_s = (mg\sin\theta - ma\cos\theta)$

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

$(mg\sin\theta - ma\cos\theta) \leq \mu(mg\cos\theta + ma\sin\theta)$

$mg(\sin\theta - \mu\cos\theta) \leq ma(\cos\theta + \mu\sin\theta)$

$\Downarrow$

$$a \geq \frac{g(\sin\theta - \mu\cos\theta)}{(\cos\theta + \mu\sin\theta)}$$

$$a_{min} = g\left(\frac{\sin\theta - \mu\cos\theta}{\cos\theta + \mu\sin\theta}\right)$$

$$a_{max} = \frac{g(\sin\theta + \mu\cos\theta)}{(\cos\theta - \mu\sin\theta)}$$

Nishant Jindal

Find maximum height up to which insect crawl without Slipping. m = (mass of insect)

μ = coffⁿ of friction b/w hemisphere and insect.

For insect not to slip.

$$mg\sin\theta = f_s$$

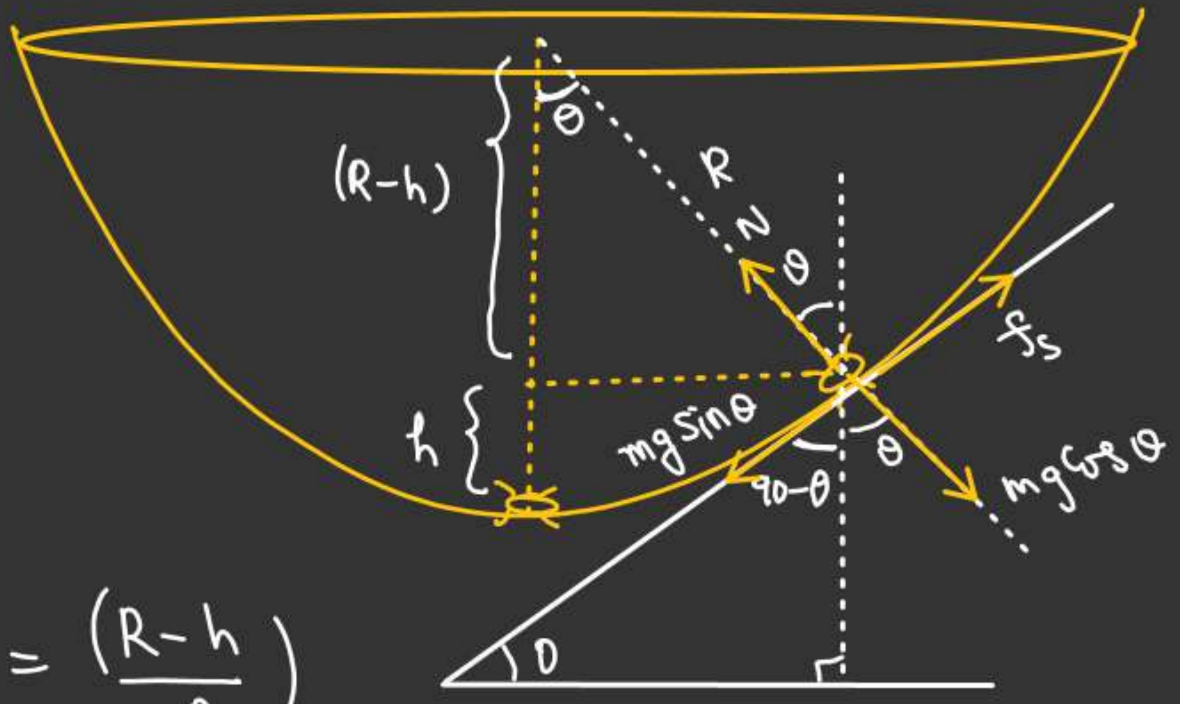
$$f_s \le (f_s)_{max}$$

$$mg\sin\theta \le \mu mg\cos\theta$$

$$\tan\theta \le \mu$$

Limiting Condition

$$\tan\theta = \mu.$$

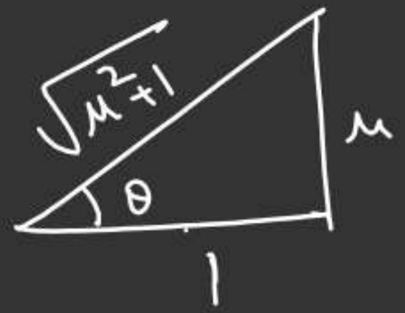


$$\cos\theta = \left(\frac{R-h}{R}\right)$$

$$\cos\theta = \left(1 - \frac{h}{R}\right)$$

$$\frac{h}{R} = (1-\cos\theta) \Rightarrow h = R(1-\cos\theta)$$

$$\underline{h_{max}} = R\left[1 - \frac{1}{\sqrt{\mu^2+1}}\right]$$



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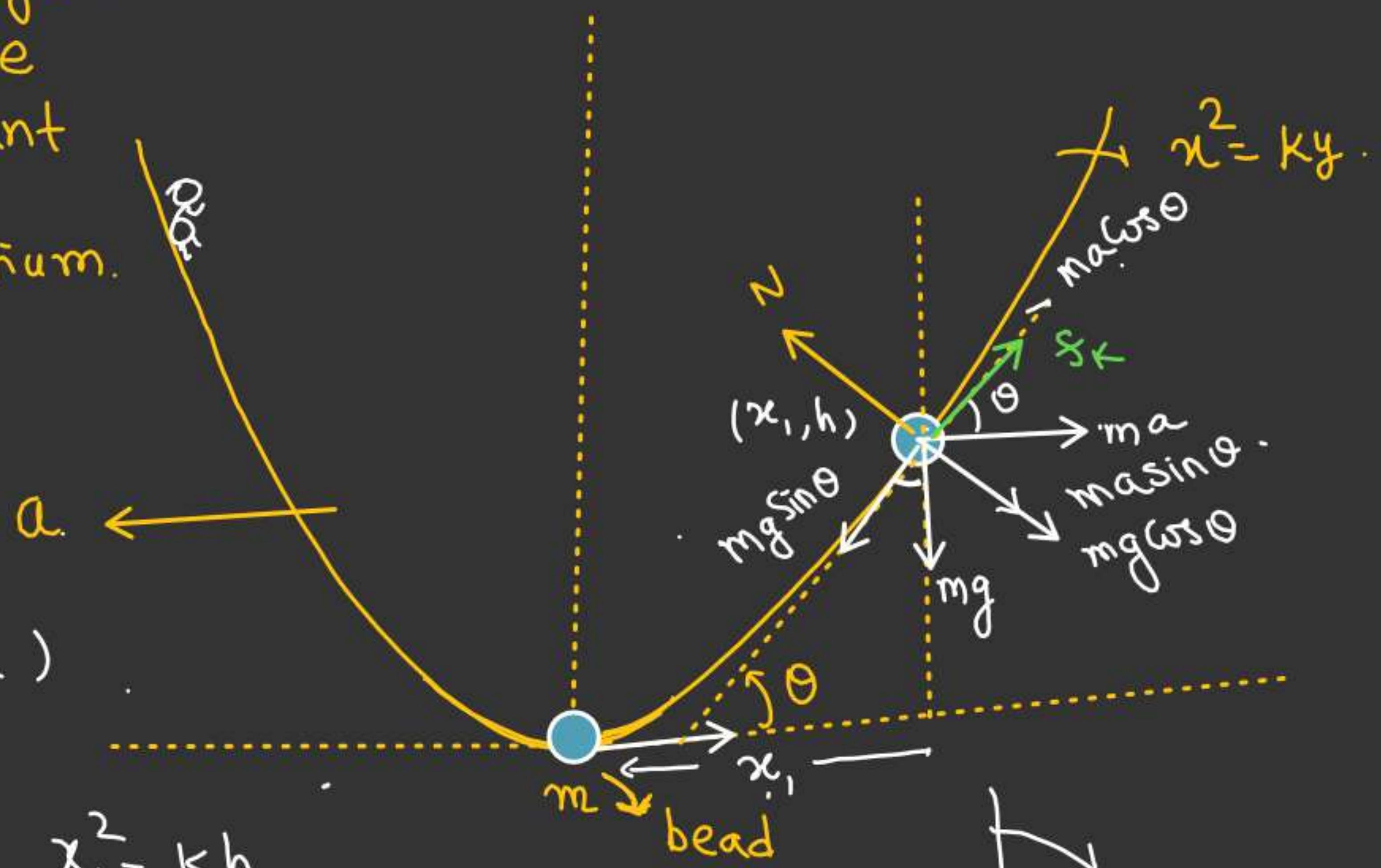
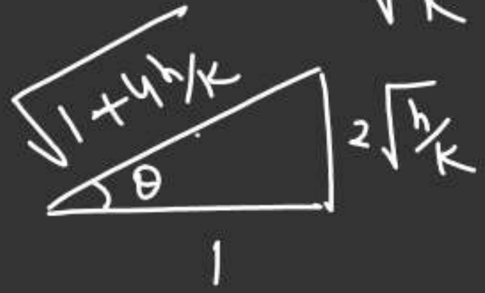
A bead of mass m at origin initially. the parabolic shape wire accelerated with constant acceleration a.
Find height of bead at Equilibrium.



let h be the maximum height gain by bead.

$$mg\sin\theta = ma\cos\theta + (f_k)$$

$$\tan\theta = 2\sqrt{\frac{h}{k}}.$$



$$x^2 = k\,y$$

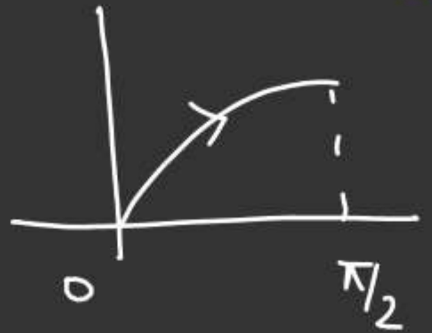
$$2x = k\frac{dy}{dx}$$

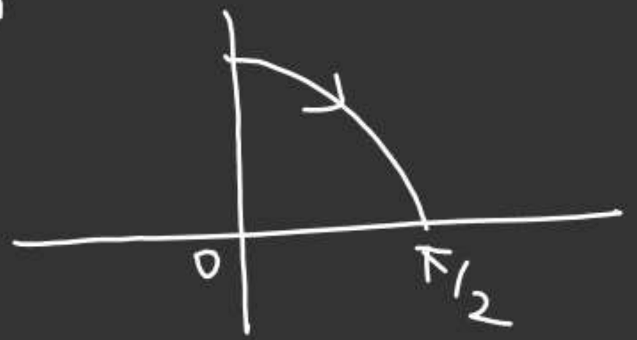
$$\frac{dy}{dx} = \left(\frac{2}{k}x\right)$$

$$\left(\frac{dy}{dx}\right)_{x=x_1} = \left(\frac{2}{k}x_1\right) = \frac{2}{k}\sqrt{kh} = \left(2\sqrt{\frac{h}{k}}\right)$$

$$x_1^2 = kh$$

$$x_1 = \sqrt{kh}$$





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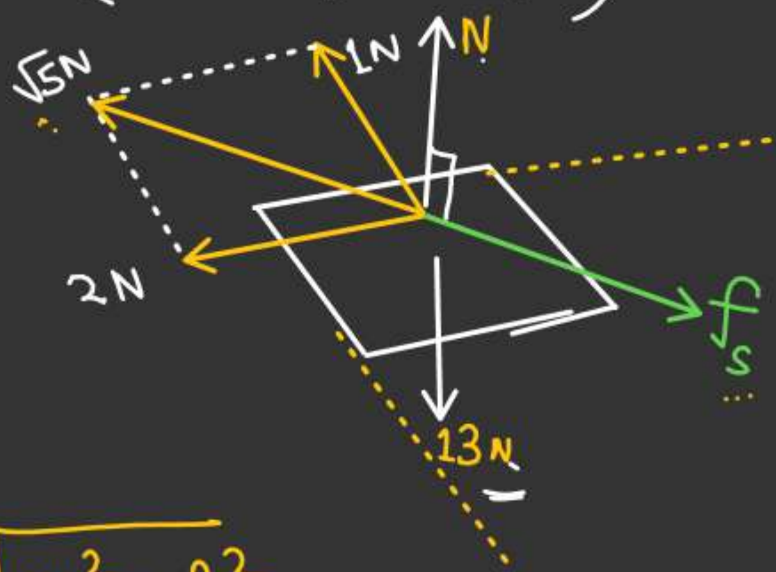
#. Velocity of board is

$\vec{v} = (2t\hat{i} + t\hat{j} + 3t\hat{k})$

Block doesn't slip with board.

Find force acting on the board due to block.

$\vec{a} = \frac{d\vec{v}}{dt} = (2\hat{i} + \hat{j} + 3\hat{k})$



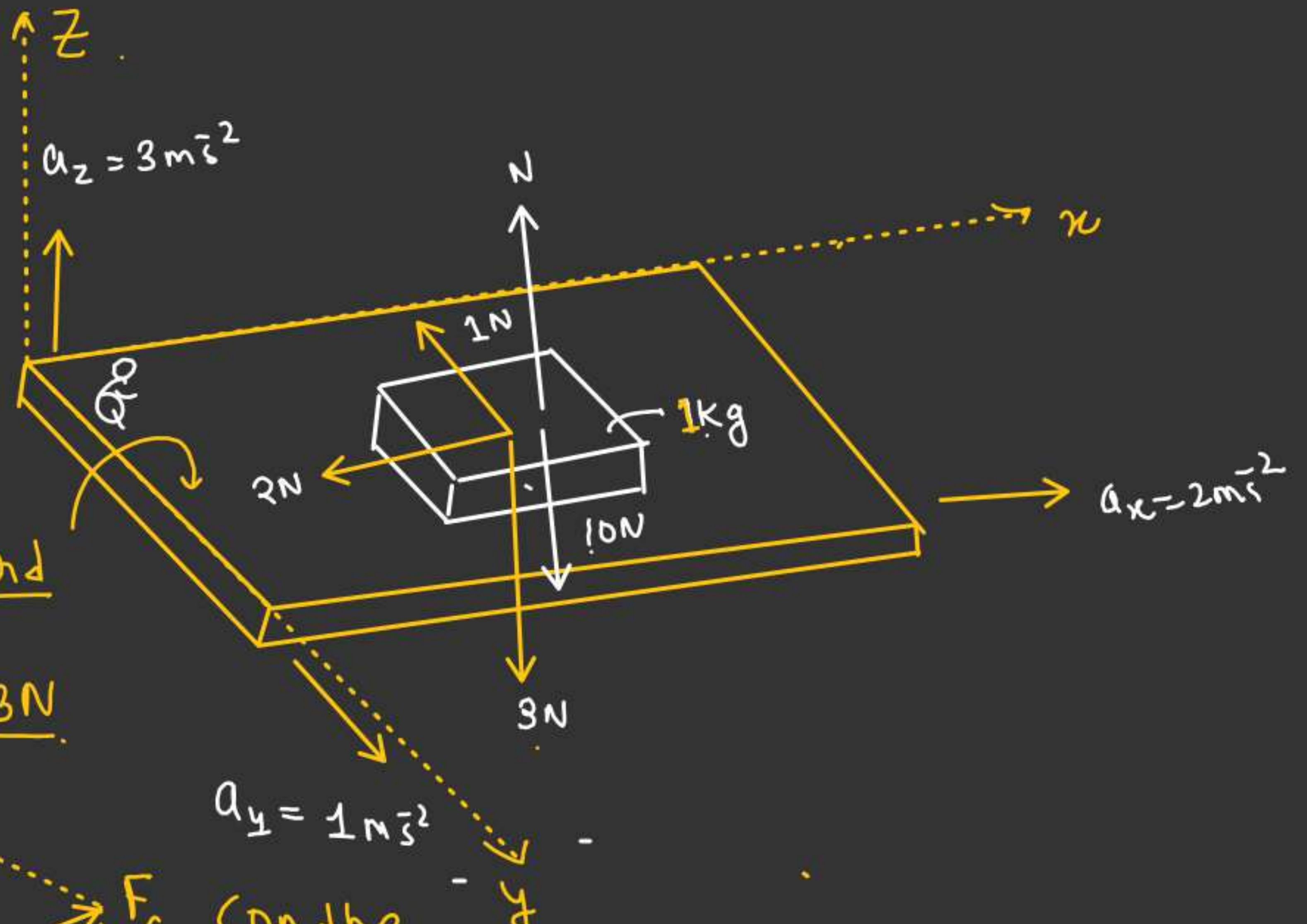
$f_s = \sqrt{5}$ N

$N = 13$N.

$F_c = \sqrt{N^2 + f_s^2}$

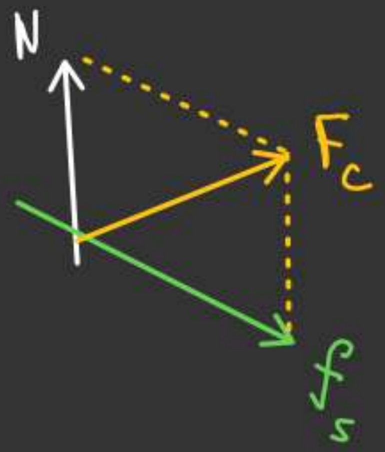
$= \sqrt{169+5}$

$= \sqrt{174}$ N



Board

N = 13N



F_c (on the block by board)

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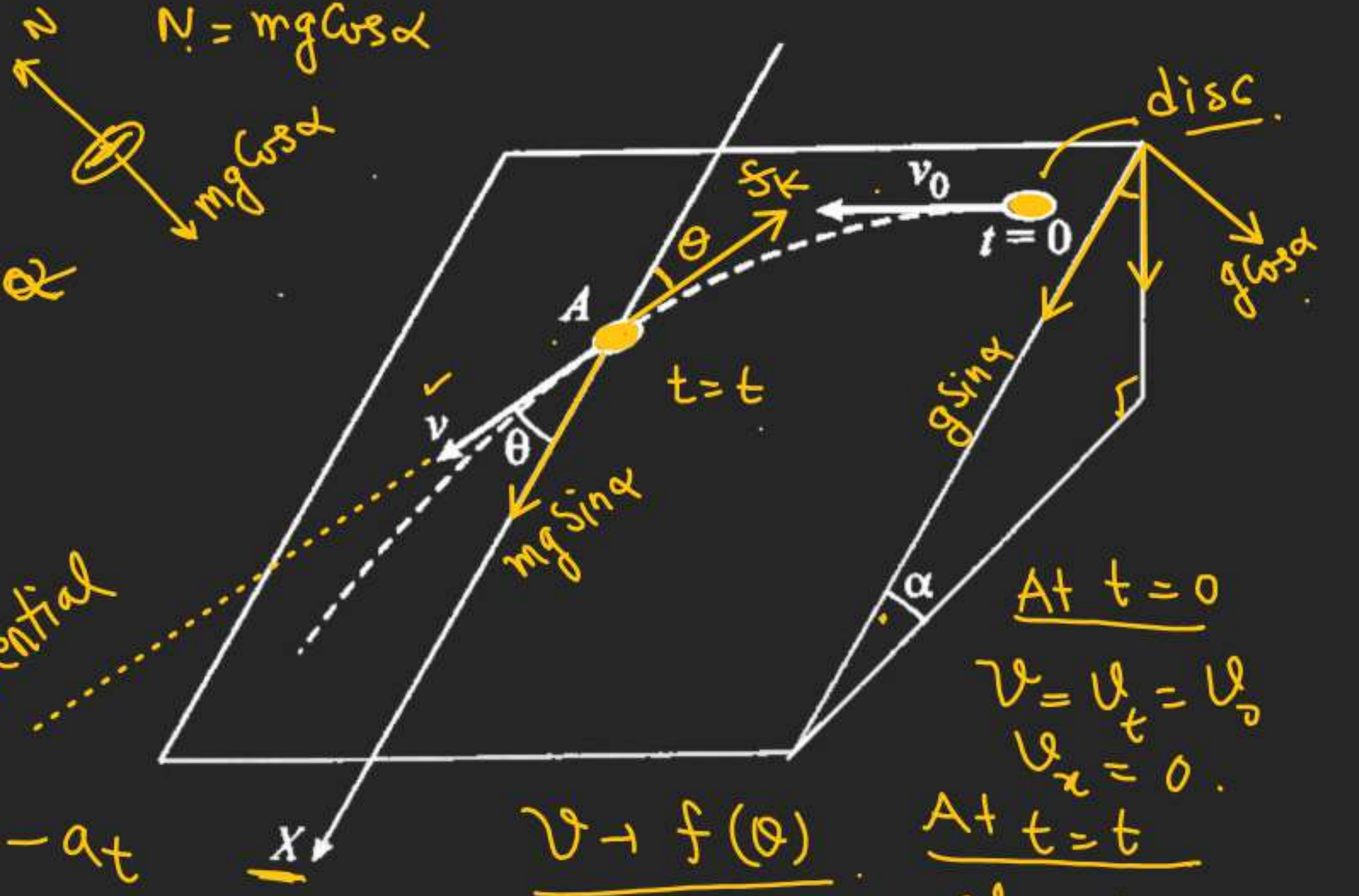
FRICTION

H-W

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 $\boxed{\mu = \tan\alpha}$ and at the initial moment $\theta = \pi/2$.



Along x-axis net force

$mg\sin\alpha - f_K\cos\theta = ma_x$

$mg\sin\alpha - mg\sin\alpha\cos\theta = ma_x$

$a_x = g\sin\alpha(1-\cos\theta)$ — (1)

$f_K = \mu N$
$= \tan\alpha \, mg\cos\alpha$
$= mg\sin\alpha$

Along tangential direction

$mg\sin\alpha\cos\theta - f_K = ma_t$

$mg\sin\alpha\cdot\cos\theta - mg\sin\alpha = ma_t$

$a_t = g\sin\alpha(\cos\theta - 1)$ — (2)

$\underline{a_x = -a_t}$

$\underline{v \to f(\theta)}$

At $t=0$

$v = v_t = v_0$

$v_x = 0$

At $t=t$

$v_t = v$

$v_x = v\cos\theta$

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$$a_x = -a_t$$

$$\Downarrow$$

$$\frac{dv_x}{dt} = -\frac{dv_t}{dt}$$

$$\int_0^{v\cos\theta} dv_x = -\int_{v_0}^{v} dv_t$$

$$v\cos\theta = -(v - v_0)$$

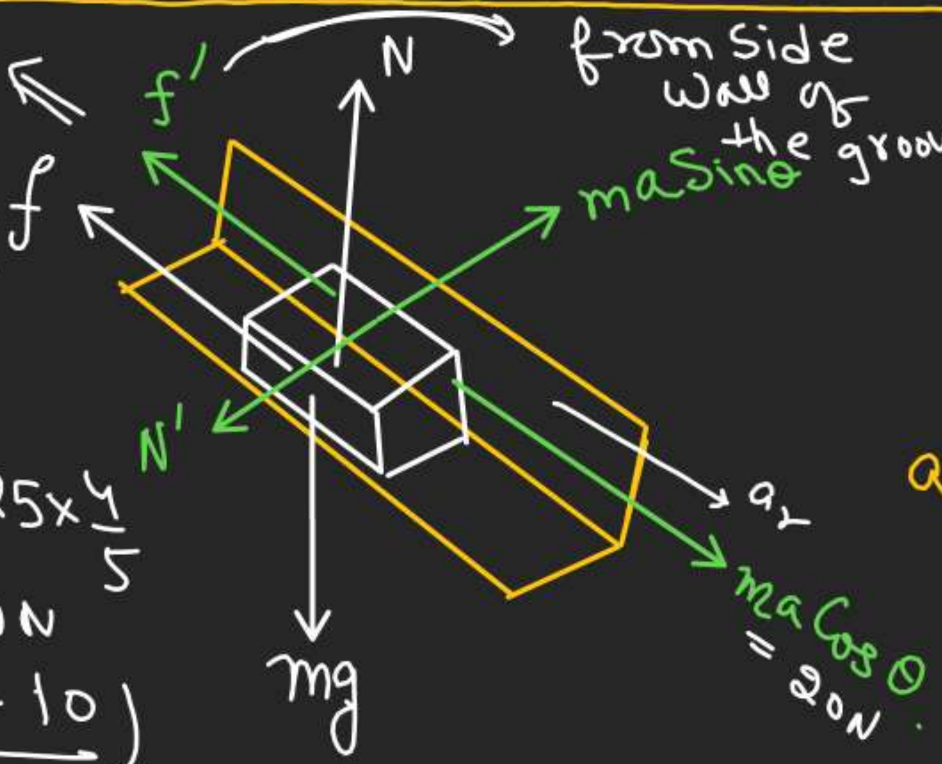
$$v(1+\cos\theta) = v_0$$

$$v = \left(\frac{v_0}{1+\cos\theta}\right) \checkmark$$

FRICTION

H.W

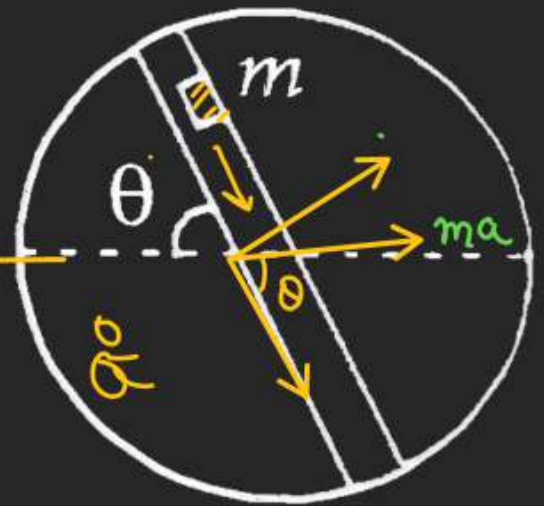
Q.5 A circular disc with a groove along its diameter is placed horizontally on a rough surface. A block of mass $1\,\text{kg}$ is placed as shown in the figure. The coefficient of friction between the block and all surfaces of groove and horizontal surface in contact is $2/5$. The disc has an acceleration 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)**



from Side wall of the groove

Perpendicular to disc & inward → ⊗ g.

from bottom of the groove



$a = 25\,ms^{-2}$

$f = \frac{2}{5} mg$

$f = \frac{2}{5} \times 1 \times 10)$

$= 4\,N$

$f' = \mu ma\sin\theta$

$= \frac{2}{5} \times 1 \times 25 \times \frac{3}{5}$

$= 6\,N$

$ma\cos\theta = 1 \times 25 \times \frac{4}{5}$

$= 20\,N$

$a_r = \left(\frac{20 - 10}{1}\right)$

$a_r = 10\,ms^{-2}$ ✓