

FRICTION

Case of push

$$N = (Mg + F \sin \theta)$$

For block to move

$$F \cos \theta \geq (f_s)_{\max}$$

$$F \cos \theta \geq \mu N$$

$$F \cos \theta \geq \mu (Mg + F \sin \theta)$$

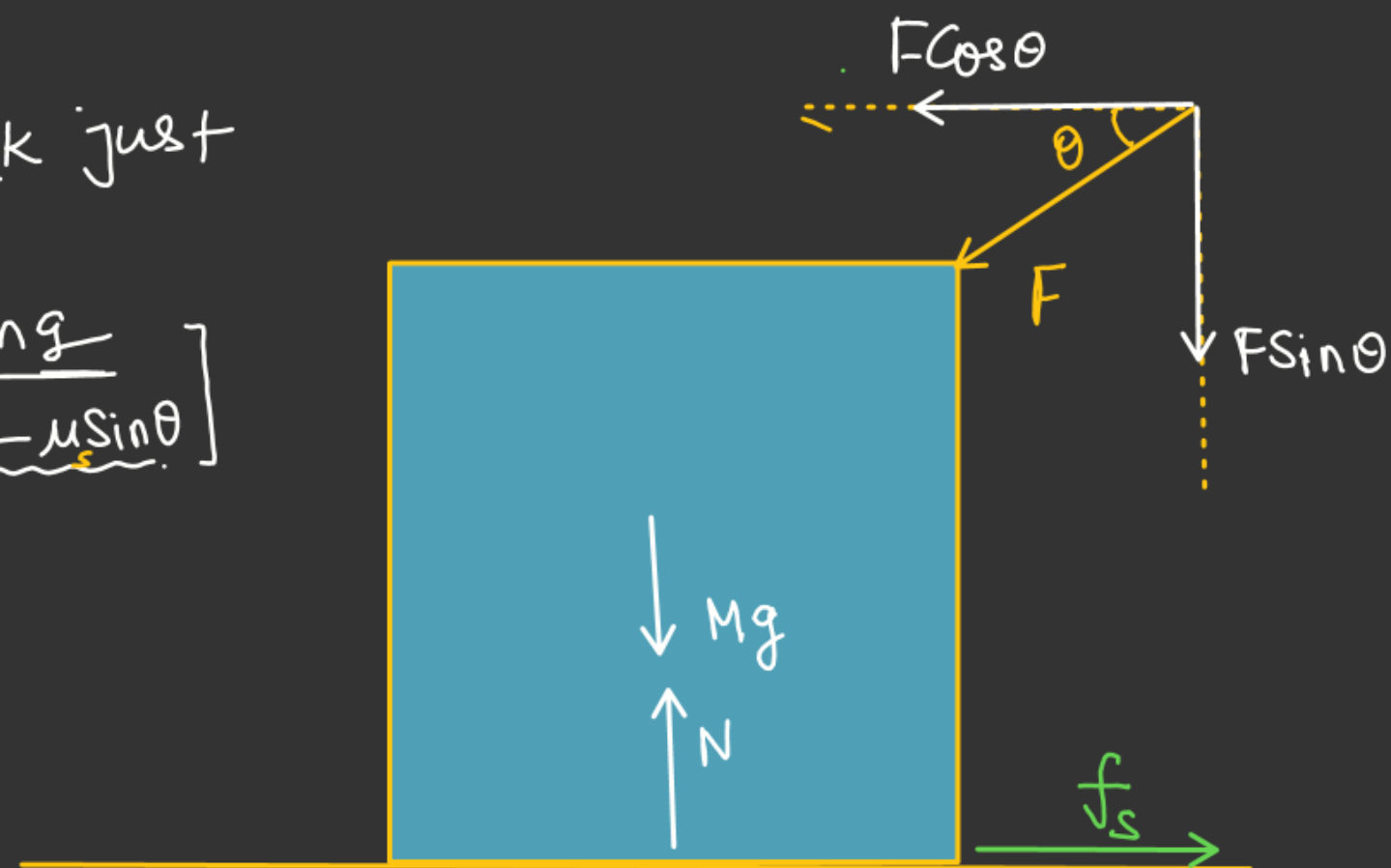
$$F (\cos \theta - \mu \sin \theta) \geq \mu mg$$

$$F \geq \left(\frac{\mu mg}{\cos \theta - \mu \sin \theta} \right)$$

For block just to move

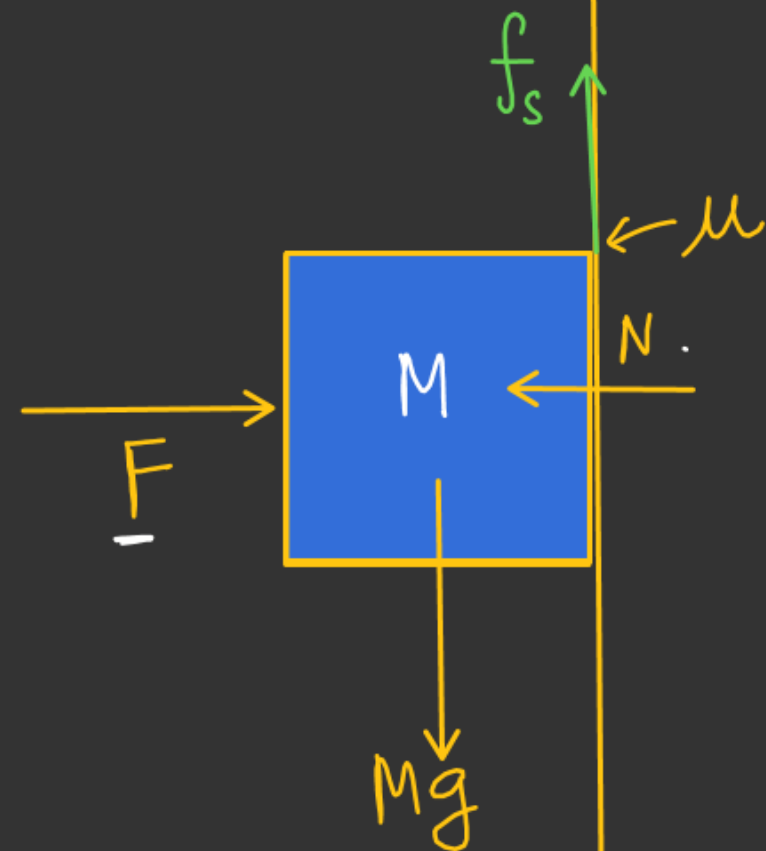
$$F = \left[\frac{\mu mg}{\cos \theta - \mu \sin \theta} \right]$$

$$F_{\min} = \frac{\mu mg}{\sqrt{1 + \mu_s^2}}$$



μ_s

→ Rough vertical wall.

 F_{\min} for block not to slide

For block not to slip.

$$f_s = Mg$$

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

$$Mg \leq \mu N$$

$$Mg \leq \mu F$$

$$F \geq \frac{Mg}{\mu}$$

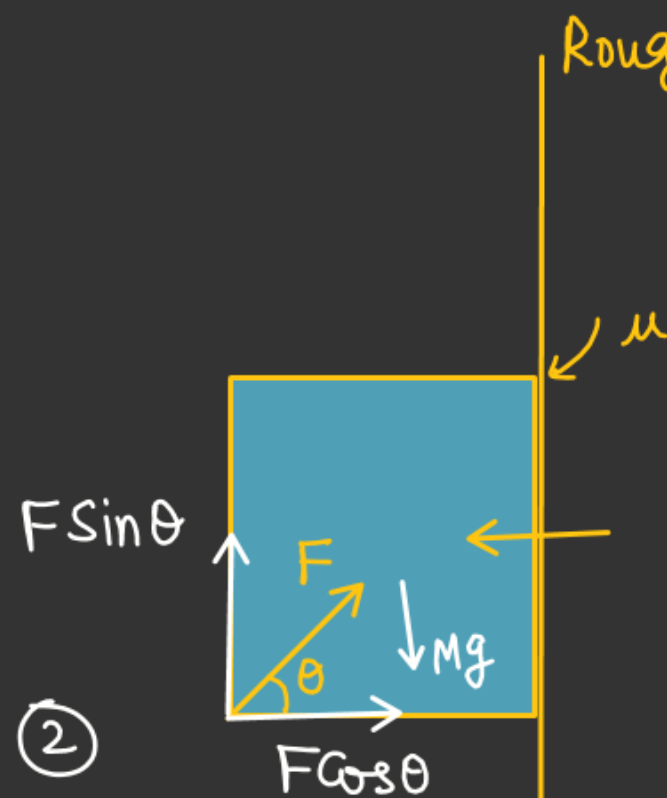
For horizontal
Equilibrium
[$N = F$]

$$0 \leq f_s \leq (f_s)_{\max}$$

For F_{\min}

$$F_{\min} = \frac{Mg}{\mu} \text{ Ans.}$$

(*) Range of F for block not to Slip →



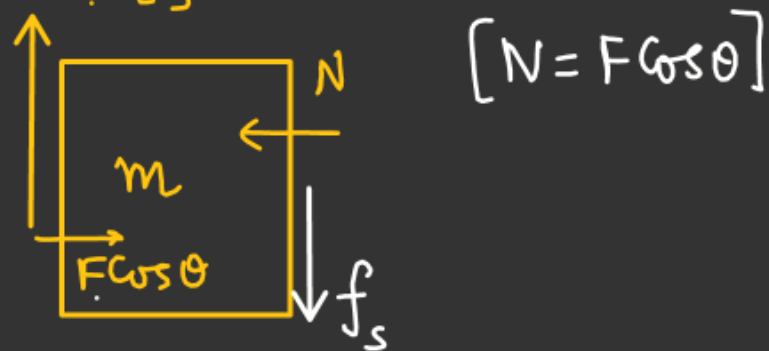
From ① & ②

$$\left(\frac{Mg}{\sin\theta + \mu\cos\theta} \right) \leq F \leq \left(\frac{Mg}{\sin\theta - \mu\cos\theta} \right)$$

$$\begin{cases} F_{\max} = \left(\frac{Mg}{\sin\theta - \mu\cos\theta} \right) \\ F_{\min} = \left(\frac{Mg}{\sin\theta + \mu\cos\theta} \right) \end{cases}$$

Rough vertical wall.

Case-1: → $F\sin\theta > Mg$
 $[F\sin\theta - Mg]$



$$[N = F\cos\theta]$$

For block not to slip

$$F\sin\theta - Mg = f_s$$

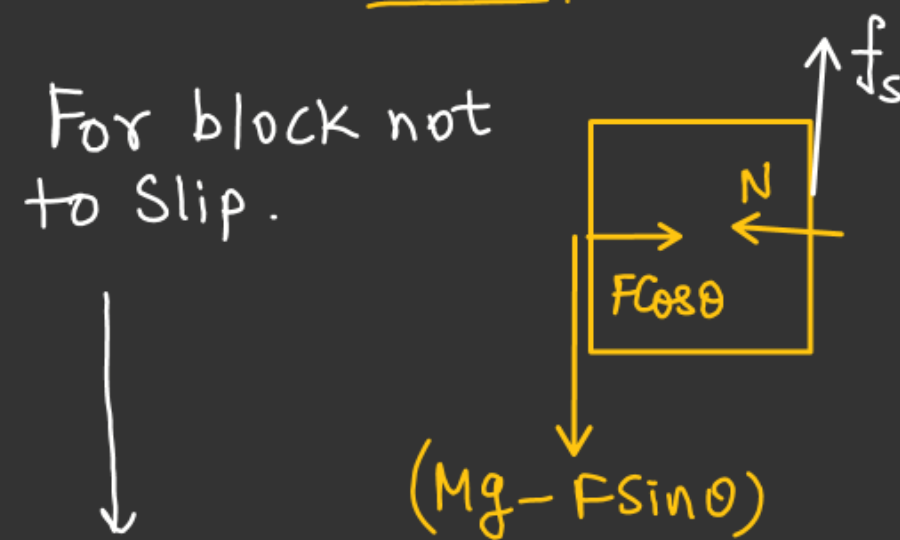
$$f_s \leq \mu N$$

$$F\sin\theta - Mg \leq \mu(F\cos\theta)$$

$$F(\sin\theta - \mu\cos\theta) \leq Mg$$

$$F \leq \left[\frac{Mg}{\sin\theta - \mu\cos\theta} \right] \text{ --- ①}$$

Case-2. $F\sin\theta < Mg$.



For block not to slip.

$$Mg - F\sin\theta = f_s$$

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

$$f_s \leq \mu F\cos\theta$$

$$Mg - F\sin\theta \leq \mu F\cos\theta$$

$$Mg \leq F(\sin\theta + \mu\cos\theta)$$

$$F \geq \left[\frac{Mg}{\sin\theta + \mu\cos\theta} \right] \text{ --- ②}$$

Find F So that there is no relative slipping b/w bigger block and smaller block

Solⁿ $F = (M+m)a$

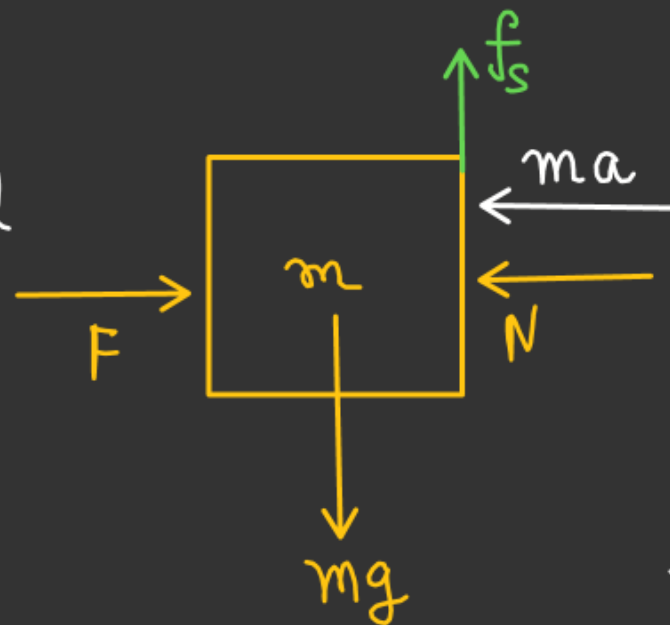
$$a = \left(\frac{F}{M+m} \right) \checkmark$$

F.B.D of smaller block w.r.t bigger block

In horizontal direction

$$F = N + ma$$

$$N = (F - ma)$$



$$f_s = mg \text{ [Block not to slip]}$$

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

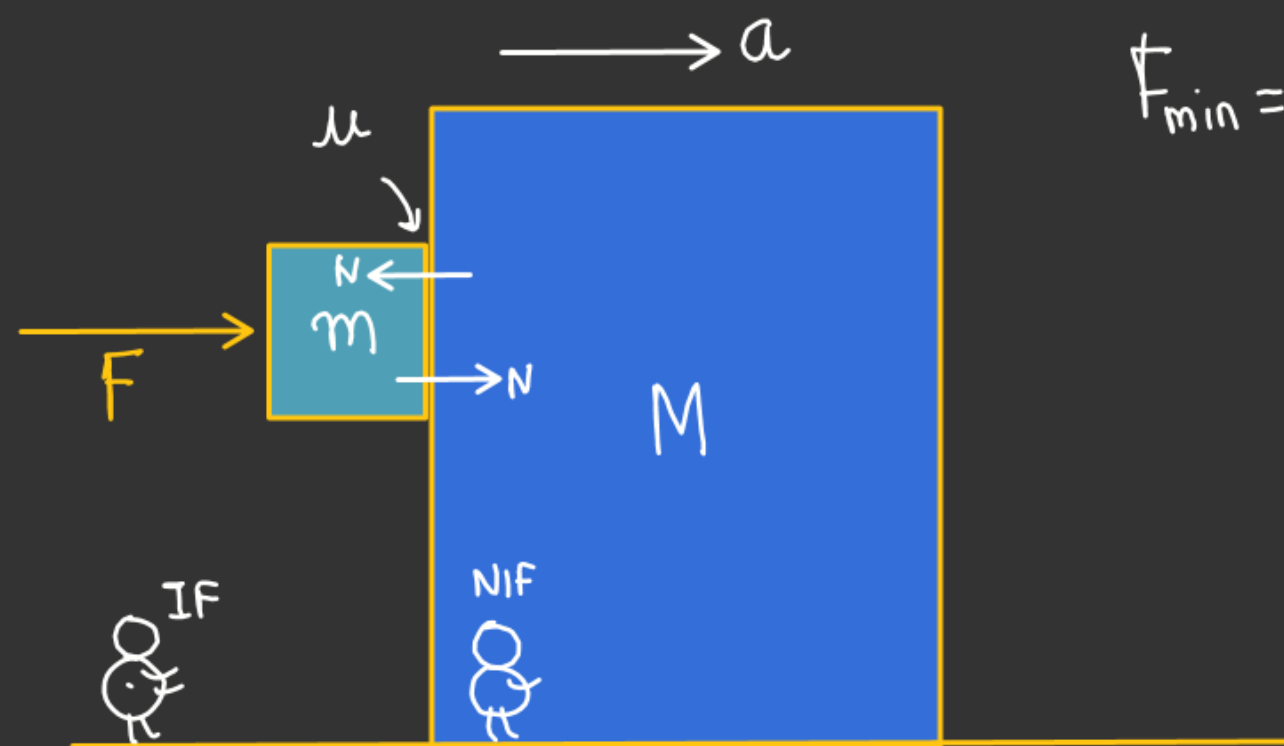
$$mg \leq \mu N$$

$$mg \leq \mu (F - ma)$$

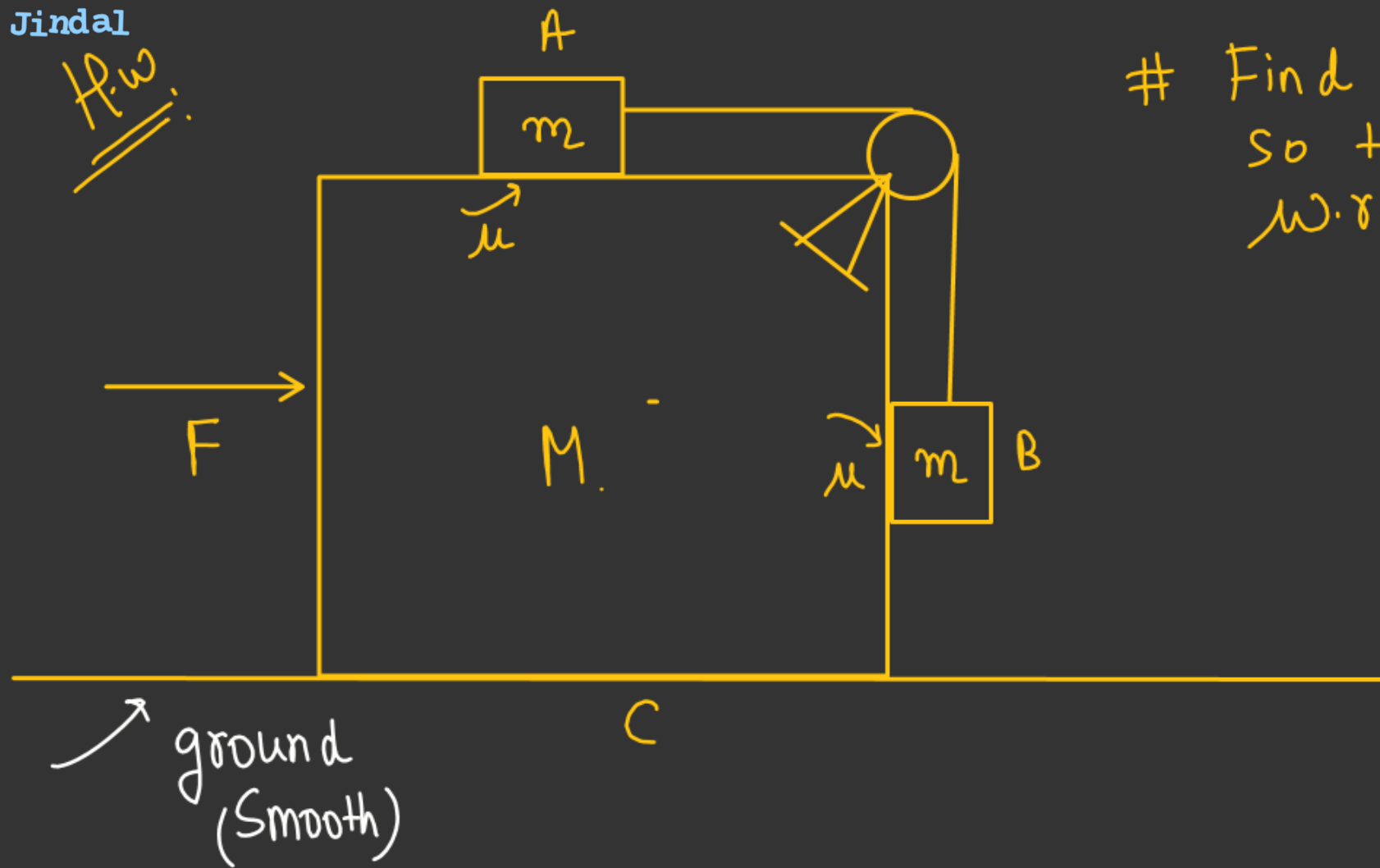
$$mg \leq \mu \left[F - \frac{mF}{M+m} \right]$$

$$mg \leq \frac{\mu MF}{(M+m)} \Rightarrow F \geq \frac{(M+m)gm}{\mu M}$$

$$F \geq \frac{mg}{\mu} \left(1 + \frac{m}{M} \right)$$



$$F_{\min} = \frac{mg}{\mu} \left(1 + \frac{m}{M} \right)$$

H.W.

Find min & max. Value of F
So that block A and B doesn't slip
w.r.t block C

FRICTION ON AN INCLINED PLANE

$$[0 < \theta < \pi/2]$$

For block not to slip.

$$N = mg \cos \theta$$

$$mg \sin \theta = f_s$$

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

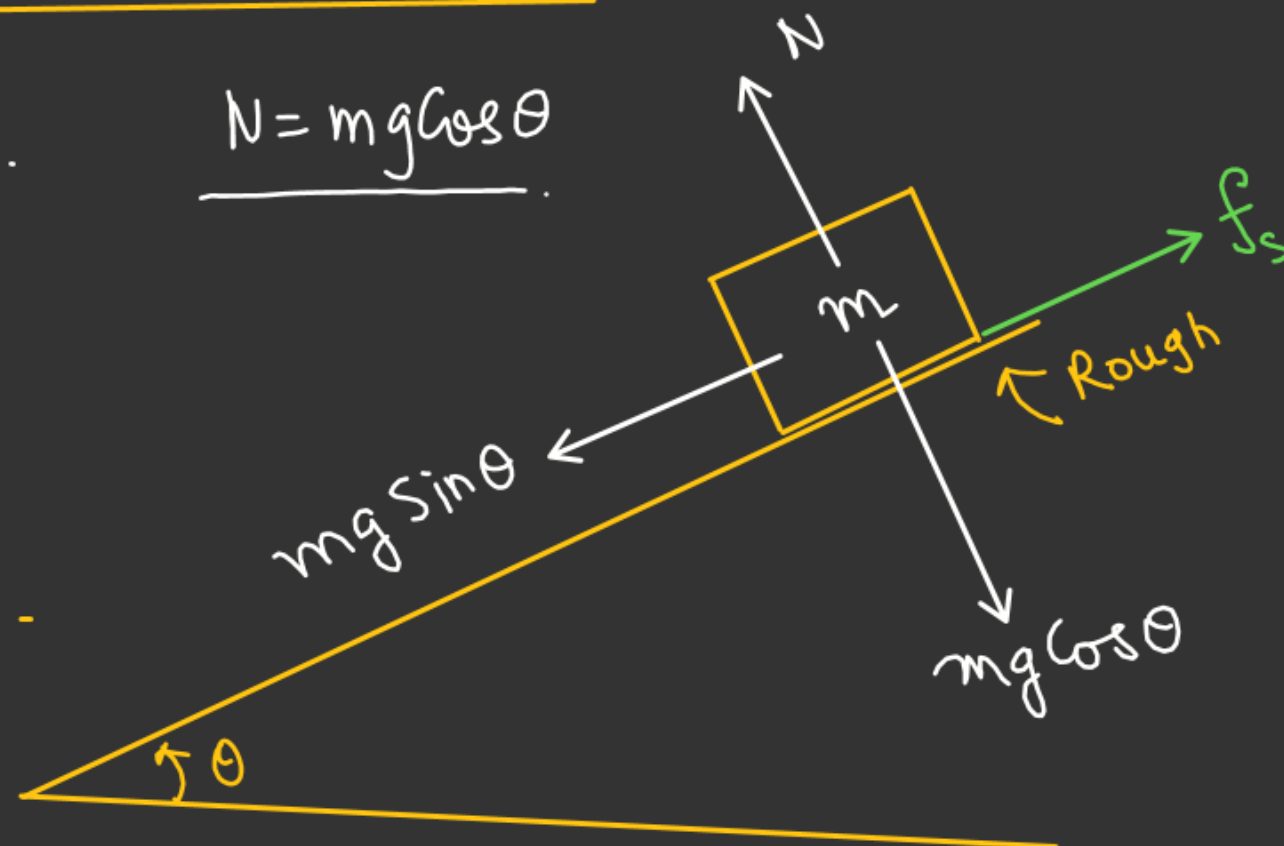
$$mg \sin \theta \leq \mu N$$

$$mg \sin \theta \leq \mu mg \cos \theta$$

$$\tan \theta \leq \mu$$

$$\theta \leq \tan^{-1}(\mu)$$

Angle of Repose: \rightarrow
Min. angle of inclination at which block is about to slip.

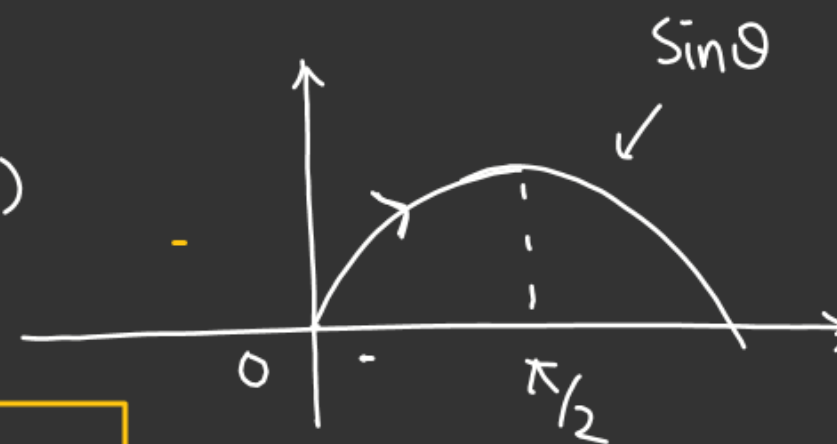


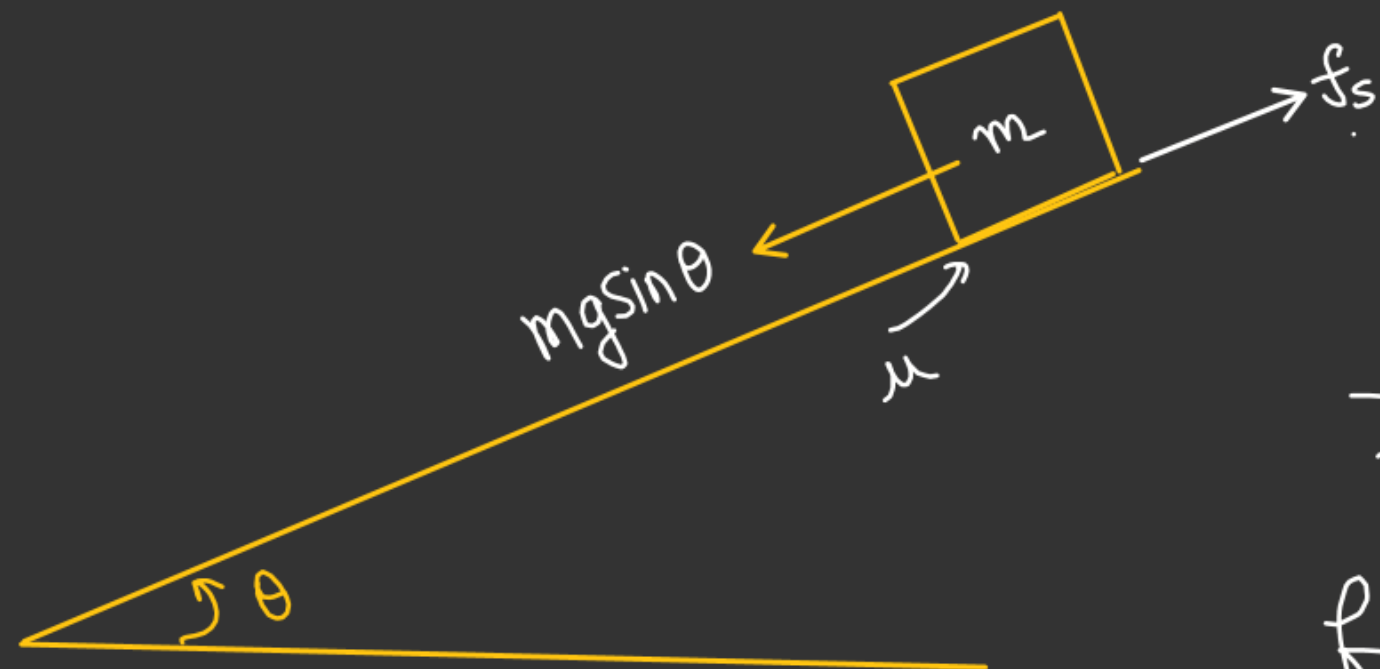
Not to slip
 $\theta_{\max} = \tan^{-1}(\mu)$

For block just to slip.

$$\theta_{\min} = \tan^{-1}(\mu)$$

Angle of Repose





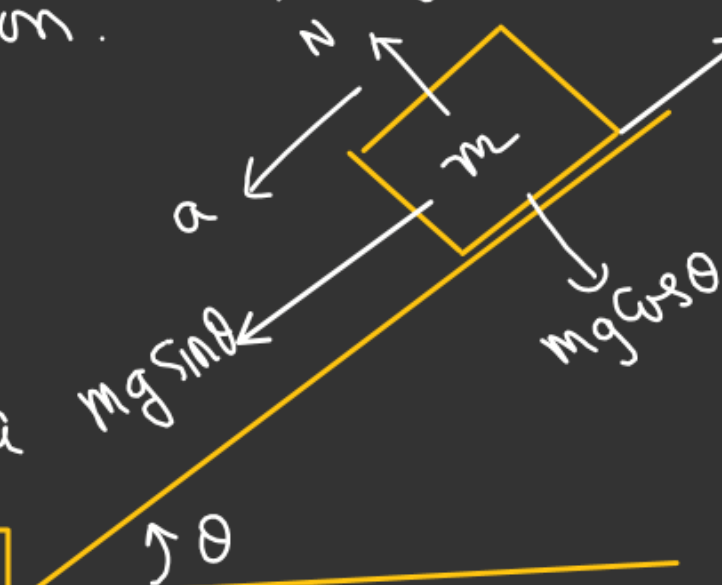
If $mg \sin \theta < (f_s)_{\max}$
 $\Rightarrow [f_s = mg \sin \theta]$

If $mg \sin \theta > (f_s)_{\max}$
 Relative slipping started & kinetic friction.

$$mg \sin \theta - f_k = ma$$

$$mg \sin \theta - \mu_k mg \cos \theta = ma$$

$$a = g (\sin \theta - \mu_k \cos \theta)$$



$$f_k = \mu_k mg \cos \theta$$

