JEE MAIN | IIT JEE

Friction

REVISION in 30 Min

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EDUNITI

Topics to covered

1. Variation of Friction with External Force
2. Direction of Friction (*learn through FBD*)
3. Pushing vs Pulling
4. Minimum force to start slipping
5. Contact Force
6. Angle of Repose
7. Two Block System
8. Friction on Chain

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Chapter	Formulae_Concept VIDEO LINK
Unit & Dimensions	https://youtu.be/wdd-wlZF4Hk
Errors and Vectors	
Vernier Calliper	https://youtu.be/pVoN045dV8I
Screw Gauge	https://youtu.be/gYd2PtmZ0mw
Kinematics_Motion in 1d	https://youtu.be/U4NNxFaFliE
Kinematics_Motion in 2d	https://youtu.be/4_Zo5WhMf7w
Laws of Motion	https://youtu.be/7JlR8gNRQIs
Friction	
Work Energy Power	https://youtu.be/kjrXoE-kDI8
Centre of Mass	
Centre of Mass of Standard Bodies	https://youtu.be/oCeACfryB-U
Collision	
Rotational Motion_Moment of Inertia	https://youtu.be/9ckZdOhy3z0
Gravitation	https://youtu.be/rAj2huLVaEk
Properties of Solids	https://youtu.be/gSXxjk89I_c
Fluids Statics (Part 1)	https://youtu.be/RFKx9B9yo3M
Fluid Dynamics (Part 2)	https://youtu.be/Y717vQpUEJQ
Fluid Properties (Part 3)	https://youtu.be/V8xUWWK2oT0
Simple Harmonic Motion	https://youtu.be/RIb7ofNG09I
Thermal Properties	
KTG	https://youtu.be/XO1tvFhIa0I
Thermodynamics	https://youtu.be/iz_kf1jRDRw
Wave Motion -Organ Pipes and Resonance Tube	https://youtu.be/fB7pfJ77za8
Wave Motion - Doppler's Effect	https://youtu.be/9-BxOaamnwg
Electrostatics	https://youtu.be/3stXbGRMcrk
Capacitors	https://youtu.be/EXEiickNUkY
Current Electricity	https://youtu.be/gm8FUfjrX18
Moving Charges and Magnetic Effect of Current	https://youtu.be/ULD2Ok1CGJk
Earth's Magnetism	https://youtu.be/a4CT5uVwAK4
Magnetic Properties	https://youtu.be/63cwdYXNlYE
EMI	https://youtu.be/puVavm_GFRM
Alternating Current	https://youtu.be/74dTY-pzM_o
Ray Optics	https://youtu.be/BhnyTWzIlBA
Wave Optics Part 1_Interference	https://youtu.be/LG5nlE8XTeI
Wave Optics Part 2_Diffraction_Polarization	https://youtu.be/ymMyyJGGqnY
Optical Instruments	https://youtu.be/OQssbDH0A4I
Electromagnetic Waves	https://youtu.be/bcVXgEkyQZY
Semiconductors_Basics + Zener Diode	https://youtu.be/_A2JomQ7-50
Semiconductors_Transistors	https://youtu.be/psDwl84Nzb0
Semiconductors_Logic Gates	https://youtu.be/pZdQAzLbFTo
Communication Systems	https://youtu.be/8NgMqK9X79Y
Modern Physics_Part 1_Atomic Physics	https://youtu.be/9VKUnE3mpHk
Modern Physics_Part 2_Photoelectric Effect	https://youtu.be/24oTQp84jrk
Modern Physics_Part 3_Dual Nature of Light	https://youtu.be/0zoR_saMAQY
Modern Physics_Part 4_Radioactivity	https://youtu.be/AdX3YBhQyog
Modern Physics_Part 5_Nuclear Physics	https://youtu.be/VDWqVahGixc
Modern Physics_Part 6_X Rays	https://youtu.be/dSHXdzX7NX0

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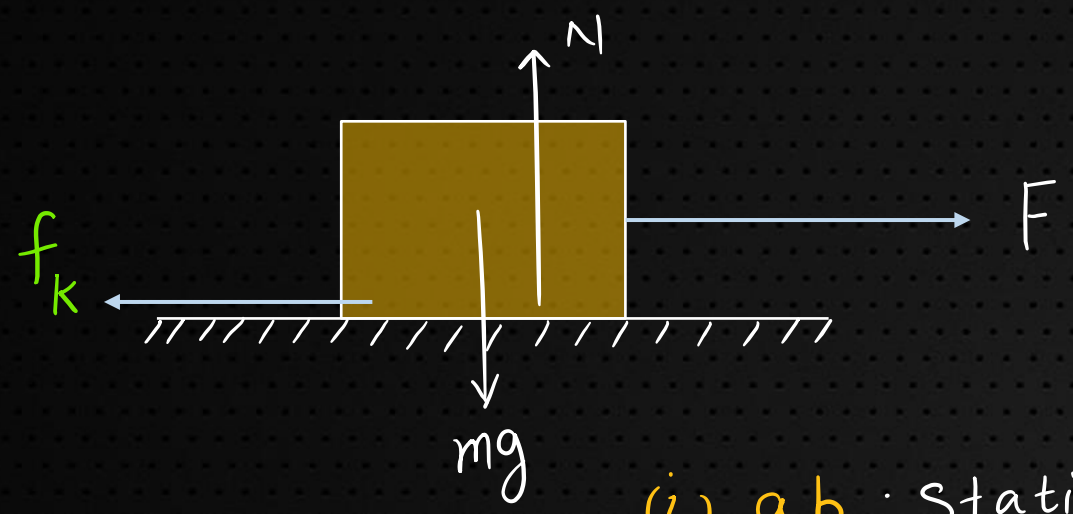
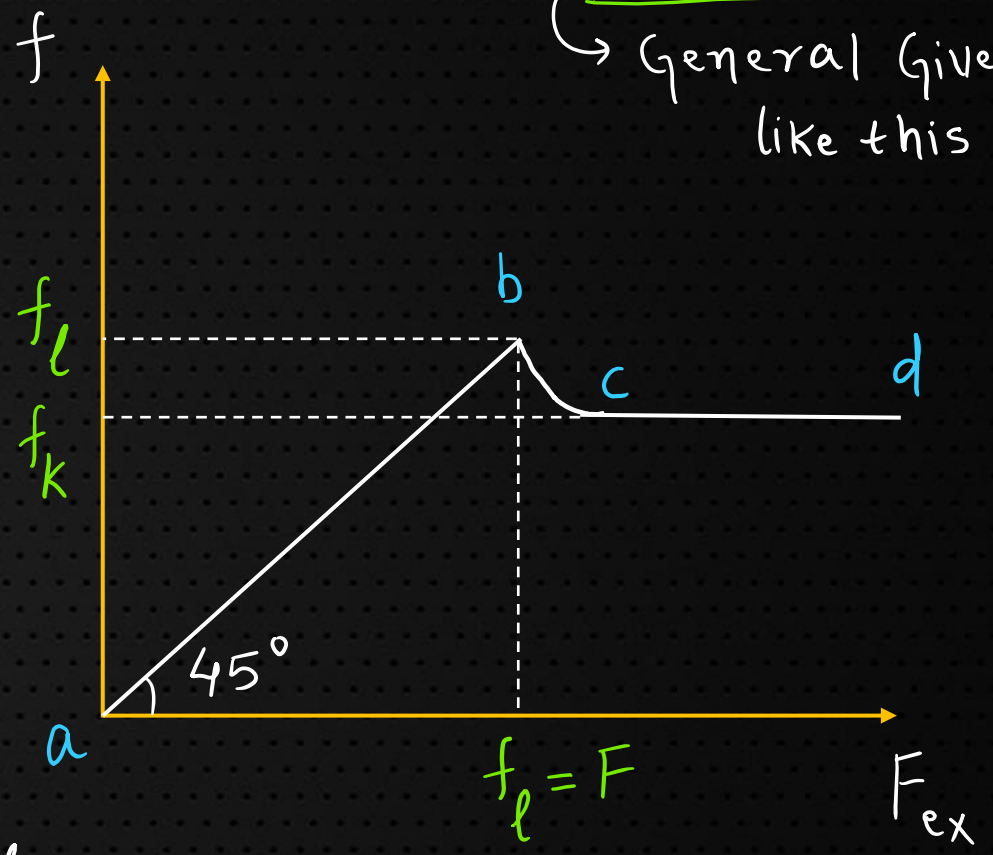
1. Variation of Friction with External Force

$\boxed{\mu_s = \mu_k = \mu}$

General Given like this





(i) ab : Static friction (block is at rest w.r.t ground)

(ii) At b : f_{smax} or f_ℓ

(iii) cd : Kinetic friction ($f_k < f_{smax}$)

(iv) $f_{smax} = \mu_s N$, $f_k = \mu_k N$

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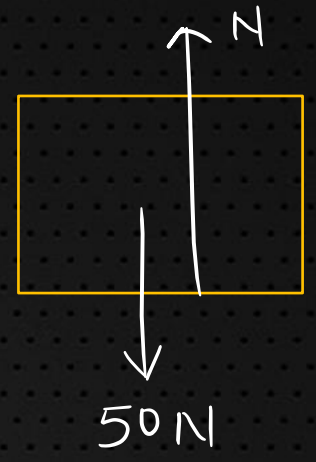
Ex.

(i) $F = 8\,N$

(ii) $F = 20\,N$

comment on a in both cases.

Sol^n:



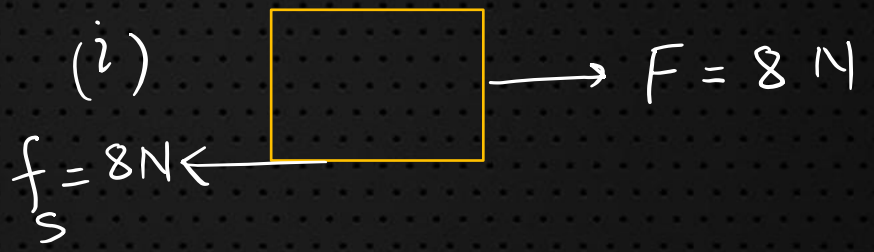
$N = 50\,N$

$f_{max} = \mu N$

$= 0.2 \times 50$

$= 10\,N$

(i)



$\boxed{a = 0}$

(ii)

$a = \frac{20 - 10}{5}$

$= \boxed{2\,m/s^2}$

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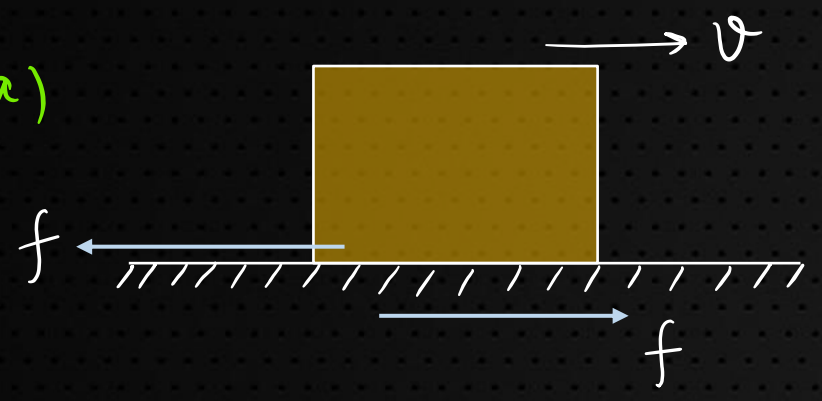
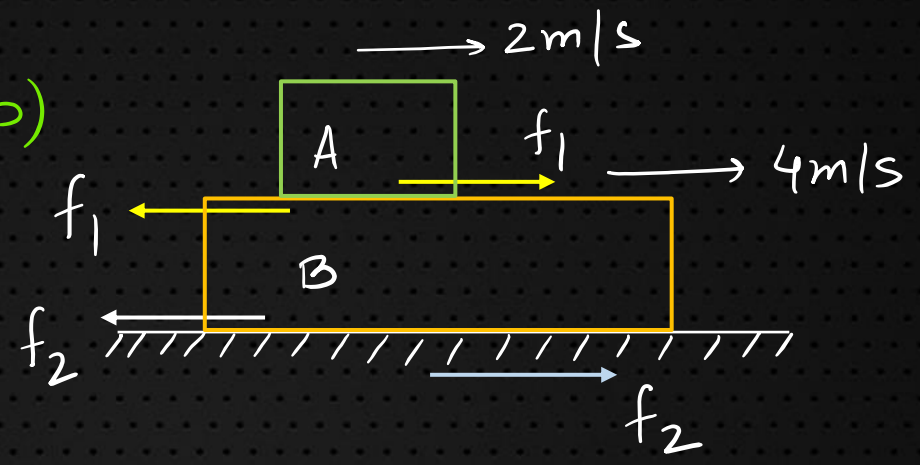
2. Direction of friction

↳ friction opposes the relative motion between two bodies

(a)

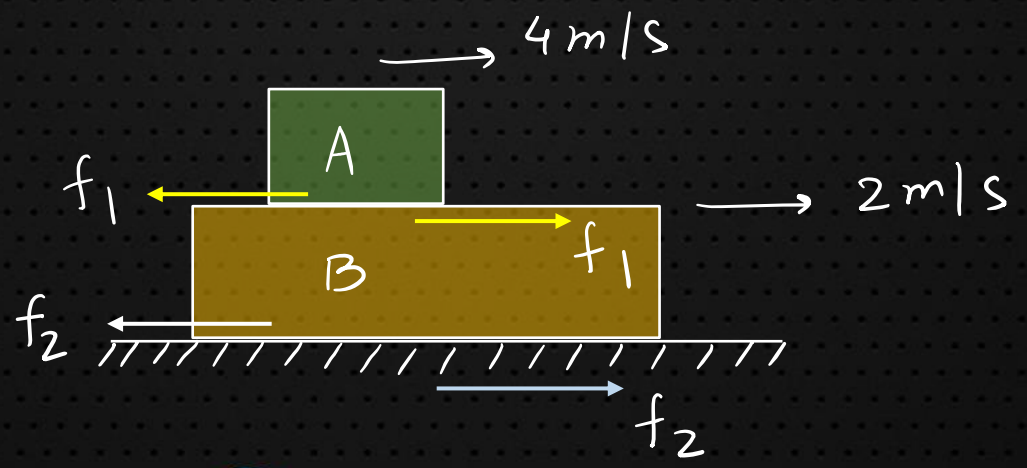


(b)



$V_{A/B} = 2-4$
$= -2$

(c)



$V_{A/B} = 4-2$
$= 2$

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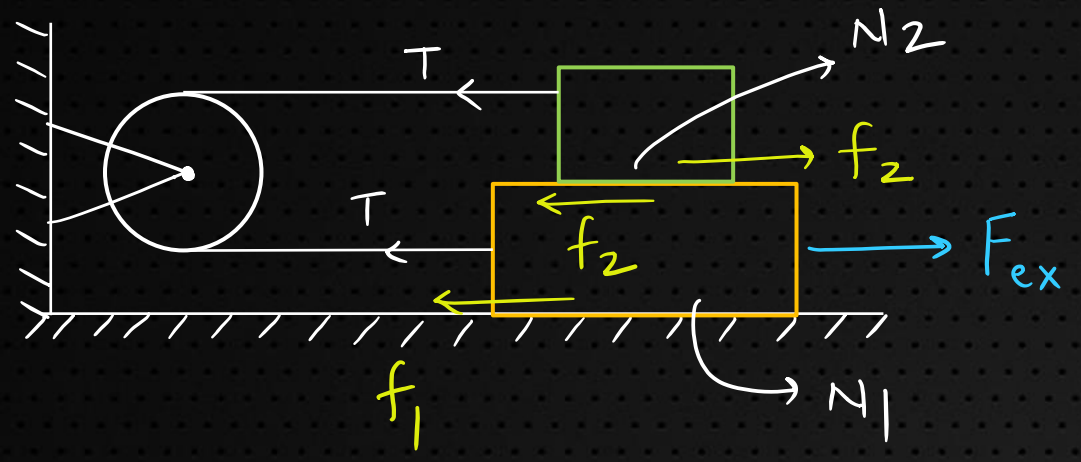
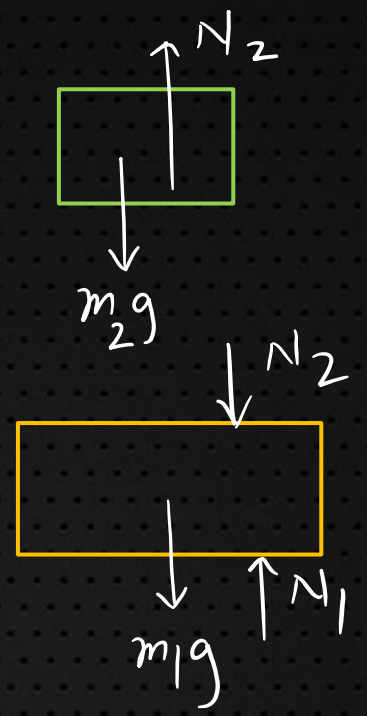
(d)





$$N_2 = m_2 g$$

$$N_1 = m_1 g + N_2$$
$$= m_1 g + m_2 g$$
$$= (m_1 + m_2) g$$

Assuming slipping at all places:

$$f_1 = \mu_1 N_1 \quad , \quad f_2 = \mu_2 N_2$$

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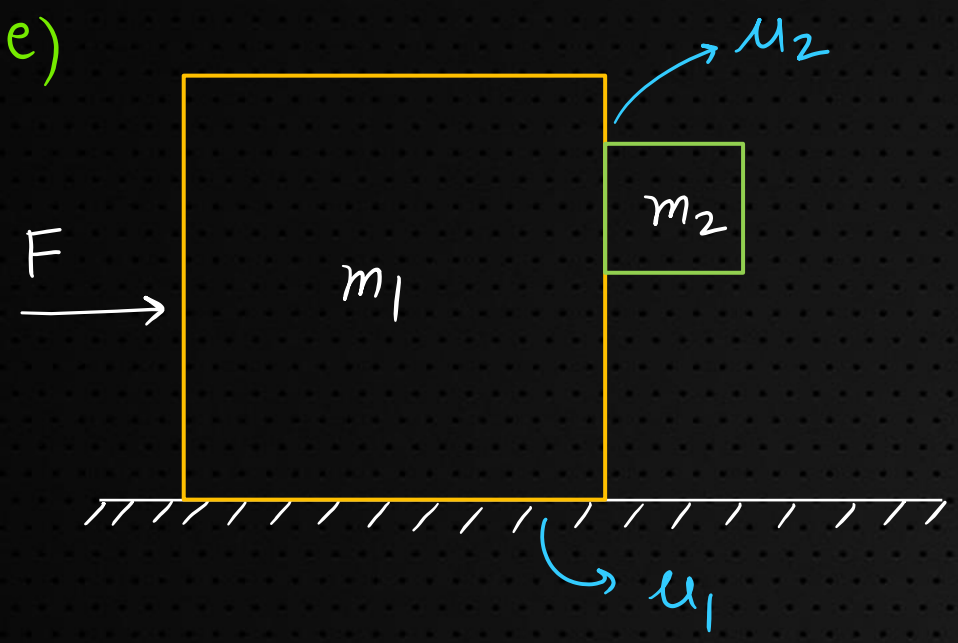
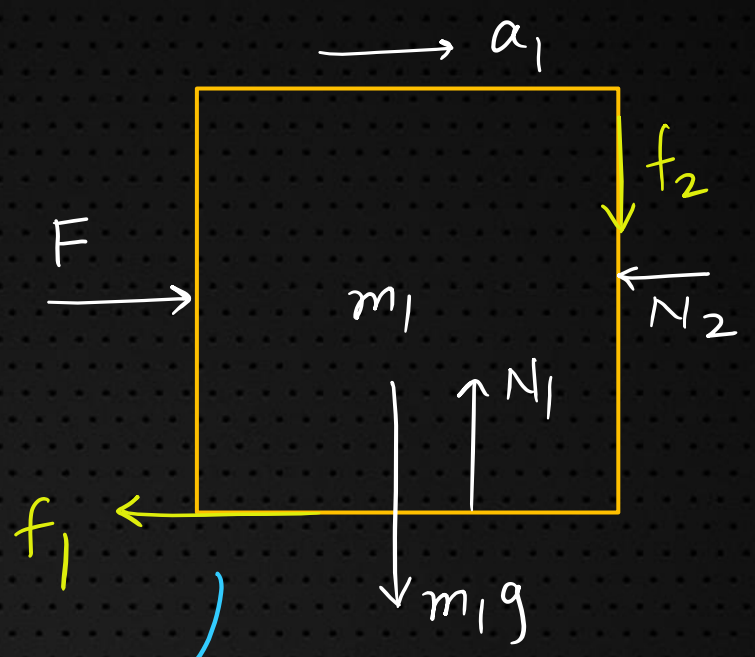
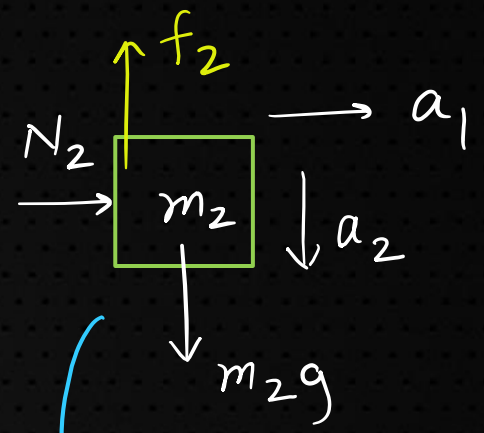
... Continued

(e)







$$F - N_2 - f_1 = m_1 a_1 \quad \text{—(i)}$$

$$f_1 = \mu_1 N_1 \quad \text{—(ii)}$$

$$N_1 = m_1 g + f_2 \quad \text{—(iii)}$$

slipping

$$\Rightarrow f_2 = \mu_2 N_2$$

where, $N_2 = m_2 a$

$$m_2 g - f_2 = m_2 a_2$$

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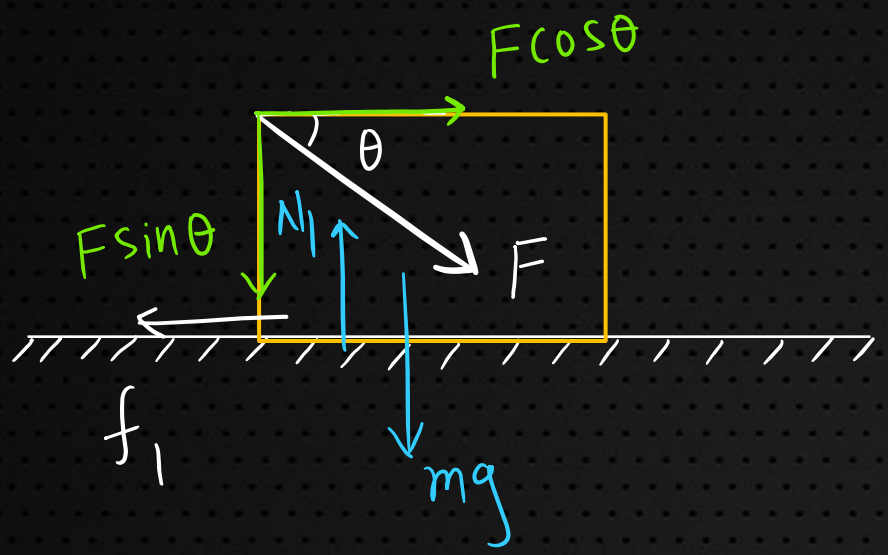
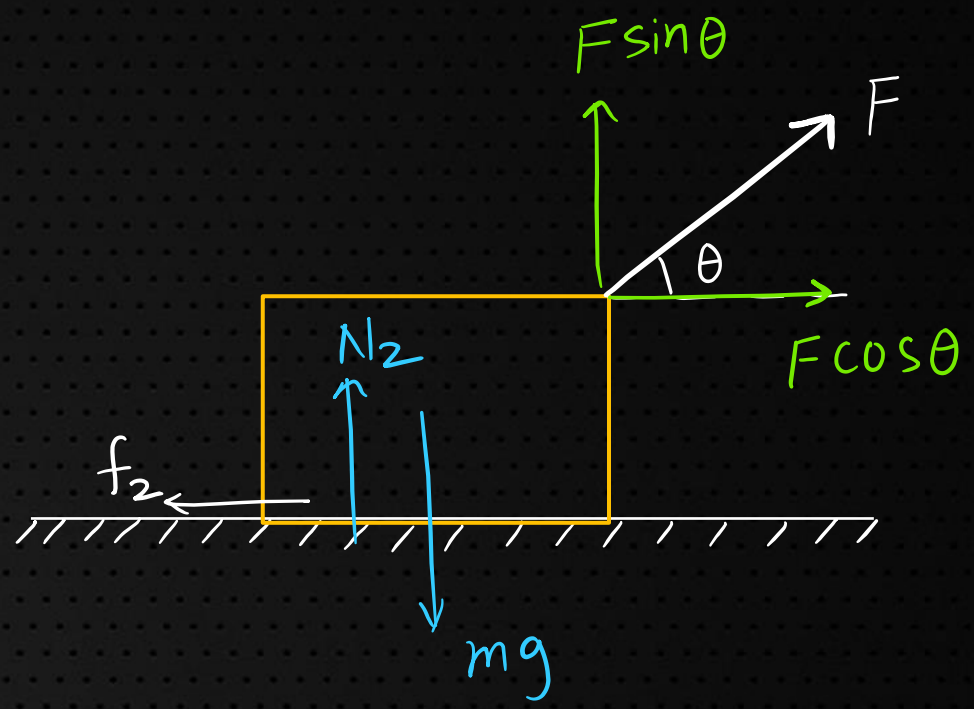
3. Pushing vs Pulling





$$N_1 = mg + F\sin\theta$$

$$N_2 = mg - F\sin\theta$$

To slide, friction to over come

$$f_1 = \mu N_1$$

$$f_2 = \mu N_2$$

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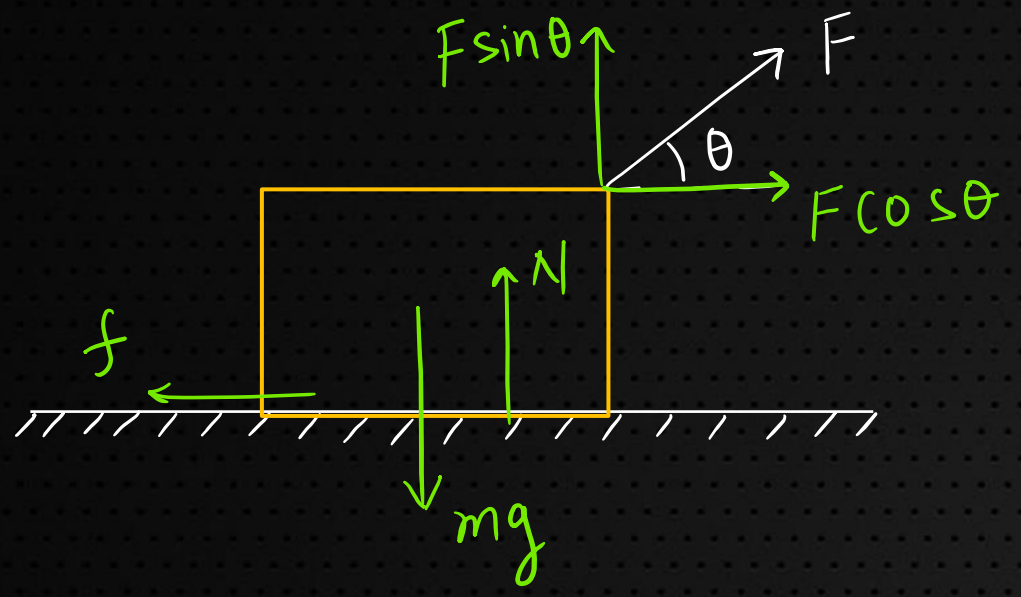
4. Minimum Force to Start slipping (cond^n on θ)



To just start slipping:

$$F\cos\theta = f = \mu N$$

$$\Rightarrow F\cos\theta = \mu(mg - F\sin\theta)$$

$$\Rightarrow F = \frac{\mu mg}{\cos\theta + \mu\sin\theta}$$

To Minimize F, $\cos\theta + \mu\sin\theta \rightarrow$ Maximized

$$\Rightarrow \frac{d}{d\theta}(\cos\theta + \mu\sin\theta) = 0 \Rightarrow \boxed{\tan\theta = \mu}$$

$$\therefore \cos\theta = \frac{1}{\sqrt{\mu^2+1}}, \quad \sin\theta = \frac{\mu}{\sqrt{\mu^2+1}} \Rightarrow \boxed{F_{min} = \frac{\mu mg}{\sqrt{\mu^2+1}}}$$

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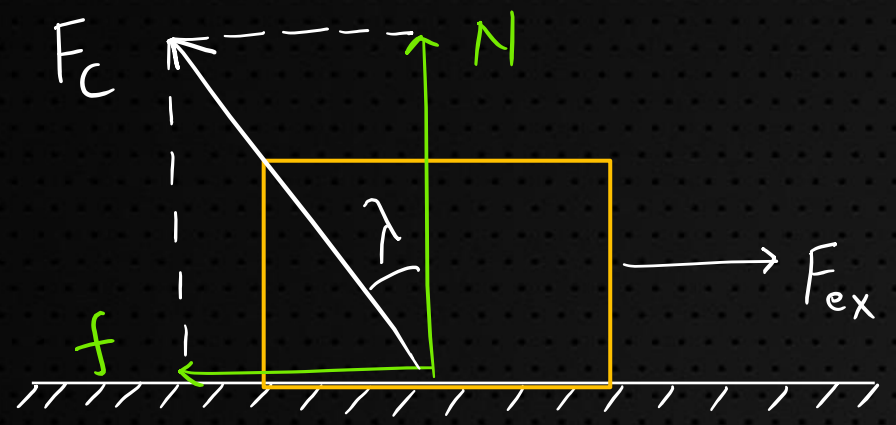
5. Contact Force (F_c)



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

$F_{c,min}$

$= N \quad \{f = 0\}$

$F_{c,max}$

$= \sqrt{N^2 + \mu^2 N^2}$

$= N\sqrt{1+\mu^2} \quad \{\mu = \mu_s$

$N \leq F_c \leq N\sqrt{1+\mu^2}$

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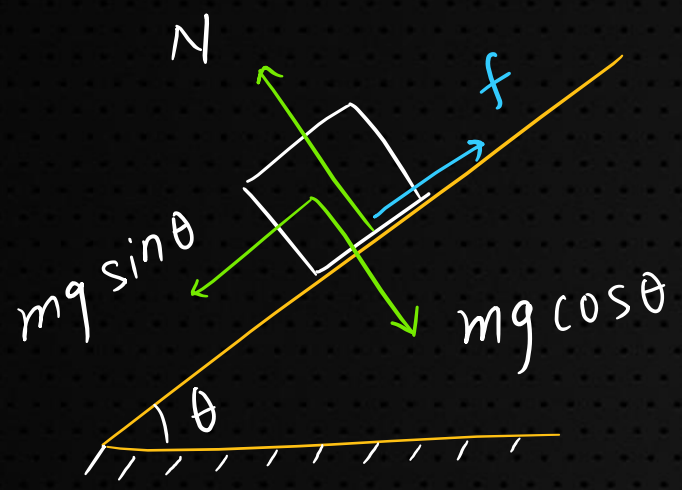
6. Angle of Repose

↳ Minimum angle for which body slips due to its weight



Block starts to just slip if:

$$mg\sin\theta = f_{s\,max}$$

$$\Rightarrow mg\sin\theta = \mu N \Rightarrow mg\sin\theta = \mu\, mg\cos\theta$$

$$\therefore \tan\theta = \mu \quad \text{or} \quad \boxed{\theta = \tan^{-1}\mu}$$

(i) If angle is $< \tan^{-1}\mu \Rightarrow$ No slipping

(ii) If angle is $> \tan^{-1}\mu \Rightarrow$ slipping

$$a = g\sin\theta - \mu g\cos\theta$$

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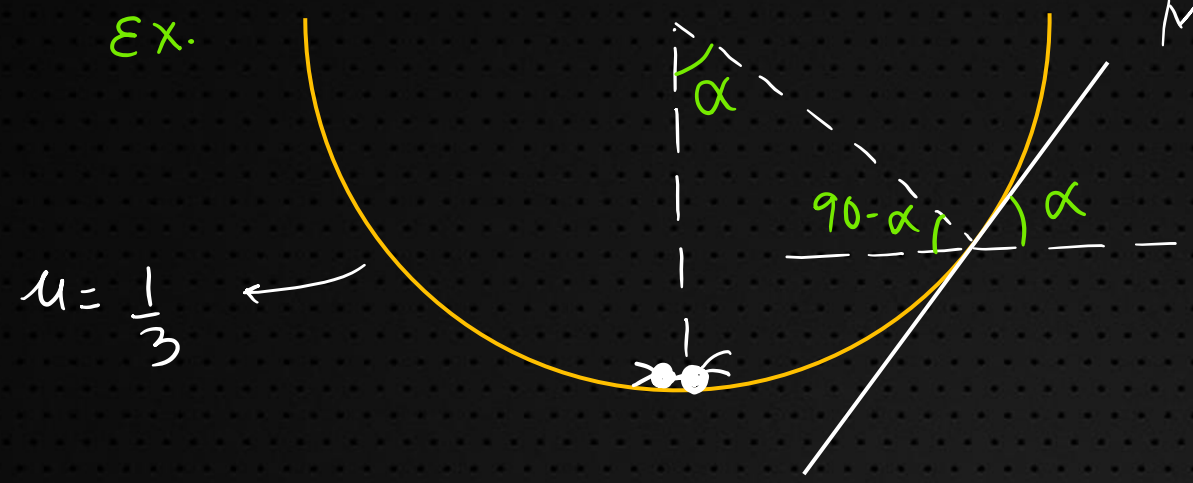
Ex.



Max possible α upto which insect can crawl without slipping.

Sol^n

$\therefore$ Limiting condition,

$$\tan\alpha = \mu = \frac{1}{3} \Rightarrow \cot\alpha = 3$$

$$\Rightarrow \boxed{\alpha = \cot^{-1} 3}$$

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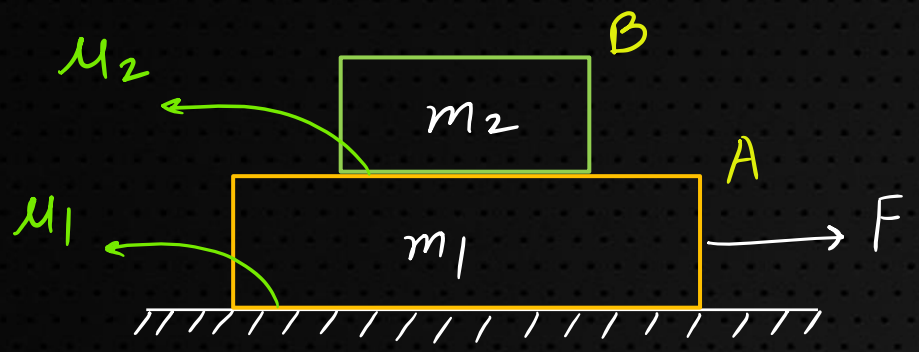
7. Two Block System (Block over block)

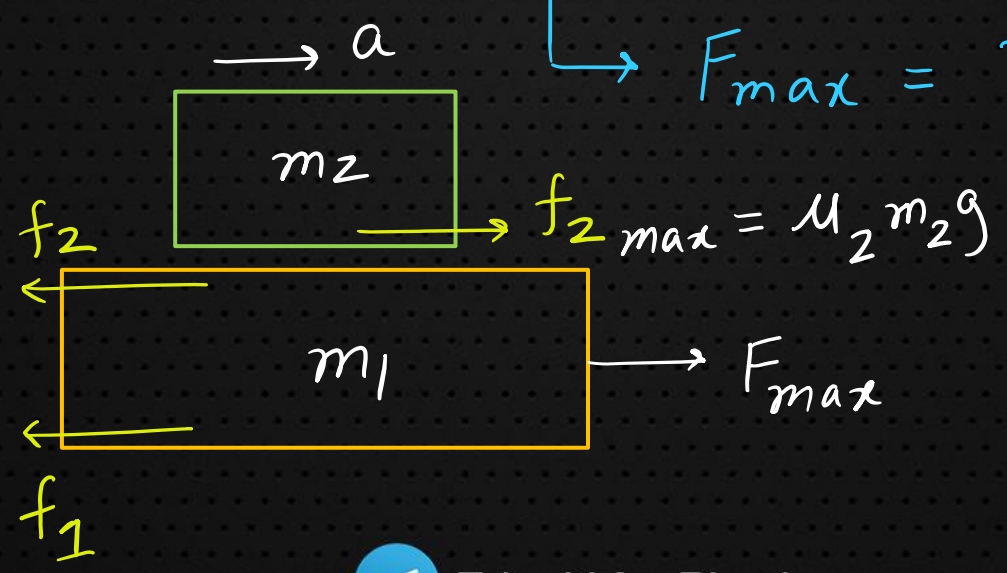


(i) Block B will never move before A

(ii) Min F to move A $= \mu_1 (m_1 + m_2) g = f_1$

(iii) On further ↑ F upto a F_{max} m_2 & m_1 moves together (m_2 not slipping on m_1)

$\hookrightarrow F_{max} = ?$



$\therefore a = \dfrac{\mu_2 m_2 g}{m_2} = \mu_2 g$

$\Rightarrow \boxed{F_{max} - f_1 = (m_1 + m_2)\mu_2 g}$

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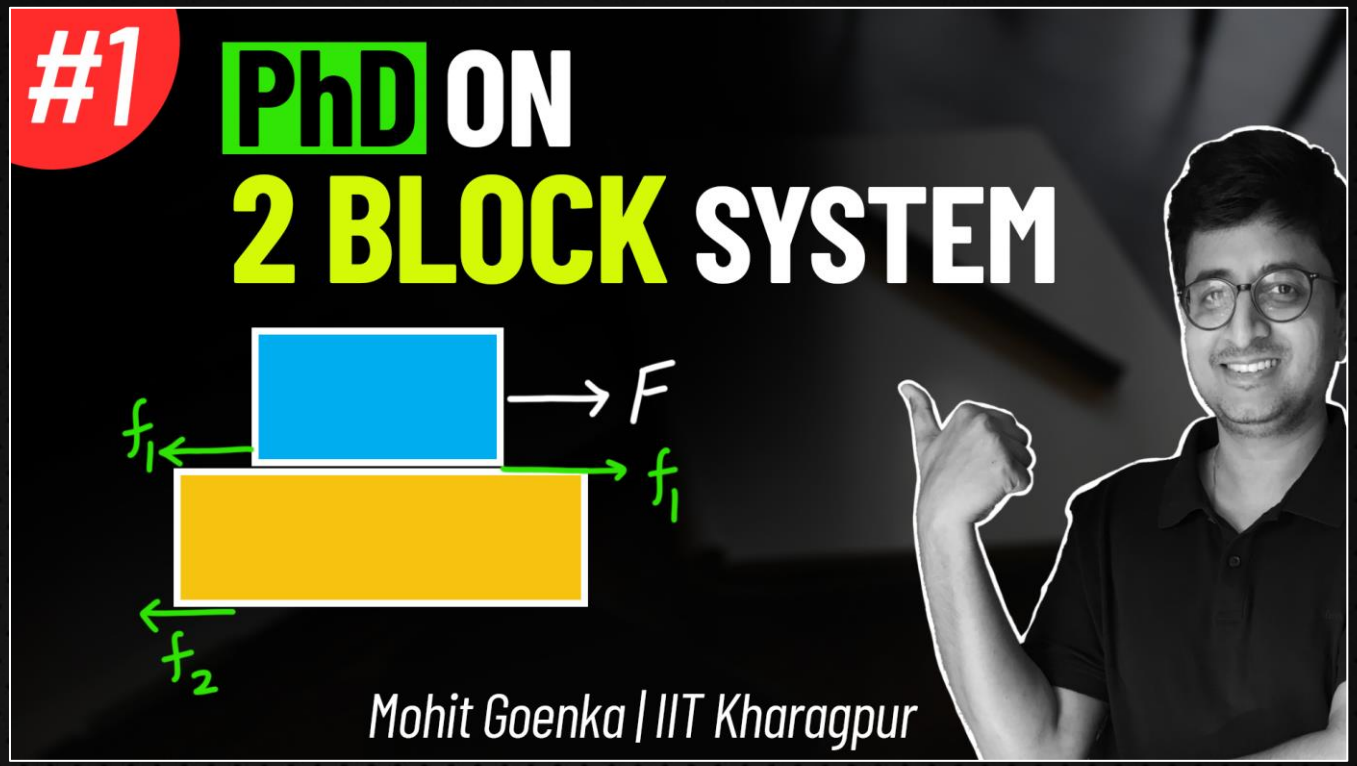

https://youtu.be/lbmDqxiet1k

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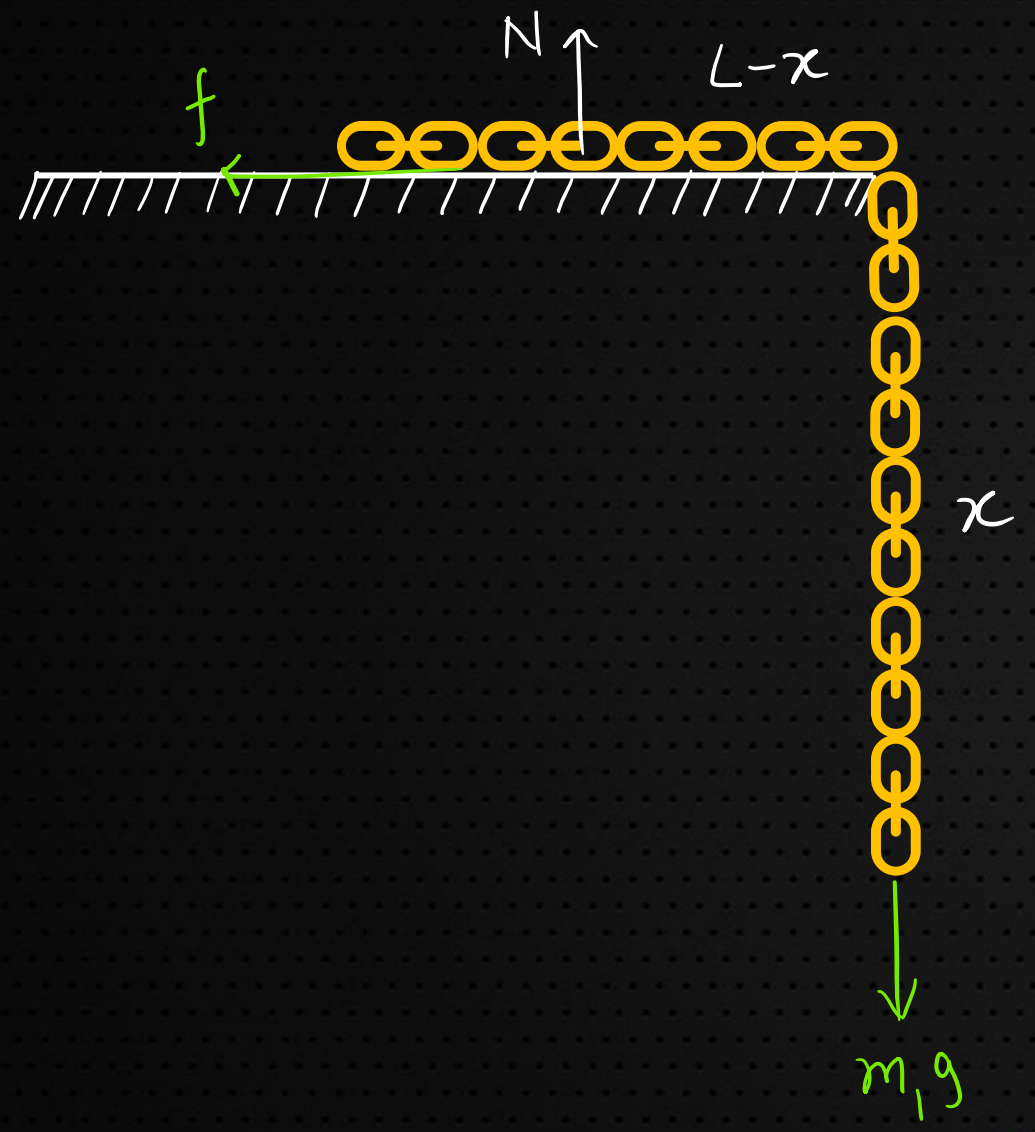
8. Friction on chain



$m_1 \rightarrow$ hanging mass

For Maximum hanging length without slipping:

$$m_1 g = f_{max}$$

$$\Rightarrow \frac{m}{L} x g = \mu \underbrace{\frac{m}{L}(L-x) g}_{N}$$

$$\Rightarrow x = \mu (L-x)$$

$$\therefore \boxed{x = \frac{\mu L}{1+\mu}}$$

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NLM PYQs LINKS (JEE MAIN)

2021 Feb	2021 March	2021 July	2021 August	2020	Top PYQs / Mix Years
https://youtu.be/2xuXY66RQWM	https://youtu.be/zUu5ccnsB_4	https://youtu.be/hCShMjLXnFo	https://youtu.be/VqOrOiq0N_I	https://youtu.be/AxW4Ibc0KkY	https://youtu.be/ZUQ1hfF7Ov4

V. Good Questions

CLICK

(Practice these Questions)

Revision Series Playlist Link https://bit.ly/3eBbib9

JEE Main PYQs Link https://bit.ly/2S54jzh Chapter wise 2021, 2020, 2018

GoldMine Link https://bit.ly/2VhOGFF

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