Dynamics 2

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IIT JEE | MEDICAL | FOUNDATION

friction : "Slipping or slipping tendency opposes" $\begin{cases} f_s = \mu_s N \\ f_k = \mu_k N \end{cases}$

"$t = 0$, rest"

$t = \text{sec}$

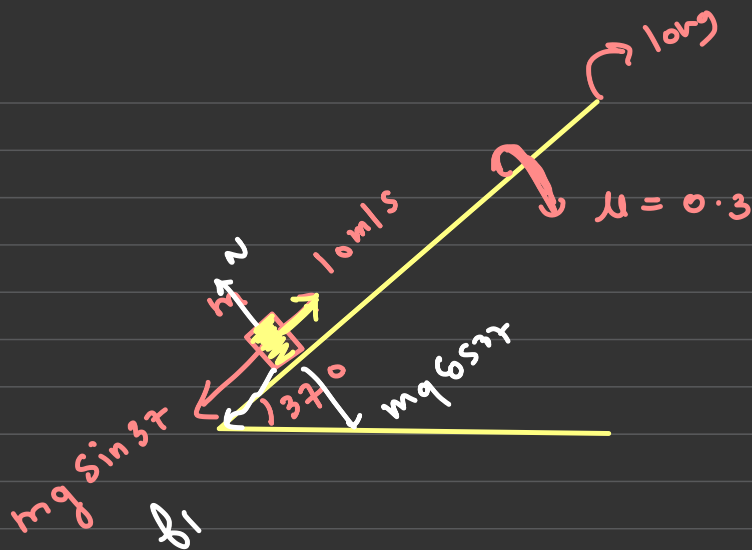
$F = 2t$ (N)

$\begin{cases} \mu_s = 0.3 \\ \mu_k = 0.2 \end{cases}$

$\begin{cases} f_s = 0.3(10\times10) \\ \quad = \underline{30\,N} \\ f_K = 0.2(10\times10) \\ \quad = \underline{20\,N} \end{cases}$

t (time)	F = (N)	a = ?	f = ? (N)
0	0	0	0
1	2	0	2
3	6	0	6
5	10	0	10
10	20	0	20
20	40	$40 - 20 = 10\times a =$	$2\,m/s^2$ 20 N Kinetic
30	60	$60 - 20 = 10\times a$	$4\,m/s^2$ 20 N Kinetic

Q)



$\mu_s = \mu_K = 0.3$

find time after which it is going to come back at same position?

\#

$$\cancel{m} g \sin 37 + \mu_K \{\cancel{m} g \cos 37\} = \cancel{m} \times a$$

$$10 \times \frac{3}{5} + 0.3 \times \overset{2}{\cancel{10}} \times \frac{4}{\cancel{5}} = a$$

$$6 + 2.4 = a_{up} \Rightarrow 8.4\ m/s^2$$

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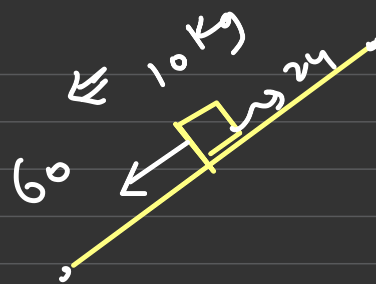


$$a_{Down} = \frac{60-24}{10}$$

$$a_{Dow} = \frac{36}{10} = 3.6\, m/s^2$$

#

$$\begin{cases} v = u + at \\ 0 = 10 - 8.4 \times t \\ \qquad t_{up} = \dfrac{10}{8.4}\ \text{sec} \end{cases}$$

up time

#

$$S = ut + \frac{1}{2}at^2$$

$$S = 10 \times \left(\frac{10}{8.4}\right) + \frac{1}{2}(-8.4) \times \left(\frac{10}{8.4}\right)^2 = S$$

$u = 0$

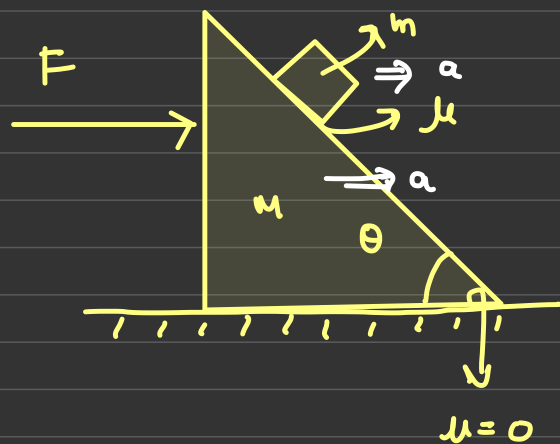
$$\text{total} = \left(\frac{10}{8.4} + \frac{25}{3.6}\right)$$

$$S = \frac{1}{2} a t^2$$

$$(\quad) = \frac{1}{2}(3.6) \times t^2$$

$$t = \frac{2S}{3.6}$$

θ)

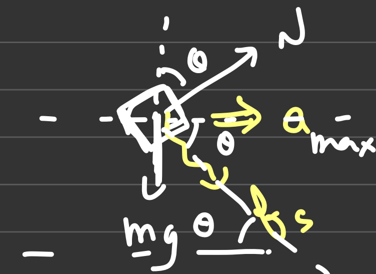


find F_{max} and F_{min} for which m and M is not slipping over each other?

due to friction F is going to be Range for which there will be no Relative motion between m and M?

if m is just about to slip upwards then $F \rightarrow F_{max}$ for which there is no slipping

$$F = (m+M)\, a_{max}$$



$$F_{max} = (m+M)\,g\left\{\frac{\sin\theta + \mu_s\cos\theta}{\cos\theta - \mu_s\sin\theta}\right\}$$

$$N\sin\theta + f_s\cos\theta = m \times a_{max}$$

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

$$F_{min} = (m+M)\,g\left\{\frac{\sin\theta - \mu_s\cos\theta}{\cos\theta + \mu_s\sin\theta}\right\}$$

$$N\sin\theta + \mu_s N\cos\theta = m\,a_{max} \quad \text{— (I)}$$

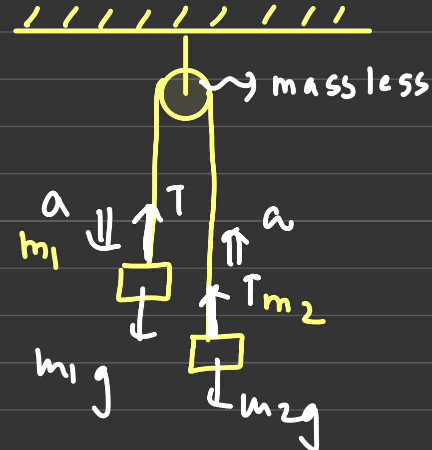
$$N\cos\theta - \mu_s N\sin\theta = mg \quad \text{— (II)}$$

$$a_{max} = g\left[\frac{\sin\theta + \mu_s\cos\theta}{\cos\theta - \mu_s\sin\theta}\right]$$

$$F_{min} < F < F_{max}$$

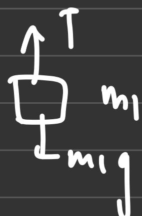
Q) (Pulley Ideal)

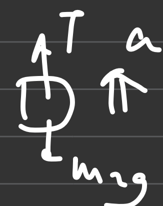
$m_1 > m_2$



Statement A₂: "if a string is passing over a fixed then acceleration of blocks must be along the string"

1. FBD
2. Acceleration Diagram
3. Y
4. X
5. $m_1 g - T = m_1 a_1$ —(I)





$T - m_2 g = m_2 a$ —(II)

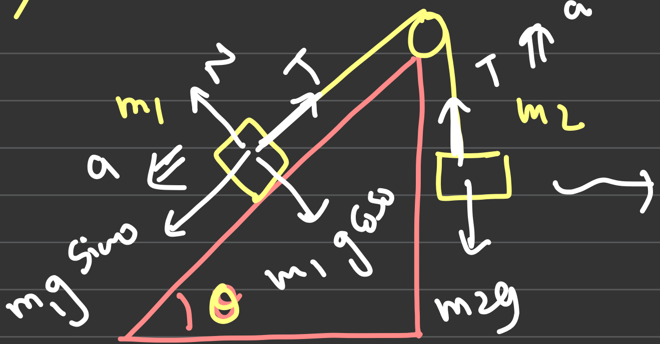
$m_1 g - m_2 g = (m_1 + m_2)\, a$

$$\boxed{a = \frac{m_1 g - m_2 g}{m_1 + m_2}}$$ Ans

Q)

No - friction

find acceleration of each block?



$$T - m_2 g = m_2 a \quad \text{--- (1)}$$

$$m_1 g \sin\theta - m_2 g = (m_1 + m_2) a$$

$$\boxed{a = \frac{m_1 g \sin\theta - m_2 g}{m_1 + m_2}}$$

(1) ✓

(2) ✓

(3), (4) ✗

$$m_1 g \sin\theta - T = m_1 a \quad \text{--- (1)}$$

find acceleration of each block?

(I) ✓

(II) ✓

(III) ✗

(IV) ✗

(V)

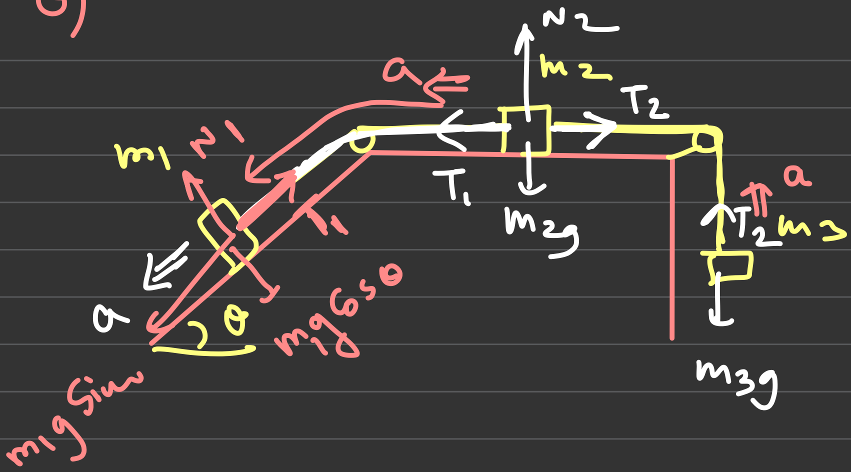
$$m_1 g - \cancel{T} = m_1 a \quad \text{— (I)}$$

$$\cancel{T} = m_2 a \quad \text{— (II)}$$

$$m_1 g = (m_1 + m_2)\, a$$

$$a = \left(\frac{m_1 g}{m_1 + m_2}\right)$$

Q)



find acceleration of m_1 m_2 and m_3?

(No-friction Here)

$F = ma$:

m_1: $m_1 g \sin\theta - \cancel{T_1} = m_1 a$ (I)

m_2: $\cancel{T_1} - \cancel{T_2} = m_2 a$ — (II)

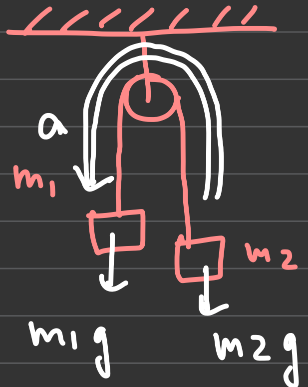
m_3: $\cancel{T_2} - m_3 g = m_3 a$ — (III)

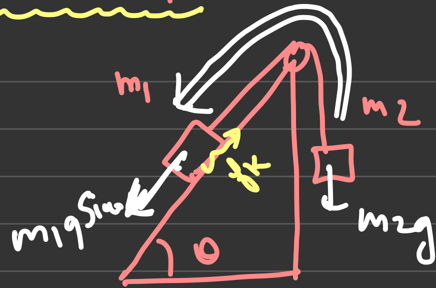
$m_1 g \sin\theta - m_3 g = (m_1 + m_2 + m_3) a$

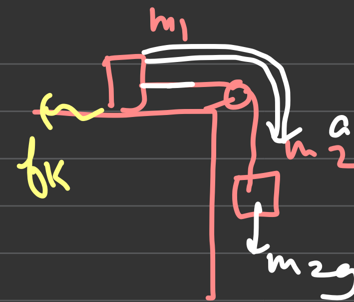
$$a = \frac{m_1 g \sin\theta - m_3 g}{m_1 + m_2 + m_3}$$

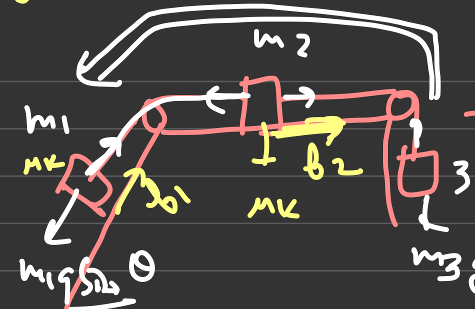
Driving force concept:

a - Apply $F = ma$ along string - a









(1) $\dfrac{m_1 g - m_2 g}{m_1 + m_2} = a$

(1) $\dfrac{m_1 g \sin\theta - m_2 g}{m_1 + m_2} = a$

(1) $\dfrac{m_2 g}{(m_1 + m_2)} = a$

(1) $a = \dfrac{m_1 g \sin\theta - m_3 g}{m_1 + m_2 + m_3}$

if friction is μ_k known

(1) $a = \dfrac{m_2 g - \mu_k m_1 g}{m_1 + m_2}$

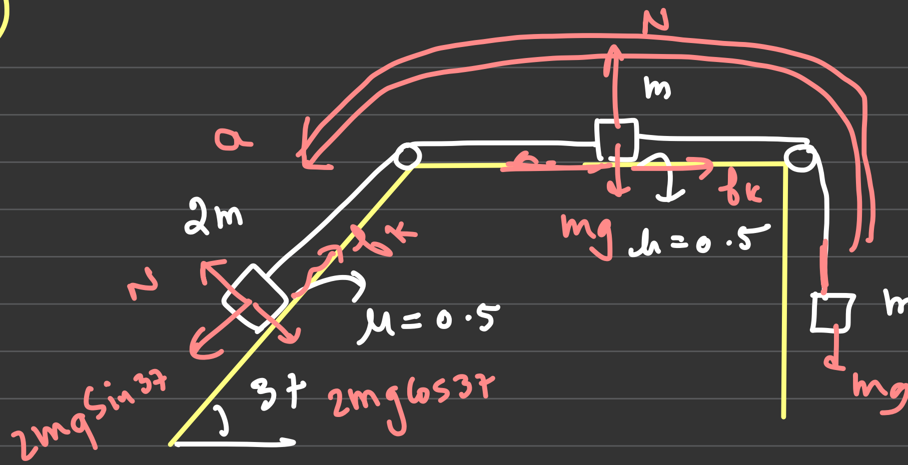
(1) $a = \dfrac{m_1 g - m_2 g}{m_1 + m_2}$

(1) $a = \dfrac{m_1 g \sin\theta - \mu_k m_1 g \cos\theta - m_2 g}{m_1 + m_2}$ ✓

✓ $a = \dfrac{m_1 g \sin\theta - \mu_k m_1 g \cos\theta - \mu_k m g - m_2 g}{m_1 + m_2 + m_3}$

Q)

find acceleration of each block?



$$a = \frac{2mg\sin 37 - 0.5\,2mg\cos 37 - 0.5mg - mg}{4m}$$

$$= \frac{2mg\times\frac{3}{5} - mg\times\frac{4}{5} - 1.5mg}{4m} = \frac{1.2mg - 2.3mg}{4m}$$

$$a = -\frac{1.1mg}{4m}$$

$a = -\frac{11}{4}\, m/s^2$

what does this mean in this Q.

$F = ma$

with friction

" or without friction "

a +ve

a -ve

Reverse the direction of a and solve it again

a = +ve

a -ve

a +ve

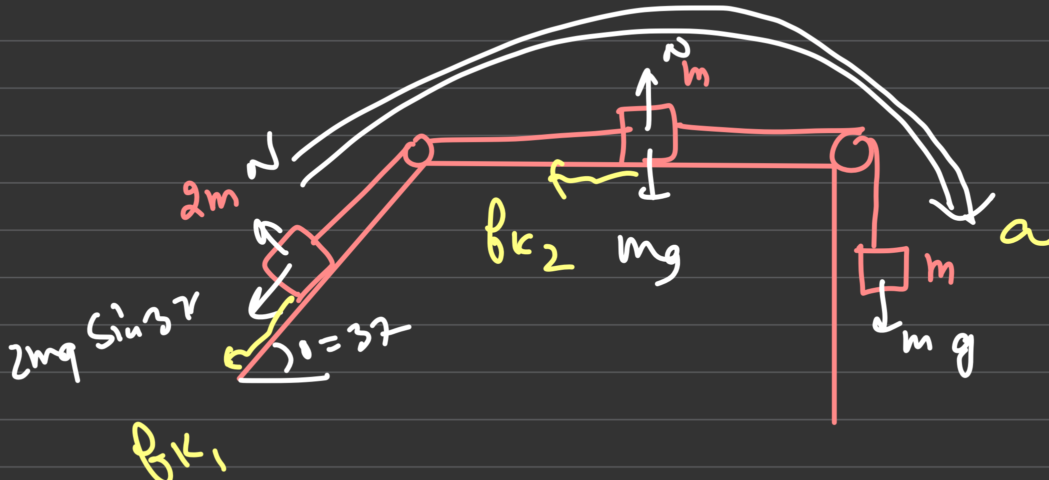
a = -ve

Direction acceleration's going to be in opposite direction

(✓)

[blocks rest]

$a = 0$



$f_{k_1} = 0.5\,(2mg\cos 37)$

$f_{k_2} = 0.5\,mg$

$$a = \frac{mg - 0.5mg - 2mg\sin 37 - 0.5\,(2mg\cos 37)}{4m}$$

$a = -ve$

"all the blocks are rest"

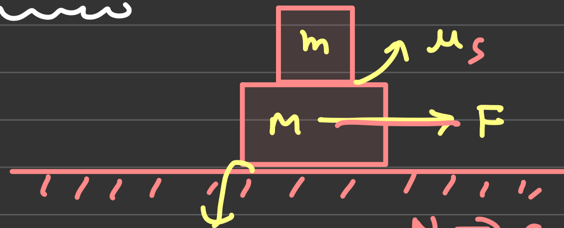
$$a_{2m} = a_m = a_m = 0$$

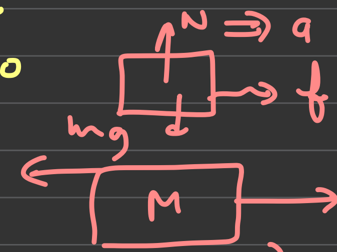
Home work: "find frictional forces acting on 2m and m" {Static}

Q)

Case I:

find F_{max} for which m and M both moves together?





$\Rightarrow a$

$f = \mu N = \mu_s mg$

$\Rightarrow a = \mu_s g$

$$f_s = \mu_s \cancel{m} g = \cancel{m} a$$

$$a = \mu_s g$$

$F > F_{max} \rightarrow$ slipping

$F < F_{max} \rightarrow$ No-Slipping

$$F_{max} - f_s = M a$$

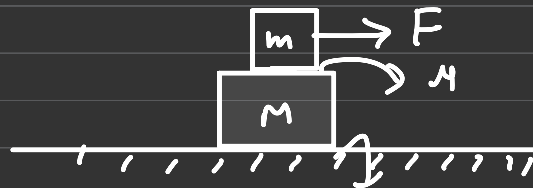
$$F_{max} = M(\mu_s g) + \mu_s mg$$

$$\boxed{F_{max} = \mu_s g (m+M)}$$

"both are moving together"

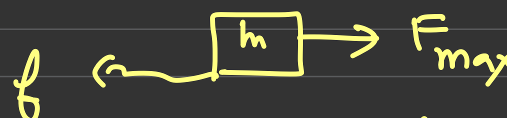
Case II:

find F_{max} for which both moves together?

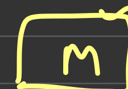


$\mu = 0$

$\Rightarrow a$



$N = mg$



$f = \mu_s N = (\mu_s m g)$

$\Rightarrow a_{max}$

$$\underline{\underline{a_{max}}} = \frac{\mu_s m g}{M}$$

$$F_{max} - f_s = m\, a_{max}$$

$$\boxed{F_{max} = \mu_s m g + m \left(\frac{\mu_s m g}{m} \right)}$$

$$\begin{cases} F > F_{max} \rightarrow \text{slipping} \\ F < F_{max} \rightarrow \text{both moves "together"} \end{cases}$$

Q)

(I) find max force for which both moves together

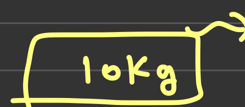
(II) find a of both if $F = 30N$

$F = 30N$

$\mu = 0.5$

$\mu = 0.0$

f

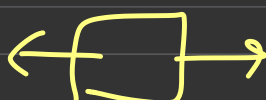


$f = 0.5(5\times10)$
$= 25$

$\Rightarrow 5\,m/s^2$

$f = 25 = 10\times a$

$a = 2.5\,m/s^2$



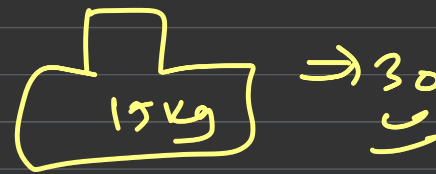
So

$\Rightarrow 2.5\,m/s^2$

$F_{max} = 2.5\,m/s^2 \times 15$

$F_{max} = 37.5\,N$

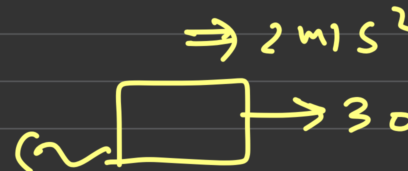
$F < F_{max}$ both moving together



$30 = 15 \times a$

$a = 2\ m/s^2$

$a = 2\ m/s^2$ Right



f

$30 - f = 5 \times 2$

$f = 30 - 10 = 20\ N$

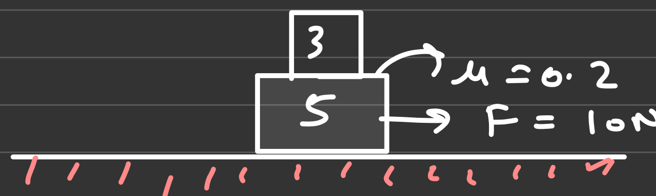
$f_{max} = 75\ N$ (both move together)

If $F = 30\ N$ $\quad a = 2\ m/s$

if $F = 30 \rightarrow$ then $f = 20$ N

Revise

Homework:



(I) find F_{max} for which both moves together

(II) if F = 10 N then find frictional force and acceleration

(III) F = 20 N

(IV) F = 40 N

1, 2

DTS → Level 1, 2

modul INEA

U $F = 60\,N$