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Div - J1

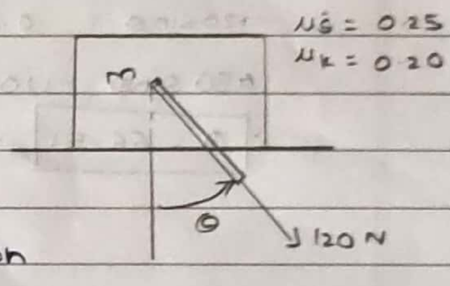
DATE:

03/05/21

Engineering Mechanics

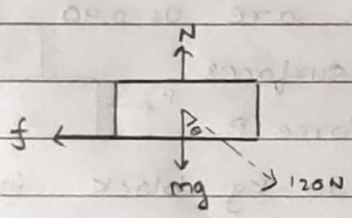
Assignment 3 : Friction

3.2) Considering only values of θ less than 90°, determine the smallest value of θ for which motion of the block to the right is impending when a) m = 30 kg , b) m = 40 kg.



→ Considering the FBD of block,

Let f be the frictional force acting on block.



$\Sigma F_y = 0$

$N - mg - 120\cos\theta = 0$

$\therefore N = mg + 120\cos\theta$

$N = 30 \times 9.81 + 120\cos\theta$

$N = 294.3 + 120\cos\theta \quad -(1)$

$\Sigma F_x = 0$

$-f + 120\sin\theta = 0 \quad -(2)$

$f = f_{max} = \mu_s N = 0.25N$

$\therefore f = 0.25(294.3 + 120\cos\theta)$

$120\sin\theta = 0.25(294.3 + 120\cos\theta)$

$480\sin\theta - 120\cos\theta = 294.3$

$\therefore \boxed{\theta = 50.54°}$ ... [when m = 30 kg]

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b) $m = 40\ kg$

$\therefore N = 392.4 + 120\cos\theta$

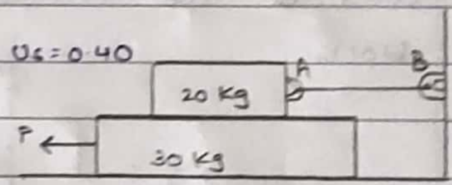
$f = \mu_s N = 0.25N = 0.25(392.4 + 120\cos\theta)$

$\therefore 120\sin\theta = 0.25(392.4 + 120\cos\theta)$

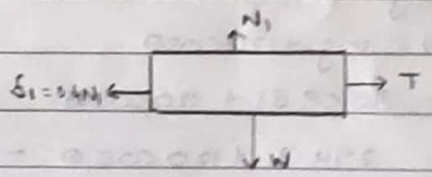
$480\sin\theta - 120\cos\theta = 392.4$

$\therefore \boxed{\theta = 66.51^\circ}$ ... [when m = 40 kg]

3.5) The coefficients of friction are $\mu_s = 0.40$ and $\mu_k = 0.30$ between all surfaces of contact. Determine the force P for which motion of the 30-kg block is impending if cable AB, a) is attached as shown, (b) is removed.



a) FBD of 20 kg block,



$\Sigma F_y = 0$

$\therefore W = N_1$

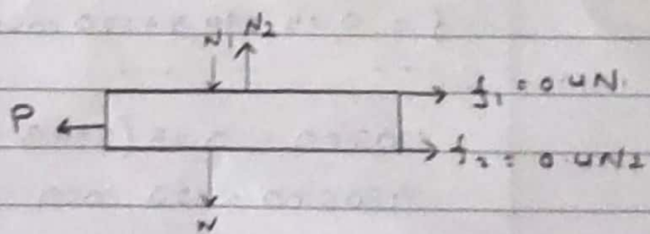
$\therefore N_1 = 20 \times 9.81 = 196.2\ N$

$\therefore \cancel{\Sigma F_x = 0}$ $f_1 = 0.4N_1$

$\therefore \cancel{T = f_1}$ $= 0.4 \times 196.2$

$f_1 = 78.48N$

FBD of 30kg block,



$\Sigma F_y = 0$

$W + N_1 = N_2$

$\therefore N_2 = 294.3 + 196.2 = 490.5\ N$

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$\therefore f_2 = 0.4 \times N_2 = 0.4 \times 490.5 = 196.2\,N$

$\Sigma F_x = 0$

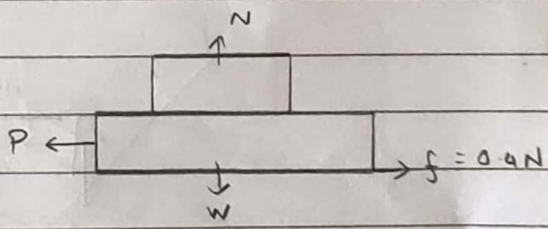
$P = f_1 + f_2$

$= 78.48 + 196.2$

$\therefore \boxed{P = 274.68\,N}$

Force P for which motion of 30 kg block is impending when string AB attached is 274.68N

b) String AB is removed.



$\Sigma F_y = 0$

$N = W = (20+30) \times 9.81$

$\therefore N = 490.5\,N$

$\Sigma F_x = 0$

$P = f$

$= 0.4 \times 490.5$

$\boxed{P = 196.2\,N}$

P for which motion of 30 kg block is impending when string AB is removed is 196.2 N

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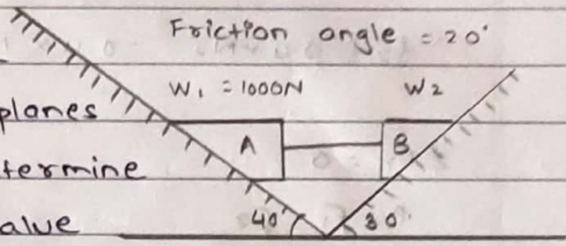
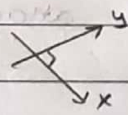
3.7) Two blocks weighing W_1 and W_2 are resting on two inclined planes as shown. If $W_1 = 1000N$, determine the minimum and maximum value of W_2 for which equilibrium can exist.

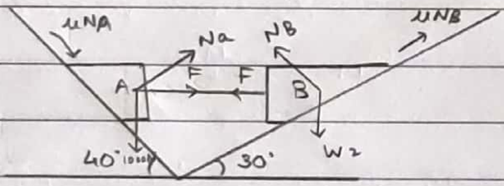


→ $\theta = 20°$, $\mu = \tan\theta = \tan 20$

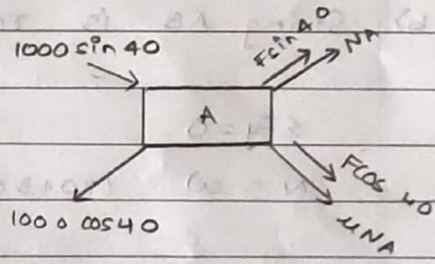
$\therefore \mu = 0.364$

Case I : $W_2 > W_1$ (for W_{max})





FBD of block A



$\Sigma F_y = 0$

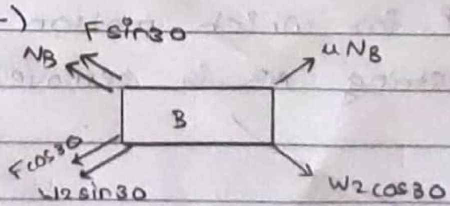
$1000\cos 40 - F\sin 40 = N_a$ — (1)

$\Sigma F_x = 0$

$1000\sin 40 + F\cos 40 + \mu N_A = 0$ — (2)

From eq (1) and (2)

$F_{AB} = -1732.16N = 1732.16N$ (←)



Now, FBD of B,

$\Sigma F_y = 0$

$N_B = W_2\cos 30 - F\sin 30$ — (3)

$\Sigma F_x = 0$

$\mu N_B = F\cos 30 + W_2\sin 30$ — (4)

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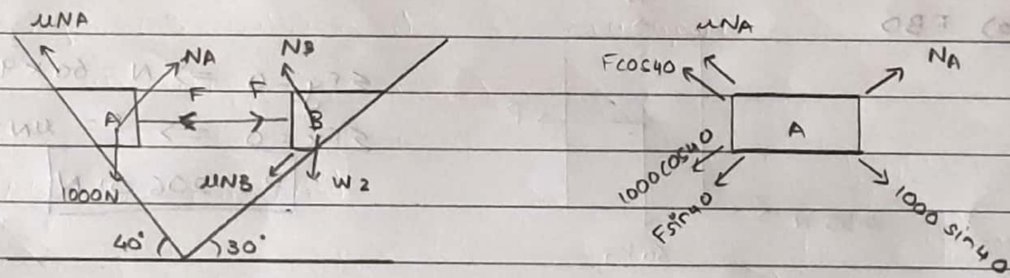
Solving eq. (3) and (4)

$N_B = 7642.687 N$

$\therefore \boxed{W_{2(max)} = 9825.078 N}$

Case 2 : $W_2 < W_1$ [for $W_{2(min)}$]



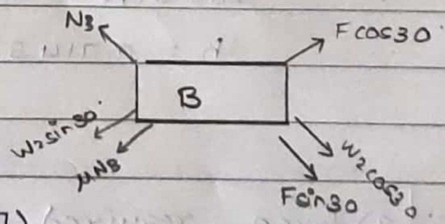
$\Sigma F_y = 0 \Rightarrow N_A = 1000\cos 40 + F\sin 40$ — (5)

$\Sigma F_x = 0 \Rightarrow \mu N_A = 1000\sin 40 - F\cos 40$ — (6)

Solving eq (5) and (6)

$F = 363.94 N$

Now, FBD of block B.



$\Sigma F_y = 0 \Rightarrow N_B = W_2\cos 30 + F\sin 30$ — (7)

$\Sigma F_x = 0 \Rightarrow \mu N_B + W_2\sin 30 = F\cos 30$ — (8)

Solving (eq), 7 and 8,

$\boxed{W_{min} = 305.36 N}$

$\therefore$ The max and min value of W_2 for which equilibrium can exist is 9825.078 N and 305.36 N respectively.

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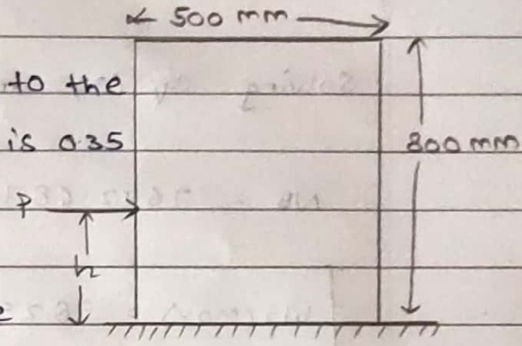
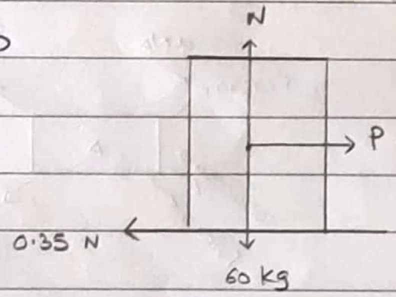
3.12) A 60 kg Cupboard is to be shifted to the right, μ_s between cupboard and floor is 0.35 as shown in figure. Determine a) The force required to move the cupboard and b) The largest allowable value of h if the cupboard is not to tip over.



a) FBD



$\Sigma F_y = 0 \Rightarrow N = 60 \times 9.81$

$\Sigma F_x = 0 \Rightarrow P = \mu N = 0.35 \times 60 \times 9.81$

$\therefore \boxed{P = 206.01\ N}$

b) To tip over, $\Sigma M_B = 0$

$\therefore -(60 \times 9.81 \times 0.25) + (P \times h) = 0$

$\therefore 206.01\,h = 147.15$

$\therefore h = 0.7143\ m = \underline{714.3\ mm}$

$\therefore$ a) force required to move the cupboard is 206 N
b) largest allowable value of 'h' is 714.3 mm.

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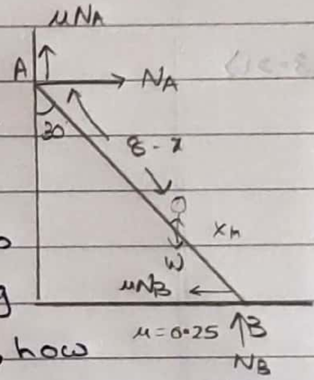
3.15) A weightless ladder of length 8 m is resting against a wall and floor. A man of weight 500 N wants to climb up the ladder. Determine a) how much distance can he climb without slipping. b) If another man weighing 800 N wants to climb up the same ladder, how much the distance he can walk along the ladder without slipping?



Ans. a) $\Sigma F_y = 0 \Rightarrow \mu N_A + N_B = 500N$ — (i)

$\Sigma F_x = 0 \Rightarrow N_A = \mu N_B$ — (2)

Solving eq. (1) and (2), we have

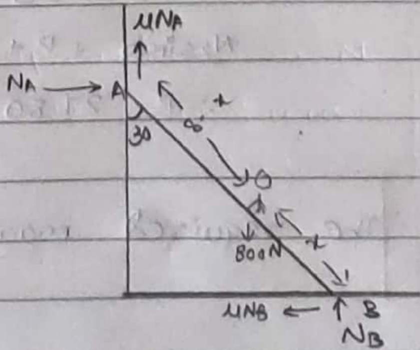
$N_A = 117.64N$, $N_B = 470.59 N$

then $\Sigma M_B = 0$

$500(x \sin 30) - N_A(8 \cos 30) - \mu N_A (8 \sin 30) = 0$

$\therefore x = 3.73$ m

$\therefore$ The man can climb upto a distance of 3.73 m up the ladder without slipping.



b) $\Sigma F_x = 0 \Rightarrow N_A = \mu N_B$ — (3)

$\Sigma F_y = 0 \Rightarrow \mu N_A + N_B = 800$ — (4)

Solving eq. (3) and (4) we get

$N_A = 188.235 N$, $N_B = 752.941 N$

Now, $\Sigma M_B = 0$

$800(x \sin 30) - \mu N_A(8 \sin 30) - N_A(8 \cos 30) = 0$

$\therefore x = 3.73 m$

$\therefore$ A man weigh 800 N can climb upto 3.73 m without slipping.

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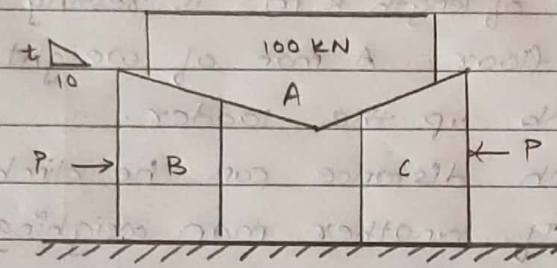
3.21)



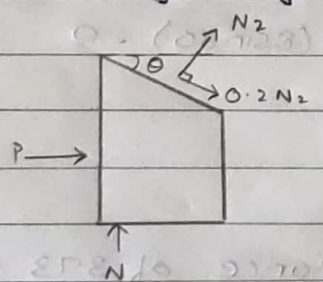
Slope 1:10 => $\tan\theta = \frac{1}{10}$

$\therefore \theta = \tan^{-1}\left(\frac{1}{10}\right) = 5.71^{\circ}$

$\Sigma F_y = 0 \Rightarrow 2N = 100$

$\therefore N = 50\,KN$

Isolating wedge B as shown,



$\Sigma F_y = 0$

$\therefore 50 + N_2\cos\theta - 0.2N_2\sin\theta = 0$

$\therefore N_2 = -51.27\,KN$

$\Sigma F_x = 0$

$N_2\sin\theta + P + 0.2N_2\cos\theta - 0.25 \times 50 = 0$

$\therefore P = 27.80\,KN$

$\therefore$ The required magnitude of horizontal force P is 27.80 KN