

Tutorial - 6

① $F_A = \mu N_A = 0.3 N_A$

Case - I

$$\sum F_y = 0, \quad 0.3 N_A = N_B$$

$$\sum F_x = 0 \quad N_A = 98.1 \text{ N}$$

$$N_B = 0.3 \times 98.1 = 29.43 \text{ N}$$

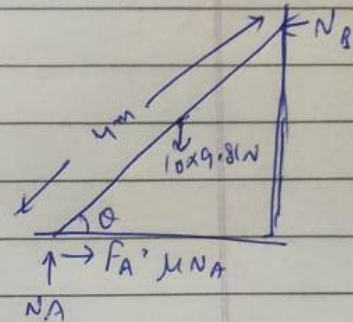
$$\sum M_A = 0$$

$$N_B \times 4 \sin \theta = 98.1 \times 2 \cos \theta$$

$$117.72 \sin \theta = 196.2 \cos \theta$$

$$\tan \theta = \frac{196.2}{117.72}$$

$$\theta = 59^\circ$$



Case - II

$$\sum F_y = 0$$

$$N_A' = 98.1 + 40 \times 9.81 = 490.5 \text{ N}$$

$$F_A' = 0.3 \times 490.5 = 147.15 \text{ N}$$

$$N_B' = F_A' = 147.15 \text{ N}$$

$$\sum M_A = 0$$

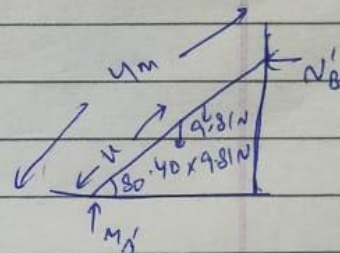
$$\mu N_A' = F_A'$$

$$392.4 \times n \cos 80^\circ + 9.81 \times 2 \cos 80^\circ = 147.15 \times 4 \sin 80^\circ$$

$$68.14n + 34.07 = 579.66$$

$$n = 8.00 \text{ m}$$

The man climbs up to the top of the ladder



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② FBD of block A'

$\sum F_y = 0$
 $N_A = 29.43 + T_1 \cos 30^\circ$
 $\sum F_x = 0 \quad F_A = 0.3 N_A = T_1 \sin 30^\circ$
 $\text{or } 0.3(29.43 + T_1 \cos 30^\circ) = T_1 \sin 30^\circ$
 $8.829 + 0.2598 T_1 = 0.5 T_1$
 $0.2402 T_1 = 8.829$
 $T_1 = 36.79 \text{ N}$

③ $\tan \alpha = \frac{4}{5} \therefore 38.7^\circ$

FBD of block

$\sum F_y = 0$
 $N_1 = W \cos 38.7^\circ$
 $\sum F_x = 0$
 $T_1 = 0.3 N_1 + W \sin 38.7^\circ$
 $\text{or } T_1 = 0.3(W \cos 38.7^\circ) + W \sin(38.7^\circ)$
 $= 0.186W \quad \text{--- II}$

FBD of block (2)

$\sum F_y = 0$
 $N_2 = W$
 $\sum F_x = 0$
 $T_2 = F_2 = \mu N_2 = 0.3W$

of high

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From FBD of block (1)

$$\sum F_x = 0$$

$$T_1 + 0.3N_1 + 0.3N_2 = 1100 \sin 38.7^\circ = 687.77 \text{ N}$$

$$T_1 + 0.3N_1 + 0.3 \times W \cos 38.7^\circ = 687.77 \quad (\because N_2 = W \cos 38.7^\circ) \quad \text{eq-3}$$

$$T_1 + 0.3N_1 + 0.234W = 687.77 \quad \text{--- II}$$

$$\sum F_y = 0$$

$$N_1 = N_2 + 1100 \cos 38.7^\circ$$

$$= W \cos 38.7^\circ + 1100 \cos 38.7^\circ$$

$$N_1 = 0.78W + 858.47$$

Put N_1 in eq-III

$$T_1 + 0.3(0.78W + 858.47) + 0.234W = 687.77$$

$$T_1 + 0.234W + 257.54 + 0.234W = 687.77$$

$$T_1 + 0.468W = 430.23 \quad \text{--- IV}$$

Also, $T_1 = T_2$, put in eq-IV, from eq-II

$$0.86W + 0.468W = 430.23$$

$$W = 323.97 \text{ N}$$

(2) $\mu = 0.25$ $\beta = 180^\circ = \pi$ rad. (angle of wrap)

$$\mu\beta$$

$$\frac{T_1}{T_2} = e^{\mu\beta} = 2.193 \quad ; \quad T_1 = 2.193 T_2$$

from eq-II, $T_2 = 0.86W$, $T_1 = 2.193 T_2 = 1.886W$

Put T_1 in eq-IV

$$1.886W + 0.468W = 430.23$$

$$2.354W = 430.23$$

$$W = 182.77 \text{ N}$$

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Let w for the wedge $= 0$
FBD of wedge

$\sum F_y = 0$

$$0.25 N_1 + 0.25 N_2 \cos 10^\circ + N_2 \sin 10^\circ = P$$

$$0.25 N_1 + 0.246 N_2 + 0.174 N_2 = P$$

$$0.25 N_1 + 0.42 N_2 = P \quad \text{--- I}$$

$\sum F_x = 0$

$$N_1 + 0.25 N_2 \sin 10^\circ = N_2 \cos 10^\circ$$

$$\Rightarrow N_1 = 0.941 N_2 \quad \text{--- II}$$

But N_1 in eq. I

$$0.25 (0.941 N_2) + 0.42 N_2 = P$$

$$P = 0.655 N_2 \quad \text{--- III}$$

FBD of block.

$\sum F_x = 0$

$$N_3 = 0.25 N_2 \cos 10^\circ + N_2 \sin 10^\circ$$

$$N_3 = 0.42 N_2 \quad \text{--- IV}$$

$\sum F_y = 0$

$$N_2 \cos 10^\circ = 2000 + 0.25 N_3 + 0.25 N_2 \sin 10^\circ$$

$$0.9848 N_2 - 0.23 (0.42 N_2) - 0.6434 N_2 = 2000$$

$$0.8364 N_2 = 2000$$

$$N_2 = 2391 N, \quad P = 1560 N$$

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$\mu' \tan \theta = \tan 21^\circ$
 $= 0.384$

FBD of block 'B'

$F_2 = 0.384 N_1$

FBD of block A

$\sum F_x = 0$
 $N_2 = 0.384 N_1 + 410 \quad \text{--- I}$
 $\sum F_y = 0$
 $N_1 = 2000 + 0.384 N_2 \quad \text{--- II}$

From eq. I

$$N_2 = 0.384 (2000 + 0.384 N_2) + 410$$

$$= 768 + 0.147 N_2 + 410$$

$$0.8526 N_2 = 1178$$

$$N_2 = 1381.66 \approx 1382 \text{ N}$$

$N_3 \cos 21^\circ = N_2 + 0.384 N_3 \sin 21^\circ$
 $0.9336 N_3 = 1382 + 0.1376 N_3$
 $N_3 = 1736.18 \approx 1736 \text{ N}$

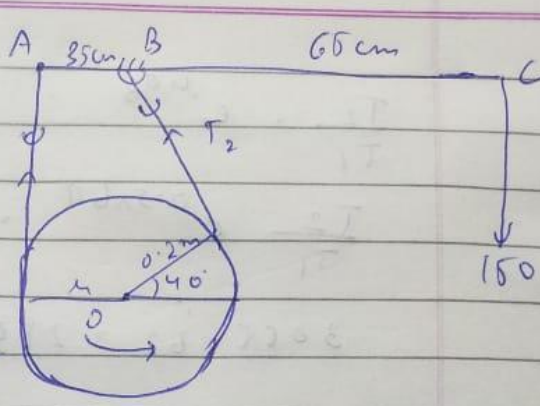
$\sum F_y = 0$
 $N_3 \sin 21^\circ + 0.384 N_3 \cos 21^\circ + 0.384 N_2 = P$
 $622.18 + 622.36 + 530.69 = P = 1775 \text{ N}$

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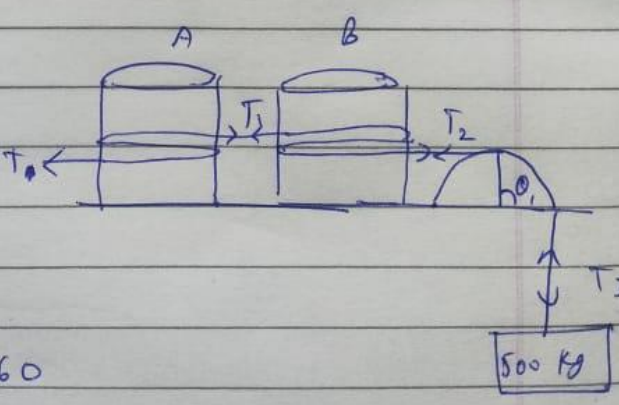
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⑥ $\mu = 0.43$
 $\theta = 22.6^\circ (18.0 + 4.0)$
 $\approx 3.84 \text{ rad}$
 $e^{\mu\theta} = 5.212$
 $\frac{T_1}{T_2} = 5.212 \Rightarrow T_1 = 5.212 T_2$



$\sum M_B = 0$
 $35 \times T_1 = 65 \times 150$
 $T_1 = 278.57 \text{ N}$
 $T_2 = 53.5 \text{ N}$
 $\text{Torque} = (T_1 - T_2) \times R$
 $= (278.57 - 53.5) \times 0.2$
 $\text{Torque} = 45 \text{ N-m}$

⑦ $\mu_s = 0.3$
 $\tau = 2$
 $\frac{T_3}{T_2} = e^{\mu\theta_1}$



$\theta_1 = \frac{\pi}{2} \text{ rad.}$
 $\frac{T_3}{T_2} = e^{(0.3 \times \frac{\pi}{2})} = 1.60$

$T_3 = 500 \times 9.81 = 4905$
 $\frac{4905}{1.60} \Rightarrow T_2 = 3065.62 \text{ N}$

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$$\frac{T_2}{T_1} = e^{\mu \theta_B}$$

$$\theta_B = 2\pi \times 3 = 6\pi \text{ rad.}$$

$$\frac{T_2}{T_1} = e^{0.3 \times 6\pi} = 285.68$$

$$3065.62 = 285.68 T_1 \Rightarrow \underline{T_1 = 10.73 \text{ N}}$$

$$\frac{T_1}{T} = e^{\mu \theta_A}$$

$$\theta_A = 4\pi$$

$$\frac{T_1}{T} = e^{0.3 \times 4\pi} = 43.38$$

$$10.73 = 43.38 T$$

$$\underline{T = 0.25 \text{ N}}$$

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