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Subject - Physics Assignment

Mechanics

Enrollment no. - 2020MMB026

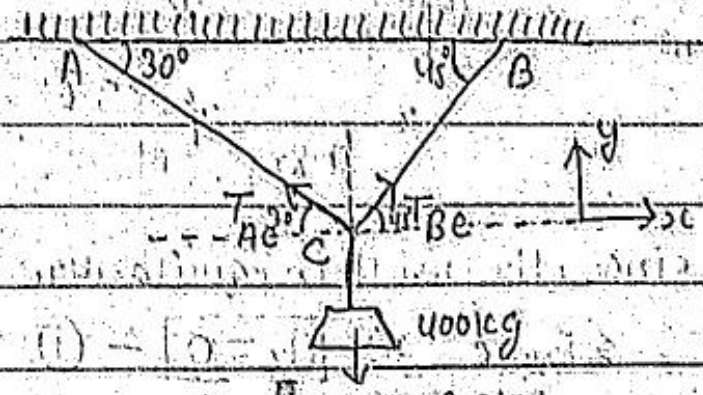
Department: Metallurgy

Problem sheet No. 1

Equilibrium

(1). Determine the tension in cables CA and CB.

Sol^n:



FBD of C

$\Sigma F_x = 0$

$T_{BC}\cos 45° - T_{AC}\cos 30° = 0$ — (i)

$\Sigma F_y = 0$

$T_{AC}\sin 30° + T_{BC}\sin 45° = 400 \times 9.81 = 0$ — (ii)

On solving we get

$$T_{BC} = T_{AC} \times \frac{\sqrt{3}}{2} \times \sqrt{2}$$

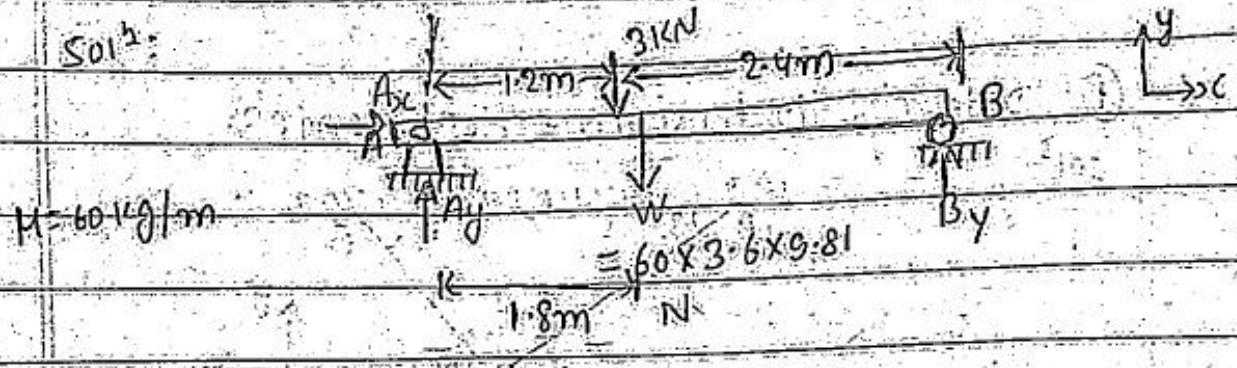
$$= T_{AC}\frac{\sqrt{3}}{\sqrt{2}}$$

$$T_{AC}\left[\frac{1}{2} + \frac{\sqrt{3}}{2}\right] = 400 \times 9.81 \Rightarrow T_{AC} = 2872.57\,N$$

$$T_{BC} = 3518.16\,N.$$

② The uniform bar has a mass per unit length of 60 kg/m. Determine the reactions at the supports

Soln:



Since, the rod is in equilibrium.

$\Sigma F_x = 0 \Rightarrow \boxed{A_x = 0}$ — ①

$\Sigma F_y = 0 ; \quad A_y + B_y = 3000 - 60 \times 3.6 \times 9.81$

$A_y + B_y = 5118.96\ N$ — ②

$\Sigma M_A = 0$

$B_y (2.4 + 1.2) - 3000 \times 1.2 - 60 \times 3.6 \times 9.81 \times 1.8 = 0$

or $\boxed{B_y = 2059.48\ N}$

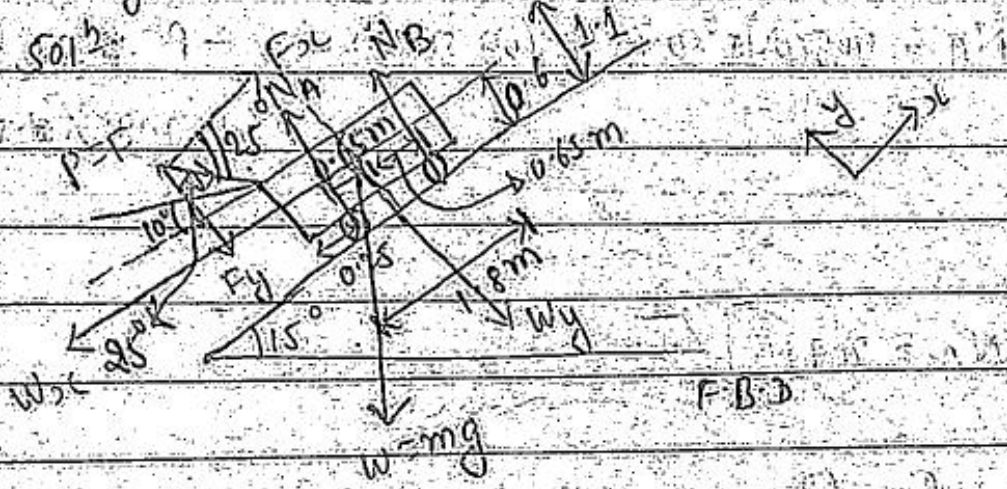
$A_y + B_y = 5118.96$

$A_y = 5118.96 - 2059.48$

$\boxed{A_y = 3059.48\ N}$

③ A man pushes the 40kg machine with mass centre at G up an incline at a steady speed. Determine the required force magnitude P and the normal reaction forces at A and B. Neglect the small effects of friction.

Sol:



Using condition of equilibrium

$$\Sigma F_y = 0$$

$$N_A + N_B - W_y - P\sin 25^\circ = 0$$

$$N_A + N_B = 40g\cos 15^\circ + P\sin 25^\circ \quad - (1)$$

$$\Sigma F_x = 0$$

$$P\cos 25^\circ - 40g\sin 15^\circ = 0$$

$$P\cos 25^\circ = 40g\sin 15^\circ$$

$$P = \frac{40 \times 9.81 \times \sin 15^\circ}{\cos 25^\circ}$$

$$\boxed{P = 112.05\,N}$$

$\Sigma M_B = 0$

$N_A \times 1.3 - 40g\cos 15° \times 0.65 - 40g\sin 15° \times 0.6 + P\cos 25° \times 1.1 - P\sin 25° (1.8 - 0.25) = 0$

$$N_A = \frac{40g\cos 15° \times 0.65 + 40g\sin 15° \times 0.6 - P\cos 25° \times 1.1 + P\sin 25° \times 1.55}{1.3}$$

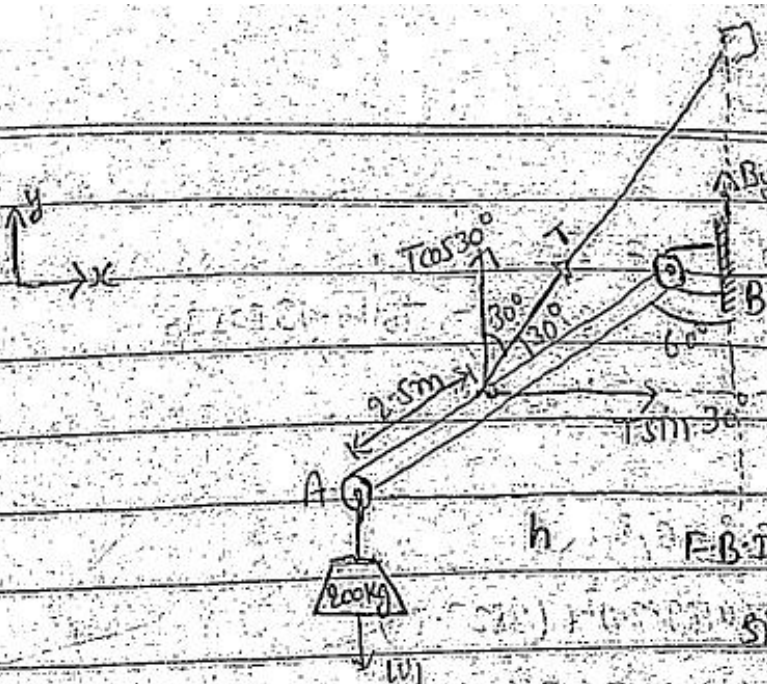
$$\boxed{N_A = 207\,N}$$

from (1)

$N_A + N_B = 40 \times 9.81 \times \cos 15° + 112.05\sin 25°$

$$\boxed{N_B = 219.4\,N}$$

④



F.B.D

$\sin 60° = \frac{h}{5}$

$h = 5 \sin 60°$

From the cond^n of equilibrium,

$\Sigma F_x = 0$

$T \sin 30° - B_x = 0 \Rightarrow T \sin 30° = B_x$ — (1)

$\Sigma F_y = 0$

$200g + 50g - T\cos 30° - B_y = 0$

$T\cos 30° + B_y = 250g = 2452.5$ — (2)

$\Sigma M_B = 0$

$200g \times \frac{5}{2} \sin 60° + 50g \times 2.5 \sin 60° = T \times 2.5 \times \sin 30°$

$\therefore T = \frac{200g \times 2 \sin 60° + 50g \sin 60°}{\sin 30°}$

$T = 7646.13N$

From (1)

$B_x = T \sin 30° = 7646.13 \sin 30°$

$B_x = 3823.06N$

→ From (2)

$T\cos 30^\circ + B_y = 2452.5$

$B_y = 2452.5 - 7646.13\cos 30^\circ$

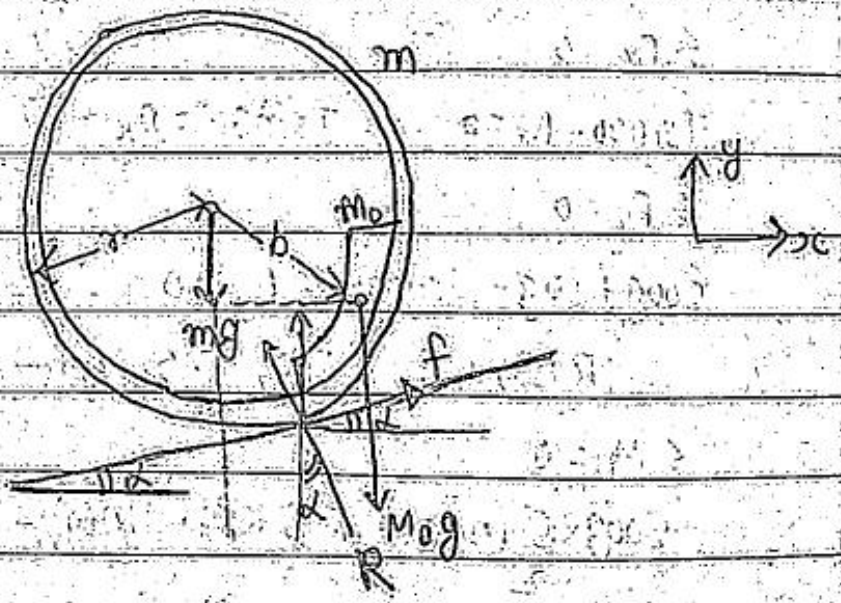
$= 4169.24$

$B = \sqrt{B_x^2 + B_y^2}$

$= \sqrt{(4169.24)^2 + (3823.06)^2}$

$\boxed{B = 5656.70\,N} \sim 5660\,N$

(5)



using conditions of equilibrium,

$\Sigma F_x = 0$

$f\cos\alpha - R\sin\alpha = 0 \Rightarrow f\cos\alpha = R\sin\alpha$ — (1)

$\Rightarrow f = R\tan\alpha$ or $R = f\cot\alpha$

$\Sigma F_y = 0$

$R\cos\alpha + f\sin\alpha - mg - m_0g = 0$ — (2)

$\sum M = 0$

$-m_0 g\, b \sin\theta + fr = 0$ — ③

From ②

$R\cos\alpha + f\sin\alpha - mg - m_0 g = 0$

$f\cos\alpha \times \cos\alpha + f\sin\alpha = (mg + m_0 g)\sin\alpha$

$f(\cos^2\alpha + \sin^2\alpha) = (m+m_0)g\sin\alpha$

$f = (m+m_0)g\sin\alpha$ — ④ [By trigonometric identity $\sin^2\alpha + \cos^2\alpha = 1$]

From ③ and ④

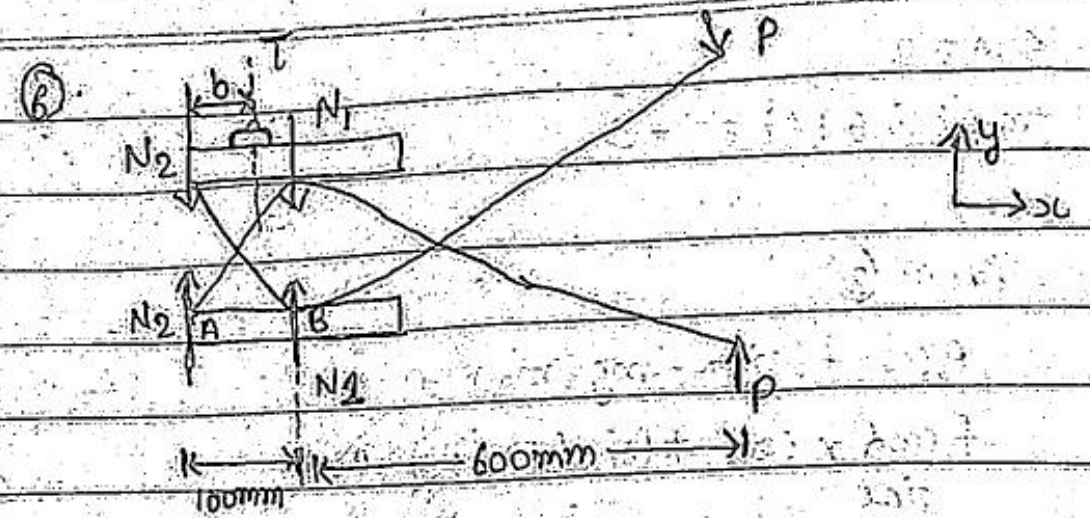
$(m+m_0)rg\sin\alpha = m_0 g b \sin\theta$

$(m+m_0)r\sin\alpha = m_0 b \sin\theta$

$\sin\theta = \left(1 + \frac{m}{m_0}\right)\frac{r}{b}\sin\alpha$

$$\boxed{\theta = \sin^{-1}\left[\left(1 + \frac{m}{m_0}\right)\frac{r}{b}\sin\alpha\right]}$$

(6)



Using condition of equilibrium [Rod L]

$\Sigma f_y = 0$

$N_1 - N_2 - P = 0, \quad N_1 = N_2 + P$ — (i)

$\Sigma M_B = 0$

$N_2 \times 100\,mm - P \times 600\,mm = 0$

$N_2 = \frac{120 \times 600}{100} = 720\,N$

$N_1 = 720 + 120 = 840\,N$

$T = (\text{Splice}) = N_2 + N_1$

$T = 840 + 720 = 1560\,N$

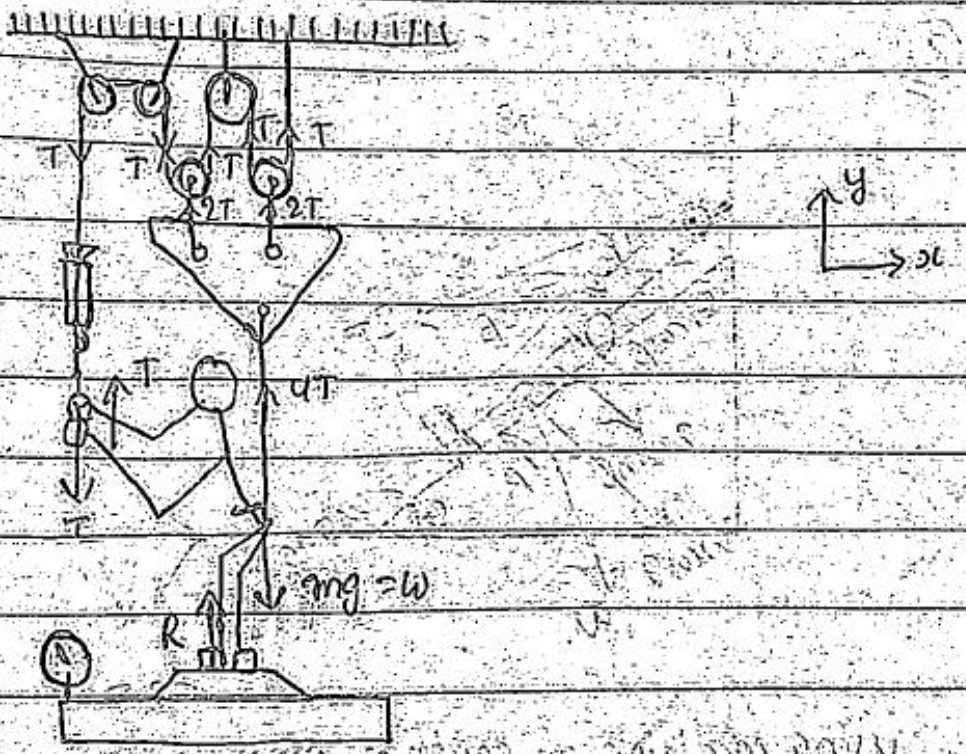
$\boxed{T = 1560\,N}$

$\Sigma M_n = 0$

$b \times T = 700\,mm \times 120\,N$

$b = \frac{700\,mm \times 120\,N}{1560\,N} \Rightarrow \boxed{b = 53.8\,mm}$

(7)



F.B.D

since, system is en equilibrium

$T + 4T + R - w = 0$ (i)

$w = R + 4T + T$

$w = 268 + 5 \times 76$ [given in question]

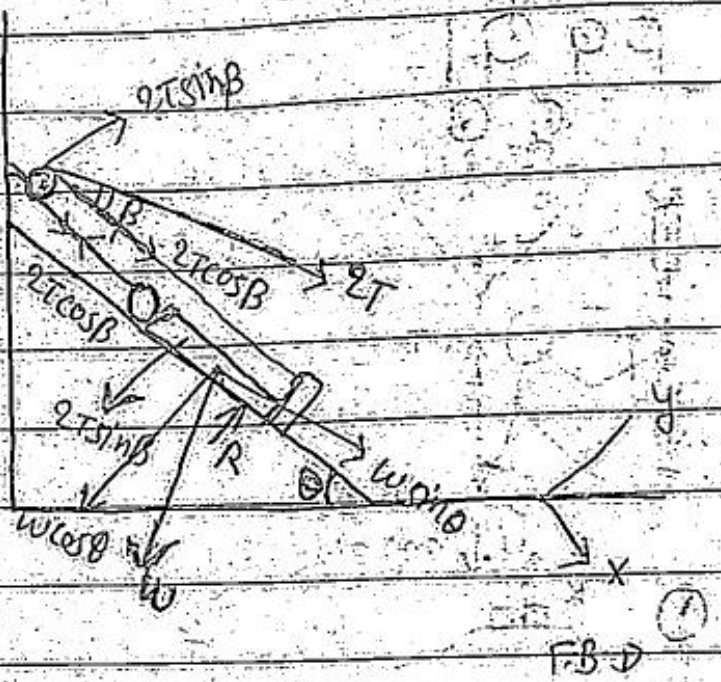
$\boxed{w = 648 N}$

$w = mg \Rightarrow m = \frac{w}{g}$

$m = \frac{648}{9.81} = 66.05 kg$

$\boxed{m = 66.05 kg}$

(8)



F.B.D (1)

using condition of equilibrium;

$\Sigma F_y = 0$

$R - w\cos\theta - 2T\sin\beta = 0$ — (1)

$\Sigma F_x = 0$

$4T\cos\beta = w\sin\theta$ — (2)

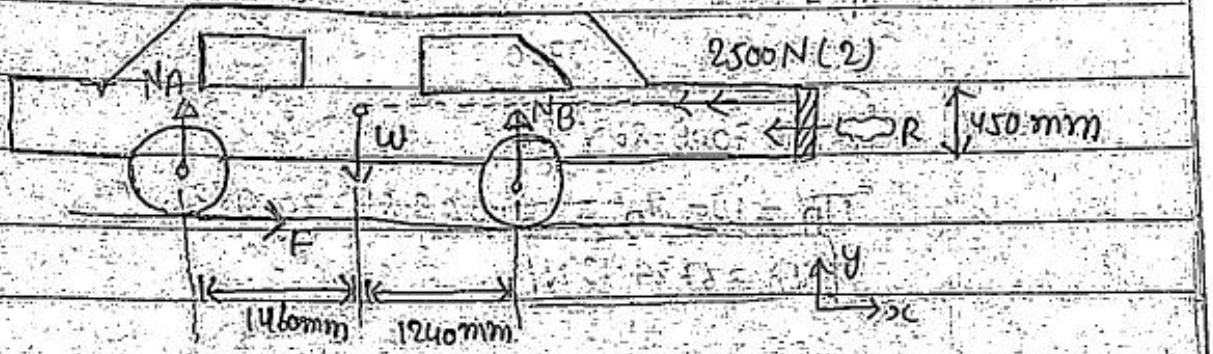
$T = \frac{70 \times 9.81 \times \sin 15^\circ}{4 \times \cos 18^\circ}$

$\boxed{T = 46.71\ N}$

$R = w\cos\theta + 2T\sin\beta$

$\boxed{R = 692.17\ N}$

(9)



case 1. under normal condition

∴ since system is in equilibrium,

$\Sigma F_y = 0$

$N_A + N_B - W = 0 \Rightarrow N_A + N_B = W$ - (1)

$\Sigma M_A = 0$

$N_B(2700mm) - W(1460mm) = 0$

$N_B = \frac{1400 \times 9.81 \times 1460}{2700}$

$N_B = 7426.53 N$

$N_A = (1400 \times 9.81 - 7426.53)$

$= 6307.47 N$

case 2. under test

∴ $\Sigma F_x = 0$

$2500N - R = 0 \Rightarrow R = 2500N$ - (1)

$\Sigma F_y = 0$

$N_A + N_B = W$ - (2)

$\Sigma M_A = 0$

$2500 \times 450 \times N + N_B(2700) - W(1460) = 0$

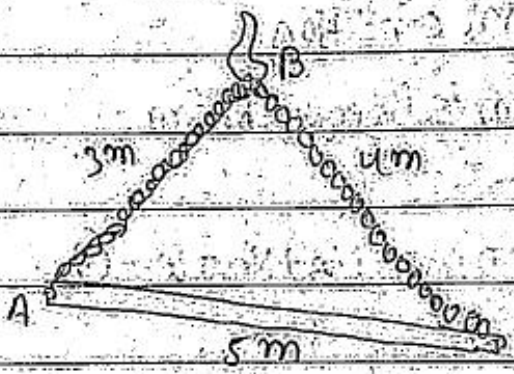
$$N_B = \left(\frac{1400 \times 9.81 \times 1460 - 2500 \times 490}{2700}\right) N$$

$$\boxed{N_B = 7009.86\ N}$$

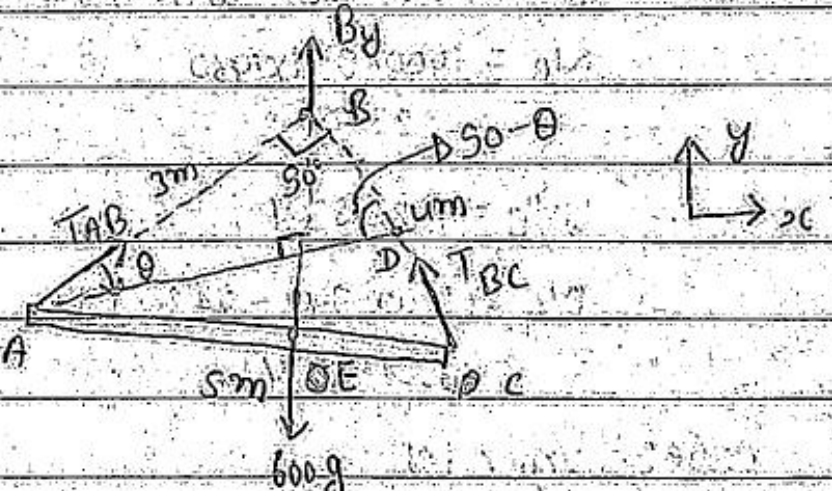
$$N_A = W - N_B = 1400 \times 9.81 - 7009.86$$

$$\boxed{N_A = 6724.13\ N}$$

(10)



FBD



$$\angle BAC = \sin^{-1}\frac{4}{5} = 53.13^\circ$$

$$\angle BCA = 90^\circ - 53.13^\circ = 36.87^\circ$$

$$\angle BCE = \angle BCA + (53.13^\circ - \theta)$$

$$= 53.13^\circ$$

$3\cos\theta = 2.5\cos(53.13 - \theta)$

$\frac{3\cos\theta}{2.5} = \cos(15.13)\cos\theta + \sin 53.13^\circ \cdot \sin\theta$

$\theta = 36.87^\circ$

$\therefore \Sigma F_x = 0$

$T_{AB}\cos\theta - T_{BC}\cos 53.13^\circ = 0$

$\Rightarrow T_{AB}\cos 36.87^\circ - T_{BC}\cos 53.13^\circ = 0$

$T_{BC} = T_{AB} \times 1.333 - (1)$

$\Sigma F_y = 0$

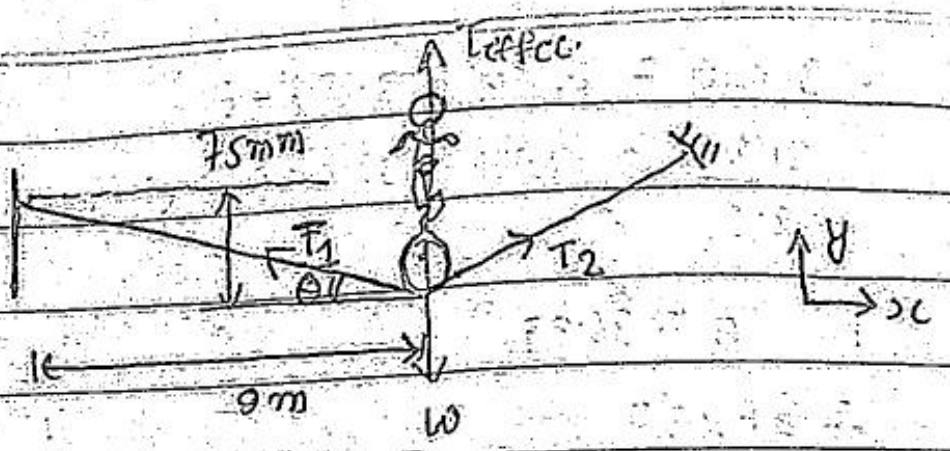
$T_{AB}\sin\theta + T_{BC}\sin 53.13^\circ - W = 0$

$T_{AB}\sin 36.87^\circ + (T_{AB} \times 1.333) \times \sin 53.13^\circ - 600 \times 9.81 = 0$

or $T_{AB} = 3532\,N$

$\boxed{T_{AB} = 3.53\,kN}$

(11)



$\tan\theta = \frac{75\times10^{-3}\ m}{9\ m} \Rightarrow \theta = 0.47$

using the condition of equilibrium;

$\Sigma F_x = 0$

$T_1\cos\theta = T_2\cos\theta \Rightarrow T_1 = T_2$

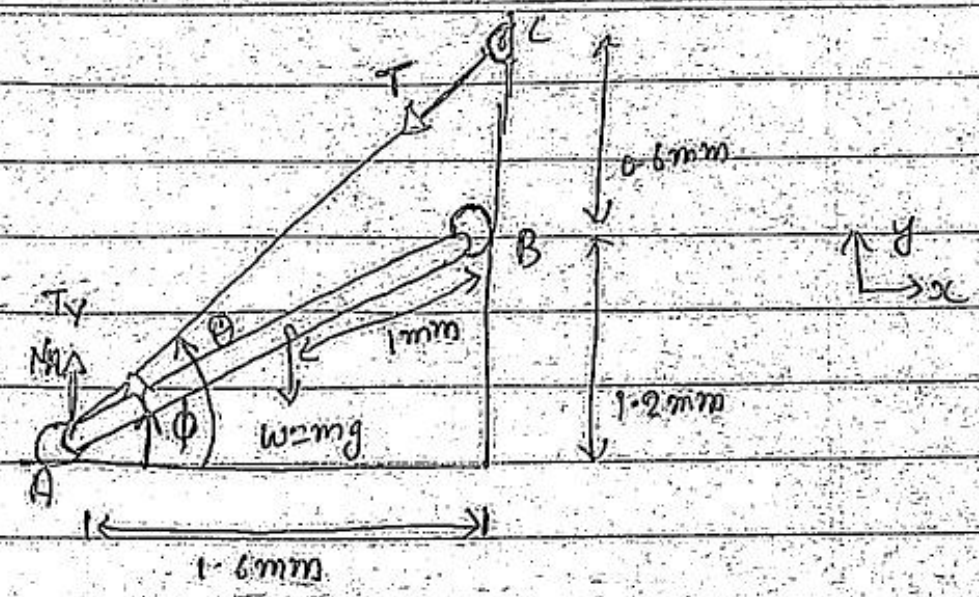
$\Sigma F_y = 0$

$2T\sin\theta = w$

$T = \frac{w}{2\sin\theta} = \frac{50\times9.81}{2\sin0.47} = 2989.76\ N$

$\boxed{T = 29.8\ kN}$

(12)



$AB = \sqrt{1.2^2 + 1.6^2} = 2$

$\tan\theta = \frac{1.2\,mm}{1.6\,mm} \Rightarrow \theta = 48.36$

using condition of equilibrium,

$\Sigma f_x = 0$

$T_x - N_B = 0 \Rightarrow T_x = N_B$ - (1)

$\Sigma f_y = 0$

$T_y + N_A - w = 0$ - (2)

$\Sigma M_A = 0$

$w(1\cos\phi) - N_B(1.2mm) = 0$

$N_B = \frac{30 \times 9.81 \times 1 \times 1.6}{2}$ $\quad \therefore \cos\phi = \frac{1.6}{2}$

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

$T\cos\theta = N_B \Rightarrow T\cos 48.36 = 196.2$

$\boxed{T = 295.28\,N}$

$N_A = w - 295.28 \sin 48.36$ (from (2))

$\boxed{N_A = 73.62\,N}$