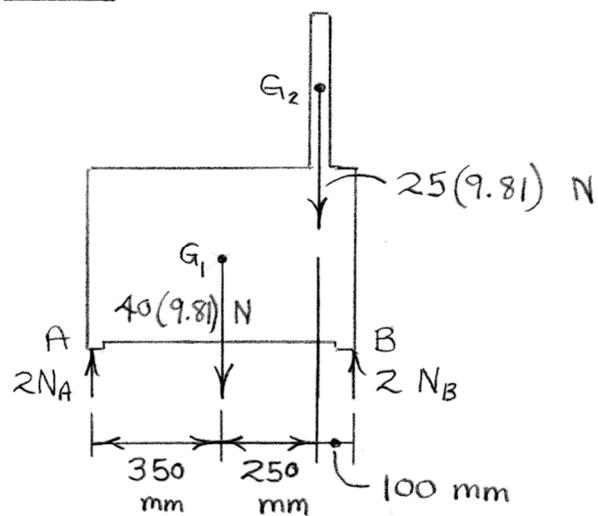


Catalog

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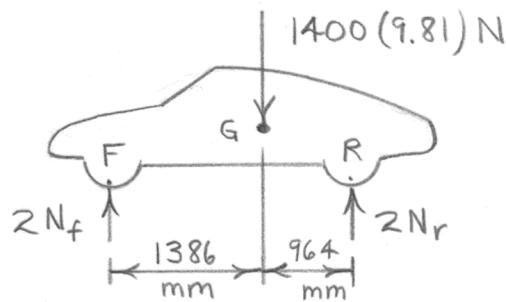


$$+\uparrow \sum F = 0 : 2N_A + 2N_B - (25 + 40)(9.81) = 0$$

$$\begin{aligned} \text{F}_\tau \sum M_A = 0 : & -40(9.81)(350) - 25(9.81)(600) \\ & + 2N_B (700) = 0 \end{aligned}$$

$$\Rightarrow \begin{cases} N_A = 115.6 \text{ N} \\ N_B = 203 \text{ N} \end{cases}$$

3/2



$$\uparrow \sum F = 0 : 2N_f + 2N_r - 1400(9.81) = 0$$

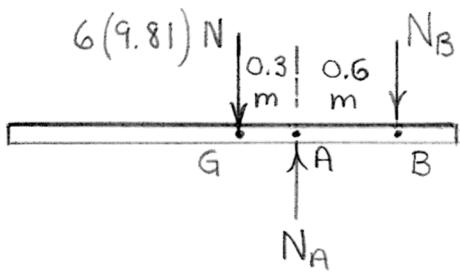
$$\nabla \sum M_F = 0 : -1400(9.81)(1386) + 2N_r(1386 + 964) = 0$$

Solution :
$$\begin{cases} N_f = 2820 \text{ N} \\ N_r = 4050 \text{ N} \end{cases}$$

Assumes G midway between left and right wheels.

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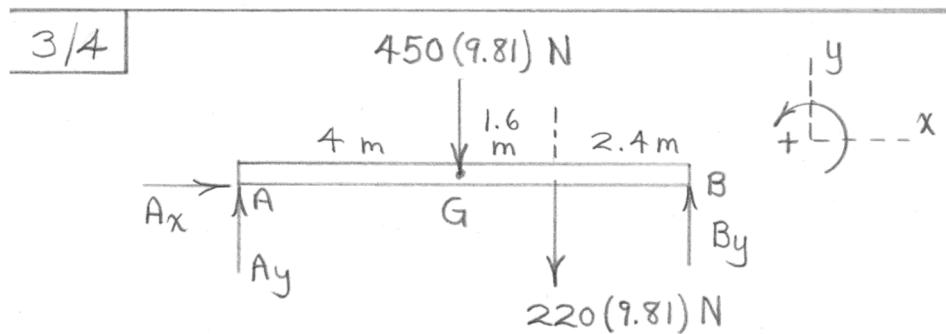
3/3



$$\text{At } \sum M_B = 0: 6(9.81)(0.9) - N_A(0.6) = 0$$

$$N_A = 88.3 \text{ N}$$

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From $\sum F_x = 0$, $A_x = 0$

$\sum M_A = 0 : -450(9.81)4 - 220(9.81)(5.6)$

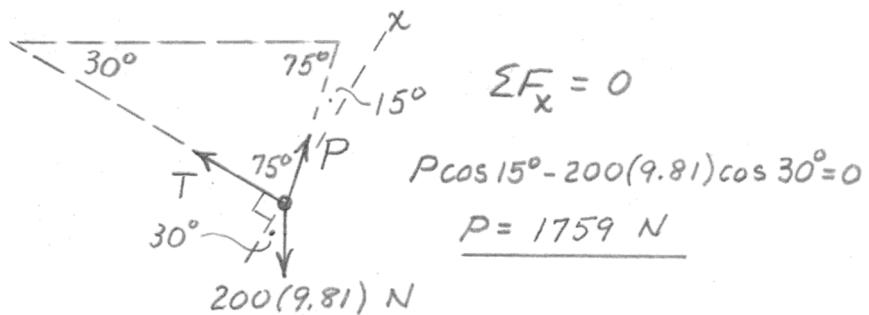
$+ By(8) = 0$, $By = 3720 \text{ N}$

$\sum F_y = 0 : Ay - 450(9.81) - 220(9.81) + 3720 = 0$

$Ay = 2850 \text{ N}$

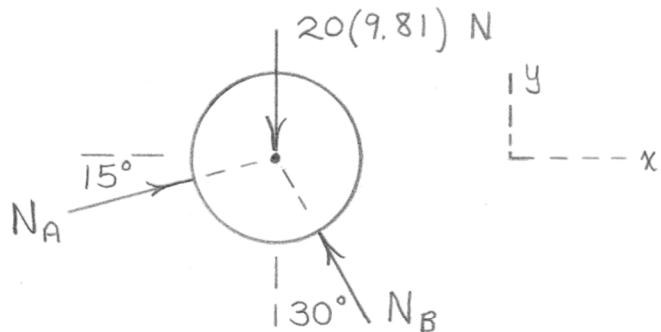
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3/5



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3/6

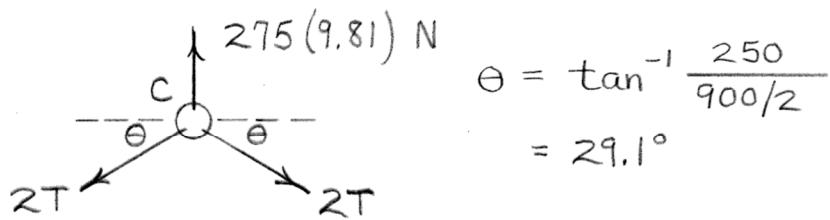


$$\begin{cases} \sum F_x = 0 : N_A \cos 15^\circ - N_B \sin 30^\circ = 0 \\ \sum F_y = 0 : N_A \sin 15^\circ + N_B \cos 30^\circ - 20(9.81) = 0 \end{cases} \quad (1)$$

Solution :
$$\begin{cases} N_A = 101.6 \text{ N} \\ N_B = 196.2 \text{ N} \end{cases} \quad (2)$$

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3/7 FBD of junction ring C:



$$\begin{aligned}\theta &= \tan^{-1} \frac{250}{900/2} \\ &= 29.1^\circ\end{aligned}$$

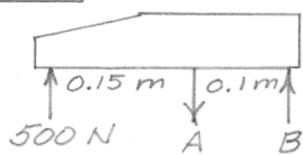
$$\uparrow + \sum F = 0: 275(9.81) - 4T \sin 29.1^\circ = 0$$

$$\underline{T = 1389 \text{ N}}$$

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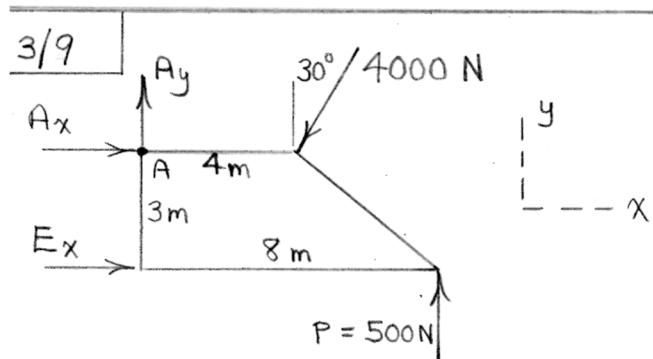
3/8



$$\sum M_B = 0; 500(0.25) - 0.1A = 0$$

$$A = 1250 \text{ N}$$

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$$\sum F_x = 0: A_x + E_x - 4000 \sin 30^\circ = 0$$

$$\sum F_y = 0: A_y - 4000 \cos 30^\circ + 500 = 0$$

$$\sum M_A = 0: E_x(3) + 500(8) - 4000 \cos 30^\circ (4) = 0$$

$$\Rightarrow A_x = -1285 \text{ N}, \quad A_y = 2960 \text{ N}, \quad E_x = 3290 \text{ N}$$

For maximum P : $E_x = 0$ and $\sum M_A = 0$:

$$P(8) - 4000 \cos 30^\circ (4) = 0, \quad P = 1732 \text{ N}$$

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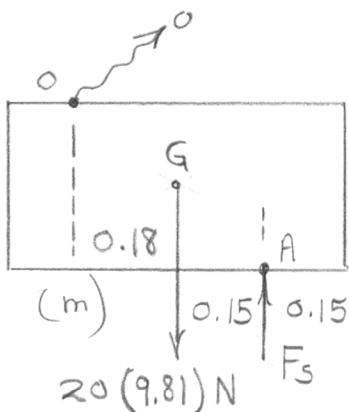
3/10

Diagram showing a horizontal beam of length 1 m. At one end, a force P acts to the left. At the other end, a weight of 1000 N hangs vertically. The beam makes an angle θ with the horizontal. The distance from the point of application of P to the vertical wall is 4 m. The distance from the vertical wall to the point where the beam meets the horizontal wall is 1 m.

$$P = 50(9.81) \tan \theta$$
$$\sin \theta = 1/4$$
$$\tan \theta = 1/\sqrt{4^2 - 1^2} = 0.258$$
$$P = 50(9.81)(0.258) = \underline{126.6 \text{ N}}$$

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3/11



$$\text{At } \sum M_0 = 0 : -20(9.81)(0.18) + F_s(0.18 + 0.15) = 0$$

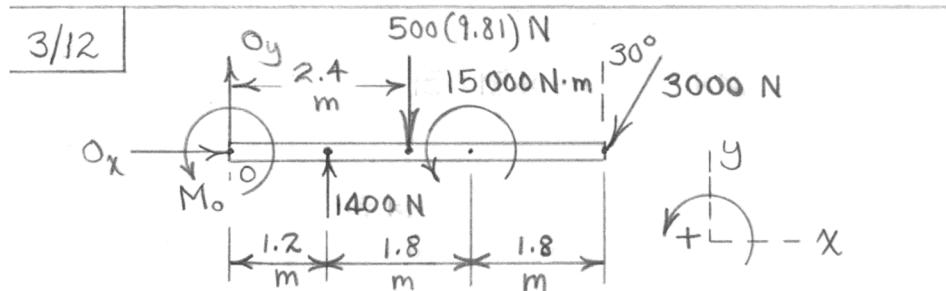
$$F_s = 107.0 \text{ N}$$

$$F_s = k\delta : 107.0 = 2000\delta, \delta = 0.0535 \text{ m}$$

or $\delta = 53.5 \text{ mm}$

$$L = 0.1 + \delta = 0.1 + 0.0535 = 0.1535 \text{ m}$$

or 153.5 mm



$$\sum F_x = 0 : O_x - 3000 \sin 30^\circ = 0 , \quad O_x = 1500 \text{ N}$$

$$\sum F_y = 0 : O_y + 1400 - 500(9.81) - 3000 \cos 30^\circ = 0$$

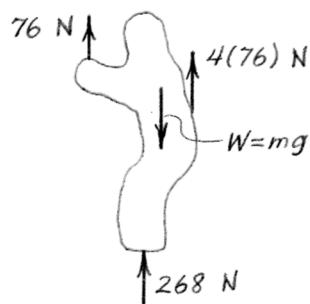
$$O_y = 6100 \text{ N}$$

$$\begin{aligned} \sum M_o = 0 : M_o + 1400(1.2) - 500(9.81)(2.4) \\ + 15000 - (3000 \cos 30^\circ)(4.8) = 0 \end{aligned}$$

$$M_o = 7560 \text{ N} \cdot \text{m}$$

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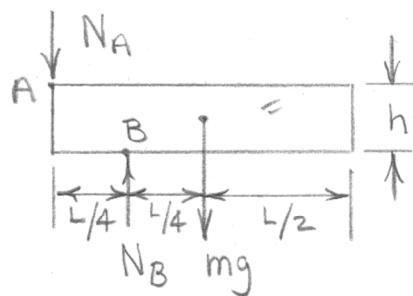


$$\sum F = 0: 76 + 4(76) + 268 - W = 0$$

$$W = 648 \text{ N}$$

$$m = \frac{W}{g} = \frac{648}{9.81} = 66.1 \text{ kg}$$

3/14



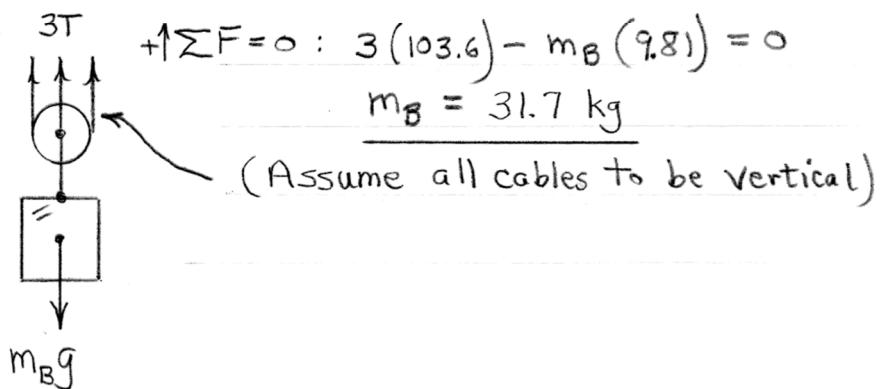
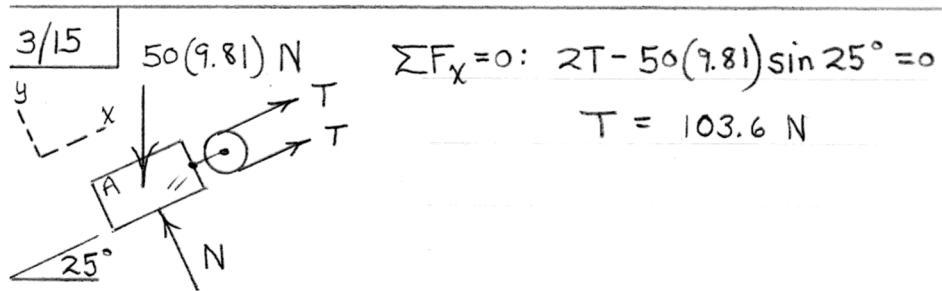
$$\uparrow \sum F = 0 : N_B - N_A - mg = 0$$

$$\leftarrow \sum M_A = 0 : N_B \left(\frac{L}{4} \right) - mg \left(\frac{L}{2} \right) = 0$$

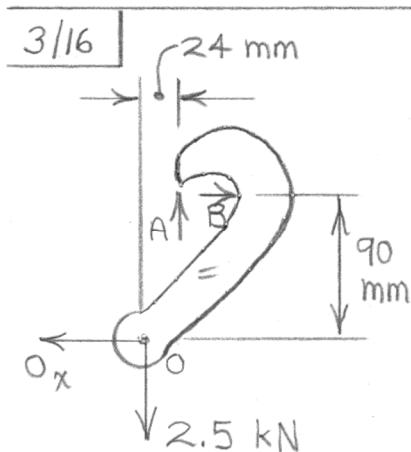
Solution : $\begin{cases} N_A = mg & (\text{down}) \\ N_B = 2mg & (\text{up}) \end{cases}$

The height h has no bearing on the above results, assuming no friction at A and B.

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From vertical equilibrium,

$$A = 2.5 \text{ kN}$$

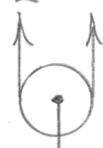
$\sum M_O = 0:$

$$2.5(24) - B(90) = 0$$
$$B = 0.667 \text{ kN}$$

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$T_2 \quad T_2$

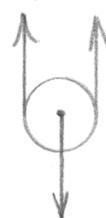


$100(9.81)$ N

$$\text{From } \uparrow \sum F = 0, \quad T_2 = \frac{100(9.81)}{2}$$

$$T_2 = 490 \text{ N}$$

$T_1 \quad T_1$

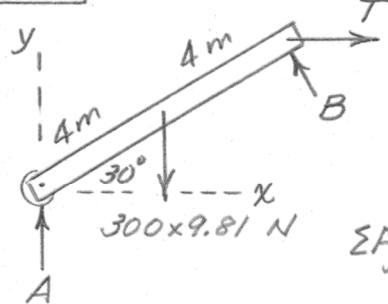


$$T_2 = 490 \text{ N}$$

$$\begin{aligned} \text{Similarly, } T_1 &= \frac{1}{2} T_2 \\ &= \frac{1}{2} (490) = \underline{\underline{245 \text{ N}}} \end{aligned}$$

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$$\sum M_B = 0;$$

$$300(9.81) 4 \cos 30^\circ - 8A \cos 30^\circ = 0,$$

$$A = 1472 \text{ N}$$

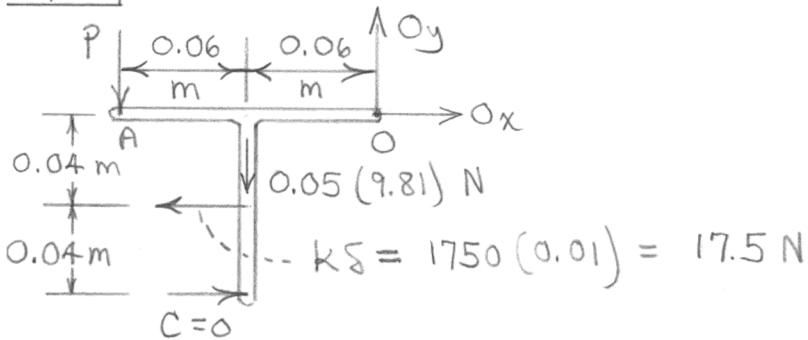
$$\sum F_y = 0; B \cos 30^\circ + 1472 - 300(9.81) = 0$$

$$B = 1699 \text{ N}$$

$$\sum F_x = 0; T - 1699 \sin 30^\circ = 0, \quad T = 850 \text{ N}$$

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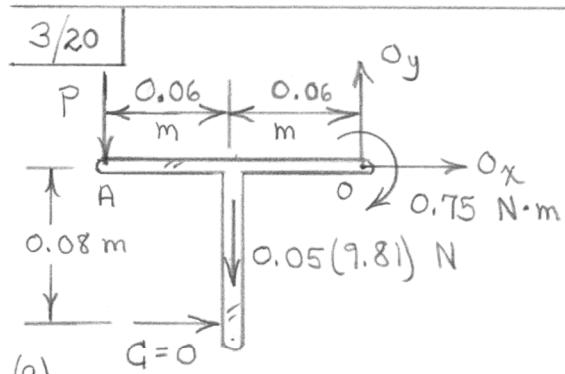
3/19



$$(a) \text{ If } \sum M_O = 0: P(0.12) + 0.05(9.81)(0.06) - 17.5(0.04) = 0 \\ P = 5.59 \text{ N}$$

$$(b) \text{ If } \sum M_O = 0: P(0.12) - 17.5(0.04) = 0 \\ P = 5.83 \text{ N}$$

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(a)

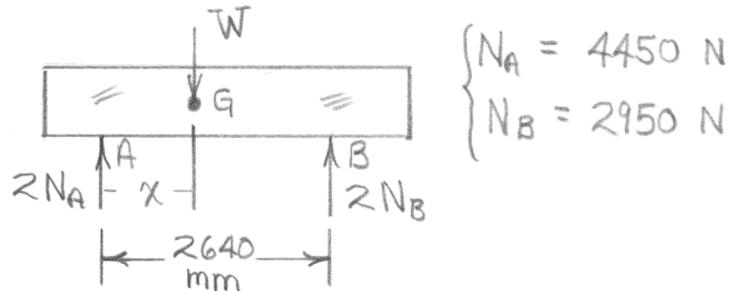
$$\text{At } \sum M_O = 0 : P(0.12) + 0.05(9.81)(0.06) - 0.75 = 0$$
$$P = 6.00 \text{ N}$$

(b)

$$\text{At } \sum M_O = 0 : P(0.12) - 0.75 = 0$$
$$P = 6.25 \text{ N}$$

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3/21 | Car modeled as a slab and viewed from the driver's (left) side :



$$\uparrow \sum F = 0 : 2(4450) + 2(2950) - W = 0$$

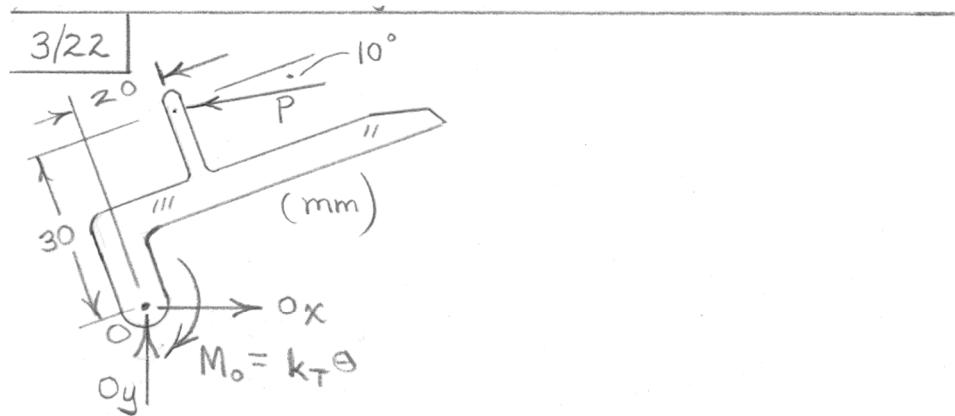
$$W = 14800 \text{ N}$$

$$m = \frac{W}{g} = \frac{14800}{9.81} = 1509 \text{ kg}$$

$$\nabla \sum M_A = 0 : - 14800x + 2(2950)(2640) = 0$$

$$x = 1052 \text{ mm}$$

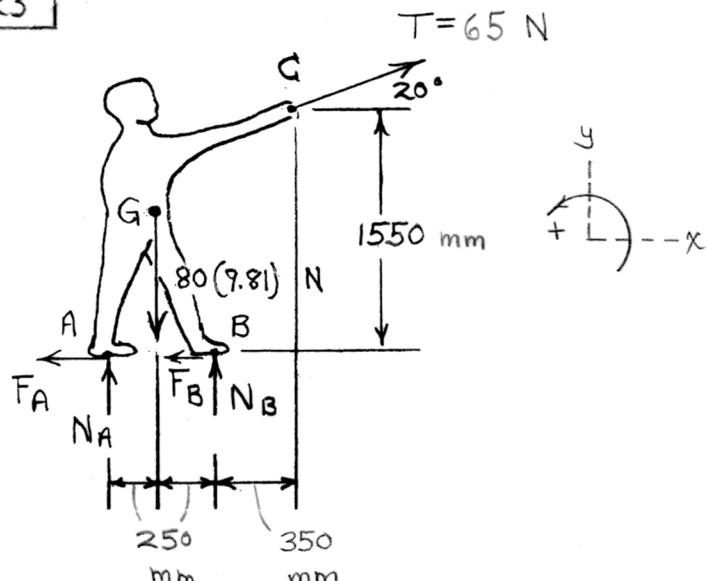
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$$\text{At } \sum M_o = 0 : P \cos 10^\circ (30) + P \sin 10^\circ (20) - 3400 \left(25 \frac{\pi}{180} \right) = 0$$
$$\underline{P = 44.9 \text{ N}}$$

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3/23

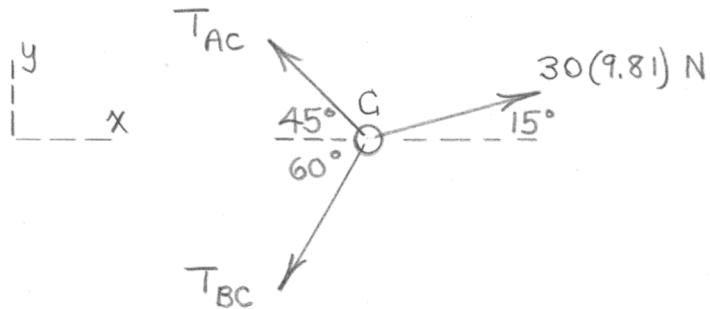


$$\sum F_y = 0 : N_A + N_B - 80(9.81) + 65 \sin 20^\circ = 0$$

$$\begin{aligned} \sum M_B = 0 : 80(9.81)(250) - N_A(500) - 65[1550 \cos 20^\circ \\ - 350 \sin 20^\circ] = 0 \end{aligned}$$

Solution :
$$\begin{cases} N_A = 219 \text{ N} \\ N_B = 544 \text{ N} \end{cases}$$

3/24 FBD of junction ring C:



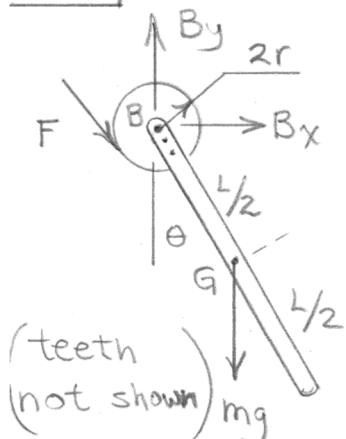
$$\begin{cases} \sum F_x = 0 : -T_{AC} \cos 45^\circ - T_{BC} \cos 60^\circ + 30(9.81) \cos 15^\circ = 0 \\ \sum F_y = 0 : T_{AC} \sin 45^\circ - T_{BC} \sin 60^\circ + 30(9.81) \sin 15^\circ = 0 \end{cases}$$

Solve simultaneously to obtain

$$\begin{cases} T_{AC} = 215 \text{ N} \\ T_{BC} = 264 \text{ N} \end{cases}$$

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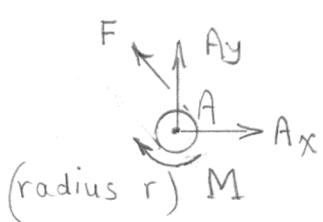
3/25



$$\text{Sum of moments about } B = 0:$$

$$F(2r) - mg \frac{L}{2} \sin \theta = 0$$

$$F = \frac{1}{4r} mg L \sin \theta$$



$$\text{Sum of moments about } A = 0:$$

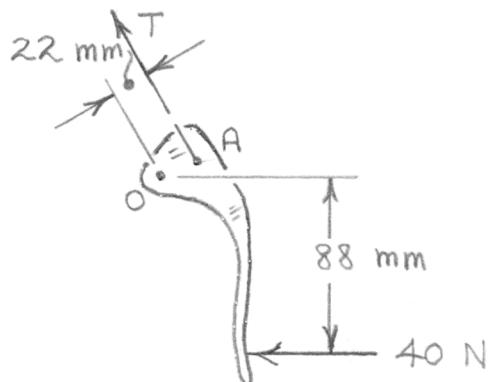
$$-M + Fr = 0$$

$$M = \frac{1}{4} mg L \sin \theta$$

(CW)

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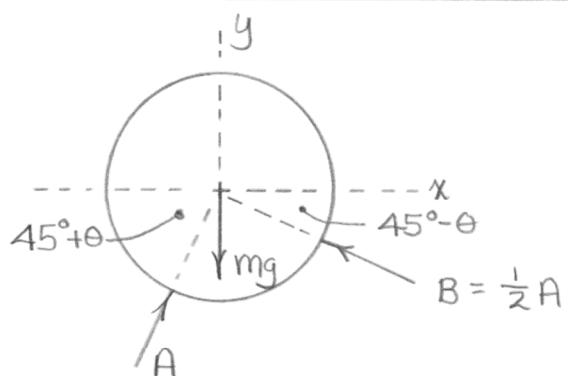
3/26 FBD of brake lever:



$$\text{Sum of moments about pivot A: } T(22) - 40(88) = 0$$
$$\underline{T = 160 \text{ N}}$$

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3/27



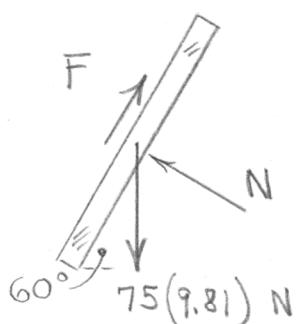
$$\sum F = 0 :$$

$$B = \frac{1}{2} A \quad \tan(45^\circ - \theta) = \frac{A/2}{A} = \frac{1}{2}$$
$$45^\circ - \theta = 26.6^\circ$$
$$\underline{\theta = 18.43^\circ}$$

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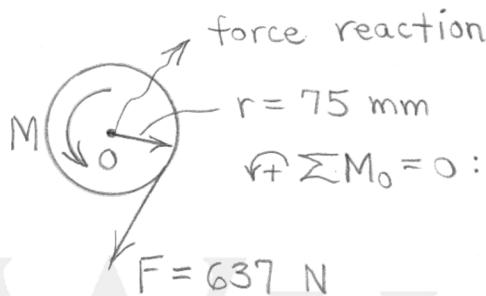
Rack :



$$+\uparrow \sum F = 0 : F - 75(9.81) \sin 60^\circ = 0$$

$$F = 637 \text{ N}$$

Gear wheel :



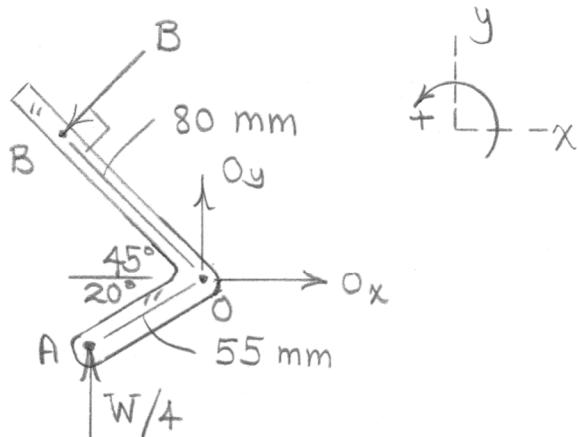
force reaction

$$r = 75 \text{ mm}$$

$$+\uparrow \sum M_O = 0 : M - 637(0.075) = 0$$

$$\underline{M = 47.8 \text{ N}\cdot\text{m}}$$

3/29



$$\sum M_0 = 0 : B(80) - \frac{W}{4} (55 \cos 20^\circ) = 0$$

$$B = 0.1615W$$

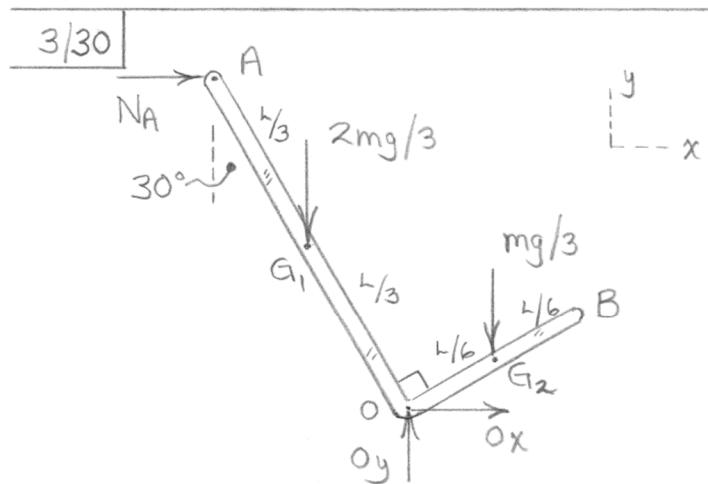
$$\sum F_x = 0 : -0.1615W \cos 45^\circ + O_x = 0$$

$$O_x = 0.1142W$$

$$\sum F_y = 0 : O_y - 0.1615W \sin 45^\circ + \frac{W}{4} = 0$$

$$O_y = -0.1358W$$

$$O = \sqrt{O_x^2 + O_y^2} = \underline{0.1774W}$$



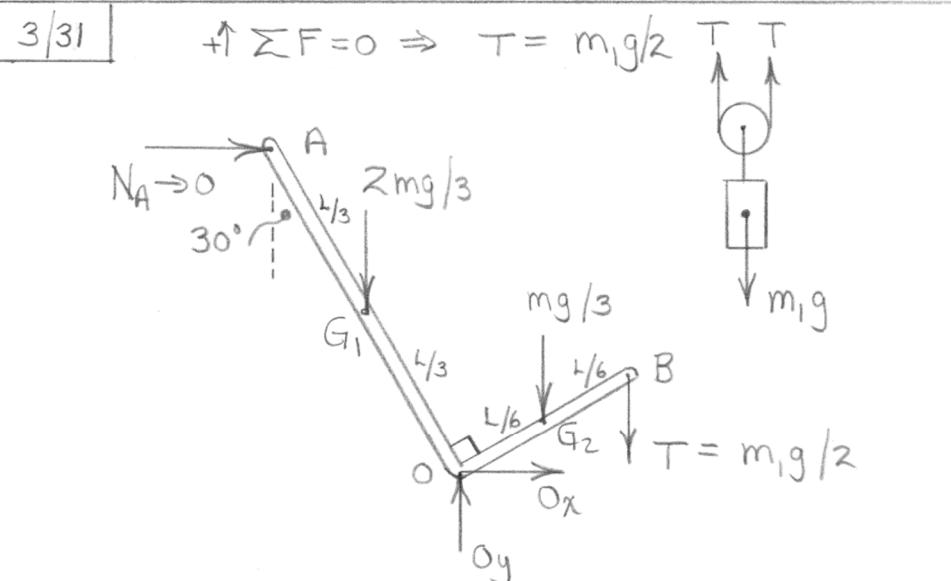
$$\text{If } \sum M_O = 0 : -N_A \left(\frac{2L}{3} \cos 30^\circ \right) + \frac{2mg}{3} \left(\frac{L}{3} \sin 30^\circ \right) - \frac{mg}{3} \left(\frac{L}{6} \cos 30^\circ \right) = 0$$

$$N_A = 0.1091 mg$$

$$\sum F_y = 0 \Rightarrow Oy = mg$$

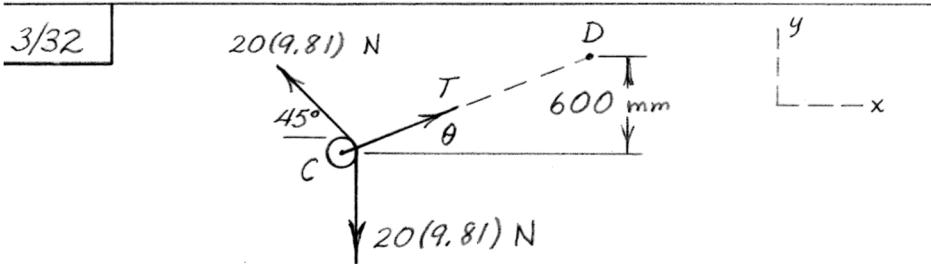
$$\sum F_x = 0 \Rightarrow Ox = -0.1091 mg$$

$$O = \sqrt{O_x^2 + O_y^2} = \underline{1.006 mg}$$



$$\text{At } O: \sum M_O = 0 : \frac{2mg}{3} \left(\frac{L}{3} \sin 30^\circ \right) - \frac{mg}{3} \left(\frac{L}{6} \cos 30^\circ \right) - \frac{m_1 g}{2} \left(\frac{L}{3} \cos 30^\circ \right)$$

$$m_1 = 0.436 \text{ m}$$



$$\sum F_x = 0: T \cos \theta - 20(9.81) \cos 45^\circ = 0$$

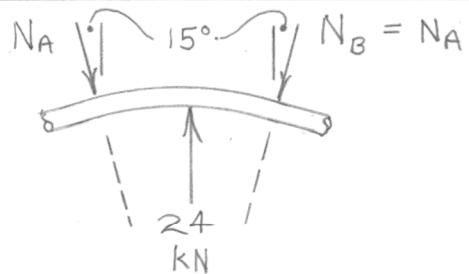
$$\sum F_y = 0: T \sin \theta + 20(9.81) \sin 45^\circ - 20(9.81) = 0$$

Solve to obtain $\theta = 22.5^\circ$, $T = 150.2 \text{ N}$

$$\frac{600}{CD} = \sin \theta = \sin 22.5^\circ, \overline{CD} = 1568 \text{ mm}$$

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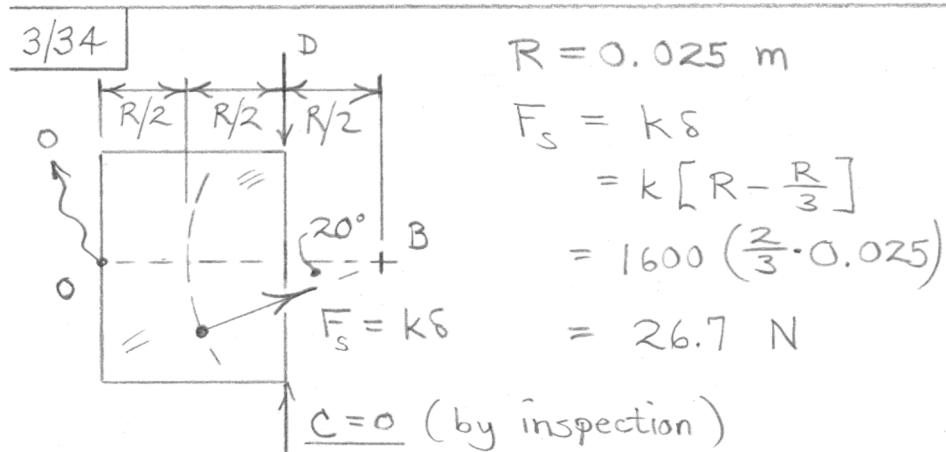
3/33



$$\uparrow \sum F = 0: 24 - 2N_A \cos 15^\circ = 0$$

$$N_A = N_B = 12.42 \text{ kN}$$

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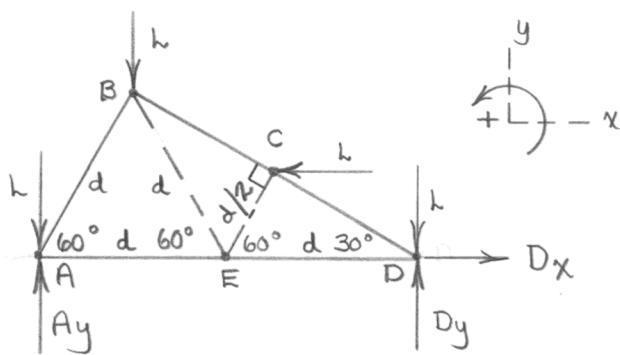


$$\text{Sum of moments about } O: 26.7 \sin 20^\circ \left(\frac{3}{2} \cdot 0.025 \right) - D(0.025) = 0$$

$D = 13.68 \text{ N}$

WILEY

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$$\sum F_x = 0 : D_x - L = 0 , \quad D_x = L$$

$$\sum F_y = 0 : A_y + D_y - 3L = 0$$

$$\sum M_A = 0 : D_y(2d) + L\left(\frac{d}{2}\frac{\sqrt{3}}{2}\right) - L\left(\frac{d}{2}\right) - L(2d) = 0$$

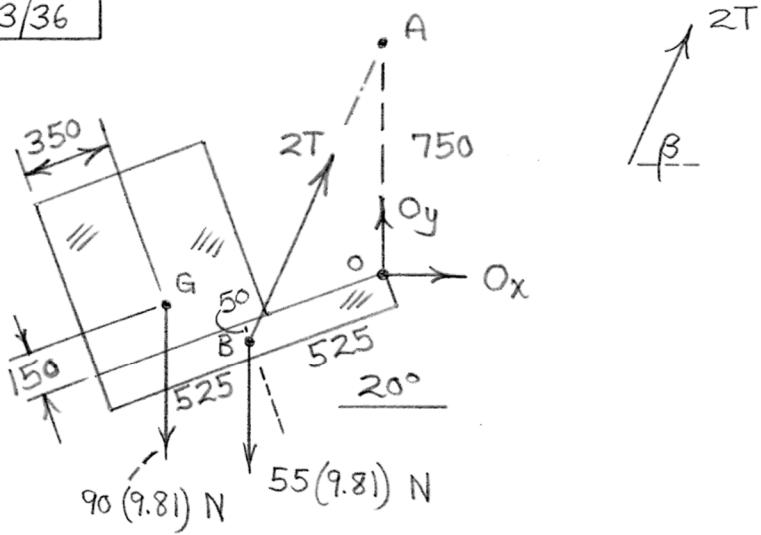
$$\text{Solving the last 2 equations : } A_y = \frac{L}{4}\left(7 + \frac{\sqrt{3}}{2}\right)$$

$$D_y = \frac{L}{4}\left(5 - \frac{\sqrt{3}}{2}\right)$$

$$(\text{or } A_y = 1.967L , \quad D_y = 1.033L)$$

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$$\beta = \cot^{-1} \left[\frac{525 \cos 20^\circ - 50 \sin 20^\circ}{750 + 525 \sin 20^\circ + 50 \cos 20^\circ} \right]$$

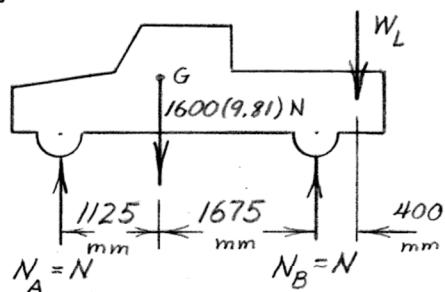
$$= 64.0^\circ$$

$\nabla \sum M_o = 0 : 55(9.81)(525 \cos 20^\circ - 50 \sin 20^\circ)$

 $+ 90(9.81)[(1050 - 350) \cos 20^\circ + 150 \sin 20^\circ]$
 $- 2T \cos \beta (750) = 0$ (transmissibility used
on $2T \rightarrow$ point A)

Solving, $T = 1343 \text{ N}$

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$$\textcircled{+} \sum M_A = 0: 1600(9.81)1.125 - N(2.80) + W_L(3.20) = 0$$

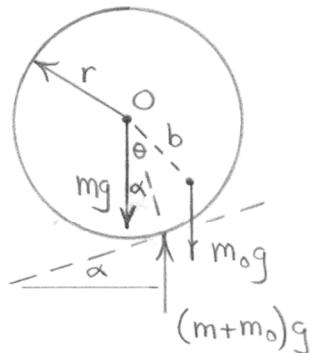
$$\uparrow \sum F = 0: 2N - 1600(9.81) - W_L = 0$$

Solve to obtain $N = 9050 \text{ N}$

$$W_L = 2400 \text{ N}$$

$$m_L = \frac{W_L}{g} = \frac{2400}{9.81} = \underline{\underline{244 \text{ kg}}}$$

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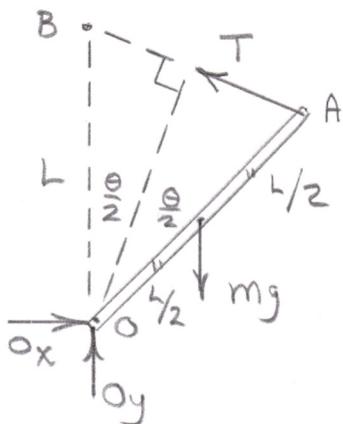


$$\text{At } \sum M_O = 0 : (m+m_0)g r \sin \alpha - m_0 g b \sin \theta = 0$$
$$\Rightarrow \theta = \sin^{-1} \left\{ \frac{r}{b} \left(1 + \frac{m}{m_0} \right) \sin \alpha \right\}$$

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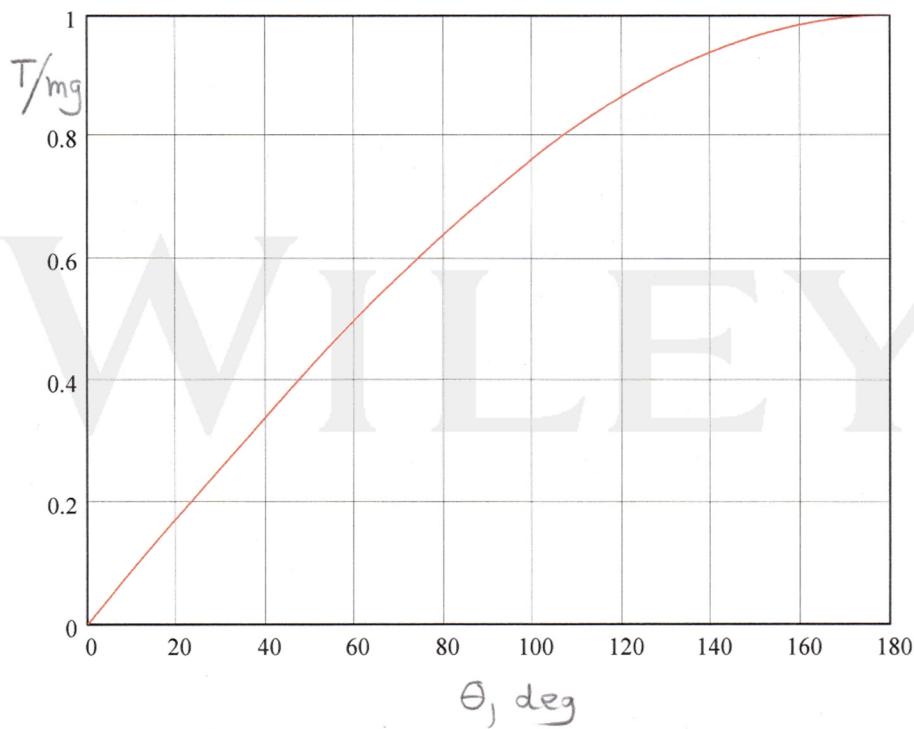
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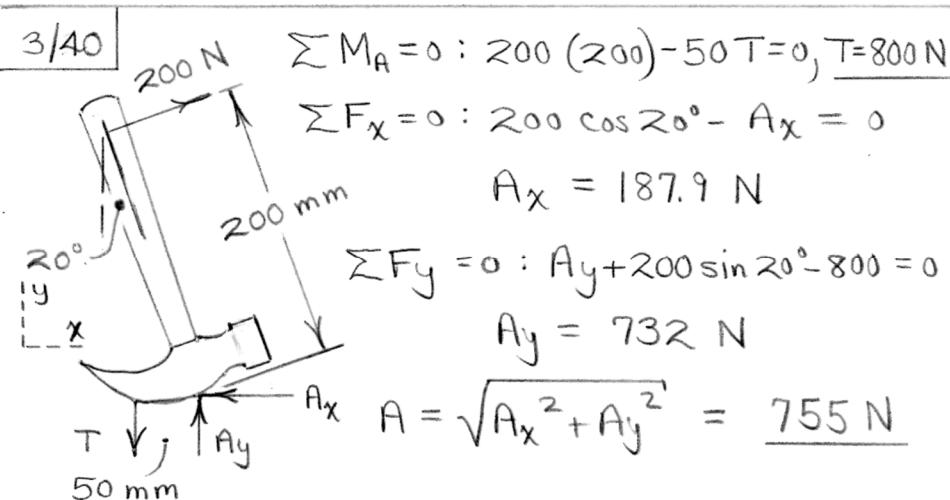
$$\sqrt{+} \sum M_O = 0 : T(L \cos \theta) - mg\left(\frac{L}{2} \sin \theta\right) = 0$$



$$T = \frac{m g \sin \theta}{2 \cos \frac{\theta}{2}}$$

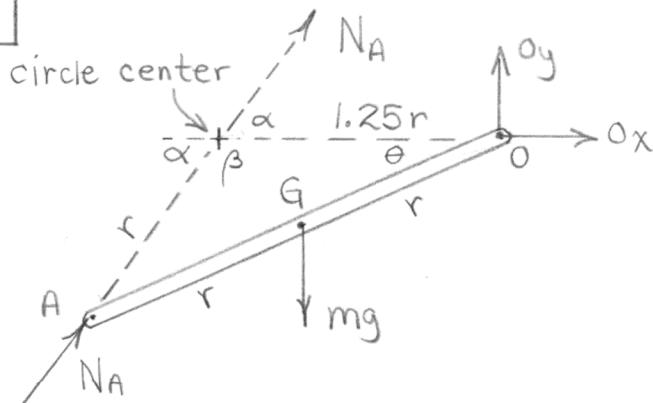
$$T_{40^\circ} = 0.342 mg$$





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$$r^2 = (1.25r)^2 + (2r)^2 - 2(1.25r)(2r) \cos \theta$$

$$\theta = 24.1^\circ$$

$$\frac{\sin \beta}{2r} = \frac{\sin \theta}{r} \Rightarrow \beta = 125.1^\circ$$

$$\alpha = 180^\circ - \beta = 54.9^\circ$$

$$\nabla \sum M_O = 0: (N_A \sin 54.9^\circ)(1.25) - mg(r \cos 24.1^\circ) = 0$$

$$N_A = 0.892mg$$

$$\nabla \sum F_x = 0: O_x + 0.892mg \cos 54.9^\circ = 0$$

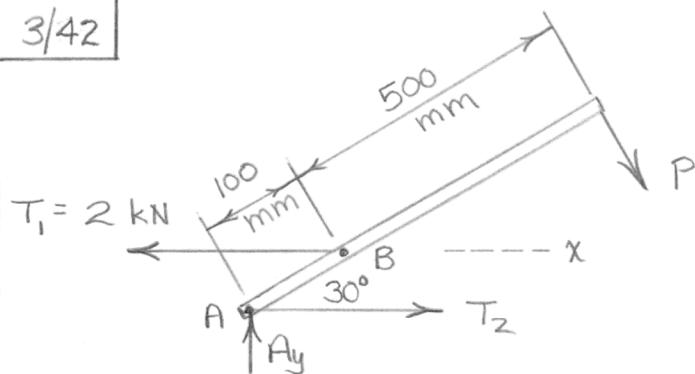
$$O_x = -0.513mg$$

$$\nabla \sum F_y = 0: O_y + 0.892mg \sin 54.9^\circ - mg = 0$$

$$O_y = 0.270mg$$

$$O = \sqrt{O_x^2 + O_y^2} = \underline{0.580mg}$$

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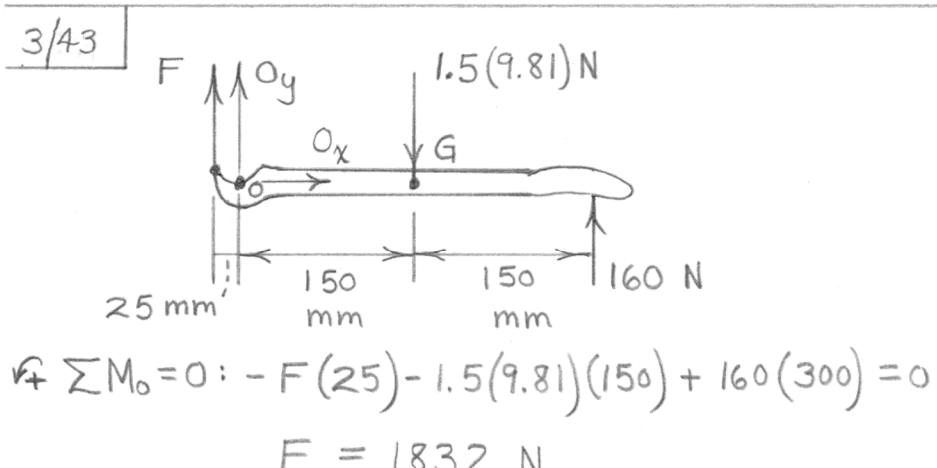
$$+\text{r} \sum M_A = 0: P(500 + 100) - 2(100 \sin 30^\circ) = 0$$

$$P = 0.1667 \text{ kN} \quad \text{or} \quad \underline{P = 166.7 \text{ N}}$$

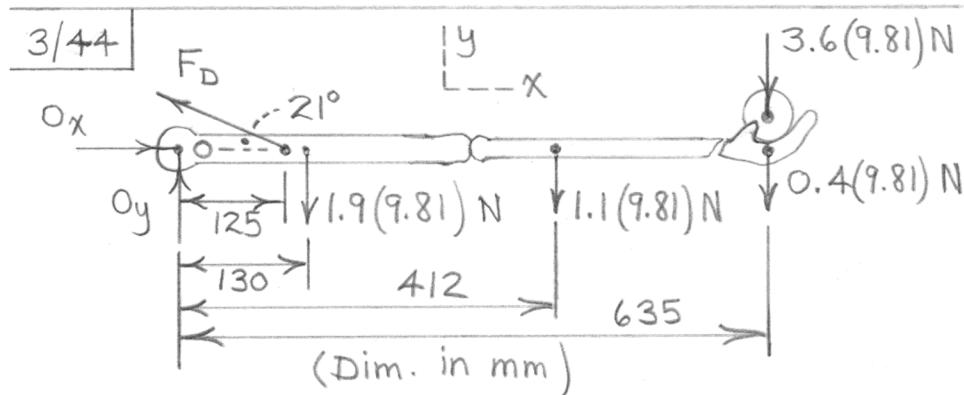
$$\sum F_x = 0: 0.1667 \sin 30^\circ + T_2 - 2 = 0$$

$$\underline{T_2 = 1.917 \text{ kN}}$$

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$$\text{At } \sum M_O = 0: F_D \sin 21^\circ (125) - 1.9(9.81)(130) - 1.1(9.81)(412) - (3.6 + 0.4)(9.81)(635) = 0$$

$$\underline{F_D = 710 \text{ N}}$$

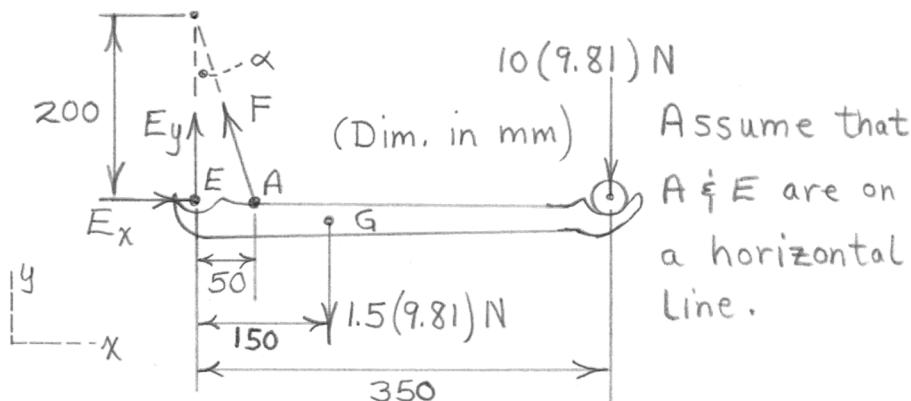
$$\therefore \sum F_x = 0: O_x - 710 \cos 21^\circ = 0, \underline{O_x = 662 \text{ N}}$$

$$+ \sum F_y = 0: O_y + 710 \sin 21^\circ - (1.9 + 1.1 + 3.6 + 0.4) 9.81 = 0, \underline{O_y = -185.6 \text{ N}}$$

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$$\alpha = \tan^{-1} \left(\frac{50}{200} \right) = 14.04^\circ$$



$$+\sum M_E = 0 : F \cos 14.04^\circ (50) - 1.5(9.81)(150) - 10(9.81)(350) = 0, \quad F = 753 \text{ N}$$

$$\sum F_x = 0 : -753 \sin 14.04^\circ + E_x = 0$$

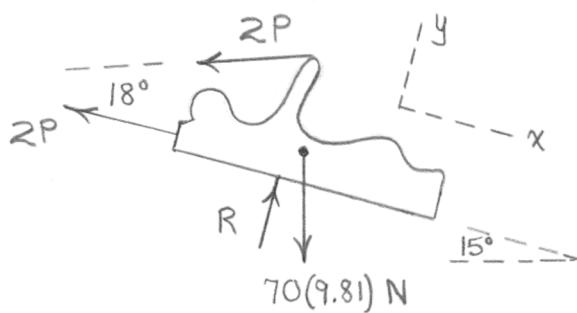
$$E_x = 182.7 \text{ N}$$

$$\sum F_y = 0 : 753 \cos 14.04^\circ - (10 + 1.5)(9.81) + E_y = 0$$

$$E_y = -618 \text{ N}$$

$$E = \sqrt{E_x^2 + E_y^2} = \sqrt{182.7^2 + 618^2} = 644 \text{ N}$$

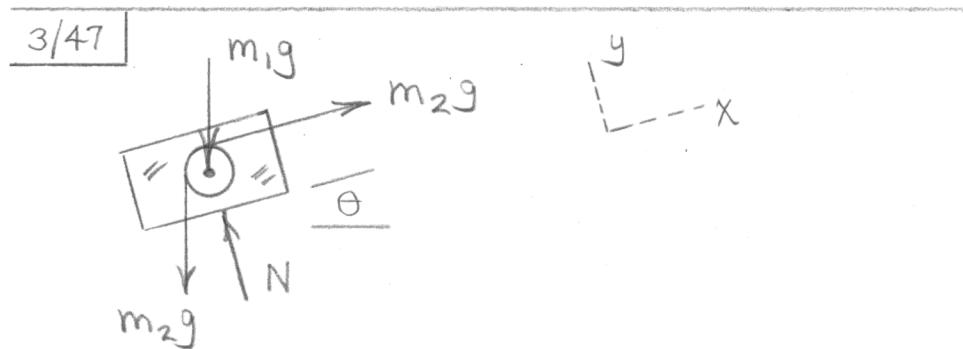
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$$\sum F_x = 0 : 70(9.81) \sin 15^\circ - 2P - 2P \cos 18^\circ = 0$$
$$P = 45.5 \text{ N}$$

$$\sum F_y = 0 : R - 70(9.81) \cos 15^\circ - 2(45.5) \sin 18^\circ = 0$$
$$R = 691 \text{ N}$$

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$$\sum F_x = 0 : m_2 g - m_1 g \sin \theta - m_2 g \sin \theta = 0$$

$$m_2 = \frac{m_1 \sin \theta}{1 - \sin \theta}$$

$$\theta = 15^\circ : m_2 = 0.349 m_1$$

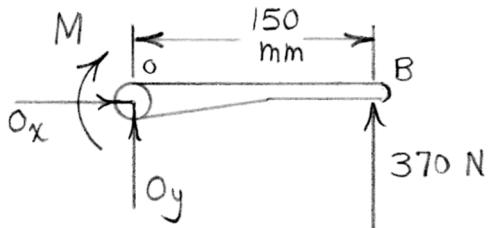
$$\theta = 45^\circ : m_2 = 2.41 m_1$$

$$\theta = 60^\circ : m_2 = 6.46 m_1$$

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Arm OB:



$$\text{At } \sum M_O = 0: 370(0.150) - M = 0$$

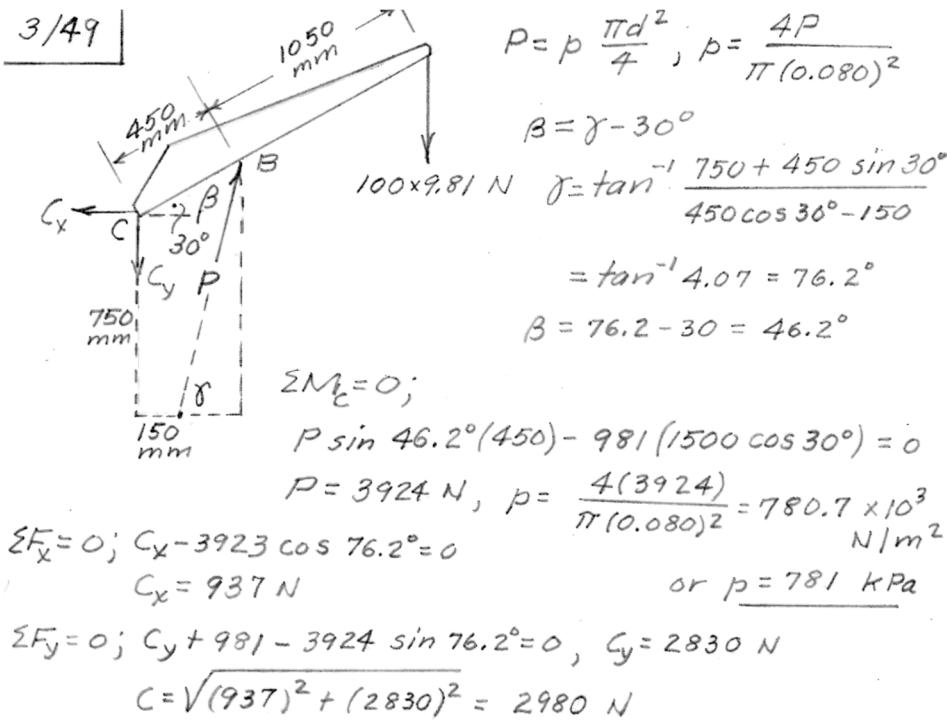
$$M = 55.5 \text{ N}\cdot\text{m}$$

$$F \cos 20^\circ (0.375) = M = 55.5$$

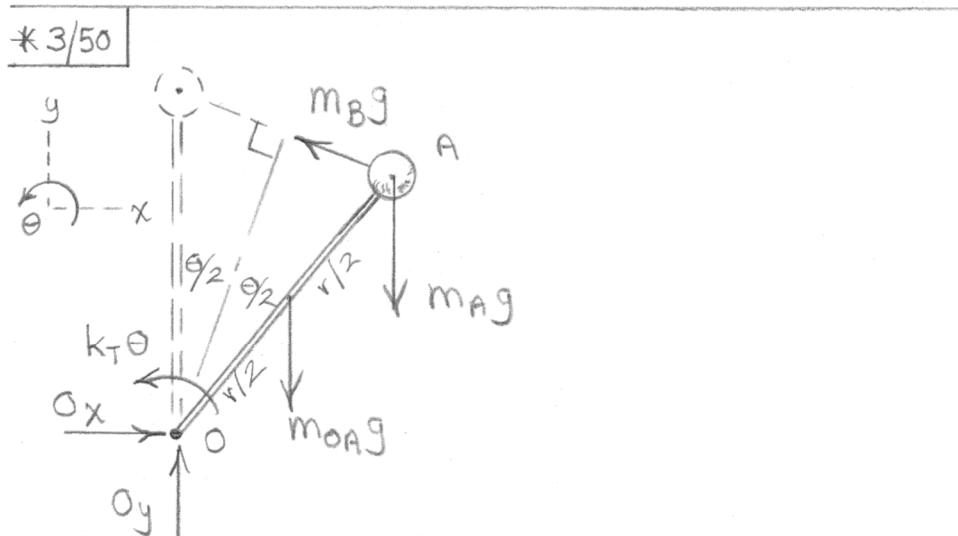
$$F = 157.5 \text{ N}$$

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$$\sum M_O = 0 : k_T \theta + m_B g \left(r \cos \frac{\theta}{2} \right)$$

$$-m_A g r \sin \theta - m_A g \frac{r}{2} \sin \theta = 0$$

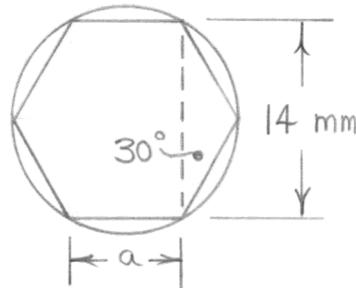
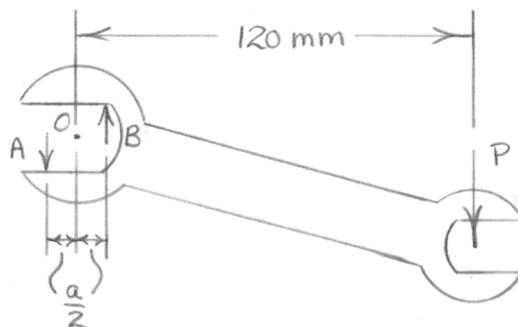
With $k_T = 50 \text{ N}\cdot\text{m}/\text{rad}$, $m_A = 10 \text{ kg}$,

$m_B = 1 \text{ kg}$, and

$r = 0.8 \text{ m}$, solve for θ to obtain

$$\underline{\theta = 9.40^\circ} \text{ and } \underline{\theta = 103.7^\circ}$$

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$$2a \cos 30^\circ = 14, \quad \frac{a}{2} = 4.04 \text{ mm}$$

$$\nabla + \sum M_o = 0: 0.120P - 24 = 0, \quad P = 200 \text{ N}$$

(for wrench and bolt)

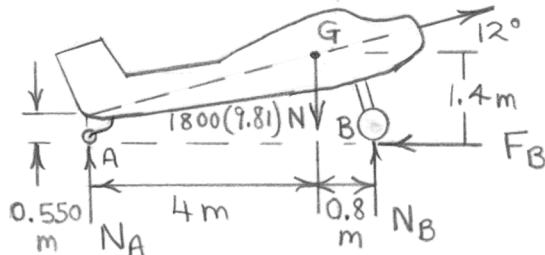
For wrench alone,

$$\nabla + \sum M_A = 0: 200(0.120 + 0.00404) - B(2 \cdot 0.00404) = 0, \quad B = 3070 \text{ N}$$

$$+\uparrow \sum F = 0: -A + 3070 - 200 = 0, \quad A = 2870 \text{ N}$$

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$$T = 3000 \text{ N}$$



$$\text{Engine off: } T = 0, F_B = 0$$

$$\begin{cases} \sum M_A = 0: 1800(9.81)4 - N_B(4.8) = 0 & N_B = 14720 \text{ N} \\ \sum F_y = 0: N_A + 14720 - 1800(9.81) = 0, & N_A = 2940 \text{ N} \end{cases}$$

$$\sum M_A = 0: 1800(9.81)4 - N'_B(4.8) + 3000 \cos 12^\circ (0.550) = 0$$

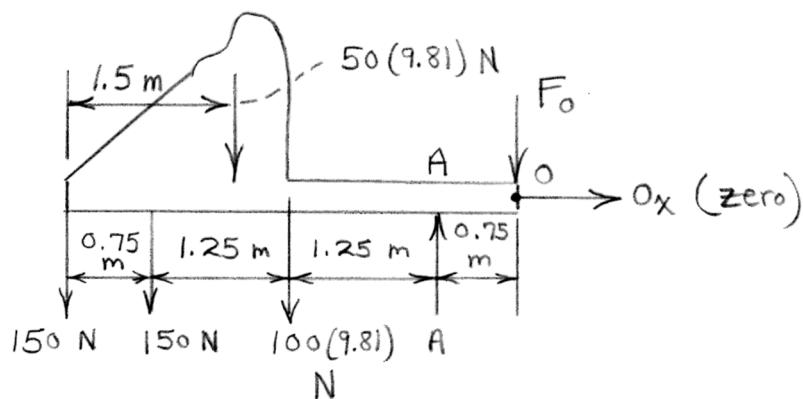
$$N'_B = 15,050 \text{ N}$$

$$\sum F_y = 0: N'_A + 15,050 - 1800(9.81) + 3000 \sin 12^\circ = 0, N'_A = 1983 \text{ N}$$

$$\Delta n_A = \frac{N'_A - N_A}{N_A} (100) = \underline{-32.6\%}, \Delta n_B = \frac{N'_B - N_B}{N_B} = \underline{2.28\%}$$

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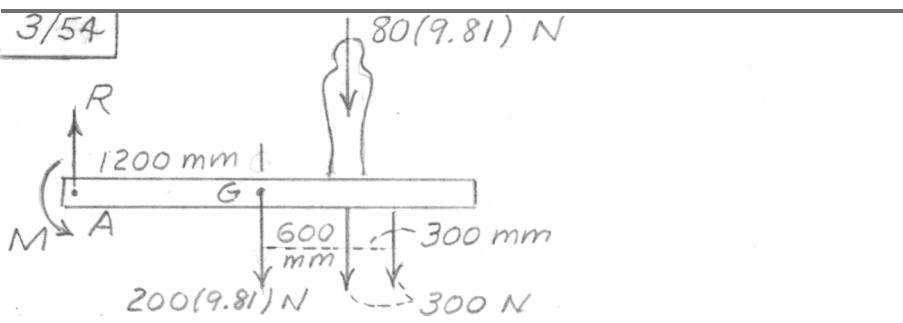
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Above FBD is for the system of beam and boat.

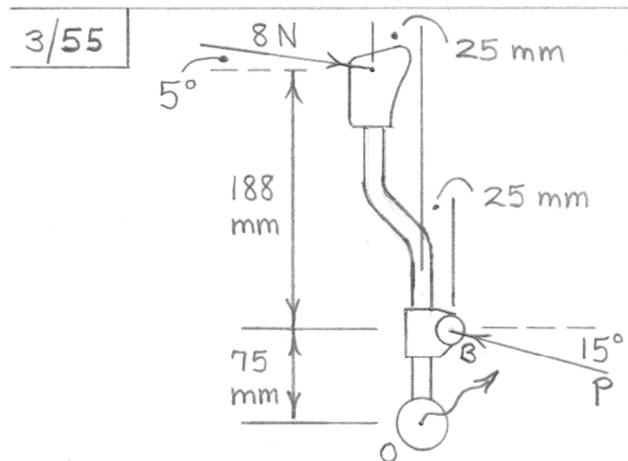
$$\sum M_A = 0 : 150(3.25) + 150(2.5) + 100(9.81)(1.25) + 50(9.81)(1.75) - 0.75 F_o = 0$$
$$F_o = 3930 \text{ N} \text{ or } F_o = 3.93 \text{ kN}$$

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$$\begin{aligned}\sum M_A = 0; \quad & 80(9.81)(1800) + 200(9.81)(1200) \\ & + 300(1800 + 2100) - M = 0 \\ M = 4.94(10^6) \text{ N} \cdot \text{mm} \quad & \text{or } M = 4.94 \text{ kN} \cdot \text{m}\end{aligned}$$

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$$\begin{aligned} \text{At } \sum M_O = 0 : -8 \cos 5^\circ (188 + 75) + 8 \sin 5^\circ (25) \\ + P \cos 15^\circ (75) + P \sin 15^\circ (25) = 0 \end{aligned}$$

$$P = 26.3 \text{ N}$$

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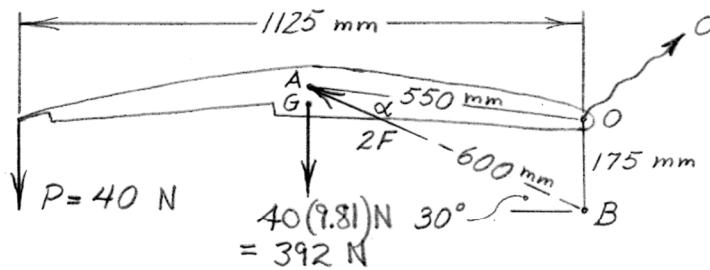
From Table D/3, $\bar{r} = \frac{r \sin \alpha}{\alpha}$
For $\alpha = \pi/4$, $\bar{r} = 2\sqrt{2} r/\pi$

$\sum M_A = 0 :$

$$M_A - mg(r \sin 15^\circ + \bar{r} \cos 60^\circ) = 0$$
$$M_A = 0.709 m g r$$

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$$\text{Law of cosines: } 175^2 = 550^2 + 600^2 - 2(550)(600) \cos \alpha$$
$$\alpha = 16.79^\circ$$

$$\begin{aligned} \text{At } \sum M_O = 0: \quad & 40(1125) - 2F(550 \sin \alpha) + 392(550 \cos [30^\circ - \alpha]) \\ & = 0, \quad F = 803 \text{ N} \end{aligned}$$

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