

# Worksheet 3.1 - Translational Equilibrium

Tough one to start!

①  $w_3 = 12 \text{ N}$  two variables! so...  $w_1 \cos(24) = w_2 \cos(50)$   
 $w_1 = w_2 \frac{\cos(50)}{\cos(24)} = 0.70 w_2$   
 $w_3 = w_1 \sin(24) + w_2 \sin(50)$   
 sub in!

$$w_3 = 0.70 w_2 \sin(24) + w_2 \sin(50)$$

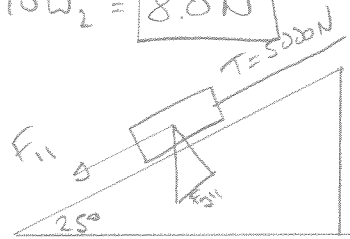
$$12 \text{ N} = 1.05 w_2$$

$$11.4 \text{ N} = w_2$$

$$w_1 = 0.70 w_2 = 8.0 \text{ N}$$

②  $T = F_{\text{net}} = F_g \sin(25)$

$$\frac{5000 \text{ N}}{\sin(25)} = 1.18 \times 10^4 \text{ N}$$

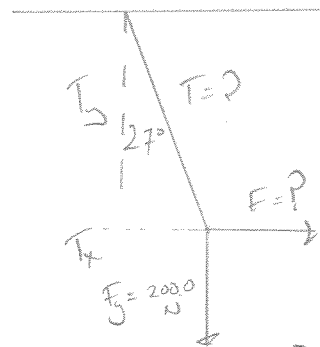


③ First find Tension in the rope

$$T \cos(27) = F_g$$

$$T = \frac{F_g}{\cos(27)} = 224.5 \text{ N}$$

$$F = T \sin(27) = 224.5 \text{ N} \cdot \sin(27) = 101.9 \text{ N}$$



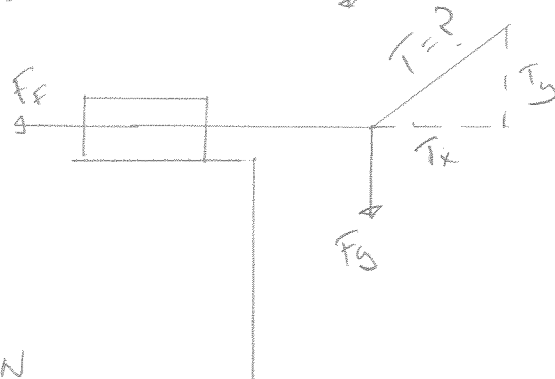
⑤  $F_f = \mu F_N = \mu F_g = 0.27(15)(9.8) = 39.69 \text{ N}$

$$F_f = T_x = T \cos(30)$$

$$T = \frac{F_f}{\cos(30)} = \frac{39.69 \text{ N}}{\cos(30)} = 45.83 \text{ N}$$

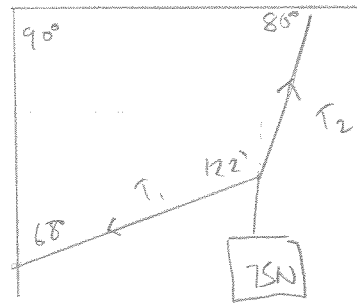
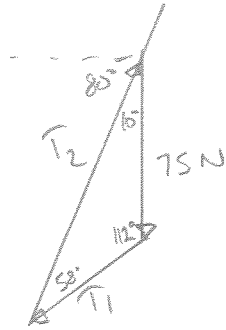
$$F_g = T_y = T \sin(30) = 45.83 \text{ N} \cdot \sin(30) = 22.92 \text{ N}$$

$$m = \frac{F_g}{g} = \frac{22.92 \text{ N}}{9.8} = 2.34 \text{ kg} = 2.3 \text{ kg}$$



See next page for #4!

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$$\frac{T_1}{\sin(10)} = \frac{75N}{\sin(58)}$$

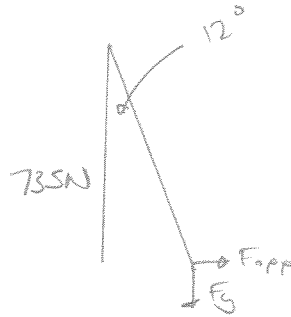
$$\frac{T_2}{\sin(112)} = \frac{75N}{\sin(58)}$$

$$T_1 = \frac{\sin(10)}{\sin(58)} \cdot 75N$$

$$T_2 = \frac{\sin(112)}{\sin(58)} \cdot 75N$$

$$T_1 = 15N \quad T_2 = 82N$$

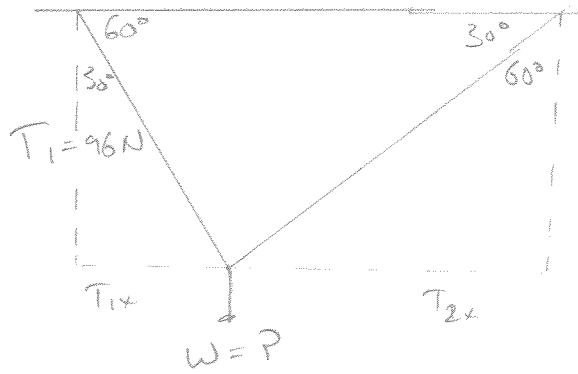
$$\textcircled{6} T = \frac{F_y}{\cos(12)} = \boxed{75 \text{ N}}$$



$$\textcircled{7} T_{1x} = T_{2x}$$

$$T_1 \cdot \sin(30) = T_2 \cdot \sin(60)$$

$$(96) \frac{\sin(30)}{\sin(60)} = T_2 = \boxed{55.4 \text{ N}}$$



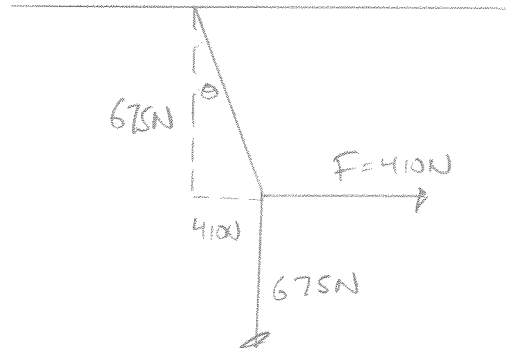
$$W = T_{1y} + T_{2y}$$

$$W = (96) \cdot \cos(30) + (55.4) \cdot \cos(60)$$

$$W = \boxed{111 \text{ N}}$$

$$\textcircled{8} \tan(\theta) = \frac{\text{opp}}{\text{adj}}$$

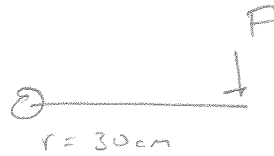
$$\theta = \tan^{-1}\left(\frac{410}{675}\right) = \boxed{31.2^\circ}$$



# Worksheet 3.2 - Torque

①  $\tau = 45 \text{ N}\cdot\text{m} = F \cdot d = 0.30 F$

$$\frac{45 \text{ N}\cdot\text{m}}{0.30 \text{ m}} = \boxed{150 \text{ N}}$$



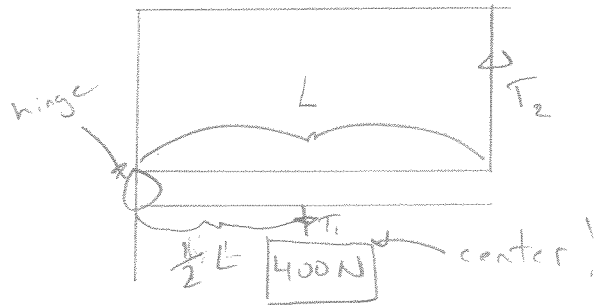
②

$$\tau = \tau_1 + \tau_2 = 0$$

$$|\tau_1| = |\tau_2|$$

$$\frac{1}{2} (400) = L \cdot T_2$$

$$\boxed{200 \text{ N} = T_2}$$



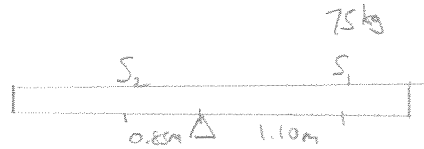
③  $\tau_1 = \tau_2$

$$|\tau_1| = |\tau_2|$$

$$d_1 F_{g1} = d_2 F_{g2}$$

$$d_1 m_1 g = d_2 m_2 g$$

$$\frac{d_1}{d_2} m_1 = m_2 = \left( \frac{1.10}{0.85} \right) (75) = \boxed{93 \text{ kg}}$$



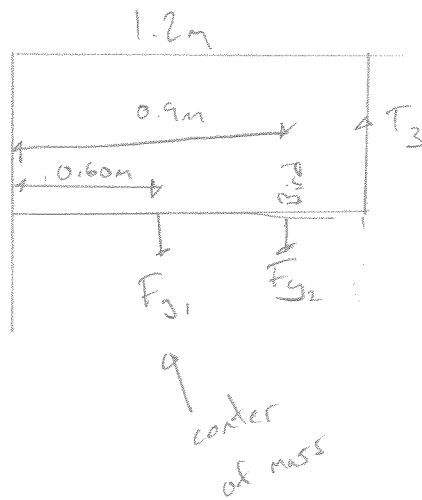
④  $\tau_{\text{net}} = 0$

$$\tau_1 + \tau_2 = \tau_3$$

$$(0.60)(10)(9.8) + (0.90)(0.75)(9.8) = 1.2 T_3$$

$$12.495 \text{ N}\cdot\text{m} = 1.2 T_3$$

$$\boxed{10.4 \text{ N} = T_3}$$



$$\textcircled{5} \sum \tau_{\text{net}} = \tau_1 + \tau_2$$

$$|\tau_c| = |\tau_{cc}|$$

$$d_1 \cdot F_{g1} = d_2 \cdot F_{g2}$$

$$(1.0 - d_2) F_{g1} = d_2 \cdot F_{g2}$$

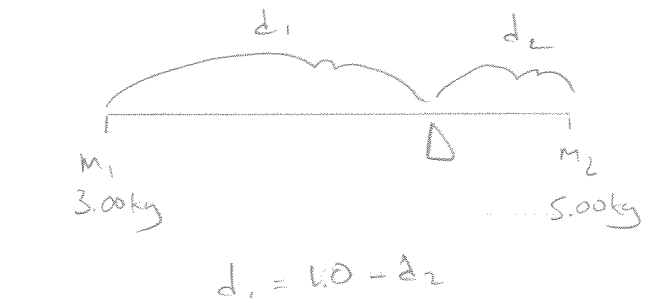
$$(1.0 - d_2)(3.00)g = d_2(5.00)g$$

$$3.00 - 3.00d_2 = 5.00d_2$$

$$3.00 = 8.00d_2$$

$$0.375\text{m} = d_2$$

$$d_1 = 0.675\text{m}$$



$$d_2 = 0.375\text{m}$$

0.675m to the left of the fulcrum

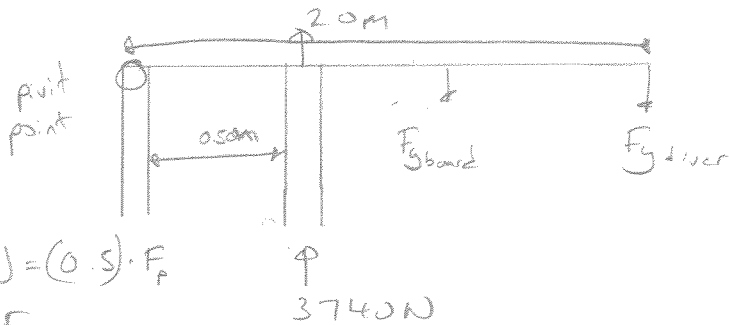
$$\textcircled{6} \sum \tau_{\text{net}} = 0$$

$$\sum \tau_{\downarrow} + \sum \tau_{\uparrow} = \tau_p$$

$$(1.0)(400\text{N}) + (2.0)(75)(9.8) = (0.5) \cdot F_p$$

$$1870 = 0.5 F_p$$

$$3740\text{N} = F_p$$



Total up = Total down

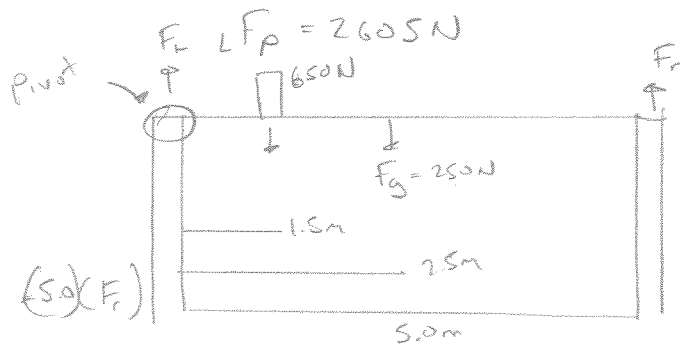
$$3740\text{N} = 2F_p + 400\text{N} + 735\text{N}$$

$$\textcircled{7} \sum \tau_{\text{net}} = 0$$

$$\textcircled{a} \sum \tau_c = \sum \tau_{cc}$$

$$(650\text{N})(1.5\text{m}) + (250\text{N})(2.5\text{m}) = (5.0)(F_r)$$

$$\frac{1600\text{N}\cdot\text{m}}{(5.0\text{m})} = F_r = 320\text{N}$$

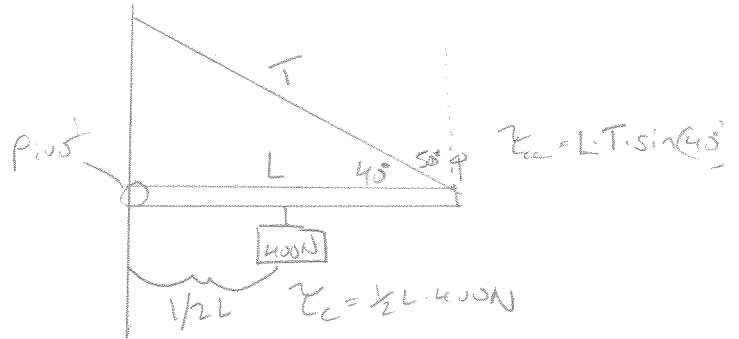


$$\textcircled{b} F_{\text{total}} = 0 = F_L + F_r - 650\text{N} - 250\text{N}$$

$$F_L = 650\text{N} + 250 - 320\text{N} = 580\text{N}$$

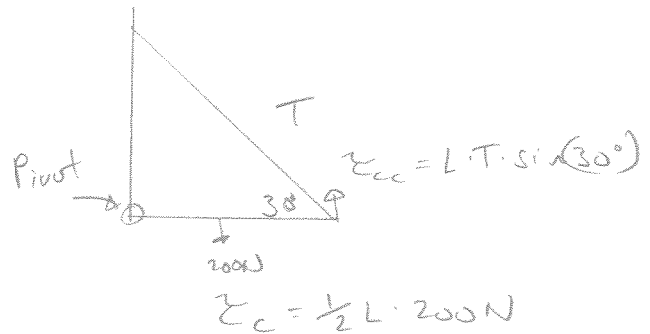
Worksheet 3.3 - Torque not at 90°

① a)  $\Sigma_{\text{net}} = 0$   
 $\Sigma_c = \Sigma_{cc}$   
 $\frac{1}{2} \ell \cdot (400\text{N}) = \ell \cdot T \cdot \sin(45^\circ)$   
 $200\text{N} = T \sin(45^\circ)$   
 $T = \boxed{311\text{N}}$

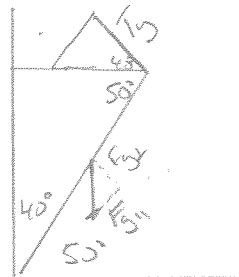


① b) horizontal  $F_{\text{wall}} = T_x = 311\text{N} \cdot \cos(45^\circ) = \boxed{238\text{N}}$   
 vertical  $F_{\text{wall}} = T_y = \boxed{200\text{N}}$  (see above)

②  $\Sigma_{\text{net}} = 0$   
 $\Sigma_c = \Sigma_{cc}$   
 $200\text{N} \cdot \frac{1}{2} \ell = T \cdot \sin(30^\circ) \cdot \ell$   
 $\frac{100\text{N}}{\sin(30^\circ)} = T = \boxed{200\text{N}}$

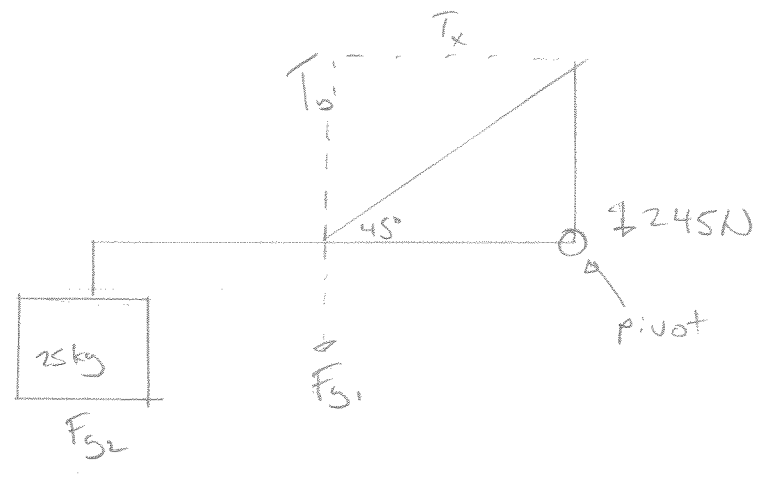


③  $\Sigma_{\text{net}} = 0$   
 $\Sigma_c = \Sigma_{cc}$   
 $\frac{1}{2} \ell \cdot F_{g\perp} = \ell T_{\perp}$   
 $\frac{1}{2} \cdot (200\text{N}) \cdot \cos(50^\circ) = T_{\perp}$   
 $64.3\text{N} = T_{\perp}$   
 $T = \frac{64.3\text{N}}{\cos(40^\circ)} = \boxed{83.9\text{N}}$



④ a)  $\sum \tau_{net} = 0$

$\sum \tau_c = \sum \tau_{cc}$   
 $\frac{1}{2}k \cdot T_y = \frac{1}{2}k(22)(9.8) + k(25)(9.8)$   
 $\frac{1}{2} \cdot T \cdot \sin(45) = 352.8$   
 $T = 998 \text{ N} = \boxed{1000 \text{ N}}$

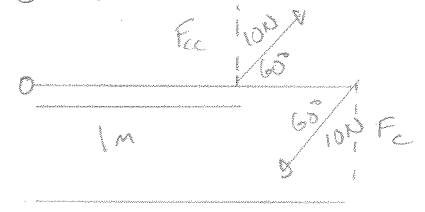


⑥  $\sum F_y = 0$   
 $0 = \bar{F}$

$F_{hinge y} = F_{g1} + F_{g2} - T_y = (25)(9.8) + (22)(9.8) - (998) \cdot \sin(45)$   
 $= -245 \text{ N}$   
 or  $\boxed{250 \text{ N down!}}$

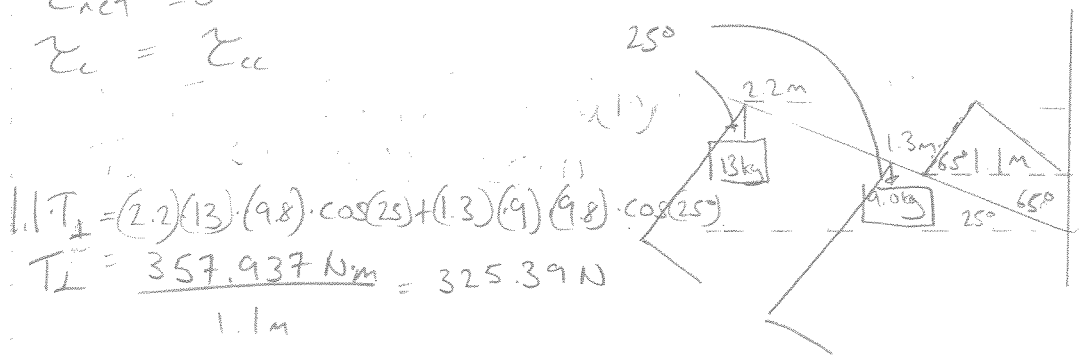
$\sum F_x = 0$   
 $T_x = F_{hinge x} = 998 \text{ N} \cdot \cos(45) = 706 \text{ N} = \boxed{710 \text{ N left}}$

⑤  $\tau_{net} = \text{not zero!}$



$\tau_{net} = \tau_c + \tau_{cc}$   
 $\tau_{net} = (2.0)(10) \cdot \sin(60) + (1.0)(10) \cdot \sin(60)$   
 $= \boxed{18.66 \text{ N}\cdot\text{m clockwise}}$

⑥  $\tau_{net} = 0$   
 $\tau_c = \tau_{cc}$



$\tau_{\perp} = (2.2)(13)(9.8) \cdot \cos(25) + (1.3)(9)(9.8) \cdot \cos(25)$   
 $\tau_{\perp} = \frac{357.937 \text{ N}\cdot\text{m}}{1.1 \text{ m}} = 325.39 \text{ N}$

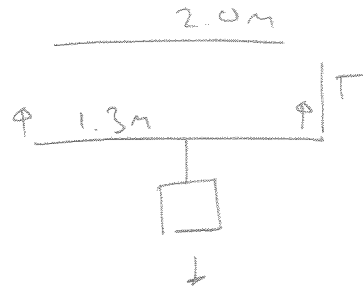
$T = \frac{\tau_{\perp}}{\cos(25)} = \frac{325.39 \text{ N}}{\cos(25)} = \boxed{770 \text{ N}}$

$$\sum \tau_{\text{net}} = 0$$

$$\sum \tau_c = \sum \tau_{cc}$$

$$(1.3)(350) = 2.0(T)$$

$$227.5 \text{ N}$$



$$\sum F_y = 0 \quad F_{\text{hinge } y} = 350 \text{ N} - 227.5 \text{ N} = 122.5 \text{ N up}$$

$$\sum F_x = 0$$

$$1.3 \cdot 65 = d \cdot 90$$

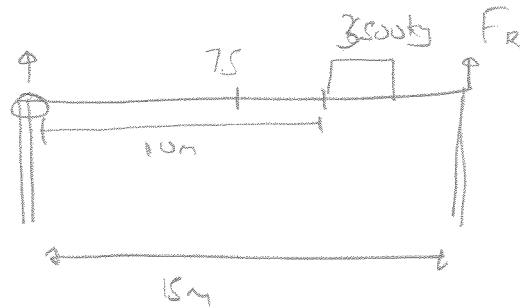
$$0.94 \text{ m}$$



choose hinge

$$\sum \tau_{\text{net}} = 0$$

$$\sum \tau_c = \sum \tau_{cc}$$



$$15 \text{ m} \cdot F_R = (7.5)(6500)(9.8) + 10(3500)(9.8)$$

$$\frac{15 F_R}{15} = \frac{820750}{15}$$

$$F_R = 54716 \text{ N}$$

$$F_L = (6500)(9.8) + (3500)(9.8) - 54716 \text{ N}$$

$$= 43283 \text{ N}$$