Torque, Rotational Equilibrium and Statics

(1) a. $\tau = F_{\perp} d = 130N \sin 36° (1.1m) = \underline{84 Nm}$

$\vec{\tau} = \underline{84 Nm \quad ccw}$

b. $\tau = F_{\perp} d = 130N \sin 36° (0.20m) = \underline{15 Nm}$

$\vec{\tau} = \underline{15 Nm \quad cw}$

c. $\tau = F_{\perp} d = 130N \sin 36° (0.60m) = \underline{46 Nm}$

$\vec{\tau} = \underline{46 Nm \quad cw}$

d. $\tau = F_{\perp} d = 45N \sin 60° (0.50m) = \underline{19 Nm}$

$\vec{\tau} = \underline{19 Nm \quad ccw}$

e. $\tau = F_{\perp} d = 45N \sin 60° (0.80m) = \underline{31 Nm}$

$\vec{\tau} = \underline{31 Nm \quad cw}$

f. $\tau = F_{\perp} d = 45N \sin 60° (1.2m) = \underline{47 Nm}$

$\vec{\tau} = \underline{47 Nm \quad cw}$

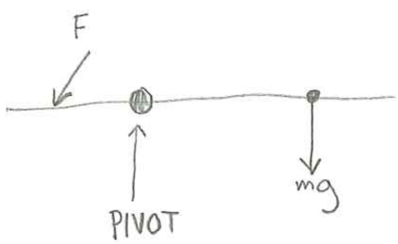
g. $\tau = 130N \sin 36 (0.35m)$

$\vec{\tau} = \underline{27 Nm \quad ccw}$

h. $\tau = 45N \sin 60° (0.25m)$

$\vec{\tau} = \underline{9.7 Nm \quad cw}$

(2)



$\sum \vec{\tau} = 0 Nm$

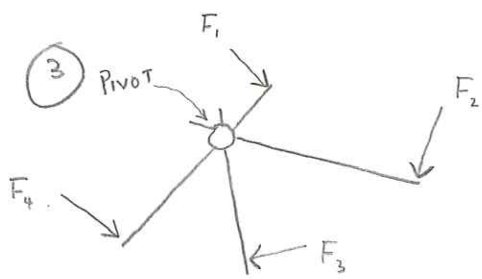
$\tau_{cw} = \tau_{ccw}$

$mg (1.20m) = F_1 \cos 49° (0.50m)$

$F_1 = 21.51... N$

$\boxed{F_1 = 22 N}$

(3)



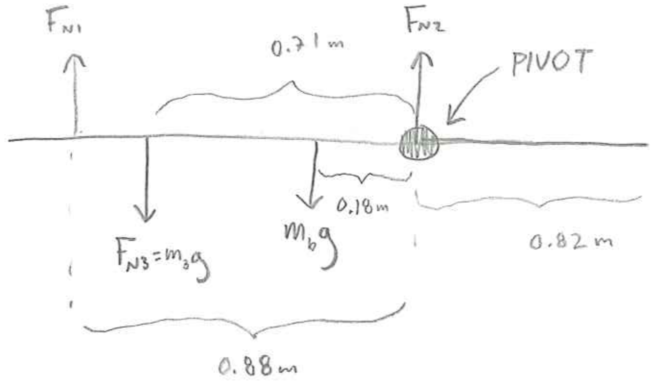
$\sum \vec{\tau} = \vec{\tau}_1 + \vec{\tau}_2 + \vec{\tau}_3 + \tau_4$

$\sum \vec{\tau} = F_1 (0.50m) + F_2 (1.0m) + F_3 (0.6m) - F_4 (0.6m)$

$\sum \vec{\tau} = 15.2 Nm \quad cw$

$\boxed{\sum \vec{\tau} = 15 Nm \, cw}$

(4.)



$$\Sigma \vec{F} = 0$$

$$F_{N1} + F_{N2} = m_3 g + m_b g$$

* PIVOT AT RIGHT SUPPORT. WHY? (1) Eliminate F_{N2} from torque calculation
(2) Distances were given relative to that point.

$$\Sigma \tau = 0$$

$$\tau_{cw} = \tau_{ccw}$$

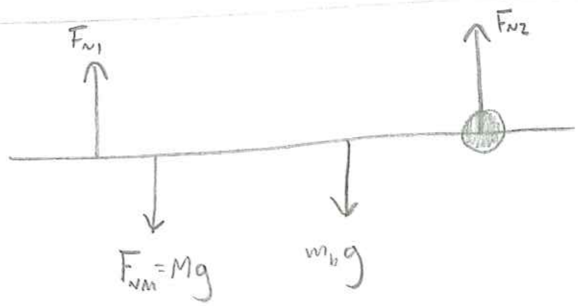
$$\tau_{N1} = \tau_3 + \tau_b$$

$$F_{N1}(0.88\text{m}) = m_3 g(0.71\text{m}) + m_b g(0.18\text{m})$$

$$F_{N1} = 25.725\text{ N}$$

so... $F_{N2} = m_3 g + m_b g - F_{N1}$ (from dynamics) $F_{N2} = 13.475\text{N}$

$$\boxed{F_{N1} = 26\text{N} \qquad F_{N2} = 13\text{N}}$$



$$\Sigma \vec{F} = 0$$

$F_{N1} + F_{N2} = Mg + mg$ (2 unknowns!)

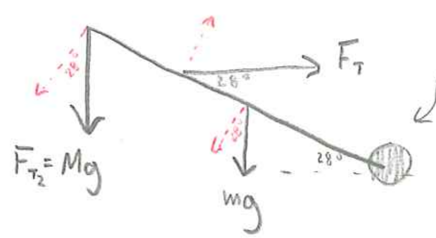
$$\Sigma \vec{\tau} = 0$$

$$\tau_{cw} = \tau_{ccw}$$

$$F_{N1}(0.88\text{m}) = Mg(0.71\text{m}) + mg(0.18\text{m})$$

$$\boxed{M = 6.0\text{kg}}$$

(6)



$$\sum \vec{\tau} = 0\,Nm$$

$$\tau_{cw} = \tau_{ccw}$$

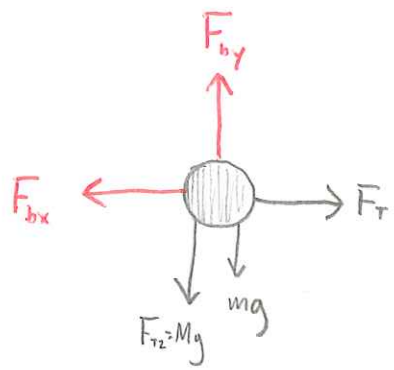
$$\tau_T = \tau_M + \tau_m$$

$$\underbrace{F_T \sin 28^\circ}_{F_{T\perp}} \underbrace{(1.3m)}_{d_T} = \underbrace{11kg(9.8)\cos 28^\circ}_{F_{M\perp}} \underbrace{(1.80m)}_{d_M} + \underbrace{3kg(9.8\,N/kg)\cos 28^\circ}_{F_{m\perp}} \underbrace{(0.90m)}_{d_m}$$

$$F_T = 319.0001428N$$

$$\boxed{F_T = 320N}$$

b.



to be in equilibrium, there must be an upward force to balance Mg and mg and a leftward force to balance F_T.

THESE MUST COME FROM THE BASE!

$$\sum \vec{F}_x = 0$$

$$F_{bx} = F_T$$

$$F_{bx} = 319.0001428N$$

$$\sum \vec{F}_y = 0$$

$$F_{by} = Mg + Mg$$

$$F_{by} = 137.2\,N$$

$$F_b = \sqrt{F_{bx}^2 + F_{by}^2} = 347.2534105$$

$$\theta = \tan^{-1}\left(\frac{F_{by}}{F_{bx}}\right) = 23.27224283^\circ$$

$$\boxed{\vec{F}_b = 350N\ [23^\circ \text{ above } -x]}$$