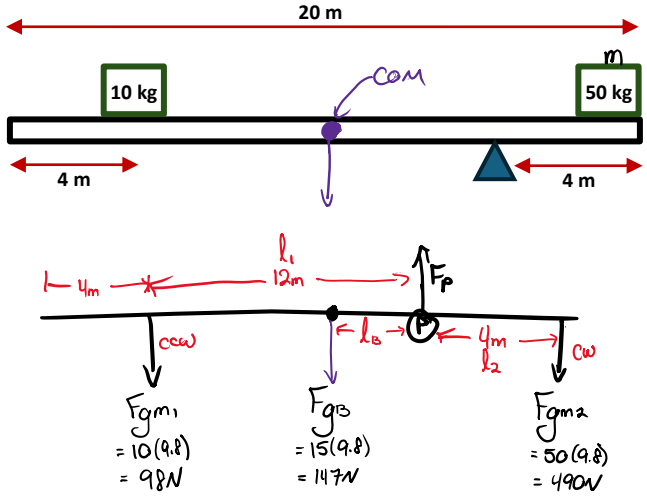
Lesson 2.5B – Rotational Equilibrium II

Unit 2: Dynamics and Equilibrium

Example 1: The system is in static equilibrium. If the beam has a mass of 15 kg, where is the center of gravity of the system?



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

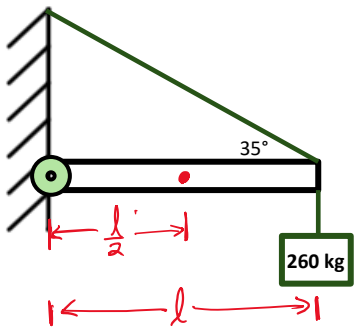
$$\tau_{m_2} = \tau_B + \tau_{m_1}$$

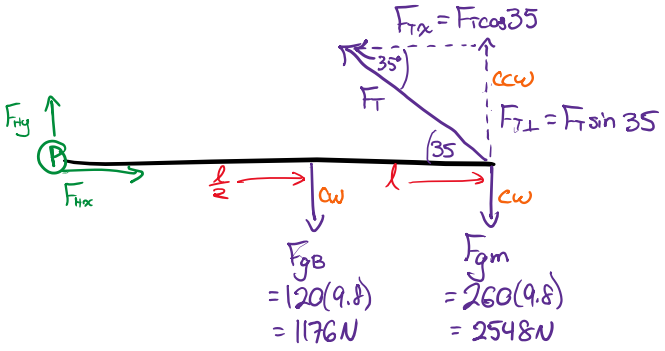
$$F_{gm_2} \cdot l_2 = F_{gB} \cdot l_B + F_{B_1} \cdot l_1$$

$$490N(4m) = 147N\, l_B + 98N(12m)$$

$l_B = 5.3m$ from the pivot.

Example 2: The beam is uniform with mass 120 kg. Find the tension in the rope and the horizonal and vertical forces exerted on the hinge at the pivot point.





Find F_T:

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

$$F_{gB}\left(\frac{l}{2}\right) + F_{gm} \cdot l = F_{T\perp} \cdot l$$

$$\frac{1176N}{2} + 2548N = F_T \sin 35$$

$$F_T = 5467.4N$$

$= 5470N$

Find Force on Hinge

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

$$F_{Hx} - F_{Tx} = 0$$

$$F_{Hx} = F_T \cos 35$$

$$= 5467.4 \cos 35$$

$F_{Hx} = 4480N$

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

$$F_{Hy} + F_{T\perp} - F_{gB} - F_{gm} = 0$$

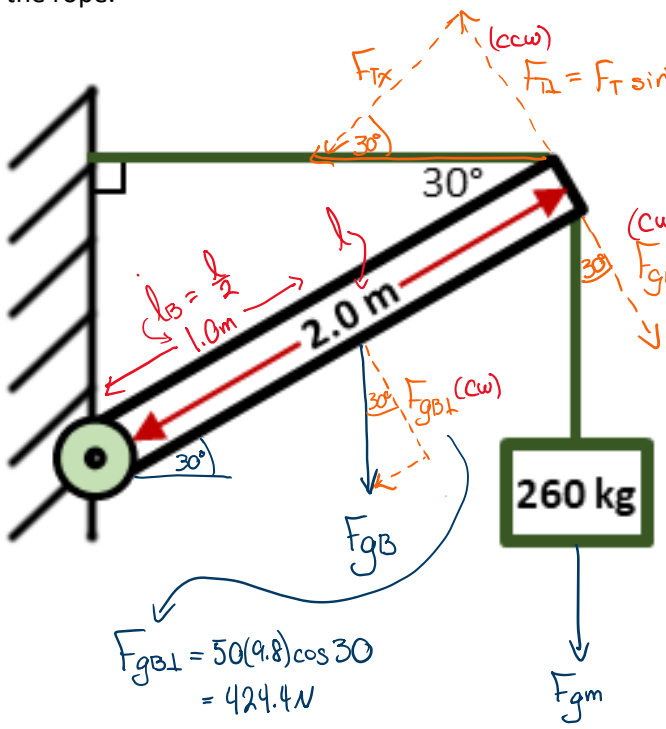
$$F_{Hy} = F_{gB} + F_{gm} - F_T \sin 35$$

$$F_{Hy} = 1176N + 2548N - 5467.4 \sin 35$$

$F_{Hy} = 588N$

$$* F_H = \sqrt{F_{Hx}^2 + F_{Hy}^2}$$

Example 3: A uniform 50 kg beam is connected to a wall by a hinge and rope as shown. Find the tension in the rope.



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

$$F_{gBL} \cdot \frac{\ell}{2} + F_{gmL} \cdot \ell = F_{TL} \cdot \ell$$

$$\frac{424.4}{2} + 2206.6 = F_T \sin 30$$

$$F_T = 4837.6$$

$$= 4840N$$

OR (without solving forces 1st – and simplifying the equation)

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

$$\tau_B + \tau_m = \tau_T$$

$$F_{gBL} \cdot \frac{\ell}{2} + F_{gmL} \cdot \ell = F_{TL} \cdot \ell$$

$$m_B g\cos 30 + m_m g\cos 30 = F_T \sin 30$$

$$F_T = \frac{g\cos 30(m_B + 2m_m)}{2\sin 30}$$

"Ooo... elegant" → $F_T = \frac{g(m_B + 2m_m)}{2\tan 30}$

$$F_T = \frac{9.8(50 + 2(260))}{2\tan 30} = 4840N$$

Assignment: Sander-Gore Pg. 27 # 5 and WS 2.5A