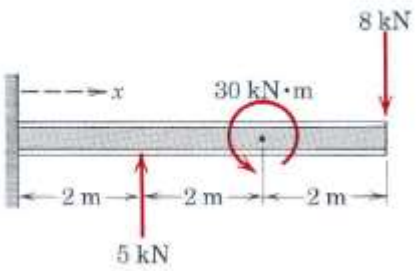
Engineering Statics – MECH 223

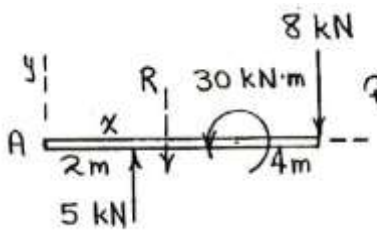
Review Problems for Midterm 1

Set 1 (Bonus. Submission deadline October 2nd)

1. Calculate the resultant $\bar{R}$ corresponding to the force-couple system descibed in the drawing, and the position where it acts on the I-beam.



Solution:

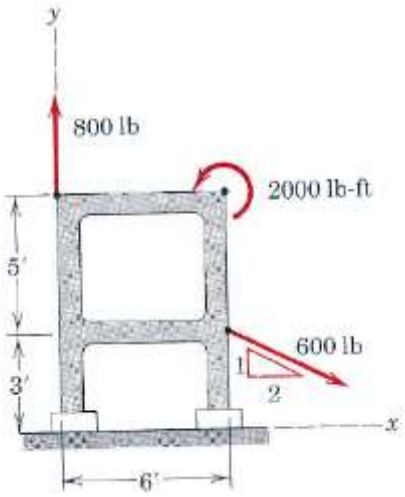


$R = \Sigma F_y = 5 - 8 = -3$ kN

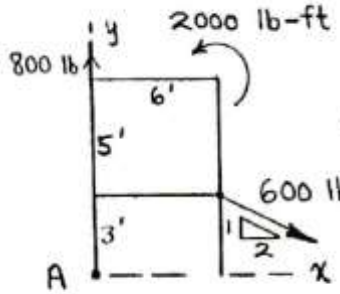
$\circlearrowleft |R|x = M_A : 3x = -5(2) - 30 + 8(6)$

$x = 2.67$ m

2. Determine the point on the *y*-axis through which the line of action of the resultant of the loading system shown in the drawing passes.



Solution:



$\underline{R} = \Sigma \underline{F} = 600\left(\frac{2}{\sqrt{5}}\underline{i} - \frac{1}{\sqrt{5}}\underline{j}\right) + 800\underline{j}$

$= 537\underline{i} + 532\underline{j}$ lb

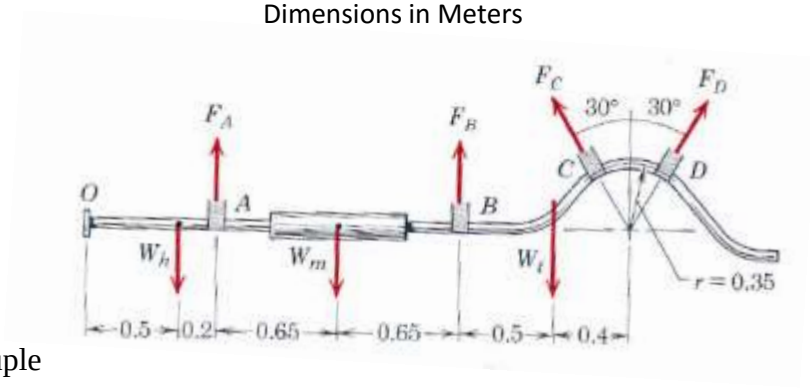
$\circlearrowleft M_A = 2000 - 600\frac{2}{\sqrt{5}}(3) - 600\frac{1}{\sqrt{5}}(6) = -12201$b-ft

$|R_x|y = |M_A|$

$537y = 1220, \quad y = 2.27$ ft

3. An exhaust system for a pickup truck is shown in the drawing. The weights W_h,W_m, and W_t of the headpipe, muffler, and tailpipe are 10, 100, and 50 N respectively, and act at the indicated points. If the exhaust hanger at point *A* is adjusted so that its tension F_A is 50 N, determine the required forces in the hangers at points *B*, *C*, and *D* so that the force couple system at point O is zero.

Dimensions in Meters



Solution:

For a zero force-couple system at point O:

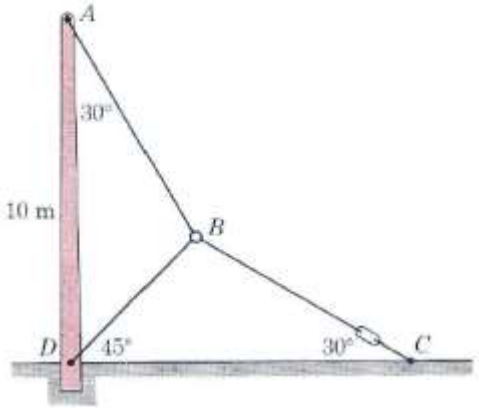
$$\underline{R} = \Sigma \underline{F} = (-F_C \sin 30^\circ + F_D \sin 30^\circ)\,\underline{i} + (50 - 10 - 100 - 50 + F_B + F_C \cos 30^\circ + F_D \cos 30^\circ)\,\underline{j} = \underline{0}$$

$$\Rightarrow F_C = F_D = F$$

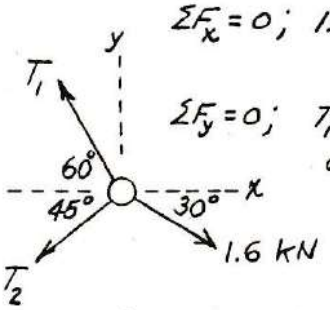
$$\Sigma M_O = -10(0.5) + 50(0.7) - 100(1.35) + F_B(2) - 50(2.5) + 2F \cos 30^\circ (2.9) = 0$$

$$F = F_C = F_D = 6.42 \text{ N}, \quad F_B = 98.9 \text{ N}$$

4. The three cables in the drawing are secured to a ring at *B*, and the turnbuckle at *C* is tightened until it supports a tension of 1.6 kN. Calculate the moment *M* produced by the tension in cable *AB* about the base of the mast at *D*.



Solution:



$\Sigma F_x = 0$; $1.6 \cos 30^\circ - T_1 \cos 60^\circ - T_2 \cos 45^\circ = 0$

$0.5\,T_1 + 0.707\,T_2 = 1.386$

$\Sigma F_y = 0$; $T_1 \sin 60^\circ - T_2 \sin 45^\circ - 1.6 \sin 30^\circ = 0$

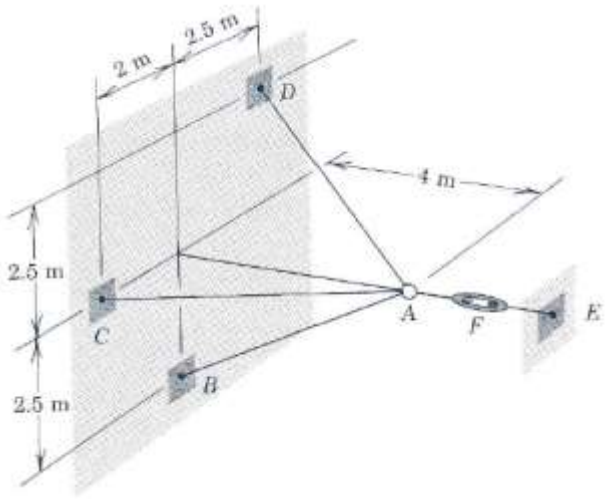
$0.866\,T_1 - 0.707\,T_2 = 0.8$

Add & get

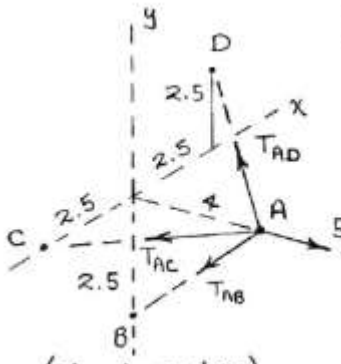
$1.366\,T_1 = 2.186$, $T_1 = 1.6$ kN

$(M_{T_1})_D = (1.6 \sin 30^\circ)10 = 8$ kN·m

5. The turnbuckle at *F* is tightened until the tension in cable *AE* is 5 kN. Determine the tension in cables *AB*, *AC*, and *AD*.



Solution:



$$\underline{T}_{AB} = T_{AB}\left(\frac{-2.5\underline{i} - 4\underline{k}}{\sqrt{2.5^2+4^2}}\right)$$

$$= T_{AB}\left(-0.530\underline{j} - 0.848\underline{k}\right)$$

$$\underline{T}_{AC} = T_{AC}\left(\frac{-2\underline{i} - 4\underline{k}}{\sqrt{2^2+4^2}}\right)$$

$$= T_{AC}\left(-0.447\underline{i} - 0.894\underline{k}\right)$$

$$\underline{T}_{AD} = T_{AD}\left(\frac{2.5\underline{i} + 2.5\underline{j} - 4\underline{k}}{\sqrt{2.5^2+2.5^2+4^2}}\right)$$

$$= T_{AD}\left(0.468\underline{i} + 0.468\underline{j} - 0.749\underline{k}\right)$$

$$\begin{cases} \Sigma F_x = 0: & -0.447\,T_{AC} + 0.469\,T_{AD} = 0 \\ \Sigma F_y = 0: & -0.530\,T_{AB} + 0.469\,T_{AD} = 0 \\ \Sigma F_z = 0: & -0.848\,T_{AB} - 0.894\,T_{AC} - 0.749\,T_{AD} + 5 = 0 \end{cases}$$

Solution: $T_{AB} = 1.814$ kN, $T_{AC} = 2.15$ kN

$T_{AD} = 2.05$ kN