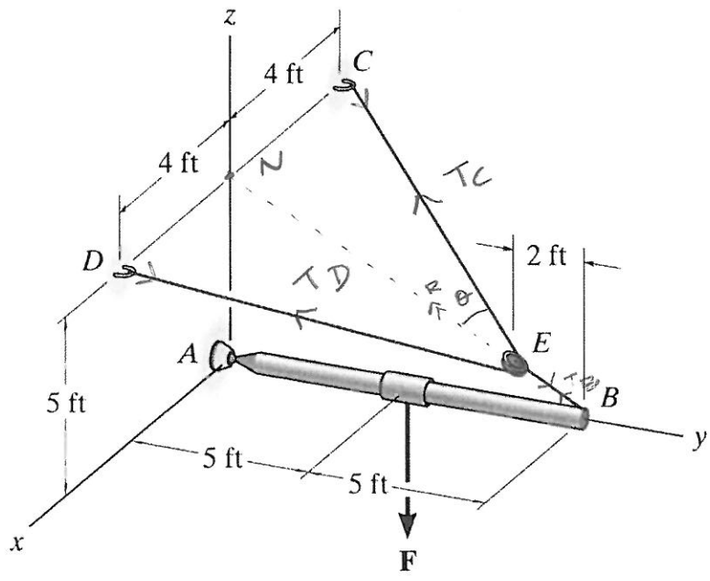
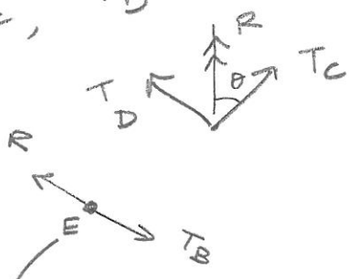
Q1. The cable CED can sustain a maximum tension of 800 lb before it fails. Determine:

a) The greatest vertical force F that can be applied to the boom (without exceeding the maximum tension cable CED can support)

b) The components of reaction at the ball-and-socket joint A.



Consider the resultant of T_C, T_D



Two forces on E

∴ equal & opposite

$E \equiv (0, 8, 1)$

$N \equiv (0, 0, 5)$

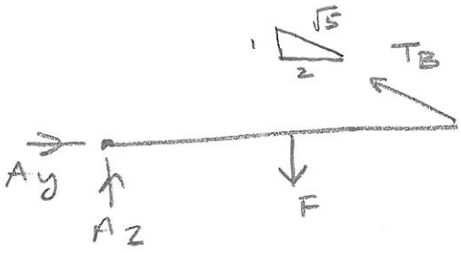
$EN = \sqrt{8^2 + 4^2} = \sqrt{80}$

$\tan\theta = \frac{4}{\sqrt{80}} = \frac{1}{\sqrt{5}}$

$T_B = R = 2T\cos\theta$

$T = \frac{T_B}{2\cdot\left(\frac{\sqrt{5}}{\sqrt{6}}\right)} = \frac{\sqrt{6}\,T_B}{2\sqrt{5}}$

Consider y - z plane



$\curvearrowleft \Sigma M_A \quad T_B\left(\frac{1}{\sqrt{5}}\right)(10) - F(5) = 0$

$T_B = \frac{\sqrt{5}\,F}{2}$

$T = \frac{\sqrt{6}}{2\sqrt{5}} \cdot \frac{\sqrt{5}\,F}{2}$

$= \frac{\sqrt{6}\,F}{4}$

for $T_{max} = 800$ lb

$F_{max} = \frac{800 \times 4}{\sqrt{6}} = 1306$ lb

$\swarrow \quad A_x = 0$

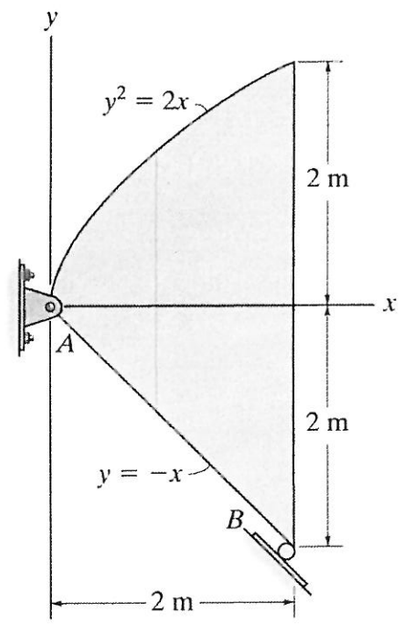
$\rightarrow \quad A_y = T_B\left(\frac{2}{\sqrt{5}}\right) = 1306$ lb

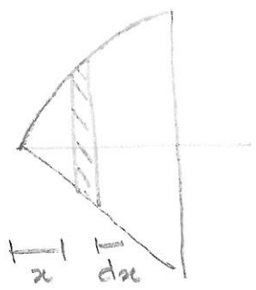
$\uparrow \quad A_z = F - T_B\left(\frac{1}{\sqrt{5}}\right) = \frac{1}{2}F = 653$ lb

[2]

Q2. A 2 cm thick steel plate is supported by a pin at A and a roller at B. The density of the material is $7850\ kg/m^3$.

1. Determine the x-component ($\bar{x}$) of the centre of gravity of the steel plate
2. Determine the support reactions at A and B.





$$dA = \left(\sqrt{2x} + x\right) dx$$

$$A = \int_0^2 x + \sqrt{2x}\ dx$$

$$= \frac{x^2}{2} + \frac{\sqrt{2}\, x^{3/2}}{3/2}\Bigg|_0^2$$

$$= 4.67\ m^2$$

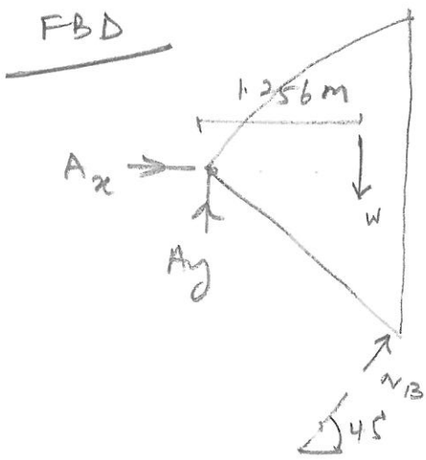
$$\bar{x} = \frac{\int x\, dA}{\int dA} = \frac{\int \left(x^2 + \sqrt{2}\cdot x^{3/2}\right) dx}{A}$$

$$= \frac{x^3}{3} + \frac{\sqrt{2}\, x^{5/2}}{5/2}\Bigg|_0^2 = \frac{5.867\ m^3}{4.67\ m^2} = 1.256\ m$$

$$W = mg = \rho V g = \rho A t \cdot g = (7850)(4.67)\left(\frac{2}{100}\right) 9.81$$

$$= 7187.5\ N$$

FBD



$\circlearrowleft \Sigma M_A$ $\quad N_B (L_{AB}) - W(\bar{x}) = 0$

$$N_B = \frac{(7187.5)(1.256)}{2\sqrt{2}}$$

$$= 3191.1 = 3192\ N$$

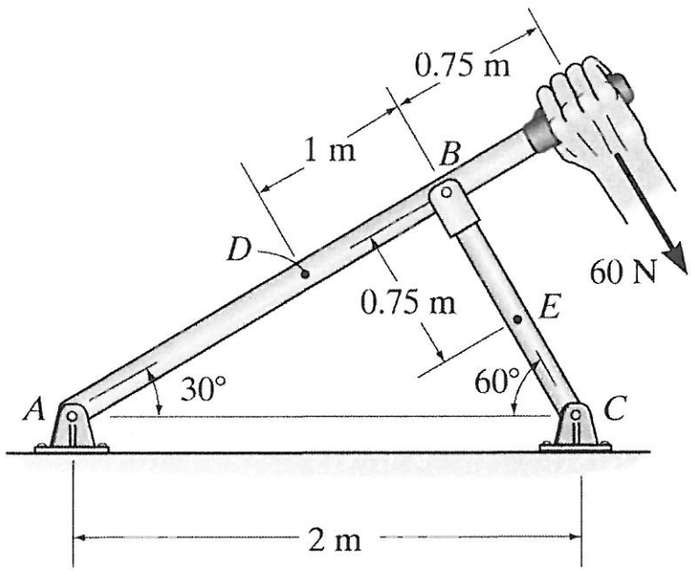
$\rightarrow$ $\quad A_x = -N_B \cos 45 = -2257\ N$

$\uparrow$ $\quad A_y + N_B \sin 45 - W = 0$

$$A_y = 4930\ N$$

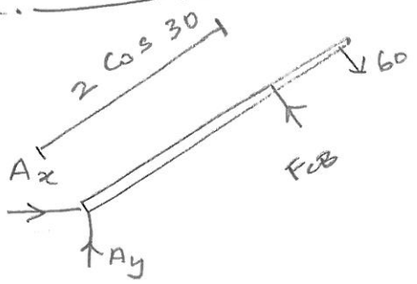
[3]

Q3. Determine the internal normal force, shear force, and moment at points D and E in the two members.



CEB → Two force member

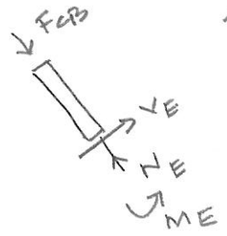
FBD for AB



$\circlearrowleft \Sigma M_A \quad F_{CB}(2\cos 30) - 60(2\cos 30 + 0.75) = 0$

$F_{CB} = 60\left[1 + \frac{0.75}{2\cos 30}\right] = \underline{86\ N}$

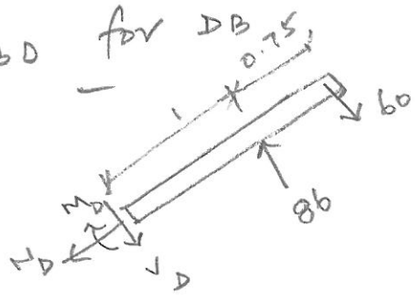
FBD for BE



$\uparrow V_E = 0 \; ; \quad M_E = 0 \; ; \leftarrow N_E = \underline{86\ N}$

Note: Since BC is a two force member, the only internal force is the axial force.

FBD for DB



$\leftarrow N_D = 0 \; ;$

$\downarrow V_D + 60 - 86 = 0, \quad V_D = \underline{26\ N}$

$\circlearrowleft \Sigma M_D \quad M_D + 60(1.75) - 86(1) = 0$

$M_D = \underline{-19\ Nm}$

[4]