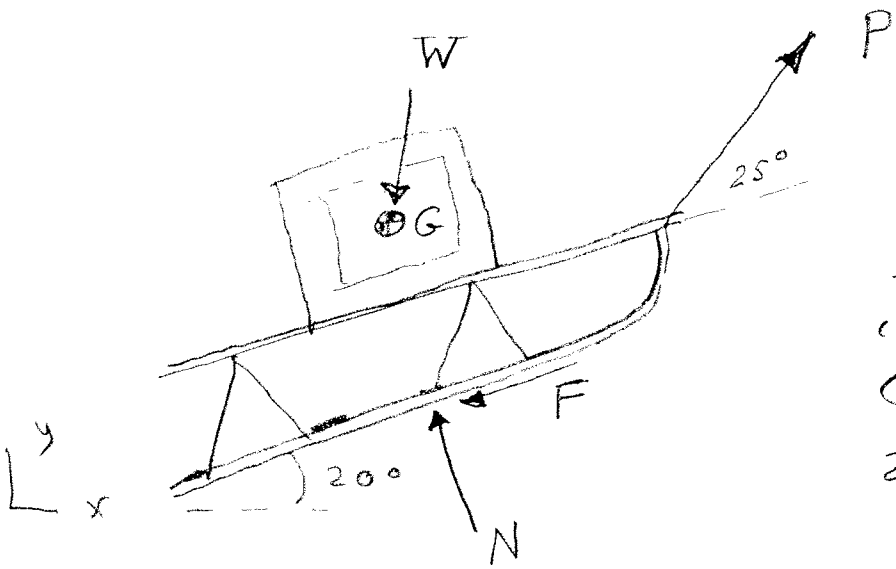
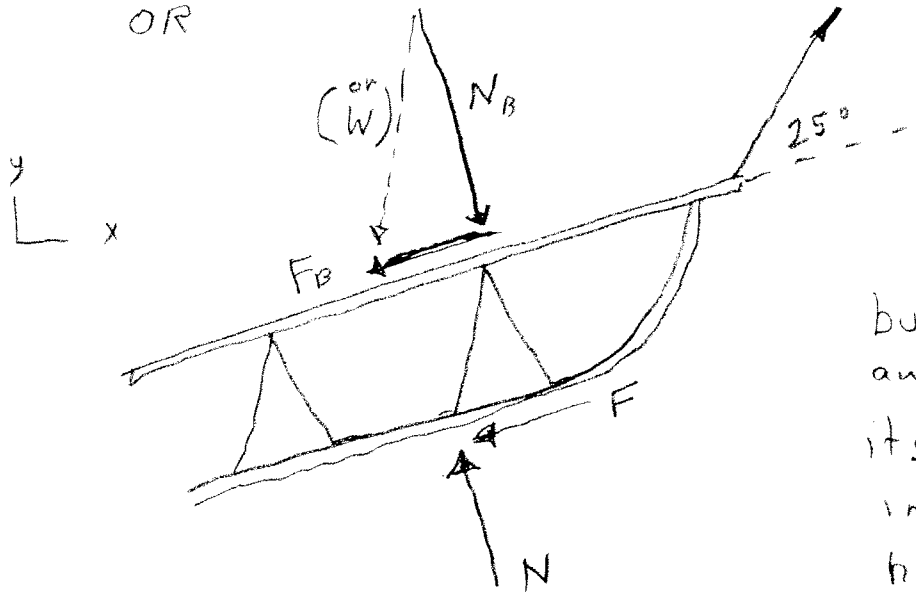
6.4



Assuming

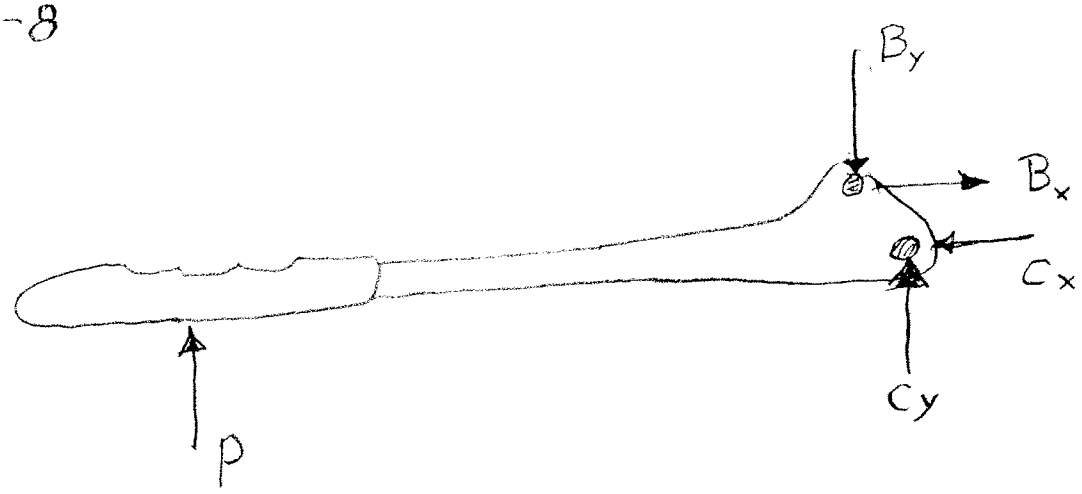
1. wt of sled small compared to box wt / G is c.m. of sys.
2. Sled is about to move up slope, friction F opposes.

OR

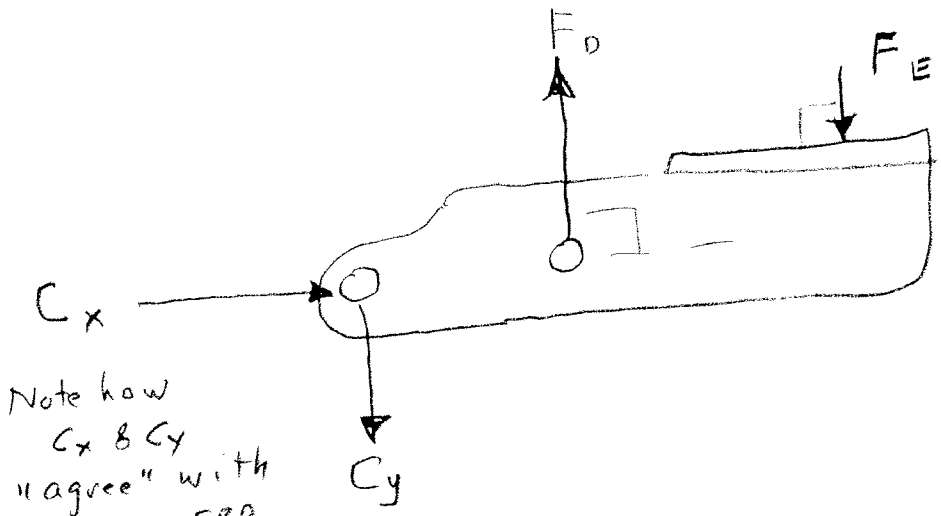


Same assumptions but block removed and replaced by its weight, (broken into components normal to and tangential to sleigh.

6-8



The directions of pin forces may not be known in advance. The above represents a gurss. It is ok to assume all above pin force components positive.

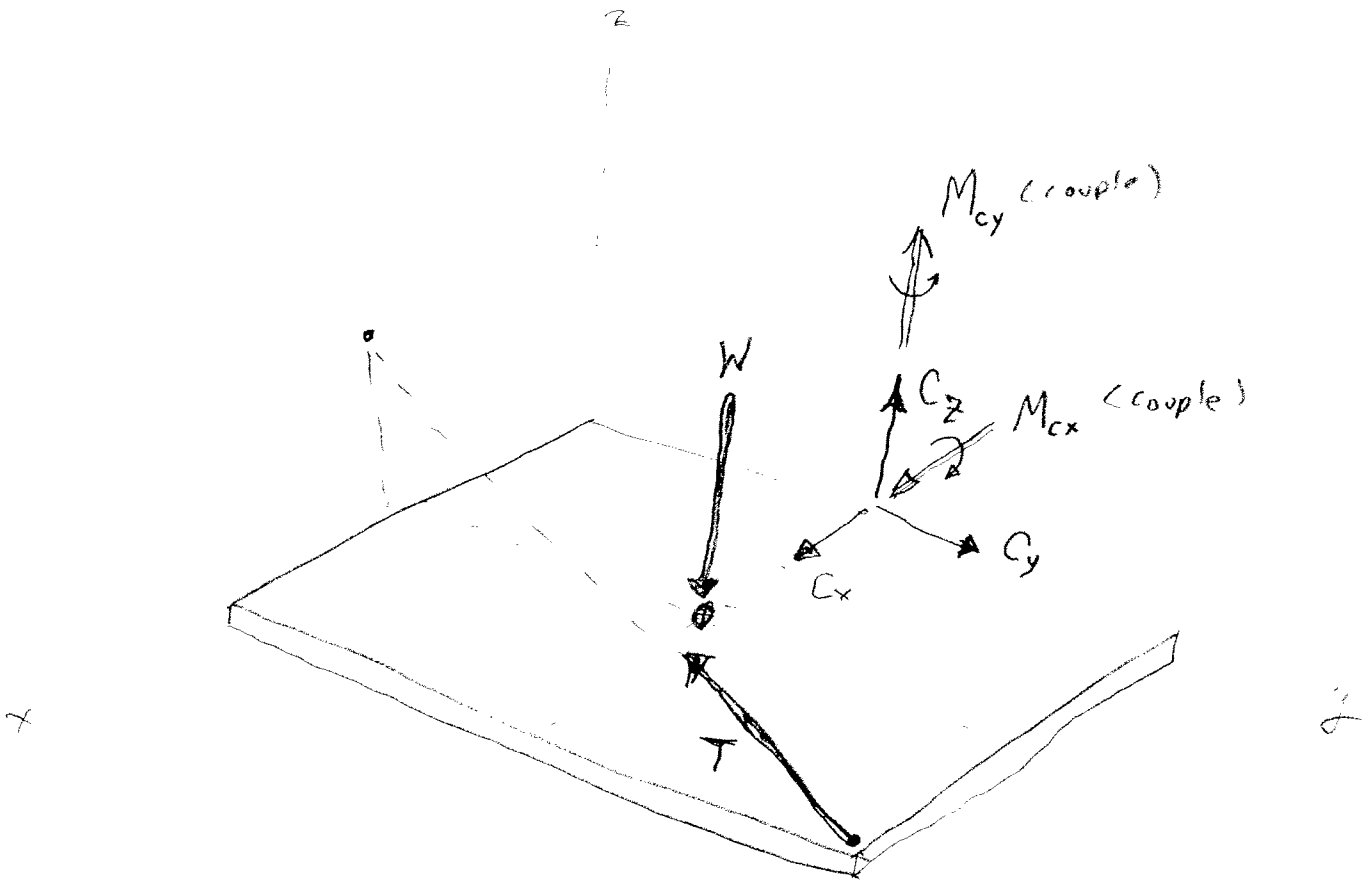


Note how C_x & C_y "agree" with previous FBD.

The link at D is a TWO-FORCE Member so force is along link. We also assome cutting force normal to cutting blade.

To GRADER: check this!

6-9



Assume

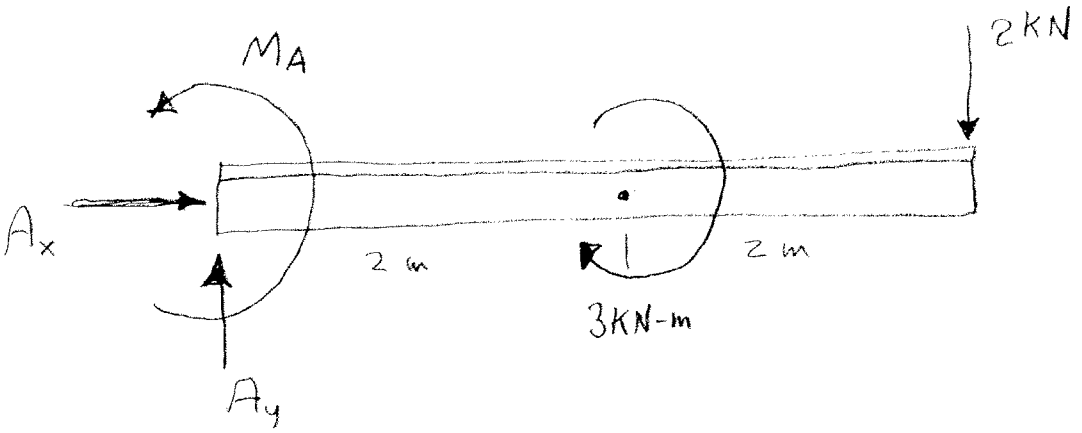
1. Wall side forces can be neglected, hinge and wire are only supports.

2. Obviously hinge will have to supply 3 reaction forces. It must supply couple reactions about x & z axes. By definition, it can't supply a reaction couple about y-axis — allows free rot. about this axis.

P23

6-14

FBD



$\Sigma F_x = 0$ $\quad A_x = 0$

$\Sigma F_y = 0$ $\quad A_y - 2 = 0$

$\Sigma M_A = 0$ $\quad M_A + 3 - 4(2) = 0$

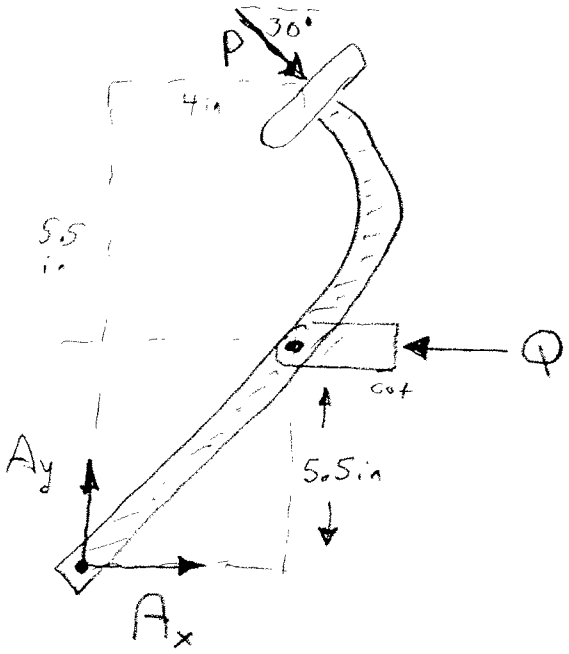
Answers support reaction at A

$A_x = 0$

$A_y = 2\,KN \uparrow$

$M_A = 5\,KN\text{-}m \circlearrowleft$ ccw

6-15



Given : P = 30 lb

$\Sigma F_x = 0$ $\quad A_x - Q + 30\cos 30° = 0$

$\Sigma F_y = 0$ $\quad A_y - 30\sin 30° = 0$

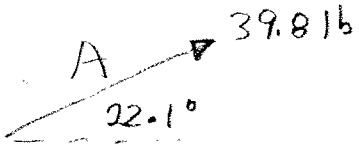
$+\circlearrowleft \Sigma M_A = 0$ $\quad -11(30\cos 30°) - 4(30\sin 30°) + 5.5Q = 0$

Solving,

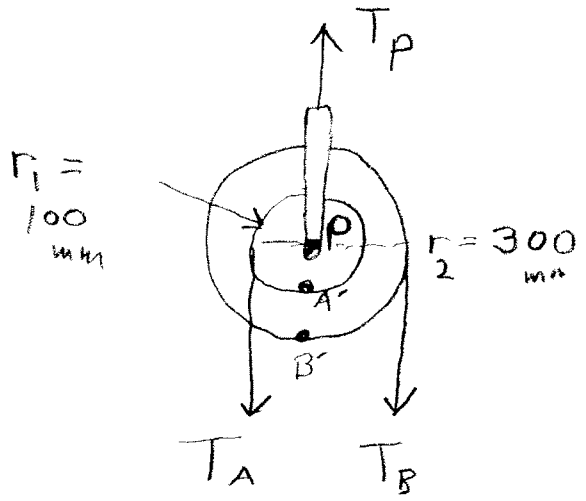
$A_x = 36.9$ lb

$A_y = 15.0$ lb

$Q = 62.87$ lb

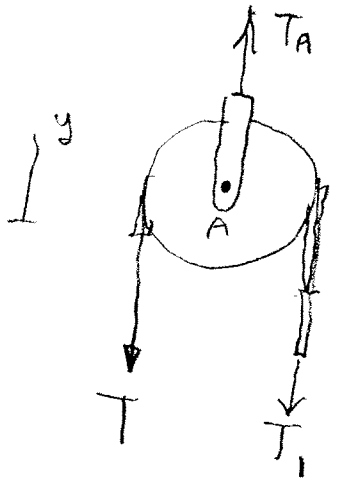


6-18



$+\circlearrowleft \Sigma M_P = 0$

$100 T_A - 300 T_B = 0$ (1)

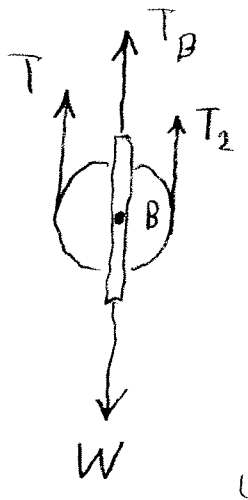


$+\circlearrowleft \Sigma M_A = 0 \quad rT - rT_1 = 0$

$T_1 = T$

$\Sigma F_y = 0$

$T_A - 2T = 0$ (2)



$+\circlearrowleft \Sigma M_B = 0 \quad -rT + rT_2 = 0$

$T_2 = T$

$\Sigma F_y = 0$

$2T + T_B - W = 0$ (3)

UNK: T, T_A, T_B EQ (1), (2), (3)

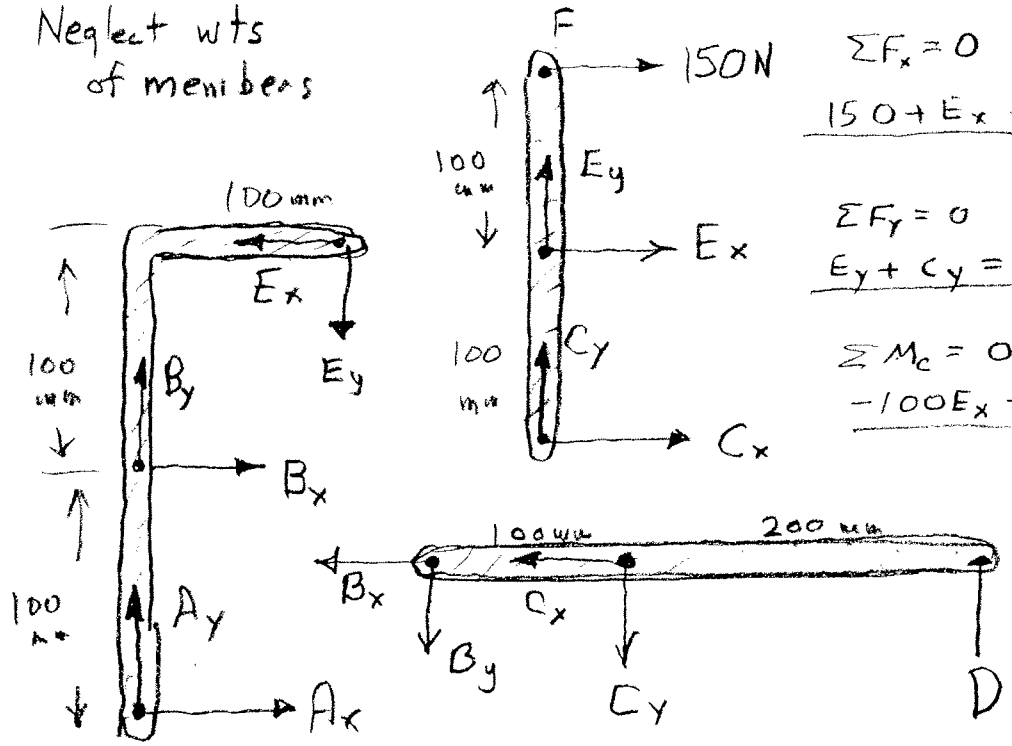
Solving $T_B = \frac{1}{4} W \quad T_A = \frac{3}{4} W \quad T = \frac{3}{8} W = \frac{3}{8}(225)(9.8)$

$T = 827\ N$

P2S

6.44

Neglect wts of members



$\Sigma F_x = 0$

$150 + E_x + C_x = 0$ (1)

$\Sigma F_y = 0$

$E_y + C_y = 0$ (2)

$\Sigma M_C = 0$

$-100E_x - 200(150) = 0$ (3)

$\Sigma F_x = 0$

$-E_x + B_x + A_x = 0$ (4)

$\Sigma F_y = 0$

$A_y + B_y - E_y = 0$ (5)

$\Sigma M_A = 0$

$200E_x - 100E_y - 100B_x = 0$ (6)

$\Sigma F_x = 0$

$-B_x - C_x = 0$ (7)

$\Sigma F_y = 0$

$D - C_y - B_y = 0$ (8)

$\Sigma M_B = 0$

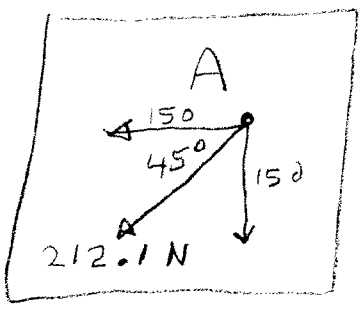
$-100C_y + 300D = 0$ (9)

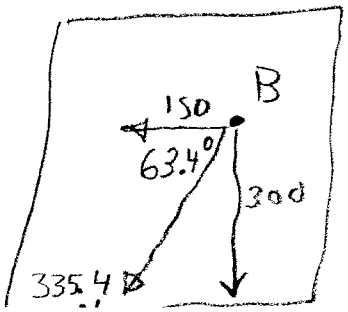
UNK: $A_x, A_y, B_x, B_y, C_x, C_y, E_x, E_y, D$ EQ: (1)—(9) ✓

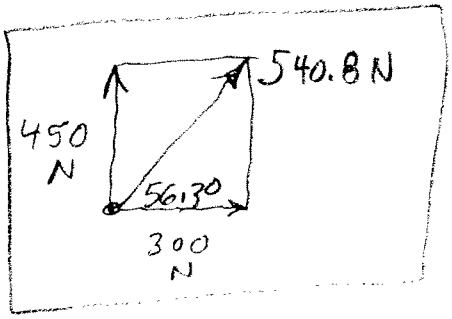
Solving: $A_x = -150$ $A_y = -150$ $B_x = -150$ $B_y = -300$ $C_x = 150$ $C_y = 450$

$E_x = -300$ $E_y = -450$ $D = 150$

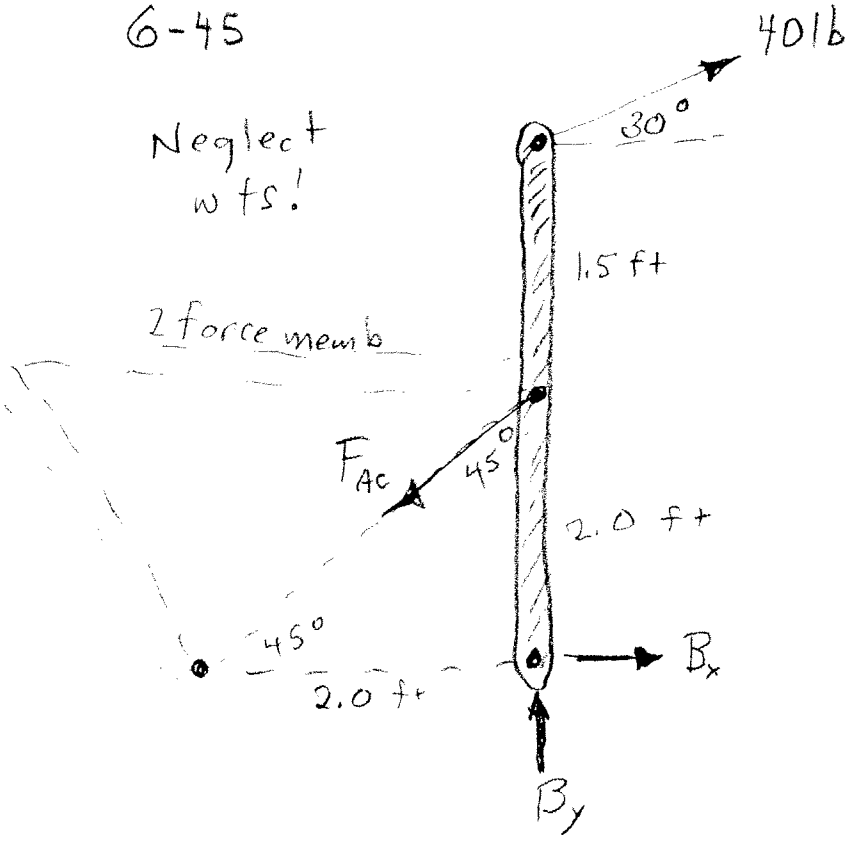
ANS







6-45



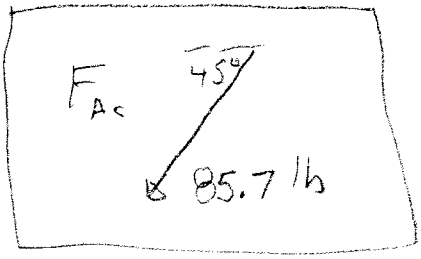
$\Sigma F_x = 0 \qquad -F_{AC}\sin 45^\circ + B_x + 40\cos 30^\circ = 0$

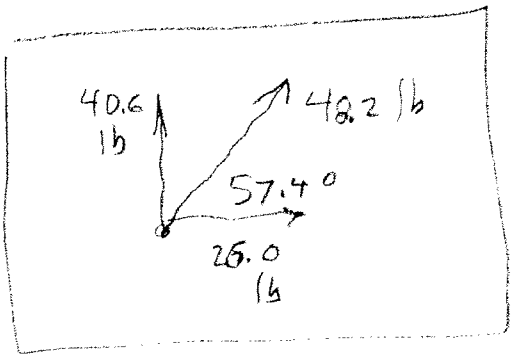
$\Sigma F_y = 0 \qquad B_y - F_{AC}\cos 45^\circ + 40\sin 30^\circ = 0$

$+\circlearrowleft \Sigma M_B = 0 \qquad 2.0\,F_{AC}\sin 45^\circ - 3.5\,(40\cos 30^\circ) = 0$

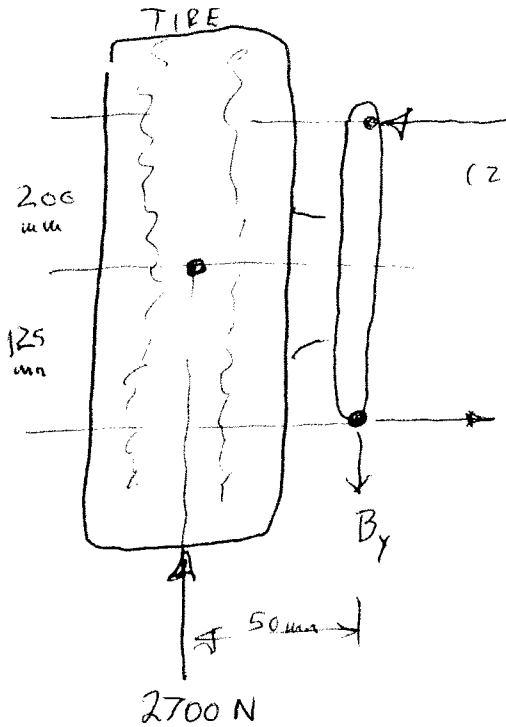
Solve $B_x = 25.98 \qquad B_y = 40.62 \qquad F_{AC} = 85.73$

give ans.





6.52



$\Sigma F_x = 0$

$-F_{CD} + B_x = 0$

$\Sigma F_y = 0$

$-B_y + 2700 = 0$

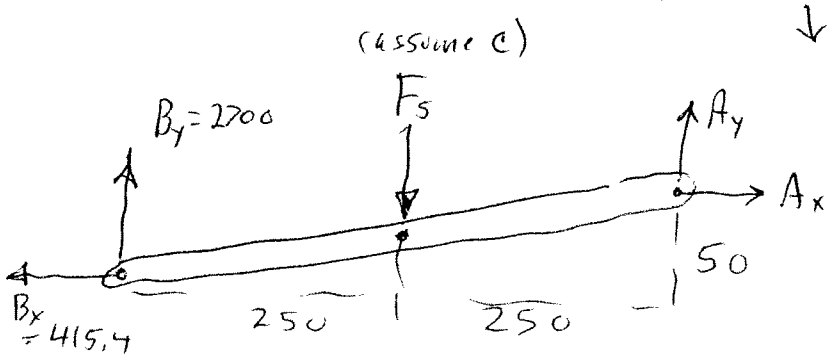
$\Sigma M_B = 0 \quad 325 F_{CD} - 50(2700) = 0$

Solving we have

$B_x = 415.4 \rightarrow \qquad F_{CD} = 415.4$

$\therefore$ force at D is 415. N to right

$B_y = 2700\text{N} \downarrow$



$\Sigma F_x = 0$

$A_x - 415.4 \Rightarrow A_x = 415.4\text{ N} \rightarrow$

$\Sigma M_A = 0 \quad 250 F_S - 500(2700) - 50(415.4) = 0$

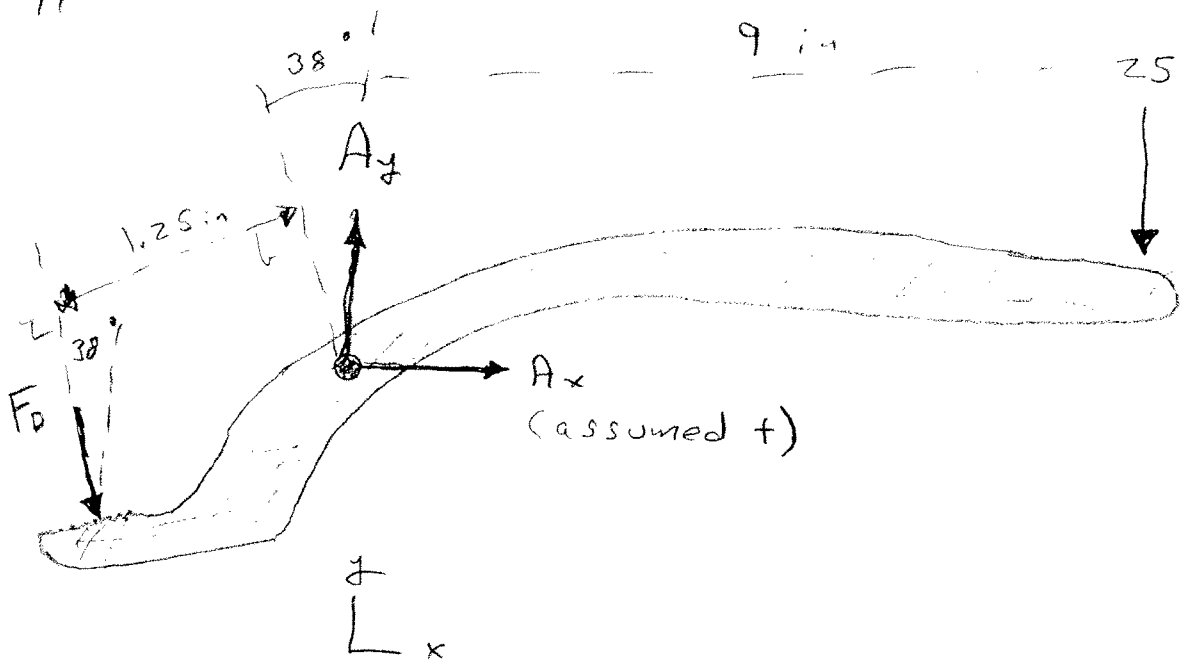
$F_S = 5650\text{ N} \downarrow \text{ comp}$

$\Sigma F_y = 0 \quad B_y - F_S + A_y = 0 \Rightarrow \underline{A_y = 2950\text{N} \uparrow}$

So A: 3200 N, 67.0° ; B: 65.2°, 2970 N ; D: 415 N $\rightarrow$

P26

6-47



$\Sigma F_x = 0$ $\quad F_D \sin 38^\circ + A_x = 0$

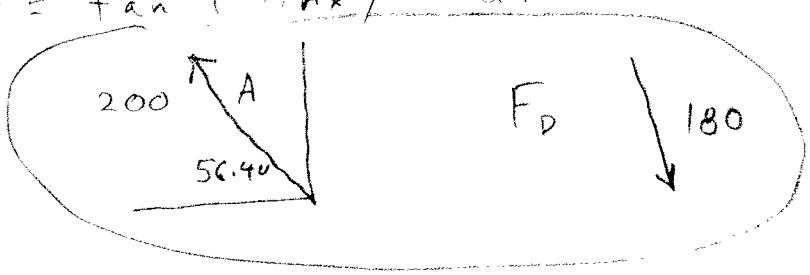
$\Sigma F_y = 0$ $\quad A_y - F_D \cos 38^\circ - 25 = 0$

$\Sigma M_A = 0$ $\quad 1.25 F_D - 9(25) = 0$

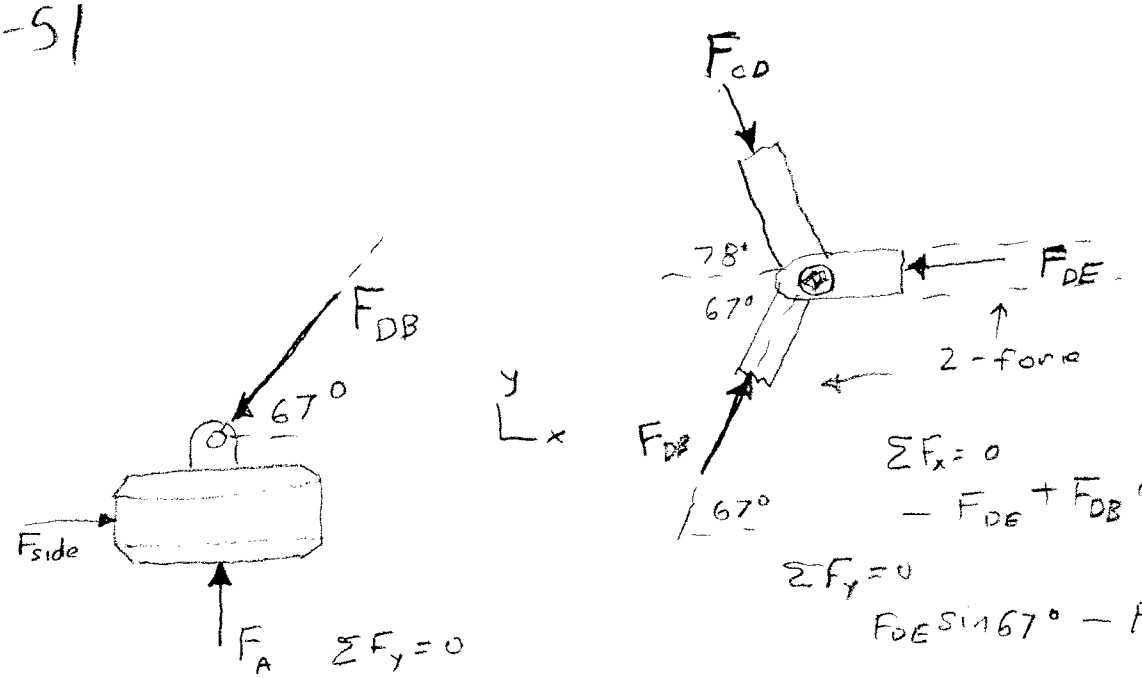
Solved, $A_x = -110.8$ lb $A_y = 166.8$ lb $F_D = 180$ lb

$A = \sqrt{A_x^2 + A_y^2} = 200.3$

$\theta = \tan^{-1}(A_y/A_x) = 56.4^\circ$



6-51



$\Sigma F_x = 0$

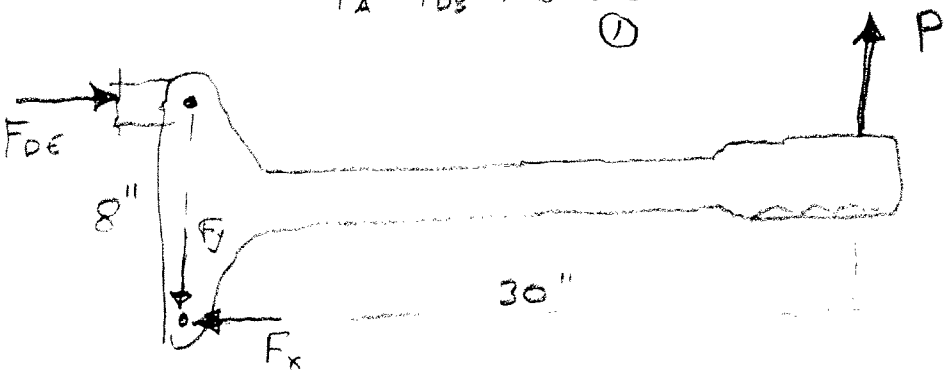
$-F_{DE} + F_{DB}\cos 67° + F_{CD}\cos 78° = 0$ (2)

$\Sigma F_y = 0$

$F_{DB}\sin 67° - F_{CD}\sin 78° = 0$ (3)

$\Sigma F_y = 0$

$F_A - F_{DB}\sin 67° = 0$ (1)



$\Sigma M_F = 0$ $\quad 30P - 8F_{DE} = 0$ (4)

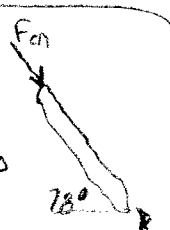
Solve $\quad F_A = 5.887P \quad F_{DB} = 6.395P \quad F_{DE} = 3.75P$

$F_{CD} = 6.018P$

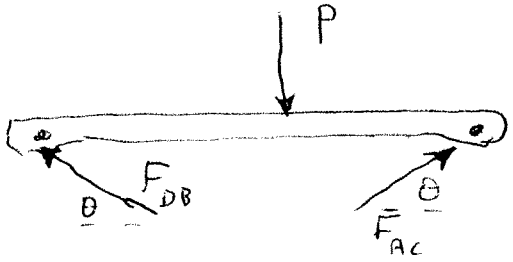
IF $P = 1000$ lb $\quad \boxed{F_A = 5890 \text{ lb}}$

$F_{CD} = 6020$ lb

Compression F_{CD}



6.54

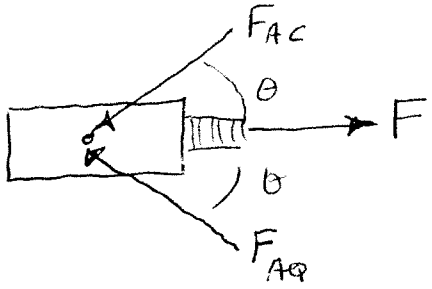


$\Sigma F_x = 0 \Rightarrow F_{DB} = F_{AC}$

$\Sigma F_y = 0$

$-P + 2F_{AC}\sin\theta = 0$ (1)

AC & DB are 2 force members.



$\Sigma F_y = 0 \Rightarrow F_{AC} = F_{AC}$

$\Sigma F_x = 0 \quad F - 2F_{AC}\cos\theta = 0$ (2)

(1) $F_{AC} = \dfrac{P}{2\sin\theta}$ (2) $F = 2\left(\dfrac{P}{2\sin\theta}\right)\cos\theta$

$F = \dfrac{P}{\tan\theta}$ $\quad P = F\tan\theta$

$P_{15} = 800\tan(15°) = 214\ N$

$P_{30} = 800\tan(30°) = 462\ N$

$P_{45} = 800\tan(45°) = 800\ N$

$\tau = \dfrac{F_{AC}}{A_s} = \dfrac{F/(2\cos\theta)}{\frac{\pi \cdot d^2}{4}}$

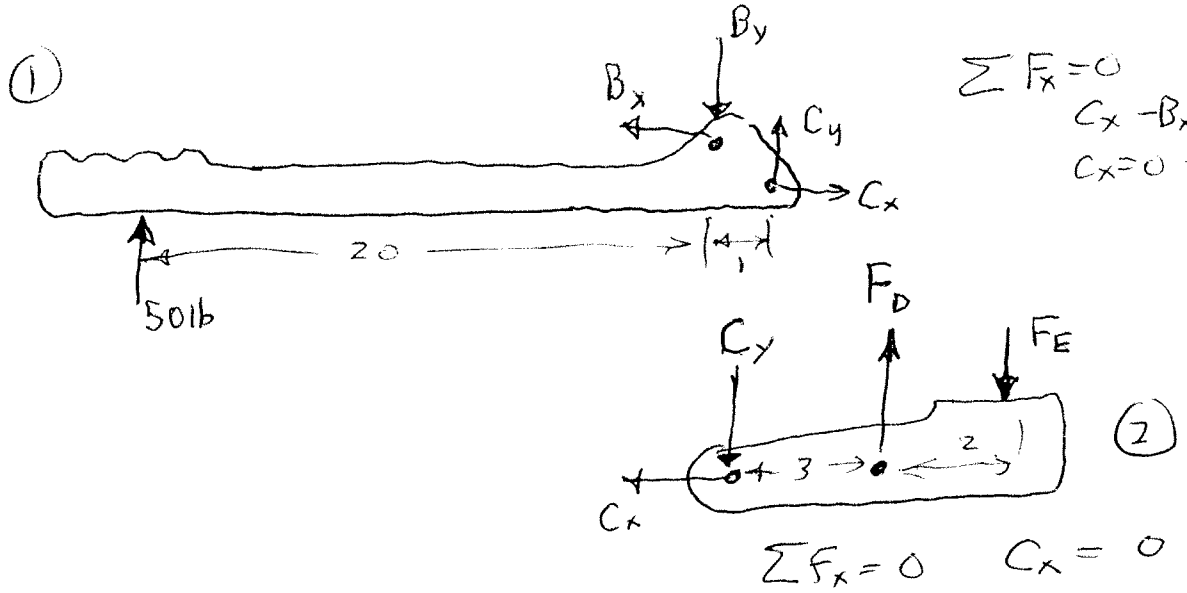
$\tau_{15} = 5.27\ MPa$

$\tau_{30} = 5.88\ MPa$

$\tau_{45} = 7.20\ MPa$

P27

6.59



$\Sigma F_x = 0$

$C_x - B_x = 0$

$C_x = 0 \Rightarrow B_x = 0$

$\Sigma F_x = 0 \quad C_x = 0$

① $\Sigma F_y = 0 \quad 50 - B_y + C_y = 0$

$\Sigma M_B = 0 \quad -20(50) + 1 \cdot C_y + 0 = 0$

$C_y = 1000 \text{ lb}$

$B_y = 1050 \text{ lb}$

② $\Sigma F_y = 0 \quad -C_y + F_D - F_E = 0$

$\Sigma M_D = 0 \quad 3C_y - 2F_E = 0$

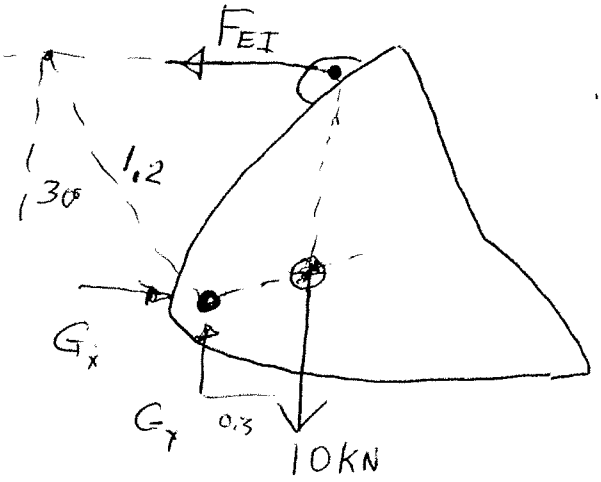
$F_E = 1500 \text{ lb}$

$F_D = 2500 \text{ lb}$

$$\sigma = \frac{F_D}{2A_D} = \frac{2500 \text{ lb}}{2(\frac{1}{8})(\frac{3}{4}) \text{ in}^2} = 13.33 \text{ ksi}$$

$$\delta = \frac{\frac{1}{2}F_D L}{A_D E} = \frac{(1250 \text{ lb})(4 \text{ in})}{(29 \times 10^6 \frac{\text{lb}}{\text{in}^2})(\frac{1}{8})(\frac{3}{4}) \text{ in}^2} = 1.839 \times 10^{-3} \text{ in}$$

6.62



$\Sigma M_G = 0$

$1.2\cos 30^\circ F_{EI} - 0.3(10) = 0$

$\Sigma F_y = 0$

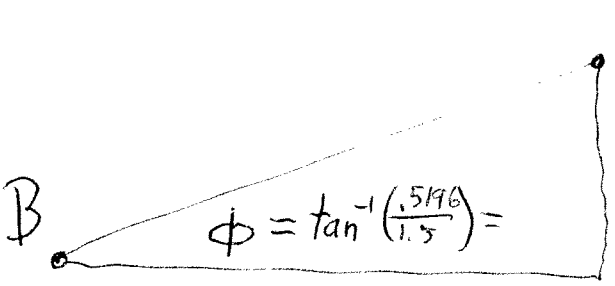
$G_y - 10 = 0$

$\Sigma F_x = 0$

$G_x - F_{EI} = 0$

Solving $G_y = 10\,KN$ $G_x = 2.89\,KN$ $F_{EI} = 2.89\,KN$

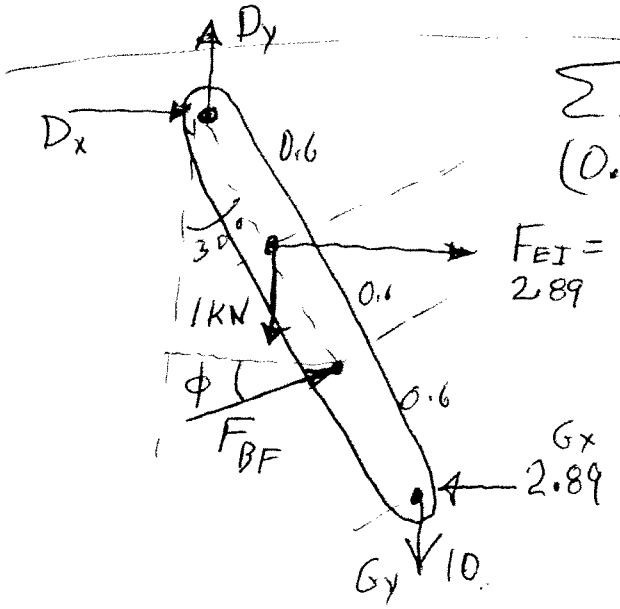
Orientation of BF



$1.8\cos 30^\circ - 1.2\cos 30^\circ = 0.5196$

$1.8\sin 30^\circ + 1.2\sin 30^\circ = 1.5$

$\phi = .3335\ rad = 19.11^\circ$



$\Sigma M_D = 0$

$(0.6\cos 30^\circ)2.89 + 1.2\cos 30^\circ F_{BF}\cos\phi + 1.2\sin 30^\circ F_{BF}\sin\phi - 1.8\cos 30^\circ(2.89) - 1.8\sin 30^\circ(10) - (0.6\sin 30^\circ)1 = 0$

$F_{BF} = 10.438\,KN$

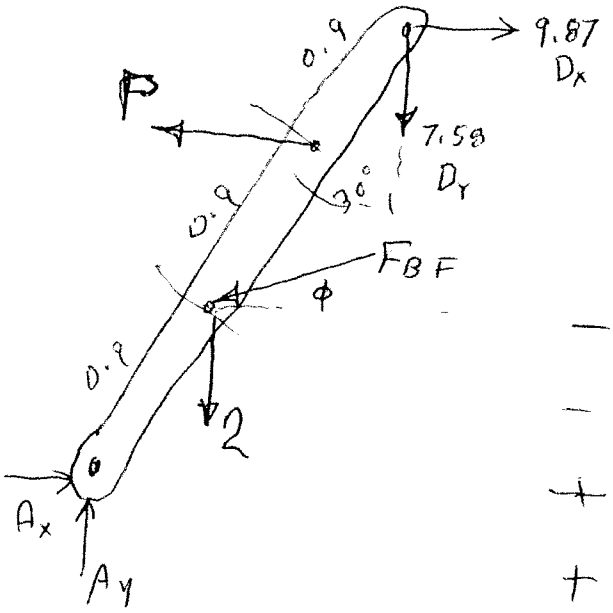
Next page, pls.

$$\Sigma F_x = 0 \qquad D_x + F_{EI} - G_x + F_{BF}\cos\phi = 0$$

$$\Sigma F_y = 0 \qquad D_y - 1 + F_{BF}\sin\phi - G_y = 0$$

$D_x = -9.863$ KN ($\leftarrow$) $\quad D_y = 7.583$

$= 9.87$ KN $\leftarrow$ $\quad = \underline{7.58\ \text{KN}}\ \uparrow$



$$\Sigma M_A = 0$$

$$-(2.7\cos30^\circ)(9.87)$$
$$-(2.7\sin30^\circ)(7.58)$$
$$+(1.8\cos30^\circ)\,P$$
$$+(0.9\cos30^\circ)\,F_{BF}\cos\phi$$
$$-(0.9\sin30^\circ)\,F_{BF}\sin\phi$$
$$-(0.9\sin30^\circ)\,2 = 0$$

$\underline{P = 18.0\ \text{KN}}$

force in CJ

$$\tau_{max} = 120\ \frac{N}{mm^2} = \frac{F_{EI}}{2A_p} = \frac{2{,}890\ N}{2A_p}$$

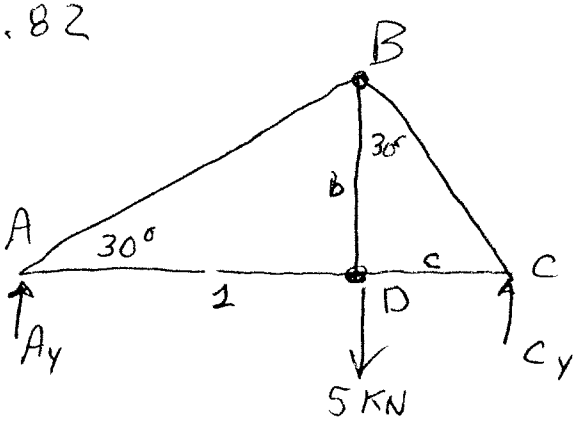
$A_p = 12.025\ mm^2$

$= \frac{\pi}{4} d^2$

$\underline{d = 3.91\ mm}$

P 29

6.82



$\frac{b}{2} = \frac{c}{b}$

$\frac{c}{b} = \tan 30°$

$b = 1.15470$ m

$c = 0.6667$ m

$\Sigma F_x = 0$

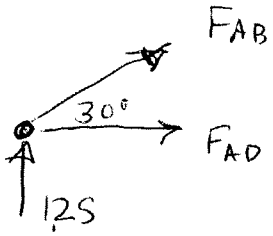
$\Sigma F_Y = 0 \quad A_y - 5 + C_Y = 0$

$\Sigma M_A = 0 \quad 2.6667 C_y - 2(5) = 0$

solve $C_y = 3.75$ KN

$A_y = 1.25$ KN

Joint A



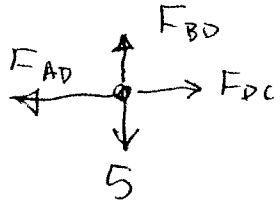
$\Sigma F_x = 0 \quad F_{AB}\cos 30° + F_{AD} = 0$

$\Sigma F_y = 0 \quad 1.25 + F_{AB}\sin 30° = 0$

$F_{AB} = -2.5$ KN C

$F_{AD} = -2.1651$ KN $= -2.17$ KN C

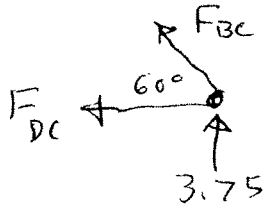
Joint D



$F_{DC} = F_{AD} = -2.17$ KN C

$F_{BD} = 5$ KN T

Joint C

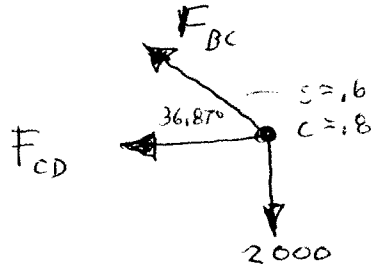


$\Sigma F_y = 0 \quad F_{BC}\sin 60° + 3.75 = 0$

$F_{BC} = -4.33$ KN C

6.83

Joint C



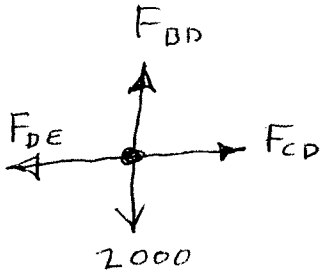
$\Sigma F_x = 0 \quad -.8F_{BC} - F_{CD} = 0$

$\Sigma F_y = 0 \quad -2000 + .6F_{BC} = 0$

$F_{CD} = -2667 = \underline{2670\ C}$ lb

$F_{BC} = 3333 = \underline{3330\ T}$ lb

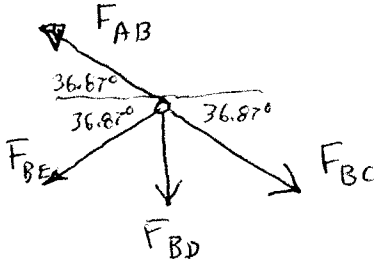
Joint D



$\Sigma F_x = 0 \quad F_{DE} = \underline{-2670\ C}$ lb

$\Sigma F_y = 0 \quad F_{BD} = \underline{2000\ T}$ lb

Joint B



$\Sigma F_x = 0 \quad -.8F_{AB} - .8F_{BE} + .8F_{BC} = 0$

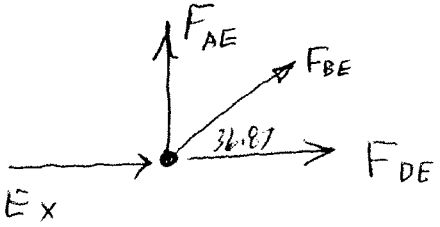
$-.8F_{AB} - .8F_{BE} + .8(3333) = 0$

$\Sigma F_y = 0 \quad .6F_{AB} - .6F_{BE} - F_{BD} - .6F_{BC} = 0$

$.6F_{AB} - .6F_{BE} - (2000) - .6(3333) = 0$

Solving $F_{BE} = \underline{-1667\ \text{lb}\ C} \quad \underline{F_{AB} = 5000\ \text{lb}\ T}$

Joint E



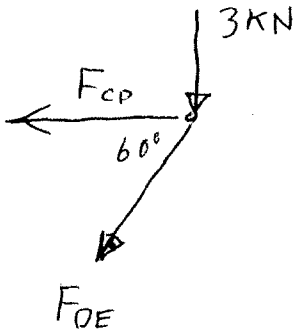
$\Sigma F_y = 0 \quad F_{AE} + .6F_{BE} = 0$

$F_{AE} = -.6(-1666.67)$

$F_{AE} = \underline{1000\ \text{lb}\ T}$

6.84

Joint D



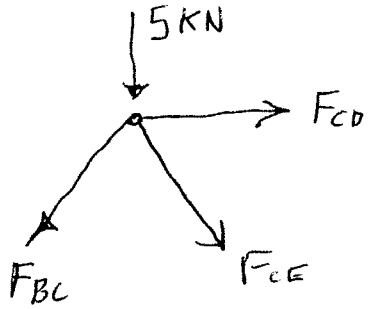
$\Sigma F_x = 0 \quad -F_{CD} - F_{DE}\cos 60° = 0$

$\Sigma F_y = 0 \quad -3 - F_{DE}\sin 60° = 0$

solving $F_{CD} = 1.732\ KN\ T$

$F_{DE} = -3.46\ KNC$

Joint C



$\Sigma F_x = 0 \quad F_{CD} + F_{CE}\cos 60° - F_{BC}\cos 60° = 0$

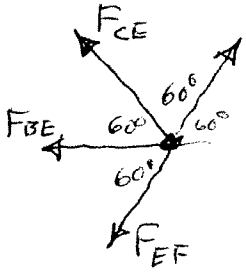
$1.732 + F_{CE}\cos 60° - F_{BC}\cos 60° = 0$

$\Sigma F_y = 0 \quad -5 - F_{BC}\sin 60° - F_{CE}\sin 60° = 0$

Solve $F_{BC} = -1.155\ KNC$

$F_{CE} = -4.62\ KNC$

Joint E



$\Sigma F_x = 0 \quad F_{DE}\cos 60° - F_{CE}\cos 60° - F_{BE} - F_{EF}\cos 60° = 0$

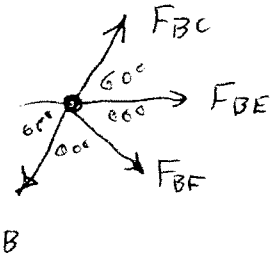
$(-3.46)\cos 60° - (-4.62)\cos 60° - F_{BE} - F_{EF}\cos 60° = 0$

$\Sigma F_y = 0 \quad F_{DE}\sin 60° + F_{CE}\sin 60° - F_{EF}\sin 60° = 0$

$(-3.46)\sin 60° + (-4.62)\sin 60° - F_{EF}\sin 60° = 0$

Solve $F_{BE} = 4.62\ KN\ T \qquad F_{EF} = -8.08\ KNC$

Joint B



$\Sigma F_x = 0 \quad F_{BC}\cos 60° + F_{BE} + F_{BF}\cos 60° - F_{AB}\cos 60° = 0$

$(-1.155)\cos 60° + 4.62 + F_{BF}\cos 60° - F_{AB}\cos 60° = 0$

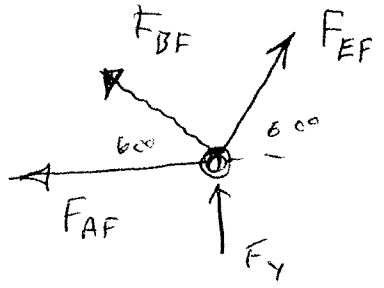
$\Sigma F_y = 0 \quad F_{BC}\sin 60° - F_{BF}\sin 60° - F_{AB}\sin 60° = 0$

$(-1.155)\sin 60° - F_{BF}\sin 60° - F_{AB}\sin 60° = 0$

Solve $F_{AB} = 3.46\ KN\ T \qquad F_{BF} = -4.62\ KN\ C$

Next Page —

Joint F



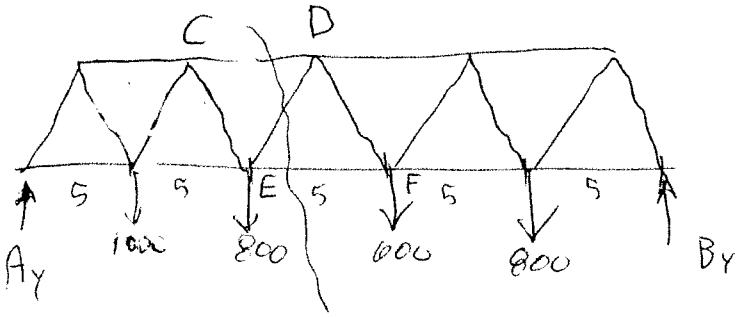
$$\sum F_x = 0 \quad -F_{AF} - F_{BF}\cos 60^\circ + F_{EF}\cos 60^\circ = 0$$

$$-F_{AF} - (-4.62)\cos 60^\circ + (-8.08)\cos 60^\circ = 0$$

$$F_{AF} = -1.732\ \text{KN}\ \ C$$

P30

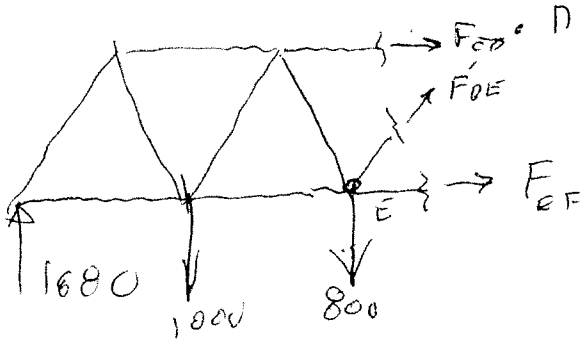
6-85



$\sum M_B = 0$

$-25A_Y + 20(1000) + 15(800) + 10(600) + 5(800) = 0$

$A_Y = 1680$



≠ section

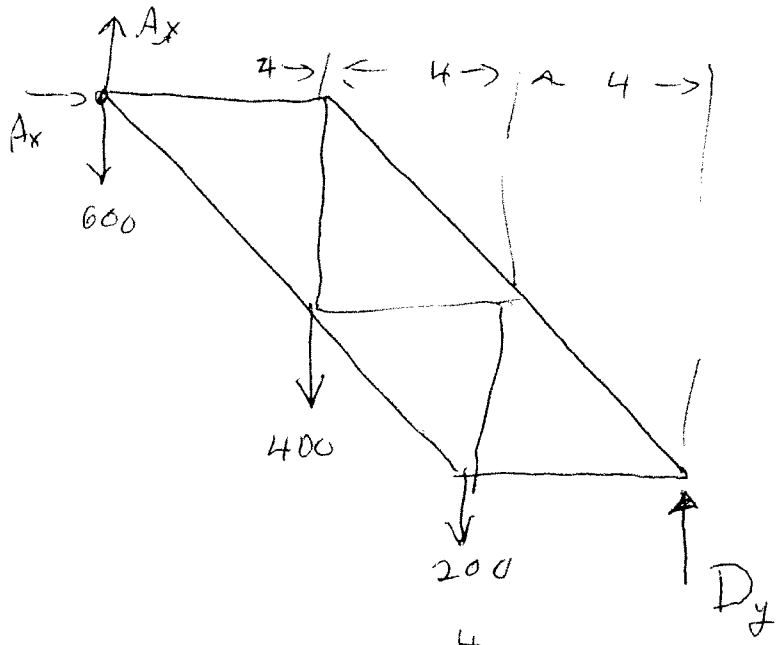
$\sum M_E = 0 \quad -(5\sin 60°)(F_{CD}) - 10(1680) + 5(1000) = 0$

$F_{CD} = \underline{-2730 \text{ lb C}}$

$\sum M_D = 0 \quad (5\sin 60°)F_{EF} + 2.5(800) + 7.5(1000) - 12.5(1680) = 0$

$F_{EF} = \underline{2660 \text{ lb T}}$

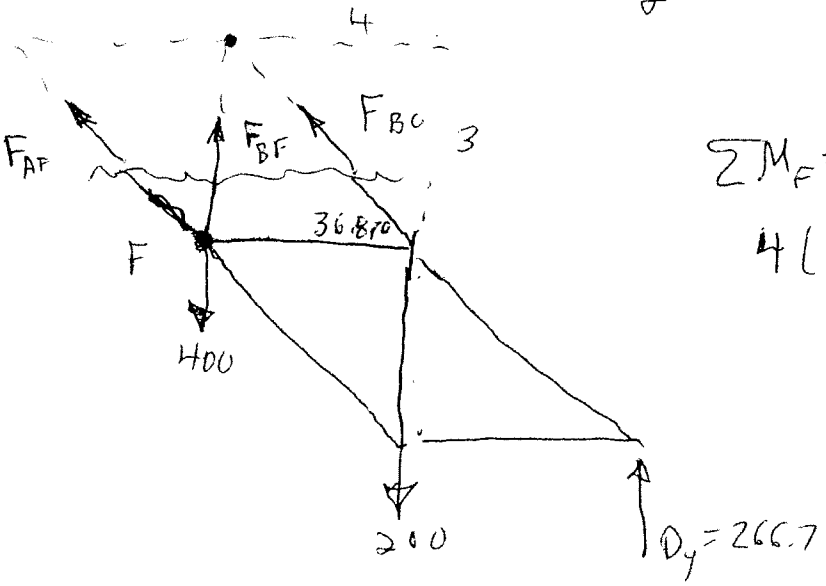
6.87



$$\sum M_A = 0$$

$$-4(400) - 8(200) + 12D_y = 0$$

$$D_y = 266.7$$



$$\sum M_F = 0$$

$$4(F_{BC}\sin 36.87^\circ) + 8D_y - 4(200) = 0$$

$$F_{BC} = -556 \text{ lb} \quad C$$

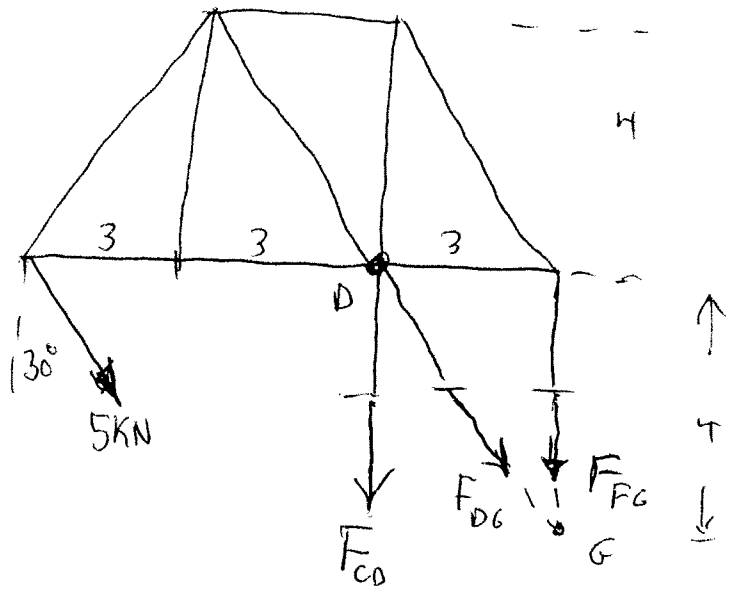
$$\sum F_x = 0 \quad -F_{AF}\cos 36.87^\circ - F_{BC}\cos 36.87^\circ = 0$$

$$F_{AF} = 556 \text{ lb} \quad T$$

$$\sum F_y = 0 \quad F_{AF}\sin 36.87^\circ + F_{BF} + F_{BC}\sin 36.87^\circ - 400 - 200 + D_y = 0$$

$$F_{BF} = 333 \text{ lb} \quad T$$

6.90



$\sum M_D = 0 \qquad 6(5\cos 30°) - 3F_{FG} = 0$

$\sum M_G = 0 \qquad 9(5\cos 30°) - 4(5\sin 30°) + 3F_{CD} = 0$

Solving $\qquad F_{FG} = 8.66\ KN$

$F_{CD} = -9.66\ KN$

$A = 300\ mm^2$, $E = 200{,}000\ \frac{N}{mm^2}$, $L = 4000\ mm$

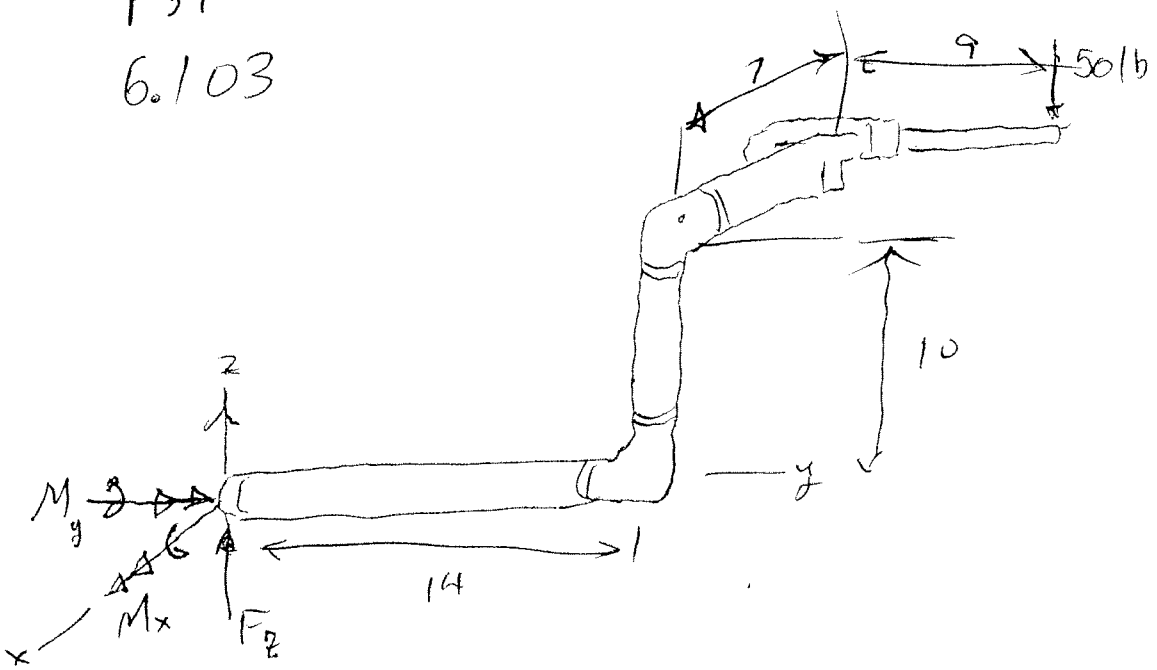
$$\delta = \frac{PL}{AE}$$

$\delta_{CD} = -0.644\ mm$

$\delta_{FG} = 0.577\ mm$

P31

6.103



$\Sigma F_z = 0$ $\quad F_z - 50 = 0$ $\quad F_z = 50$ lb

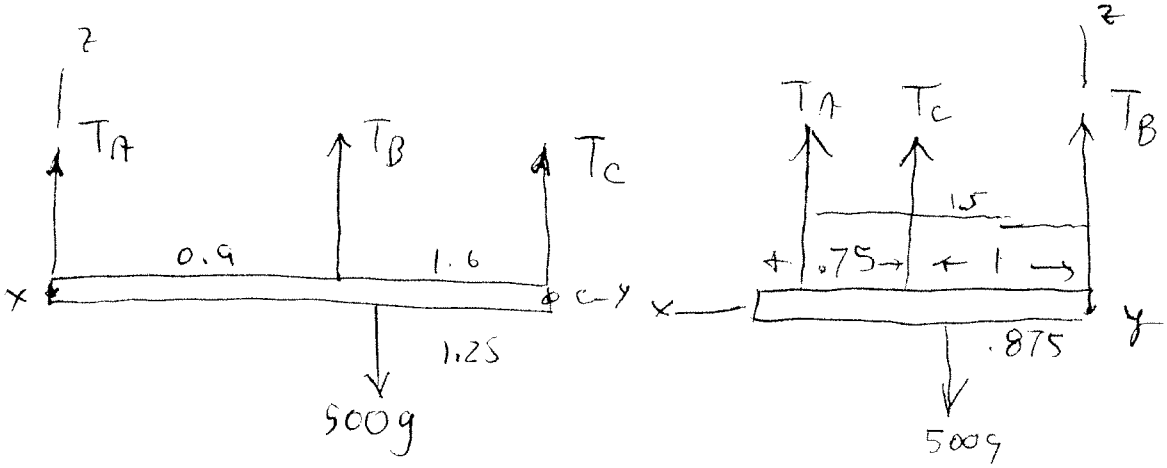
$\Sigma M_x = 0$ $\quad M_x - (23)(50) = 0$ $\quad M_x = 1150$ in-lb

$\Sigma M_y = 0$ $\quad M_y - 7(50) = 0$ $\quad M_y = 350$ in-lb

Reaction force $\quad 50\vec{k}$ lb

couple $\quad 1150\vec{i} + 350\vec{j}$ in-lb

6.104



$\Sigma F_z = 0 \quad T_A + T_B + T_C - 500g = 0$

$\Sigma M_{Ax} = 0 \quad 0.9\,T_B + 2.5\,T_C - 1.25(500g) = 0$

$\Sigma M_{Ay} = 0 \quad -1.5\,T_A - 1\,T_C + .875(500g) = 0$

$T_A = 159.7g = \underline{1559\ N}$

$T_B = 142.9g = \underline{1392\ N}$

$T_C = 199g = \underline{1949\ N}$

$$\delta_A = \frac{PL}{AE} = \frac{(1559\ N)(1500\ mm)}{\left(200{,}000\ \frac{N}{mm^2}\right)\left(\frac{\pi}{4}(10)^2\ mm^2\right)} = \underline{0.1490\ mm}$$

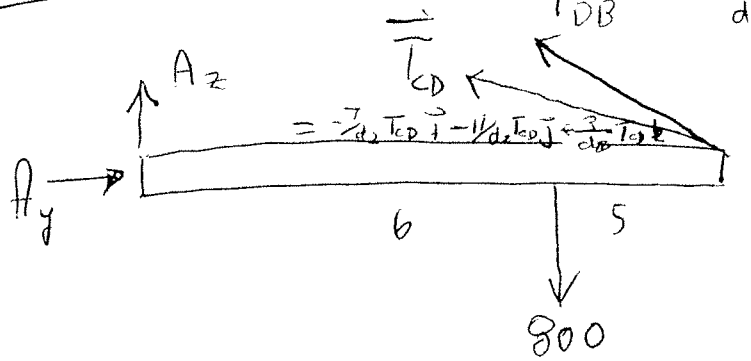
6.107

$d_1 = \sqrt{11^2+6^2}$

$d_2 = \sqrt{11^2+7^2+3^2}$

SIDE

$\vec{T}_{DB} = -\frac{11}{d_1} T_{DB}\vec{j} + \frac{6}{d_1} T_{DB}\vec{k}$

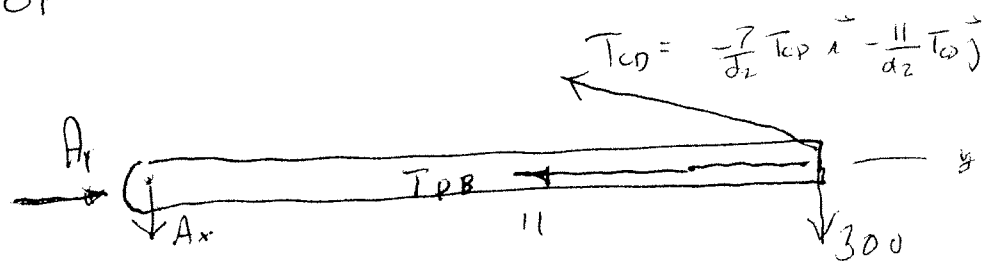


$\Sigma F_y = 0 \quad A_y - \frac{11}{d_2} T_{CD} - \frac{11}{d_1} T_{DB} = 0$ (1)

$\Sigma M_{A_x} = 0 \quad -6(800) + 11\left(\frac{3}{d_2} T_{CD}\right) + 11\left(\frac{6}{d_1}\right) T_{DB} = 0$ (2)

$\Sigma F_z = 0 \quad A_z - 800 + \frac{6}{d_1} T_{DB} + \frac{3}{d_2} T_{CD} = 0$ (3)

TOP



$\Sigma M_{A_z} = 0$

$-11(300) + \frac{7}{d_2} T_{CD} = 0$ (4)

$\Sigma F_x = 0 \quad A_x + 300 - \frac{7}{d_2} T_{CD} = 0$ (5)

JNK

$T_{DB}, T_{CD}, A_x, A_y, A_z$

EQ

(1) – (5)

$A_x = 0 \quad A_y = 1036\text{ lb} \quad A_z = 363\text{ lb} \quad T_{CD} = 643\text{ lb} \quad T_{BD} = 575\text{ lb}$

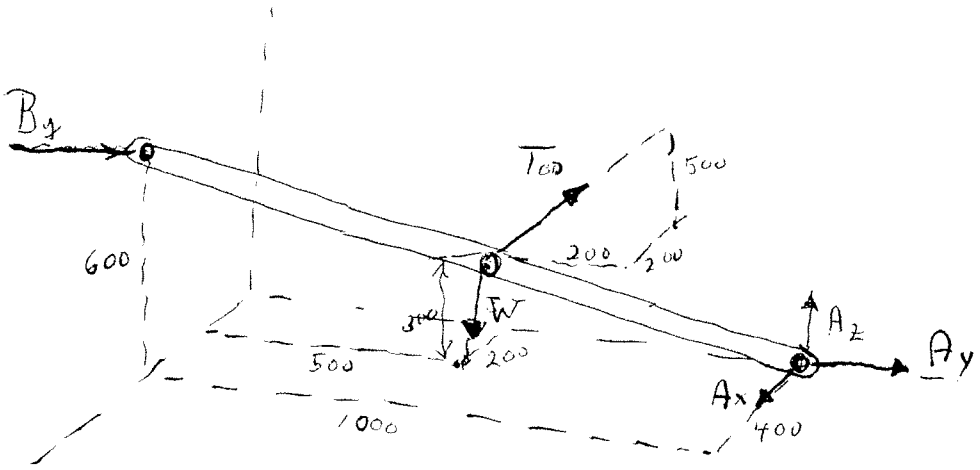
$\sigma_{BD} = T_{BD}/A = 13.09\text{ ksi}$

$\sigma_{CD} = T_{CD}/A = 11.08\text{ ksi}$

$\delta = \frac{PL}{AE} \Rightarrow \delta_{BD} = 0.0656\text{ in} \quad \delta_{CD} = 0.0625\text{ in}$

P33

6/110



FBD of system.

UNK: B_y, T_{CD}, A_x, A_y, A_z

eq: ① - ⑤

$$\vec{T}_{CD} = -0.348\,T_{CD}\,\vec{i} + 0.348\,T_{CD}\,\vec{j} + 0.870\,T_{CD}\,\vec{k}$$

$\sum \vec{F} = 0$

$$A_x - 0.348\,T_{CD} = 0 \quad (1)$$

$$A_y + 0.348\,T_{CD} + B_y = 0 \quad (2)$$

$$A_z + 0.870\,T_{CD} - 2450 = 0 \quad (3)$$

$\sum \vec{M} = 0$

$$\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 700 & -1000 & 600 \\ 0 & B_y & 0 \end{vmatrix} + \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 200 & -500 & 300 \\ 0 & 0 & -2450 \end{vmatrix} + \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 200 & -500 & 300 \\ -.348 & .348 & .870 \end{vmatrix} T_{CD} = 0\vec{i} + 0\vec{j} + 0\vec{k}$$

Resulting in

x: $-600\,B_y + .1225 \times 10^7 - 539.6\,T_{CD} = 0$

y: $490000 - 278.5\,T_{CD} = 0 \quad (4)$

z: $400\,B_y - 104.44\,T_{CD} = 0 \quad (5)$

only 2 are needed. There is actually one non-constrained d.o.f. - rotation of bar about its axis.

$A_x = 613\,N$, $A_y = -1072\,N$, $A_z = 919\,N$, $T_{CD} = 1759\,N$, $B_y = 459\,N$