

# CH. 5 SECTION 5.1 2D EQUILIBRIUM

INTRO:  $\sum F_{EXT} = m \underset{\downarrow}{a} = 0$

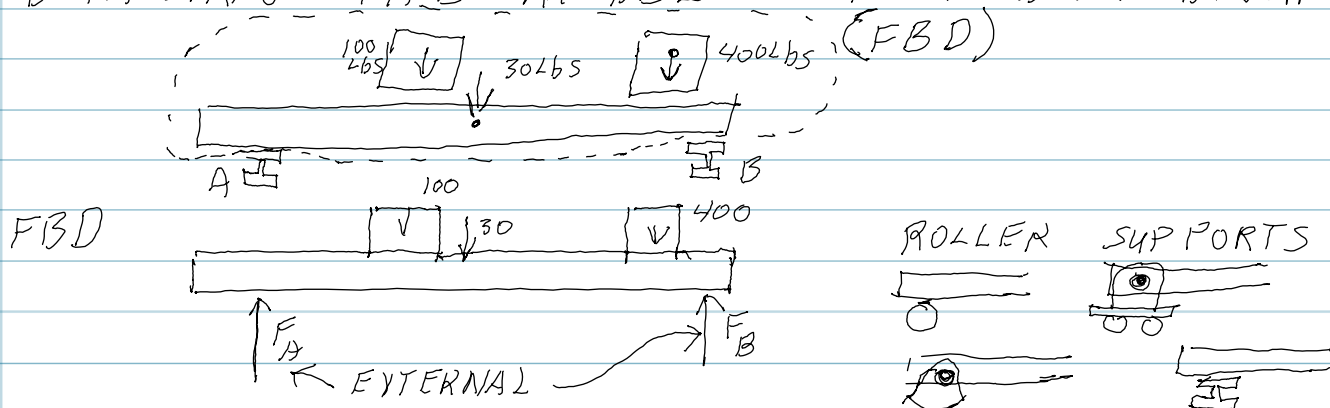
$\sum F_{X,EXT} = 0, \sum F_{Y,EXT} = 0$

$\sum M_{EXT} = \sum \uparrow = I \underset{\downarrow}{a} = 0$

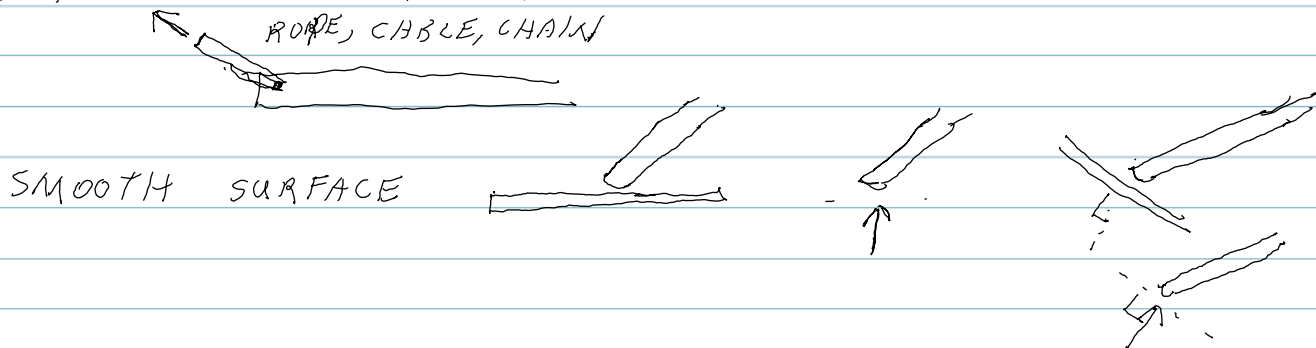
CATEGORIES OF EXTERNAL FORCE:

- 1) CONTACT - FORCE, MOMENT
- 2) FORCES AT A DISTANCE - g, EM

DRAWING THE MODEL - FREE-BODY DIAGR.

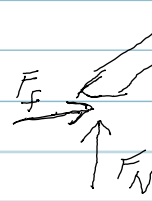
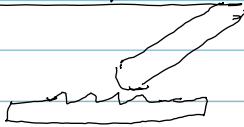


SUPPORTS - CATEGORIES



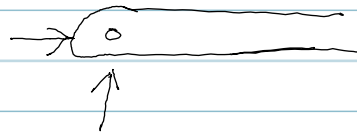
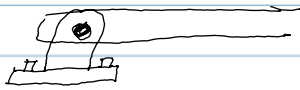
CH. 5 SECTION 5.1 (CONT.)

ROUGH SURFACE



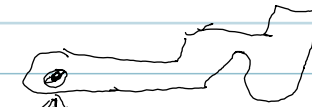
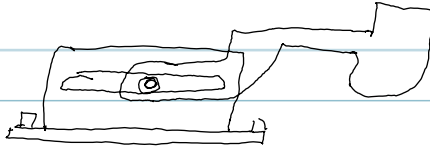
2 UNKNOWN

PIN SUPPORT

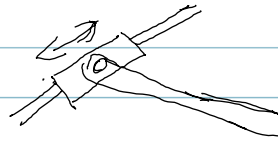


2 UNK.

SLIDER

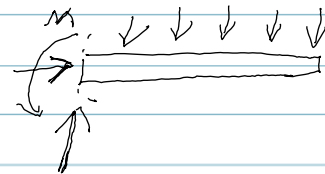
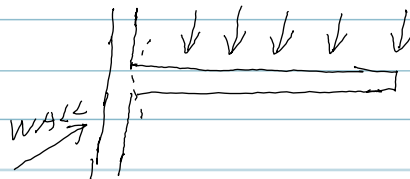


1 UNK



1 UNK

FIXED SUPPORT



3 UNK

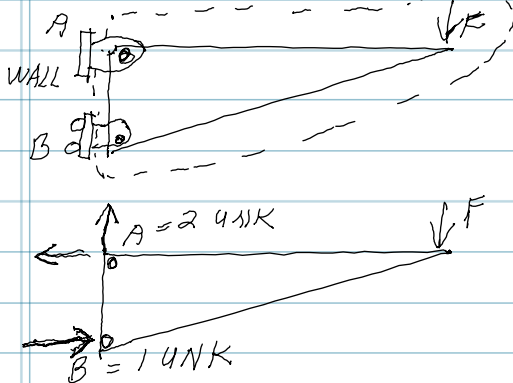
V.I.P. !!

MUST DRAW FBD CORRECTLY

1) REMOVE EACH CONTACT (JOINT) & SHOW FORCE - USE SUPPORT

2) CHECK # UNKNOWN  $\leq 3$

EXAMPLE! DRAW FBD

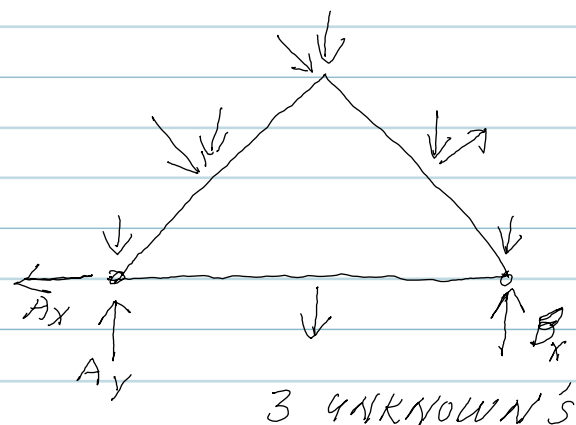
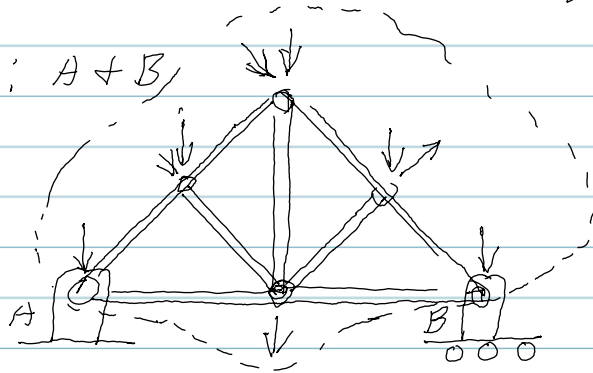


FIND: FORCE A & B @ WALL



CH. 5 SECTION 5.1 (CONT.) FBD EXAMPLES

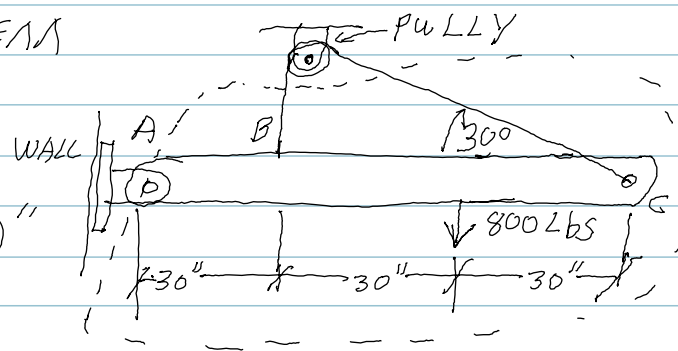
FIND: A + B,



PROB 5-19 FBD PROBLEM

GIVEN:

FIND:  $T = ?$ , REACTIONS @ "A"



SOLUTION: 1)  $\sum M = 0$   
 $\sum F_x \uparrow + M = 0$

(A)  $0 = (A_y)0 + (T)30 - (800)60 + (.5T)90 + (.866T)0 = 0$

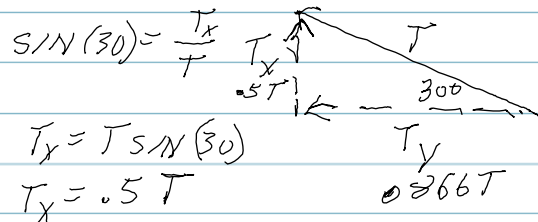
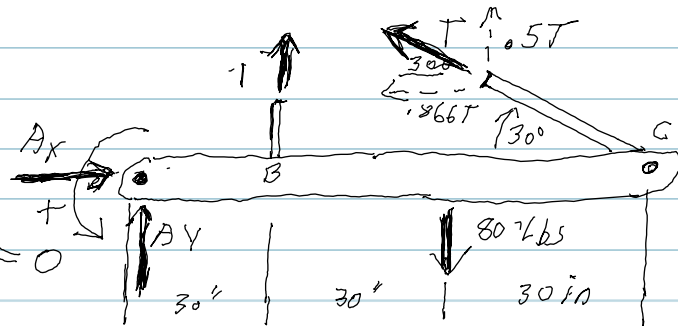
$30T - 48000 + 45T = 0$

$75T = 48000$

$T = 640 \text{ Lbs}$

2)  $\sum F_y = 0 \Rightarrow +A_y + 640 + 320 - 800 = 0$   
 $A_y = -160 \text{ Lbs}$

3)  $\sum F_x = 0 \Rightarrow +A_x - .866T = 0$   
 $A_x - .866(640) = 0$   
 $A_x = 554 \text{ Lbs}$



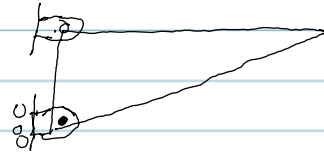
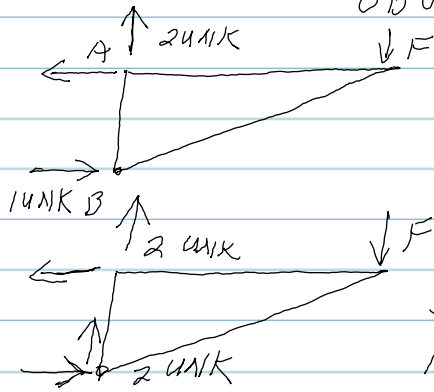
$\cos(30) = \frac{A}{H} = \frac{T_y}{T}$

$T_y = T \cdot \cos(30) = .866T$

COMMENT: BREAK FORCE INTO "X" + "Y" COMPONENT

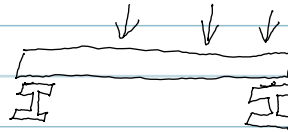
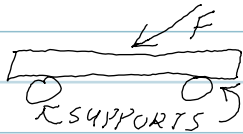
# CH.5 SECTION 5.2 STATICALLY INDETERMINATE OBJECTS

INTRO:



INDETERMINATE  
REDUNDANT SUPPORTS

IMPROPER

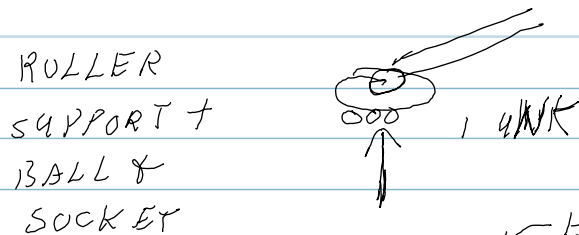
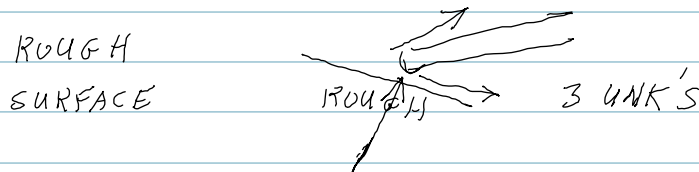
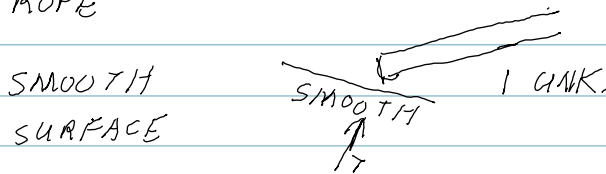
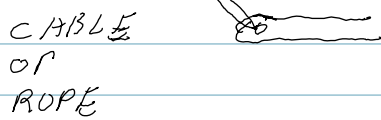
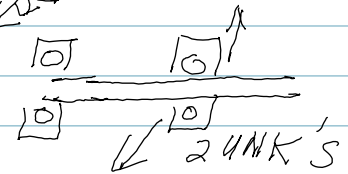
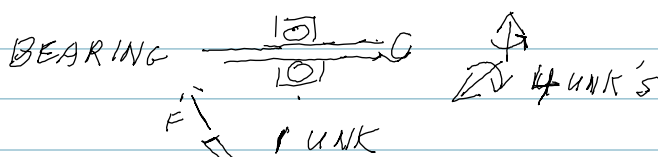
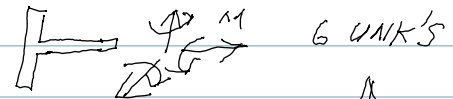
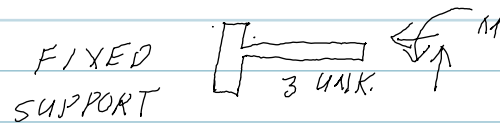


# CH. 5 SECTION 5.3 3D APPLICATIONS

EQUILIBRIUM:  $\sum_{EXT} F = 0 \Rightarrow \sum F_x = 0, \sum F_y = 0, \sum F_z = 0$

$\sum M = 0 \Rightarrow \sum M_x = 0, \sum M_y = 0, \sum M_z = 0$

6 EQUATION



CH. 5 SECTION 5.3 PROBLEM 5-92

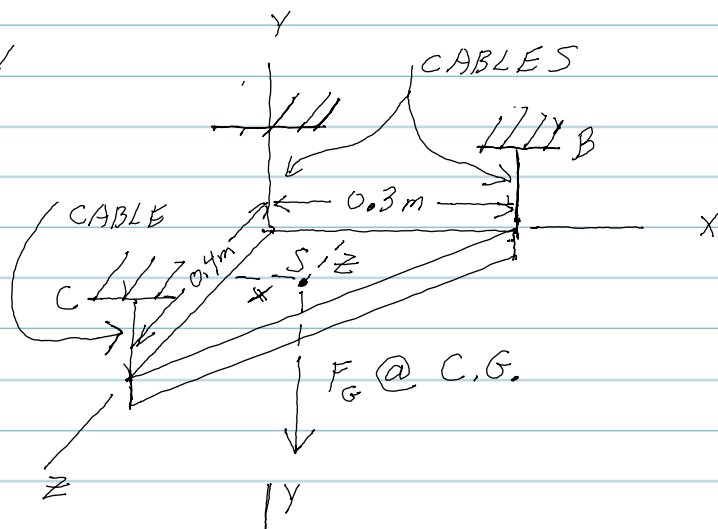
GIVEN:  $F_A = F_B = F_C = 80 \text{ N}$

$\Sigma F_x = 0, \Sigma F_y = 0, \Sigma F_z = 0$

$\Sigma M = 0 \Rightarrow \Sigma M_x = 0, \Sigma M_y = 0$   
ANY LINE X AXIS Y AXIS

$\Sigma M_z = 0$

NOTE:  $\Sigma M_p = 0$

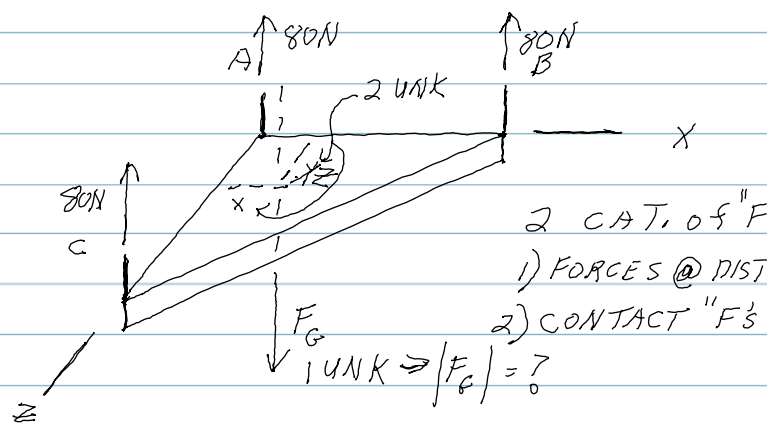


FIND:  $S = (x, 0, z) = ?$   
 $|F_G| = ?$

1)  $\Sigma F_y = 0$

$+80 + 80 - F_G + 80 = 0$

$|F_G| = 240 \text{ N}$



2)  $\Sigma M = 0 \{2D\}$

$\Sigma M = 0 \Rightarrow \Sigma M_x = 0$

$-F_C(0.4) \pm (F_A)0 + (F_G)z \pm (F_B)0 = 0$

$-80(0.4) + (240)z = 0 \Rightarrow 240z = 32$

$z = \frac{32}{240} = 0.133 \text{ m}$

3)  $\Sigma M_z = 0 \Rightarrow \pm(80\text{N})0 \pm (80\text{N})0 - (240\text{N})x + (80\text{N})(0.3\text{m}) = 0$

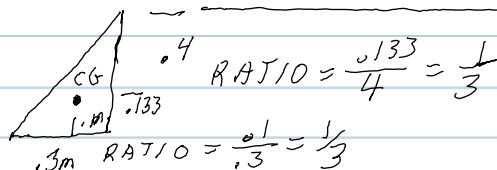
$-240x + 24 = 0$

$240x = 24$

$x = \frac{24}{240} = 0.100 \text{ m}$

CONCLUSION:

SOLID  $\Delta$  SHEET



CH 5 SECTION 5.3 PROB 5-87 3D EQUILIBRIUM

GIVEN:  $|F| = 8 \text{ kN}$

$$e_f = 0.512i - 0.384j + 0.768k$$

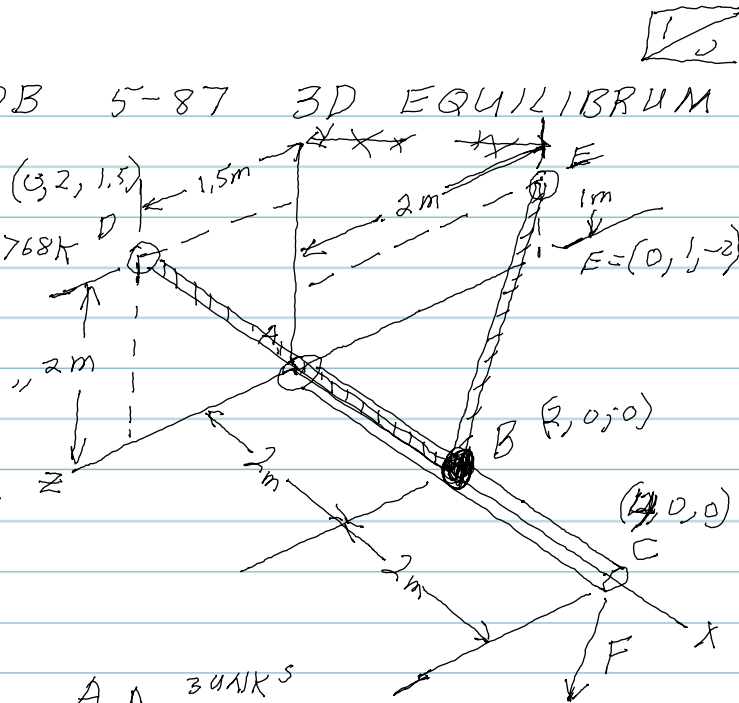
BALL JOINT "A"

ROD FROM "A" TO "C"

ROPES FROM "D" TO "B" + "E" TO "B"

FIND:  $R_a = ? = Li + Mj + Nk$

$$|T_{bd}| = ? , |T_{be}| = ?$$

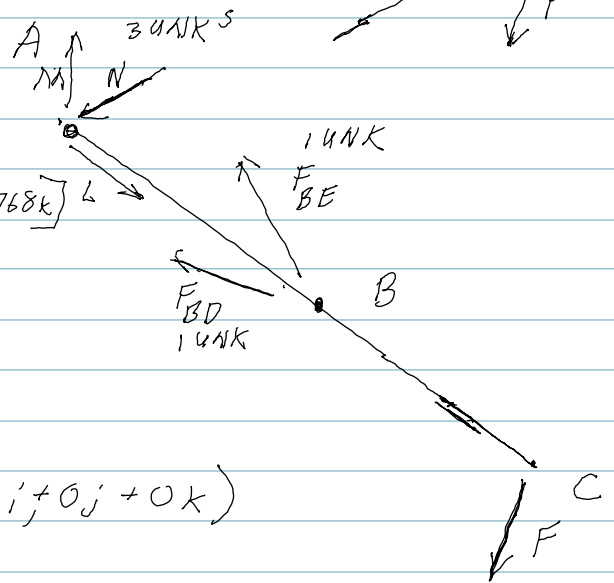


SOLUTION:

a) BREAK FORCES INTO COMP.

$$F = |F| e_f = [8 \text{ (kN)}] [0.512i - 0.384j + 0.768k]$$

$$F = 4.10i - 3.07j + 6.14k$$



b)  $R_a = Li + Mj + Nk$

$$c) r_{bd} = (0i + 2j + 1.5k) - (2i + 0j + 0k)$$

$$r_{bd} = -2i + 2j + 1.5k$$

$$|r_{bd}| = \sqrt{2^2 + 2^2 + 1.5^2} = 3.5$$

$$e_{bd} = \frac{r_{bd}}{|r_{bd}|} = \frac{-2i + 2j + 1.5k}{3.5} = -0.571i + 0.571j + 0.429k$$

$$T_{bd} = |T_{bd}| e_{bd} = -0.571 T_{bd} i + 0.571 T_{bd} j + 0.429 T_{bd} k$$

$$d) r_{be} = (0i + 1j - 2k) - (2i + 0j + 0k) = -2i + 1j - 2k$$

$$|r_{be}| = \sqrt{2^2 + 1^2 + 2^2} = 3$$

$$e_{be} = \frac{r_{be}}{|r_{be}|} = \frac{-2i + 1j - 2k}{3} = -\frac{2}{3}i + \frac{1}{3}j - \frac{2}{3}k$$

$$T_{be} = |T_{be}| e_{be} = -\frac{2}{3} T_{be} i + \frac{1}{3} T_{be} j - \frac{2}{3} T_{be} k$$

PROB. 5-87 (CONT.)

2/3

NEXT STEP:  $\Sigma F = 0 \Rightarrow F + T_{BD} + T_{BE} + R_a = 0$

$$T_{bd} = -0.571 T_{bd} i + 0.571 T_{bd} j + 0.429 T_{bd} k$$

$$F = 4.10 i - 3.07 j + 6.14 k$$

$$R_a = L i + M j + N k$$

$$+ T_{be} = -\frac{2}{3} T_{be} i + \frac{1}{3} T_{be} j - \frac{2}{3} T_{be} k$$

$$0 = 0 i + 0 j + 0 k$$

①  $-0.571 T_{bd} + 4.10 + L - \frac{2}{3} T_{be} = 0$

②  $+0.571 T_{bd} - 3.07 + M + \frac{1}{3} T_{be} = 0$

③  $+0.429 T_{bd} + 6.14 + N - \frac{2}{3} T_{be} = 0$

NEXT STEP:  $\Sigma M = 0$  "A" - B -  
POINT = B

$$r_{ab} \times R_a + r_{cb} \times F = 0$$

$$r_{ab} \times R_a = \begin{vmatrix} i & j & k \\ 2 & 0 & 0 \\ L & M & N \end{vmatrix} \begin{vmatrix} i & j \\ 2 & 0 \\ L & M \end{vmatrix} = 2MK - [2Nj] = 0i - 2Nj + 2MK$$

$$r_{cb} \times F = \begin{vmatrix} i & j & k \\ -2 & 0 & 0 \\ 4.10 & -3.07 & 6.14 \end{vmatrix} \begin{vmatrix} i & j \\ -2 & 0 \\ 4.10 & -3.07 \end{vmatrix} = 6.14k - [-12.28j]$$

$$= 0i + 12.28j + 6.14k$$

○  $6.14k + 12.28j - 2Nj + 2MK = 0$

PROB. 5-87 (CONT.)  
SIMPLIFY!

3/3

$$0i + [12.28 - 2N]j + [6.14 + 2M]k = 0$$

$$\textcircled{4} \quad \underline{12.28 - 2N = 0}$$

$$N = 6.14 \text{ (KN)}$$

$$\textcircled{5} \quad \underline{6.14 + 2M = 0}$$

$$M = -3.07 \text{ (KN)}$$

TYPES OF SOLUTIONS: CRAMER'S RULE - LINEAR  
MATHCAD - NON-LINEAR  
PROB 5-87 3D

$$T_{bd} = 0$$

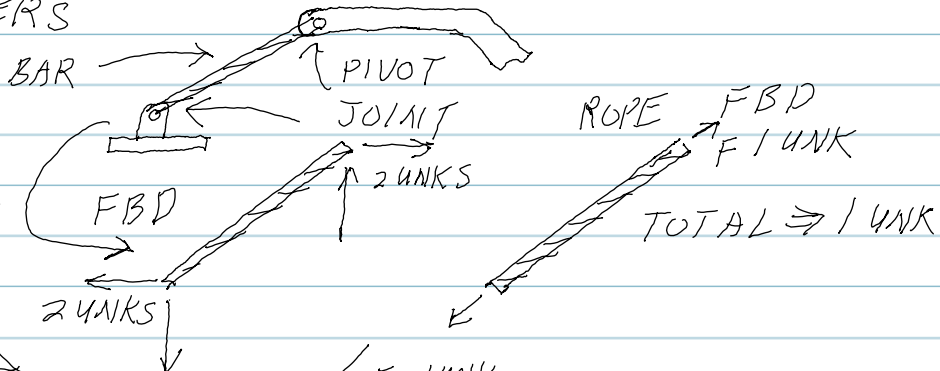
$$T_{be} = 18.43 \text{ KN}$$

$$R_a = 8.19i - 3.07j + 6.14k \text{ (KN)}$$

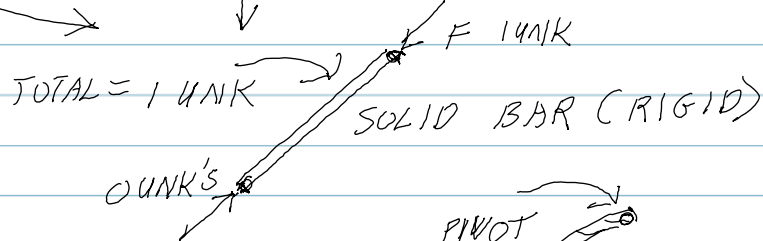
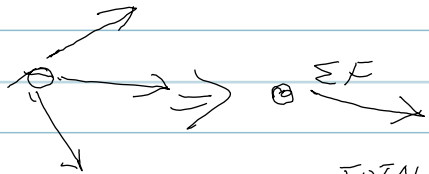
# SECTION 5.4 TWO-FORCE & 3 FORCE MEMBERS

## TWO-FORCE MEMBERS

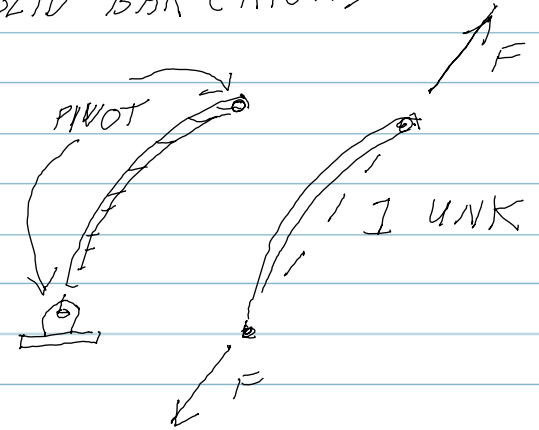
a) ONLY HAVE 2 POINT OF FORCE APPLICATION



b) CONCURRENT FORCE



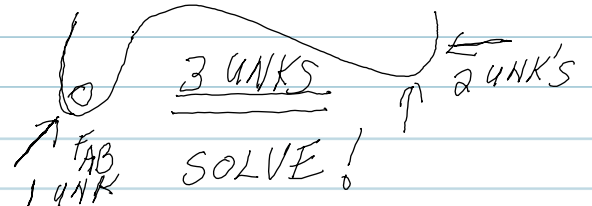
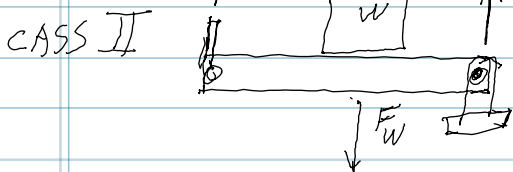
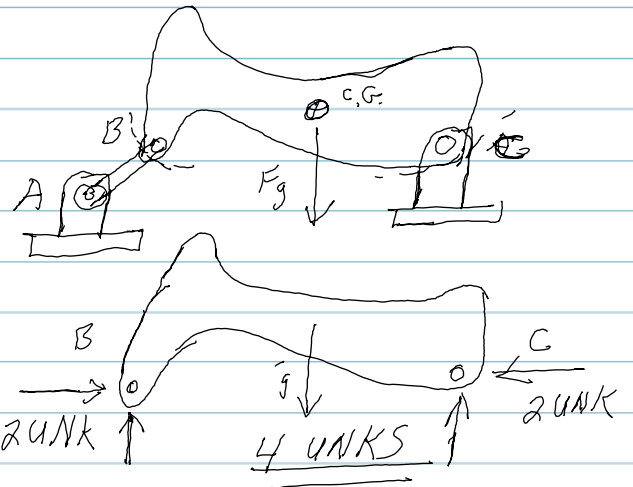
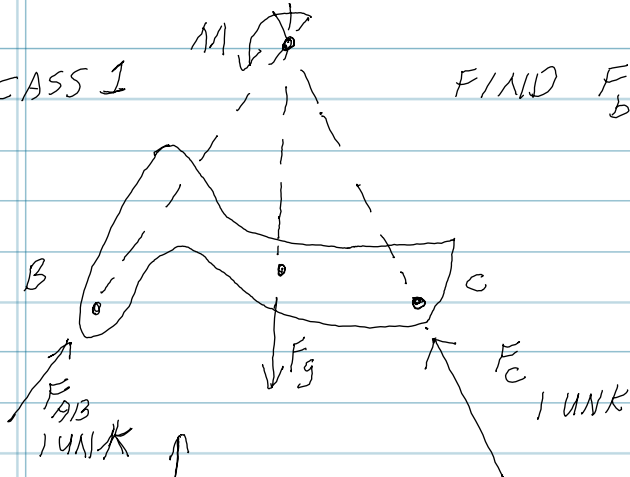
c) REDUCTION OF # OF UNKNOWNNS



d) PIVOT POINTS AT POINTS OF FORCE APPLICATION

## THREE FORCE MEMBER

CASS I FIND  $F_B + F_C$





CH 5 SECTION 5.4 PROB 5-23 2 FORCE MEMBER

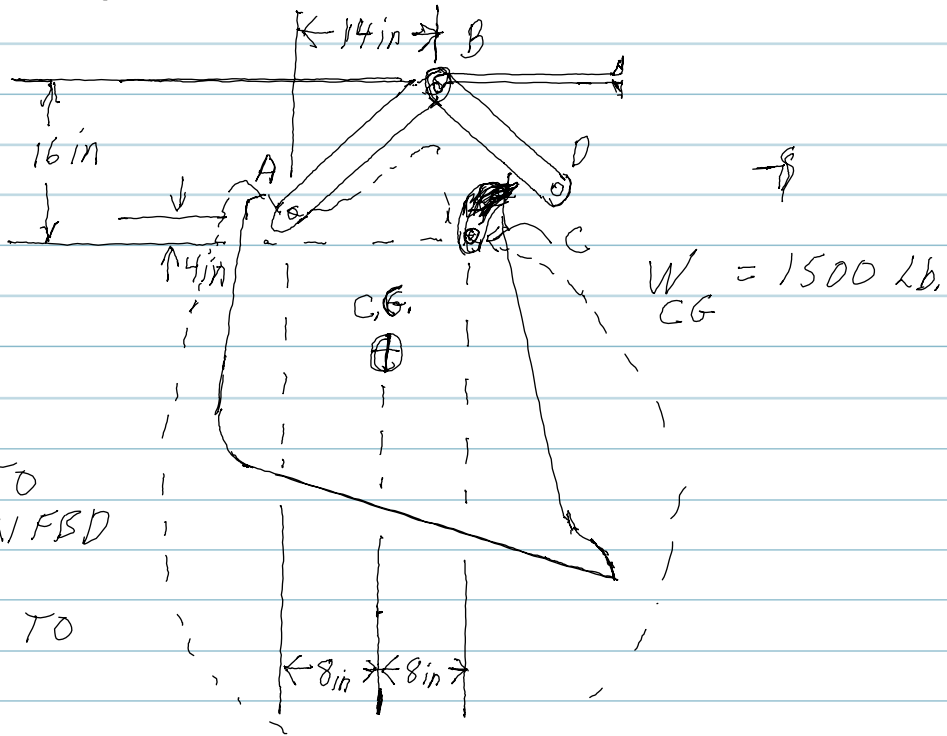
GIVEN:

FIND:  $R_C = ?$

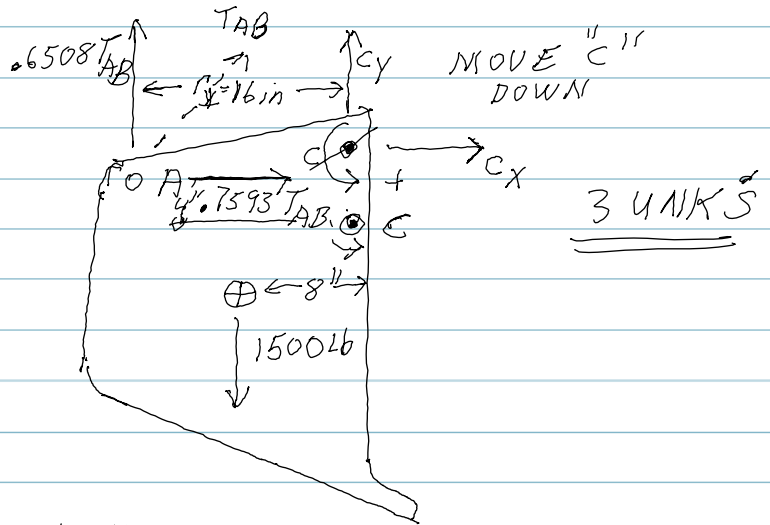
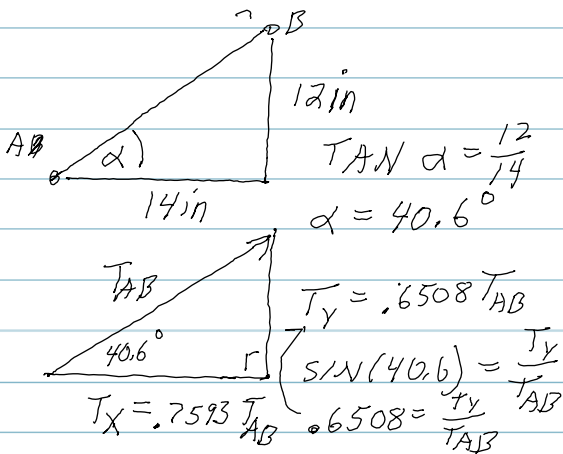
SOLUTION:

a) BREAK  $F$ 'S INTO COMPONENTS ON FBD

b) SHOW EACH  $\perp$  TO PIVOT POINT



a)  $T_{AB} \parallel r_{ab}$



b) PICK PIVOT POINT  $\Rightarrow$  "C"

$$\sum F_x = 0, \sum F_y = 0, \sum M = \sum F \cdot r_{\perp} = 0$$

$$\sum F \cdot r_{\perp} = 0$$

$$-(0.6508 T_{AB})(16 \text{ in}) - (0.7593 T_{AB})(4 \text{ in}) + (1500 \text{ lb}) 8'' = 0$$

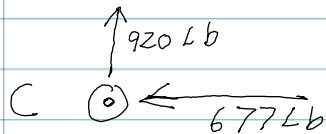
$$\underline{\underline{T_{AB} = 892 \text{ lbs}}}$$

$$\sum F_y = 0$$

$$.6508 T_{AB} - 1500 + C_y = 0$$

$$.6508(892 \text{ lb}) - 1500 \text{ lb} + C_y = 0$$

$$\underline{\underline{C_y = 920 \text{ lb}}}$$

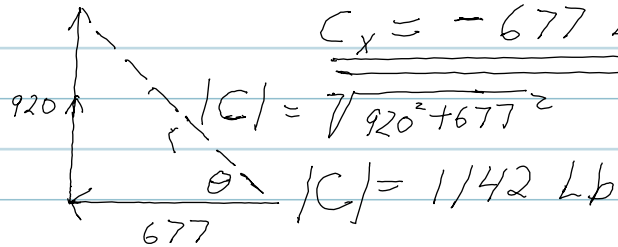


$$\sum F_x = 0$$

$$.7593 T_{AB} + C_x = 0$$

$$.7593(892 \text{ lb}) + C_x = 0$$

$$\underline{\underline{C_x = -677 \text{ lb}}}$$



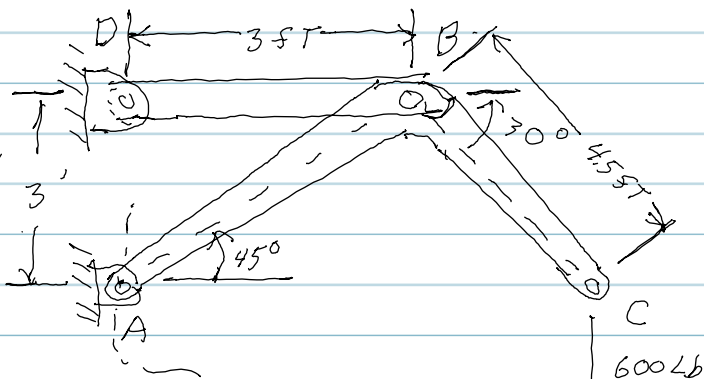
MAX LOAD: PLAN FOR FOOLS!  
GREATER FOOL THEORY!

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CH. 5 SECTION 5.4 PROB. 5-127 3 FORCE MEMBER

GIVEN!

FIND! JOINT "A" DIRECTION OF FORCE



$$\sum F_y = 0$$

$$F_A \sin(23.5) - 600 = 0$$

$$.399(F_A) - 600 = 0$$

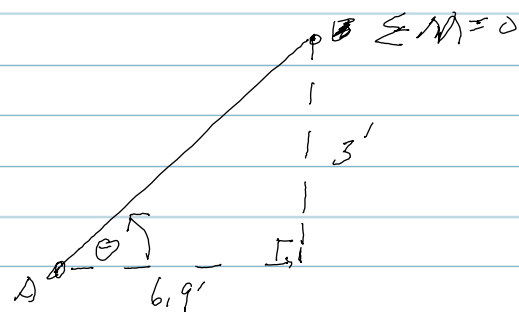
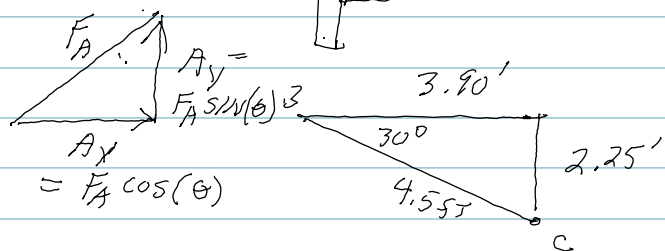
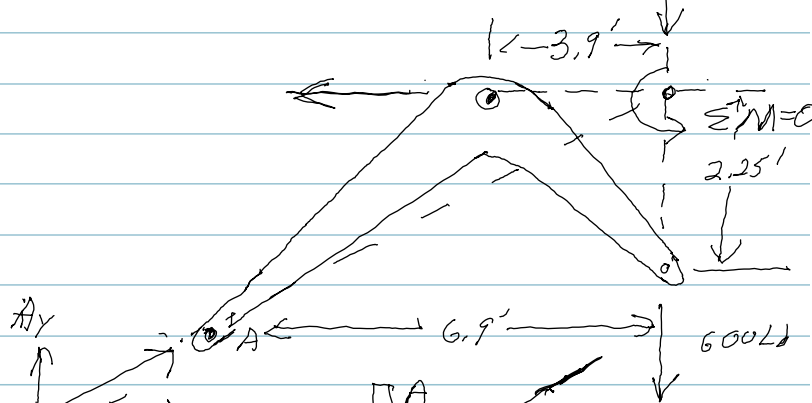
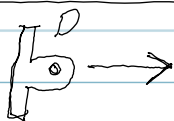
$$.399 F_A = 600$$

$$F_A = 1505 \text{ Lbs}$$

$$\sum F_x = 0$$

$$-B + F_A \cos(\theta) = 0$$

$$B = (1505)(.917) = 1380 \text{ Lbs}$$



$$\tan(\theta) = \frac{3}{6.9}$$

$$\theta = 23.5^\circ$$