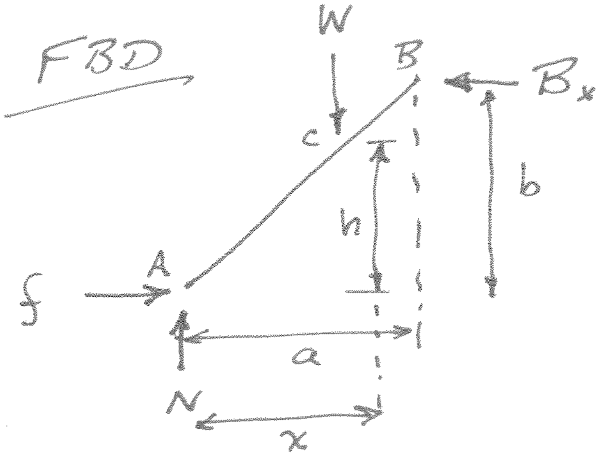
1. FBD



$$x = \left(\frac{h}{b}\right) a$$

$$\Sigma F_y = 0 = N - W \Rightarrow N = W$$

$$\Sigma M_A = 0 = B_x b - W\frac{ah}{b} \Rightarrow B_x = W\frac{ah}{b^2}$$

IF IN EQUILIBRIUM:

$$\Sigma F_x = 0 = f - B_x \Rightarrow f = B_x = W\frac{ah}{b^2}$$

IF IN EQUILIBRIUM: $f < \mu N$

IMPENDING SLIP: $f = \mu N \Rightarrow W\frac{ah}{b^2} = \mu W \Rightarrow$

$$\boxed{\mu_{MIN} = \frac{ah}{b^2}}$$

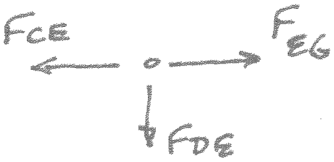
SANITY CHECKS: IF a IS SMALL, NECESSARY μ IS SMALL. (MAKES SENSE)

IF h IS SMALL, μ_{MIN} IS SMALL (MAKES SENSE)

IF b IS SMALL, μ_{MIN} IS LARGE (DON'T WANT A LADDER AT A SHALLOW ANGLE!)

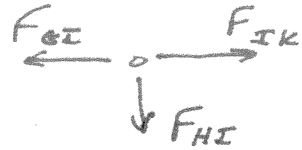
2\. a) Zero force members: $\boxed{DE,\ HI,\ KM,\ LM}$

FBD of joint E



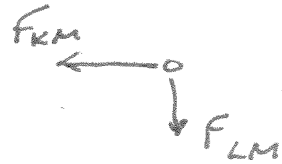
$\sum F_y = 0 \Rightarrow F_{DE} = 0$

FBD of joint I



$\sum F_y = 0 \Rightarrow F_{HI} = 0$

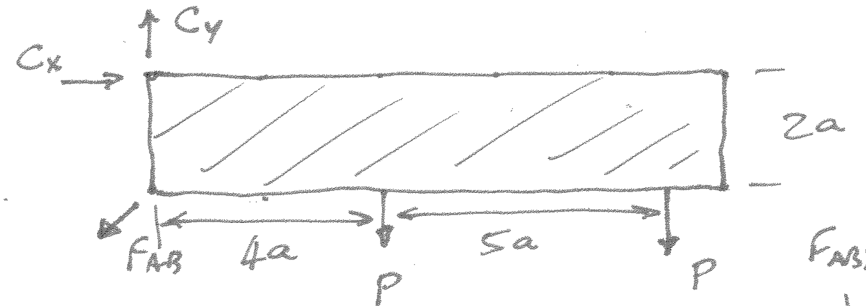
FBD of joint M



$\sum F_x = 0 \Rightarrow F_{KM} = 0$

$\sum F_y = 0 \Rightarrow F_{LM} = 0$

b) FBD of entire structure



F_{AB} is at $45°$

$F_{ABx} = F_{ABy} = \dfrac{F_{AB}}{\sqrt{2}}$

$$\sum M_c = 0 = -4Pa - 9Pa - (2a)\left(\frac{F_{AB}}{\sqrt{2}}\right)$$

$$F_{AB} = -\frac{13\sqrt{2}}{2} P \quad \text{(compression)}$$

$$\sum F_x = 0 = -F_{ABx} + C_x \Rightarrow C_x = -\frac{13}{2} P$$

$$\sum F_y = 0 = C_y - F_{ABy} - 2P$$

$$C_y = 2P + F_{ABy} = 2P - \frac{13}{2} P = -\frac{9}{2} P$$

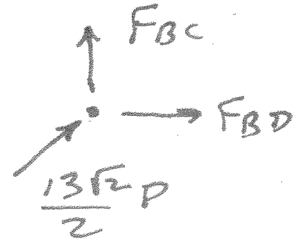
2b) (CONTINUED)

$$\boxed{F_{AB} = -\frac{13\sqrt{2}}{2} P \quad \text{(COMPRESSION IN AB)}}$$

$$\boxed{C_x = -\frac{13}{2} P \quad \text{(ACTS TO THE LEFT)}}$$

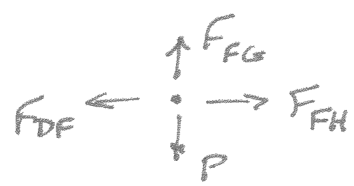
$$\boxed{C_y = -\frac{9}{2} P \quad \text{(ACTS DOWN)}}$$

c) BC:



$$\boxed{\Sigma F_y = 0 \Rightarrow F_{BC} = -\frac{13}{2} P \quad \text{(COMPRESSION)}}$$

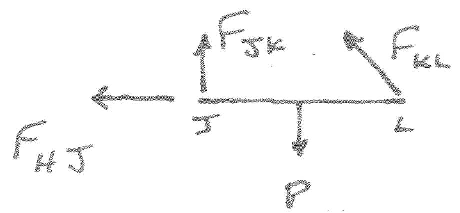
~~BD~~ FG:



$\Sigma F_y = 0 \Rightarrow$ $\boxed{F_{FG} = P \quad \text{(TENSION)}}$

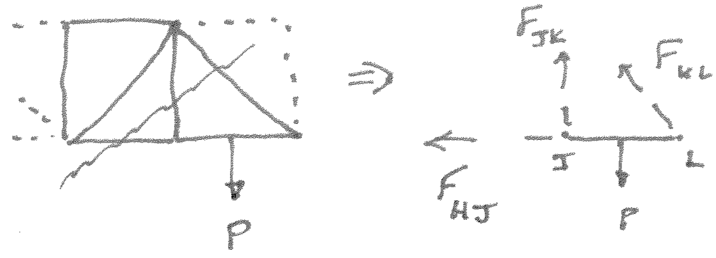
JK: THIS ONE IS TRICKIER SINCE JL IS NOT A TWO-FORCE MEMBER. AS SUCH, WE DON'T KNOW THE DIRECTION OF THE FORCE THAT MEMBER JL EXERTS ON JOINT J.

DRAW A FREE BODY DIAGRAM OF JL:



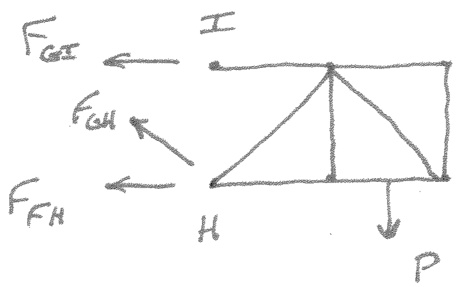
$\Sigma M_L = 0 = Pa - 2F_{JK}a \Rightarrow$ $\boxed{F_{JK} = P/2 \quad \text{(TENSION)}}$

2c) (CONTINUED) AN ALTERNATE WAY OF GETTING F_{JK} IS BY USING THE METHOD OF SECTIONS. SINCE $F_{KM} = F_{LM} = 0$ WE CAN CUT A SECTION THROUGH KL, JK & HJ



THIS IS ESSENTIALLY THE SAME AS THE FBD FOR JL, SO $\Sigma M_L = 0 \Rightarrow$ $\boxed{F_{JK} = P/2 \text{ (TENSION)}}$

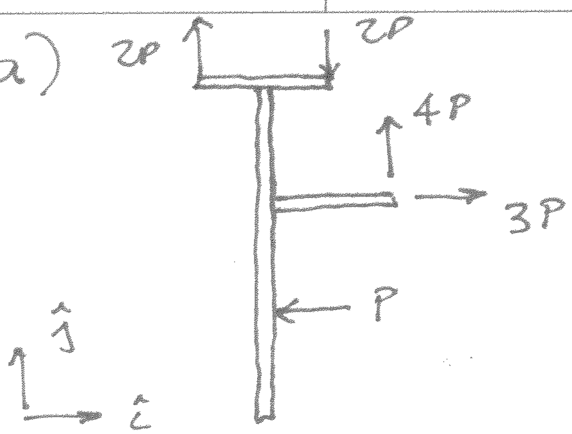
d) TO GET FORCES IN FH & GI, USE METHOD OF SECTIONS THROUGH GI, GH & FH - AND USE THE RIGHT-HAND PORTION OF THE STRUCTURE



$$\Sigma M_H = 0 = (F_{GI})2a - 3Pa \Rightarrow \boxed{F_{GI} = \frac{3P}{2} \text{ (TENSION)}}$$

$$\Sigma M_G = 0 = -2aF_{FH} - 5Pa \Rightarrow \boxed{F_{FH} = -\frac{5P}{2} \text{ (COMPRESSION)}}$$

3. a)



SUM OF APPLIED FORCES:

$$\underset{\sim}{F} = 2P\hat{i} + 4P\hat{j}$$

MOMENTS OF APPLIED FORCES ABOUT POINT C

$$\underset{\sim}{M}_C = (\underbrace{4PL}_{\underset{\sim}{r} \times \underset{\sim}{F}_D} - \underbrace{2PL}_{\text{COUPLE MOMENT EF}} - \underbrace{PL}_{\underset{\sim}{r} \times \underset{\sim}{F}_B})\hat{k} = PL\,\hat{k}$$

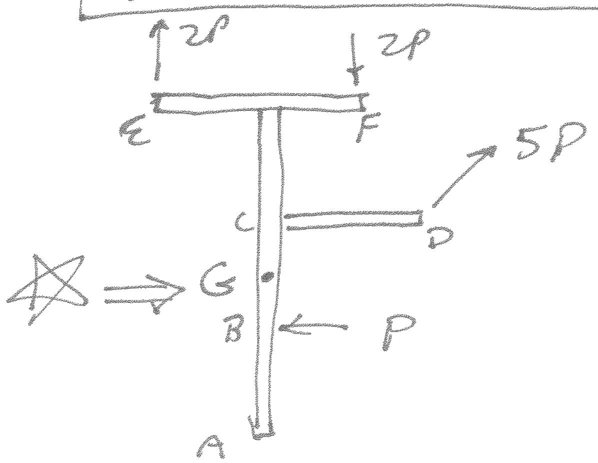
POSITIVE ⇒ COUNTER CLOCKWISE

EQUIVALENT FORCE-MOMENT PAIR AT C:

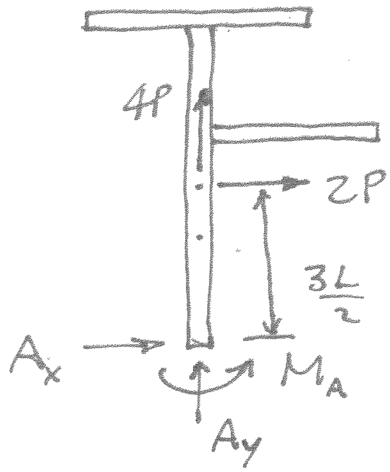
$$\boxed{\begin{array}{l} \underset{\sim}{F} = 2P\hat{i} + 4P\hat{j} \\ \underset{\sim}{M} = PL\,\hat{k} \ (\text{CCW}) \end{array}}$$

b) IF $\underset{\sim}{F}$ ACTS AT A POINT MIDWAY BETWEEN B + C (A DISTANCE L/2 BELOW C), THE SYSTEM IS STATICALLY EQUIVALENT.

$$\boxed{\underset{\sim}{F} = 2P\hat{i} + 4P\hat{j} \quad \text{ACTING AT } G(\star)}$$



3 c)



USING THE RESULTS OF PART (b)

$\Sigma F_x = 0 \Rightarrow \boxed{A_x = -2P \text{ (LEFT)}}$

$\Sigma F_y = 0 \Rightarrow \boxed{A_y = -4P \text{ (DOWN)}}$

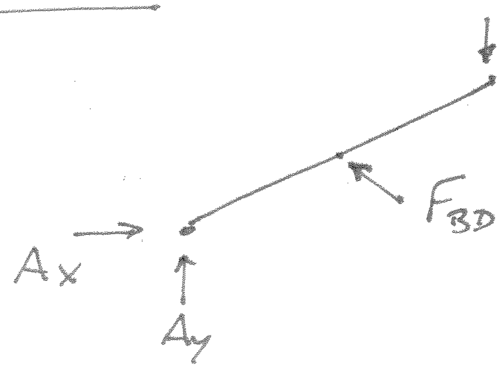
$\Sigma M_A = 0 \Rightarrow M_A = \left(\frac{3L}{2}\right)(2P)$

$\boxed{M_A = 3PL \text{ (CCW)}}$

4. THIS PROBLEM CAN BE SOLVED IN SEVERAL WAYS. TWO WILL BE SHOWN HERE.

FIRST WE RECOGNIZE THAT MEMBER BD IS A 2-FORCE MEMBER, SO WE KNOW THAT THE FORCE IN BD IS ALONG THE LINE CONNECTING THE TWO POINTS.

<u>APPROACH 1</u> FBD OF ABC:



$$\underset{\sim}{r}_{AB} = L(\cos\theta\,\hat{i} + \sin\theta\,\hat{j})$$

$$\underset{\sim}{r}_{AC} = 2L(\cos\theta\,\hat{i} + \sin\theta\,\hat{j})$$

$$\underset{\sim}{P} = -P\hat{j}$$

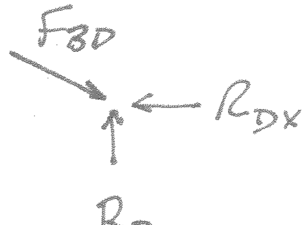
$$\underset{\sim}{F}_{BD} = F_{BD}(-\cos\theta\,\hat{i} + \sin\theta\,\hat{j})$$

$$\Sigma \underset{\sim}{M}_A = \underset{\sim}{r}_{AB} \times \underset{\sim}{F}_{BD} + \underset{\sim}{r}_{AC} \times \underset{\sim}{P}$$

$$= 2F_{BD}L\cos\theta\sin\theta\,\hat{k} - 2PL\cos\theta\,\hat{k} \Rightarrow$$

$$F_{BD} = \frac{P}{\sin\theta}$$

FBD OF POINT D:



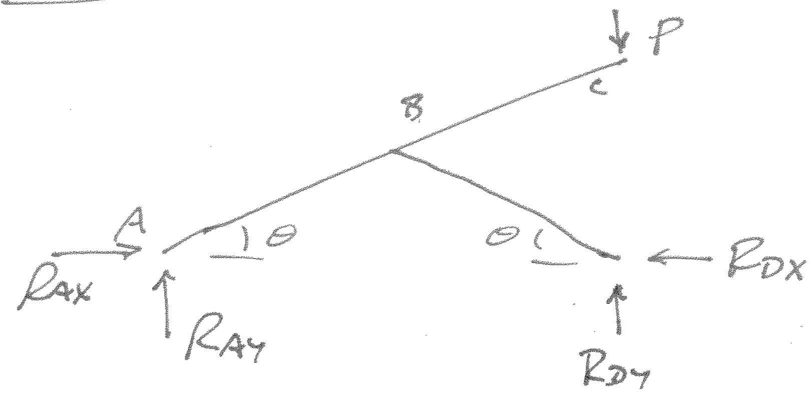
$$\Sigma F_x = 0 \Rightarrow R_{Dx} = F_{BD}\cos\theta$$

$$\boxed{R_{Dx} = \frac{P\cos\theta}{\sin\theta}}$$

THE FORCE THAT D EXERTS ON THE WALL IS R_{DX} ACTING TO THE RIGHT

4 (CONTINUED)

APPROACH 2 FBD of ENTIRE STRUCTURE



$\Sigma M_A = 0 \Rightarrow$

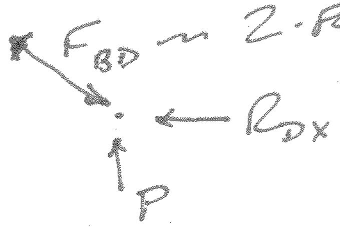
$R_{DY} = P$

$\Sigma M_D = 0 \Rightarrow$

$R_{AY} = 0$

FBD of POINT D:

F_{BD} ~ 2-FORCE MEMBER ⇒ DIRECTION KNOWN



IN ORDER FOR P (VERTICAL) & R_{DX} (HORIZONTAL) to BALANCE F_{BD}, THE GEOMETRY IS SUCH THAT

$$\frac{R_{DX}}{P} = \frac{\cos\theta}{\sin\theta} \Rightarrow R_{DX} = \frac{P\cos\theta}{\sin\theta}$$

OR ... FROM FBD OF D

$$\Sigma F_x = 0 = F_{BD}\cos\theta - R_{DX} = 0$$

$$R_{DX} = F_{BD}\cos\theta$$

$$\Sigma F_y = 0 = P - F_{BD}\sin\theta \Rightarrow F_{BD} = \frac{P}{\sin\theta}$$

$$\boxed{R_{DX} = P\,\frac{\cos\theta}{\sin\theta}}$$

~ FORCE D EXERTS ON THE WALL - ACTING →.