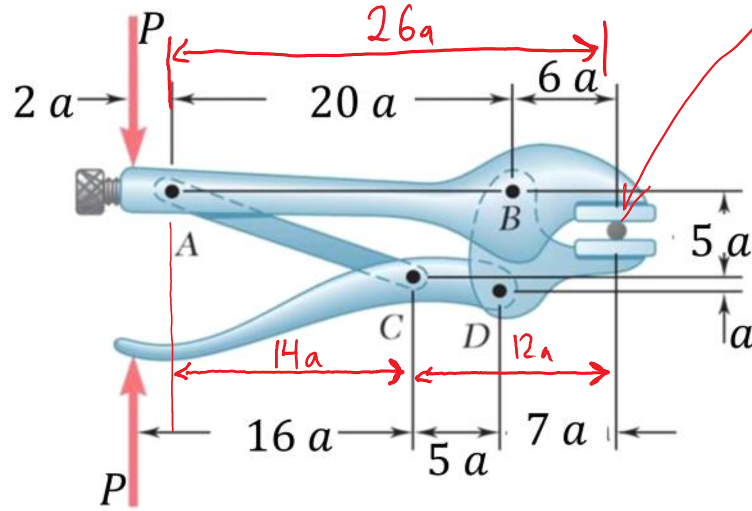
goal: find force here



Determine the magnitude of the gripping forces produced when the force P is applied as shown.

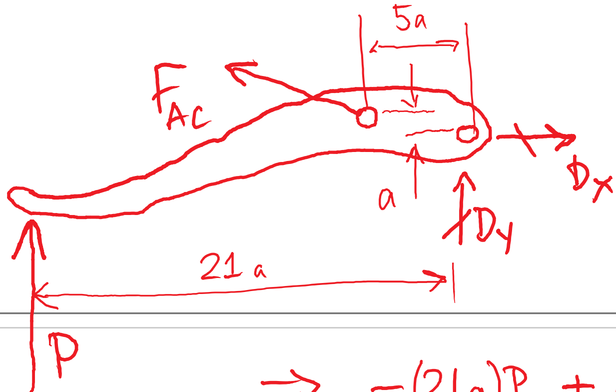
See that AC is a two-force member

Find geometry of AC.

$26a - 12a = 14a$

$\sqrt{5^2 + 14^2} = \sqrt{221}$

FBD of lower handle



$(\Sigma M)_D = 0$

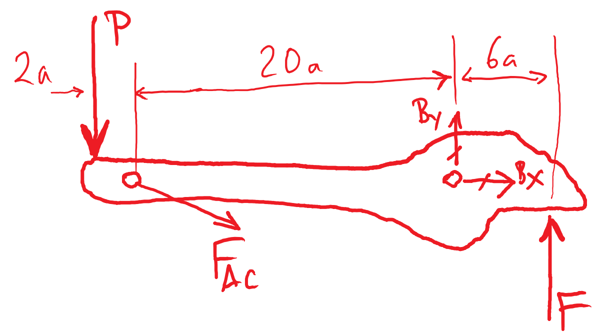
$$\Rightarrow -(21a)P + a \cdot F_{AC} \cdot \frac{14}{\sqrt{221}} - (5a)F_{AC} \cdot \frac{5}{\sqrt{221}} = 0$$

$$-21\cancel{a} \cdot P + \cancel{a} \cdot F_{AC} \cdot \frac{14-25}{\sqrt{221}} = 0$$

$$\Rightarrow \boxed{F_{AC} = \frac{-\sqrt{221}}{11} \cdot 21 \cdot P}$$

Now that F_{AC} is known, the FBD of the upper handle should lead to the clamping force.

2a |P 20a 1.6a | $(\Sigma M) = 0$



$$(\Sigma M)_B = 0$$

$$(22a)\cdot P + (6a)\cdot F + (20a)F_{AC}\cdot\frac{5}{\sqrt{221}} = 0$$

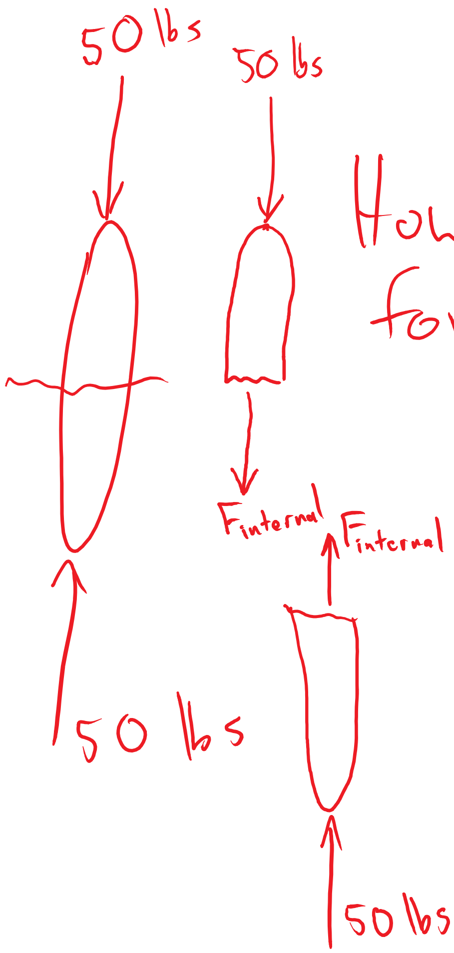
$$6F = -22P - \frac{100}{\sqrt{221}}\cdot F_{AC}$$

$$F = -\frac{22}{6}P - \frac{50}{3\cancel{\sqrt{221}}}\left(-\frac{21}{11}\cancel{\sqrt{221}}\cdot P\right)$$

$$F = P\cdot\left(-\frac{11}{3} + \frac{350}{11}\right)$$

$$F = P\cdot\left(\frac{-121+1050}{33}\right)$$

$$\boxed{F = \frac{929}{33}\cdot P \qquad F \approx 28.2\cdot P}$$



How much compressive force does the member "feel"?

A) 50 lbs

B) 100 lbs

C) 0 lbs

D) None of above

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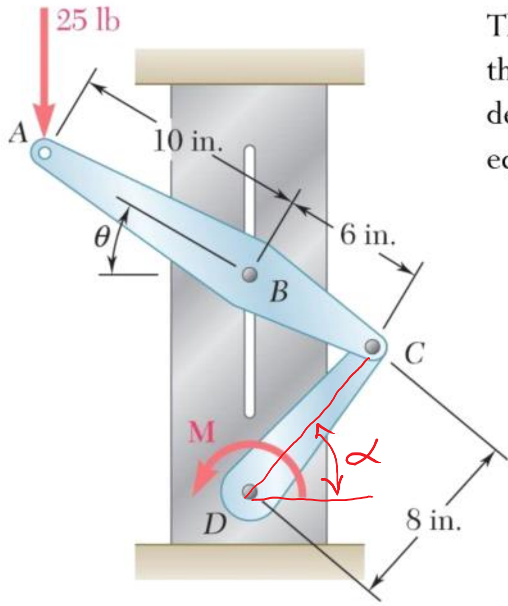
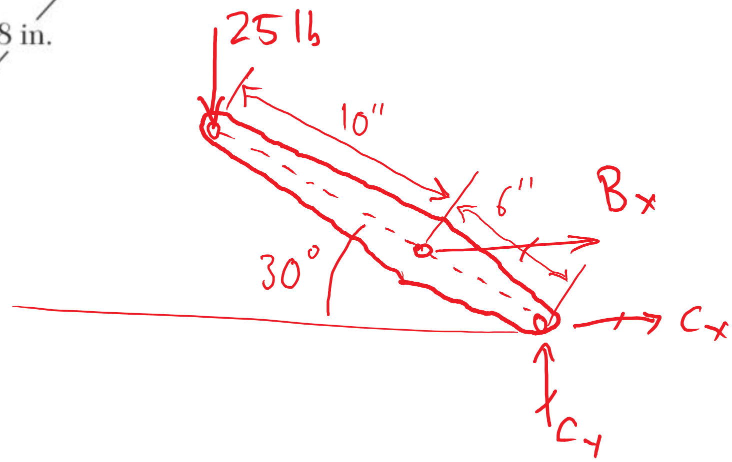


The pin at B is attached to member ABC and can slide freely along the slot cut in the fixed plate. Neglecting the effect of friction, determine the couple **M** required to hold the system in equilibrium when $\theta = 30°$.

Note: No two-force members.

FBD of ABC



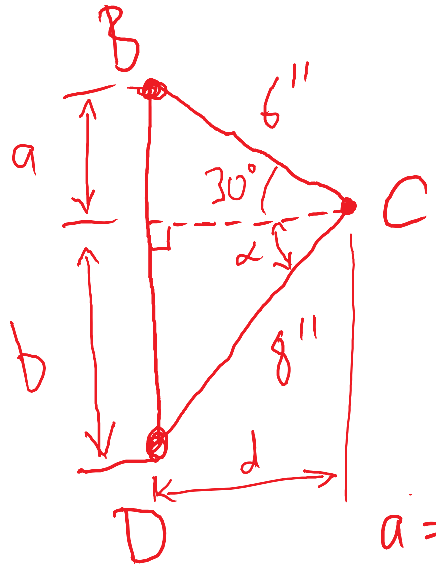
$$(\Sigma M)_C = 0 = (16''\cdot\cos 30°)(25\text{ lb}) - (6''\cdot\sin 30°)B_x = 0$$

$$B_x = \frac{16\cos(30°)}{6\cdot\sin(30°)}\cdot(25\text{ lb}) = \frac{8}{3}\cdot\sqrt{3}\cdot(25\text{ lb})$$

$$B_x = 115.5\text{ lb} \qquad \boxed{B_x = 116\text{ lb}}$$

$$\Sigma F_x = 0 \Rightarrow B_x + C_x = 0 \Rightarrow \boxed{C_x = -B_x = -116\text{ lb}}$$

$$\Sigma F_y = 0 \Rightarrow C_y - 25\text{ lb} = 0 \Rightarrow \boxed{C_y = 25\text{ lb}}$$



Find distance (a+b) from D to B

$$a = (6'')\cdot\sin(30^\circ) = \tfrac{1}{2}\cdot(6'') = 3''$$

$$d = 6''\cdot\frac{\sqrt{3}}{2} = 3\sqrt{3}'' = 5.196''$$

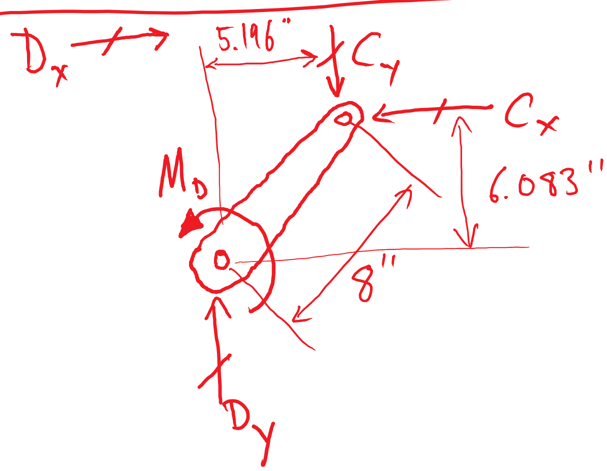
Find α. $\cos(\alpha) = d/8'' = 5.196''/8''$

$$\Rightarrow \alpha = \cos^{-1}\left(\frac{5.196}{8}\right) = 49.5^\circ$$

$$\Rightarrow b = 8''\cdot\sin(\alpha) = 8''\cdot\sin(49.5^\circ) = 6.083''$$

$$(a+b) = 9.083''$$

FBD of CD



$$\left(\sum M\right)_D = 0 = M_D - (5.196'')C_y + (6.083'')\cdot C_x = 0$$

$$\Rightarrow M_D = (5.196'')(25\text{ lb}) - (6.083'')(-116\text{ lb})$$

$$M_D = 129.9\text{ lb-in} + 705.6\text{ lb-in}$$

$$M_D = 835.5\text{ lb-in}$$

$$\boxed{M_D = 836\text{ lb-in}}$$

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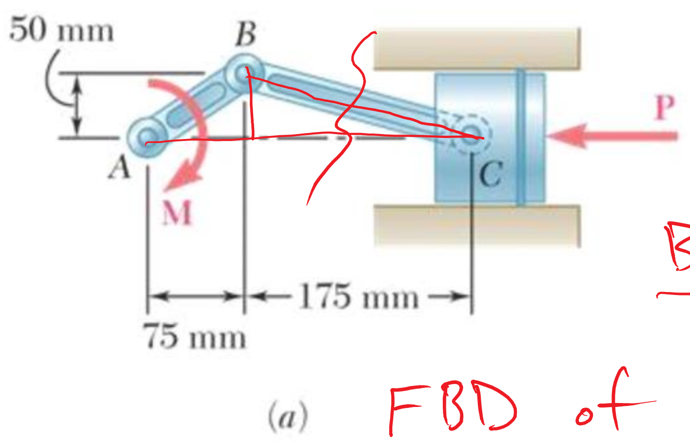
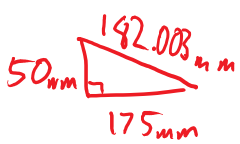
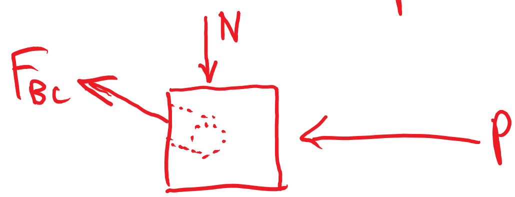


A couple **M** of magnitude 1.5 kN · m is applied to the crank of the engine system shown. ~~For each of the two positions shown,~~ determine the force **P** required to hold the system in equilibrium.

BC is a 2-force member

FBD of the piston



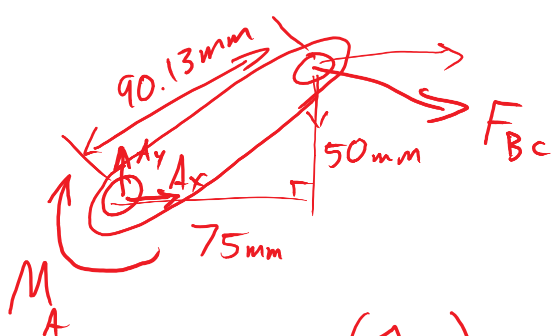


$$\Sigma F_x = 0 \Rightarrow -F_{BC} \cdot \frac{175}{182} - P = 0$$

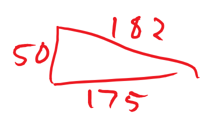
$$\Rightarrow P = -F_{BC} \cdot \frac{175}{182}$$

$$\text{-or-} \quad F_{BC} = -P \cdot \frac{182}{175}$$

FBD of AB



$$(\Sigma M)_A = 0$$



$$-M_A - (50\,mm) \cdot F_{BC} \cdot \frac{175}{182} - (75\,mm) \cdot F_{BC} \cdot \frac{50}{182} = 0$$

$$M_A = -F_{BC} \cdot \left(\frac{50\,mm \cdot 175}{182} + \frac{75\,mm \cdot 50}{182} \right)$$

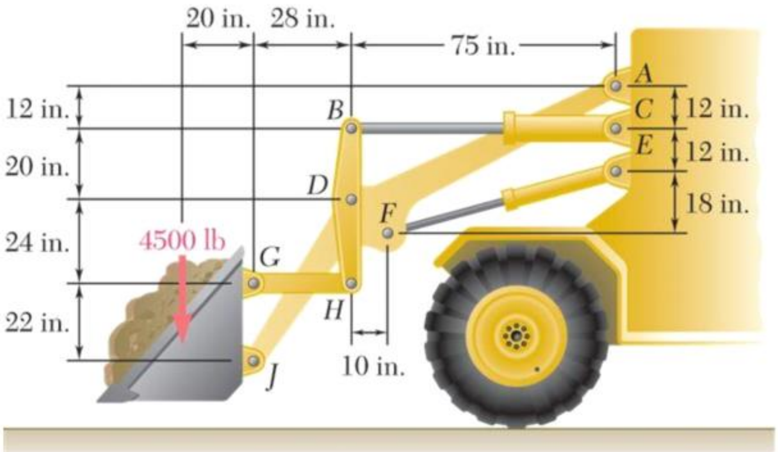
$$M_A = P \cdot \frac{\cancel{182}}{175}\left(50\text{mm} \cdot \frac{175}{\cancel{182}} + 75\text{mm} \cdot \frac{50}{\cancel{182}}\right)$$

$$M_A = P \cdot \underbrace{\left(50\text{mm} + 75\text{mm} \cdot \frac{50}{175}\right)}_{71.43\text{mm}}$$

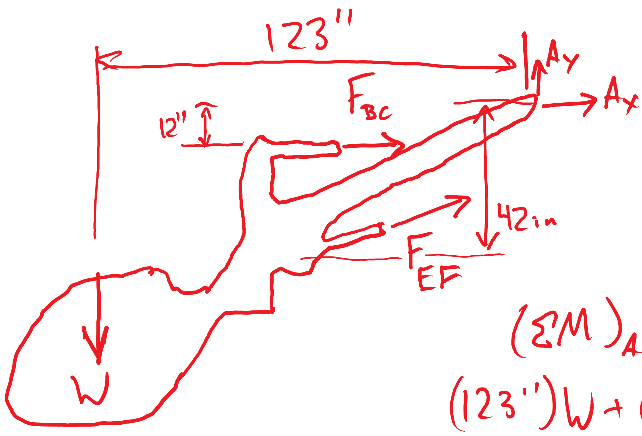
$M_A = 1.5\ \text{kN}\cdot\text{m}$

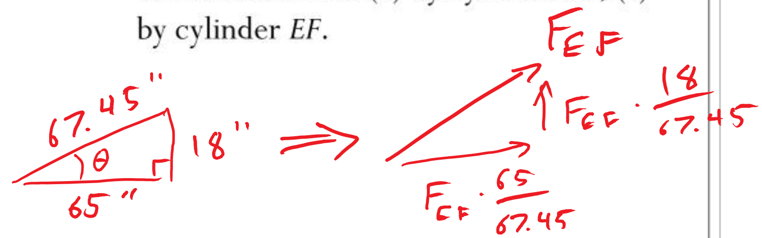
$$P = \frac{M_A}{71.43\text{mm}} = \frac{1.5\ \text{kN}\cdot\text{m}}{0.07143\ \text{m}} = 20.9996\text{kN}$$

$$\boxed{P = 21\text{kN}}$$



The motion of the bucket of the front-end loader shown is controlled by two arms and a linkage that are pin-connected at *D*. The arms are located symmetrically with respect to the central, vertical, and longitudinal plane of the loader; one arm *AFJ* and its control cylinder *EF* are shown. The single linkage *GHDB* and its control cylinder *BC* are located in the plane of symmetry. For the position and loading shown, determine the force exerted (*a*) by cylinder *BC*, (*b*) by cylinder *EF*.



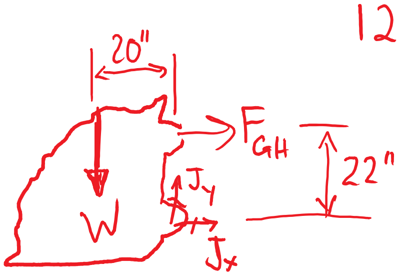


$$(\Sigma M)_A = 0$$

$$(123'')W + (12'')F_{BC} + (42'')F_{EF}\cdot\frac{65}{67.45} - (65'')F_{EF}\frac{18}{67.45} = 0$$

$$\Rightarrow 123W + 12F_{BC} + F_{EF}\left(\frac{42\cdot 65}{67.45} - \frac{18\cdot 65}{67.45}\right) = 0$$

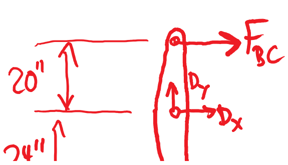
$$123\cdot W + 12\cdot F_{BC} + (23.128)\cdot F_{EF} = 0$$



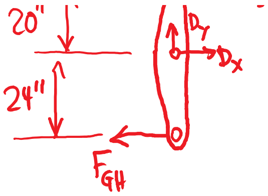
$$(\Sigma M)_J = 0$$

$$\Rightarrow (20'')W - (22'')\cdot F_{GH} = 0$$

$$\Rightarrow F_{GH} = \frac{20}{22}\cdot W = \frac{10}{11}(4{,}500\text{ lbs}) = 4{,}090.9\text{ lbs}$$



$$(\Sigma M)_D = 0$$



$$(\Sigma M)_D = 0$$

$$\Rightarrow \quad -24 \cdot F_{GH} - 20 \cdot F_{BC} = 0$$

$$\Rightarrow \quad F_{BC} = -\frac{24}{20} F_{GH} = -\frac{6}{5}(4{,}090.9 \text{ lbs}) = -4{,}909.09 \text{ lbs}$$

$$\boxed{F_{BC} = -4{,}910 \text{ lbs}}$$

Recall equation (☆):

$$123 \cdot W + 12 \cdot F_{BC} + (23.128) \cdot F_{EF} = 0$$

$$F_{EF} = \frac{-123 \cdot W - 12 \cdot F_{BC}}{23.128} = \frac{-123(4{,}500 \text{ lbs}) - 12(-4{,}909.09 \text{ lbs})}{23.128}$$

$$F_{EF} = \frac{-553{,}500 \text{ lbs} + 58{,}909 \text{ lbs}}{23.128} = -21{,}384.9 \text{ lbs}$$

$$\boxed{F_{EF} = -21{,}400 \text{ lbs}}$$

[InClass_Chapter7_InternalForces.pptx]

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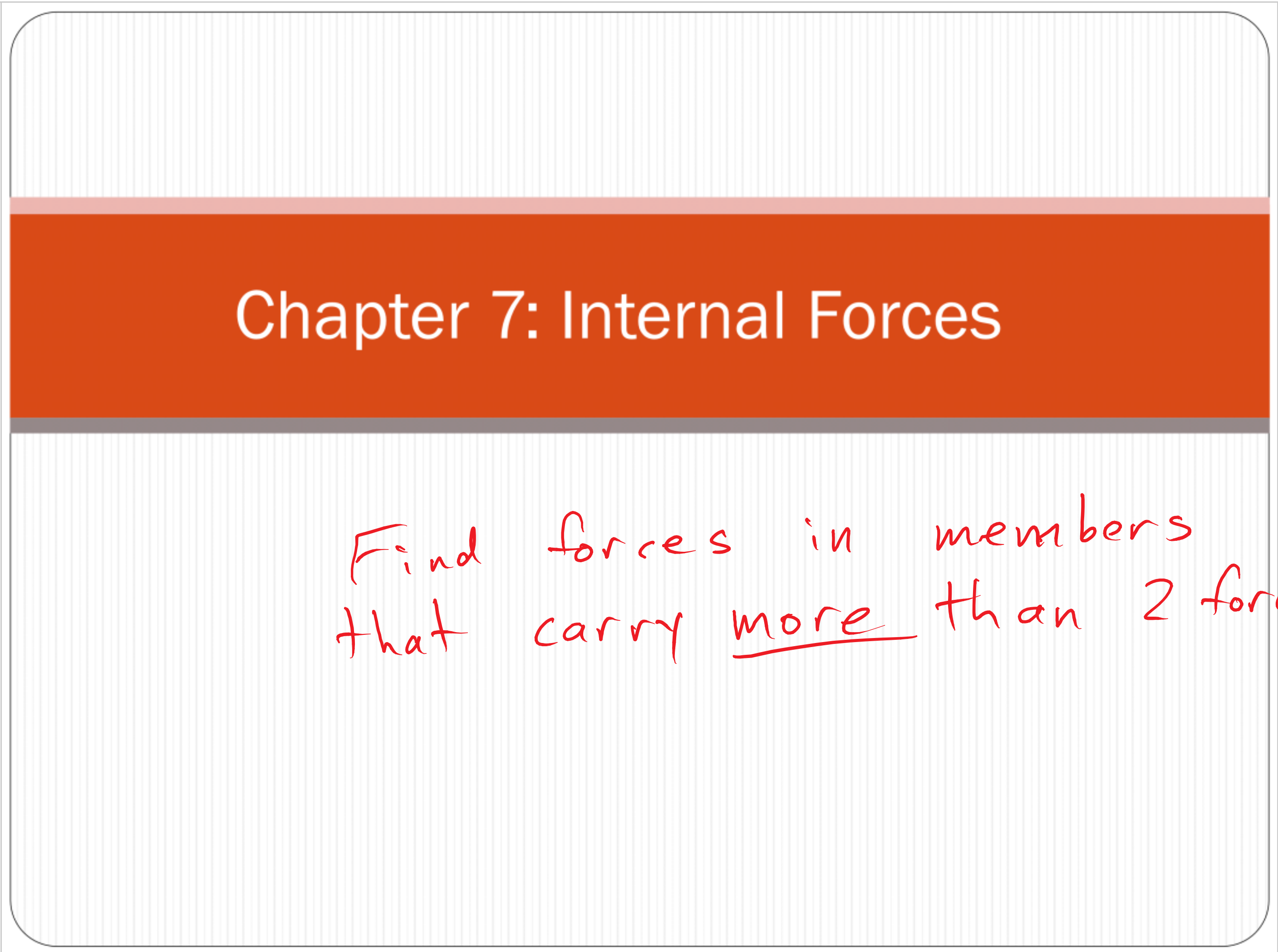

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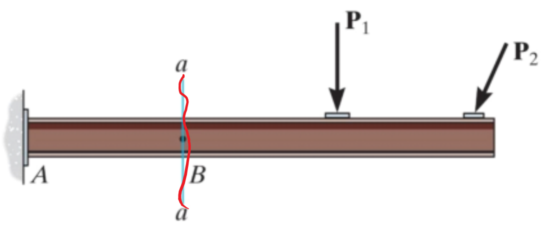
- Reaction forces in each leg approximately the same in both loading scenarios

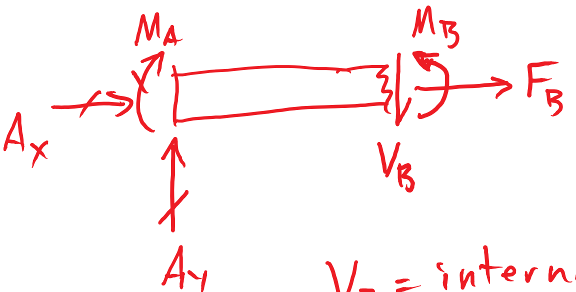
- However, each location of the table top experiences different values for the internal forces

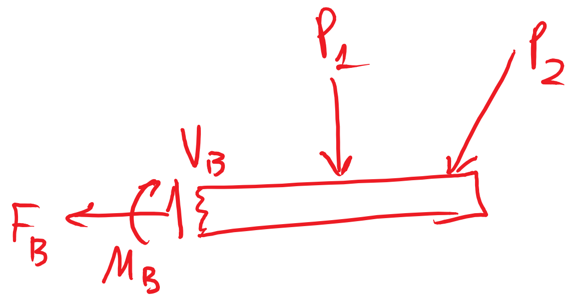
Internal loadings developed in structural members

Structural Design: need to know the loading acting within the member in order to be sure the material can resist this loading

Cutting members at internal points reveal **internal forces and moments.**







V_B = internal shear force

F_B = internal axial force

M_B = internal bending moment