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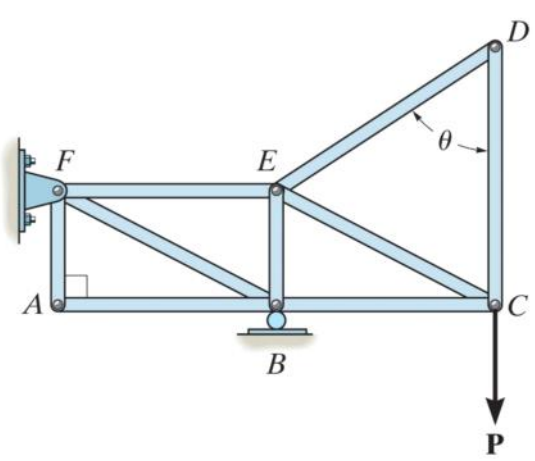
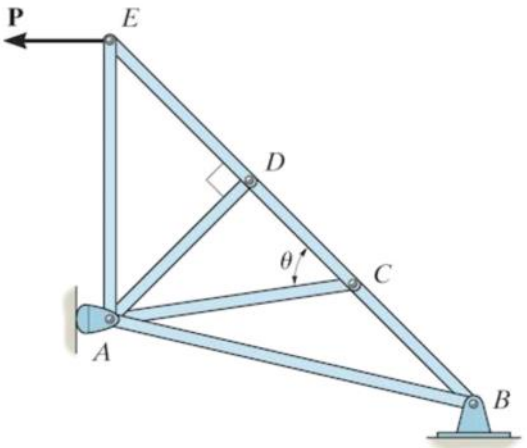
Zero-force members

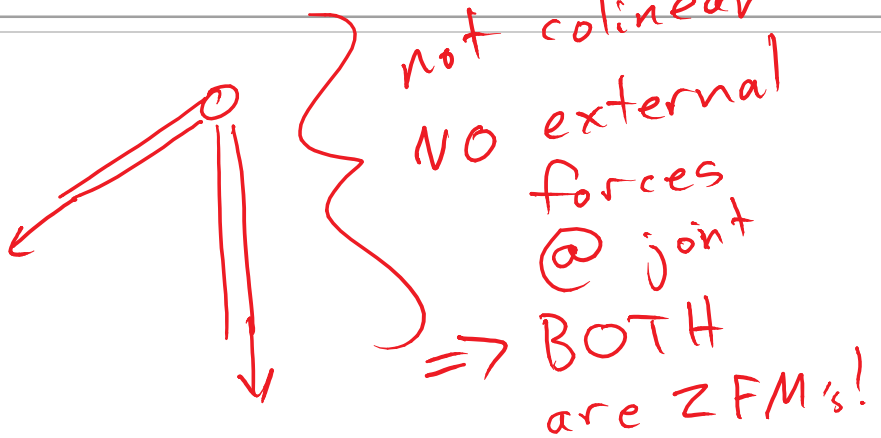
- Particular members in a structure may experience no force for certain loads.
- Zero-force members are used to increase instability
- Identifying members with zero-force can expedite analysis.

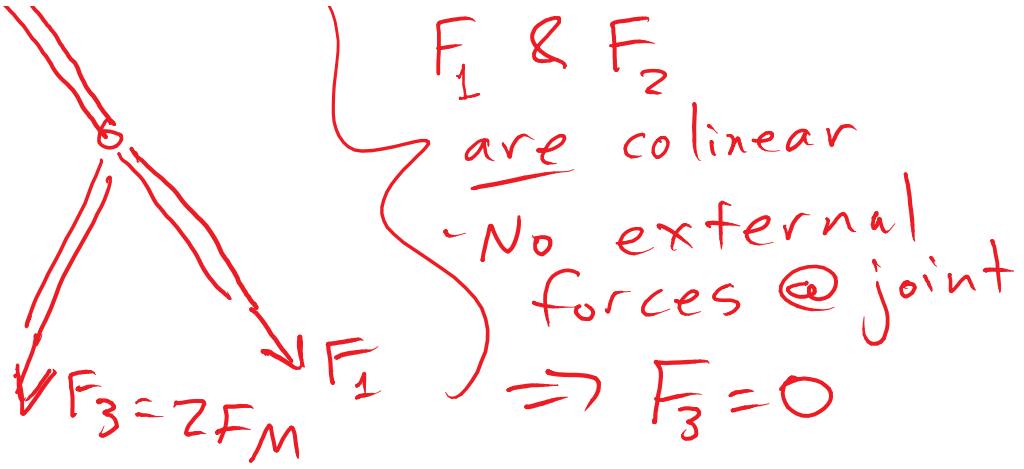
Two situations:

- Joint with two non-collinear members, no external or support reaction applied to the joint → **Both members are zero-force members.** (ZFM)
- Joint with two collinear member, plus third non-collinear, no loads applied to the joint → **Non-collinear member is a zero-force member.**








F_1 & F_2
are colinear
- No external forces @ joint
$\Rightarrow F_3 = 0$
F_1
$F_3 = 2F_M$

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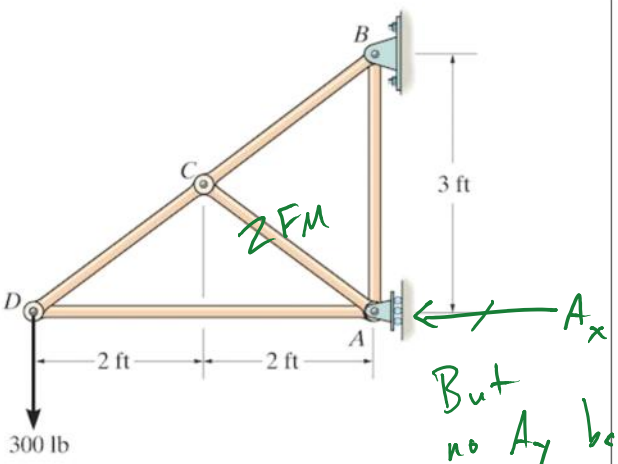
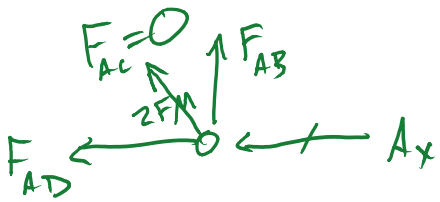
Which are zero-force members?

A. None
B. AB
C. AC ✓
D. AB, AC
E. BC, CD



But no A_y b.c. of the roller support

FBD of A



$\Sigma F_y = 0 = F_{AB}$

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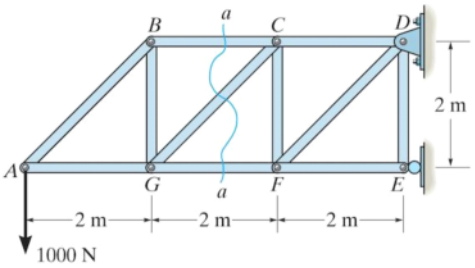
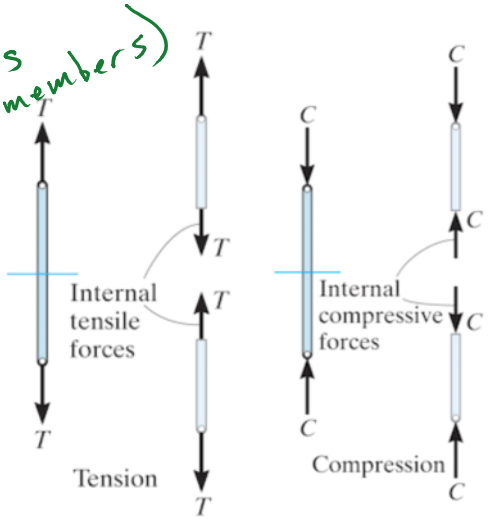
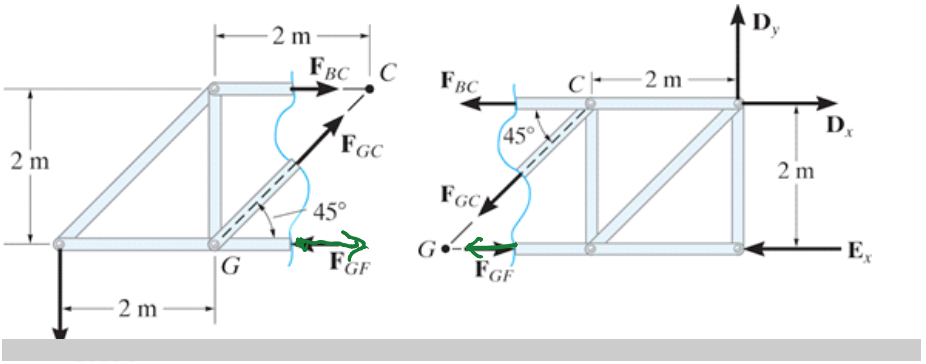
Method of sections – Truss Analysis (2-force members)

- Determine external support reactions
- "Cut" the structure at a section of interest into two separate pieces and set either part into force and moment equilibrium (your cut should be such that you have up to three unknowns)







- Determine equilibrium equations (e.g.,moment around point of intersection of two lines)
- Assume all internal loads are tensile.

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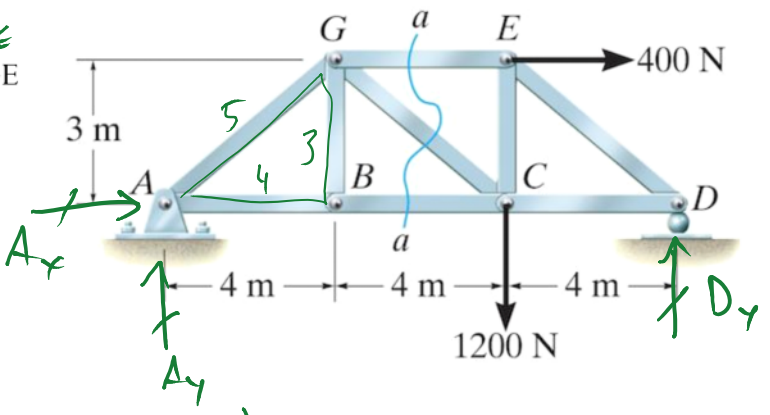
Example 4) F_{GC} F_{GE}

Determine the force in members GC and GE of the truss and state if the members are in tension or compression.



Start w/reax. forces

$(\Sigma M)_A = 0$

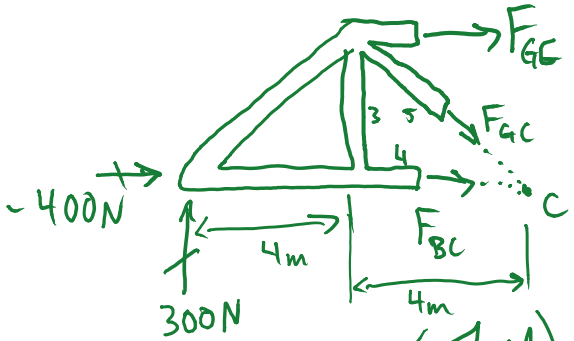
$\Rightarrow (12m)\cdot D_y - (8m)(1200N) - (3m)(400N) = 0$

$$D_y = \frac{10800\,N\cdot m}{12\,m} = 900\,N$$

$\Sigma F_x = 0 \Rightarrow A_x + 400N = 0 \Rightarrow A_x = -400N$

$\Sigma F_y = 0 \Rightarrow A_y - 1200N + D_y = 0$

$\Rightarrow A_y = 1200N - (900N) = 300N$



$\Sigma F_y = 0 \Rightarrow 300N - F_{GC}\cdot\frac{3}{5} = 0$

$$F_{GC} = 300N\cdot\frac{5}{3} = 500N$$ Tension

$(\Sigma M)_C = 0 \Rightarrow -F_{GE}\cdot(3m) - (300N)(8m) = 0$

$$F_{GE} = \frac{-(300N)(8m)}{3m} = -800N$$ Compression

$$\Sigma F_x = 0 \Rightarrow -400N + F_{BC} + F_{GE} + F_{GC} \cdot \frac{4}{5} = 0$$

$$-400N + F_{BC} + (-800N) + \frac{4}{5}(500N) = 0$$

$$\boxed{F_{BC} = 800N} \text{ Tension}$$

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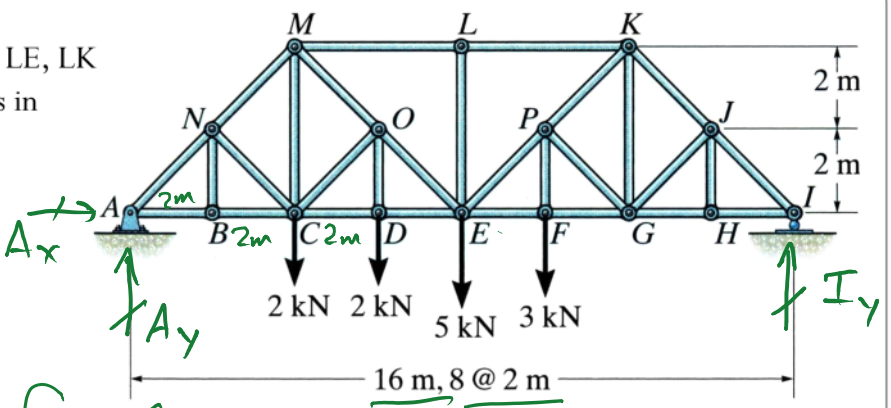
Example 5)
Determine the force in member OE, LE, LK of the truss and state if the member is in tension or compression.



$F_{LE} = 0$ (ZFM)

1. Find reaction forces.

$\Sigma F_x = \boxed{A_x = 0}$

$(\Sigma M)_A = 0$

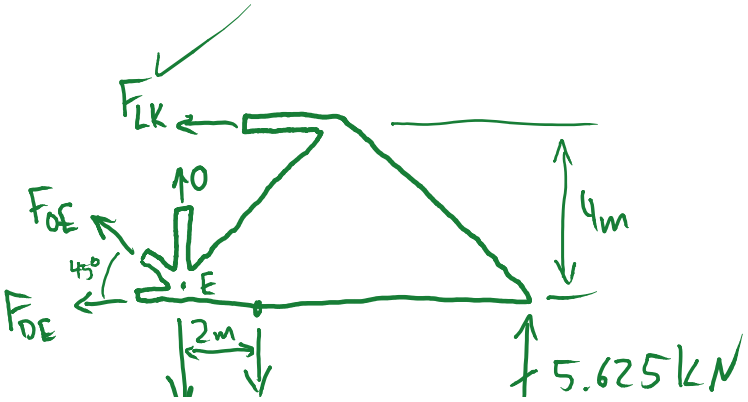
$\Rightarrow -(4m)(2kN) - (6m)(2kN) - (8m)(5kN) - (10m)(3kN) + (16m)I_y = 0$

$(-8 - 12 - 40 - 30)kN = -16 \cdot I_y$

$\boxed{I_y = 5.625kN}$

$\uparrow F_y = 0 \Rightarrow A_y - (2+2+5+3)kN + I_y = 0$

$\boxed{A_y = 6.375kN}$



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

$$\Rightarrow -(2m)(3kN) + (4m)F_{LK} + (8m)(5.625kN)$$

$$\therefore \boxed{F_{LK} = -9.75\,kN} \text{ Compression!}$$

$$\Sigma F_y = 0 \Rightarrow 5.625kN - 5kN - 3kN + 0 + F_{OE}\cdot\frac{\sqrt{2}}{2} = 0$$

$$\therefore \boxed{F_{OE} = 3.36kN} \text{ Tension}$$

$$\Sigma F_x = 0 \Rightarrow -F_{DE} - F_{OE}\frac{\sqrt{2}}{2} - F_{LK} = 0$$

$$-F_{DE} - (3.36kN)\frac{\sqrt{2}}{2} - (-9.75kN) = 0$$

$$\therefore \boxed{F_{DE} = 7.38kN} \text{ Tension}$$

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Which are zero-force members?

A. AB, BC

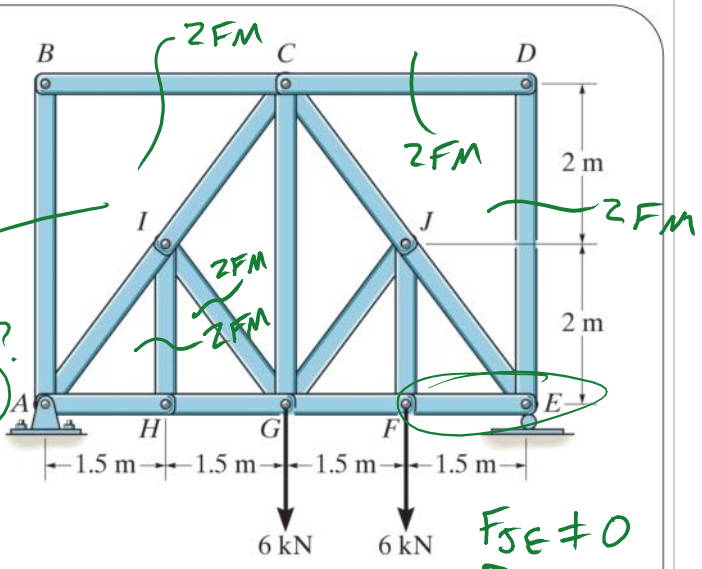
B. AB, BC, CD, ED

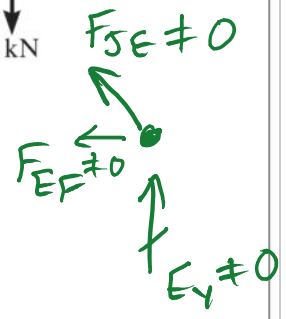
C. ~~AB, BC, CD, ED, EF~~

D. AB, BC, CD, ED, HI, GI

E. AB, BC, CD, ED, HI, GI, EF

Determine the internal force in members IG and CG.





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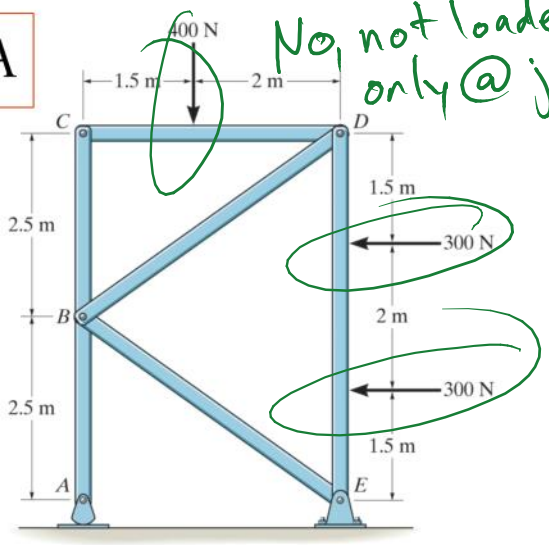
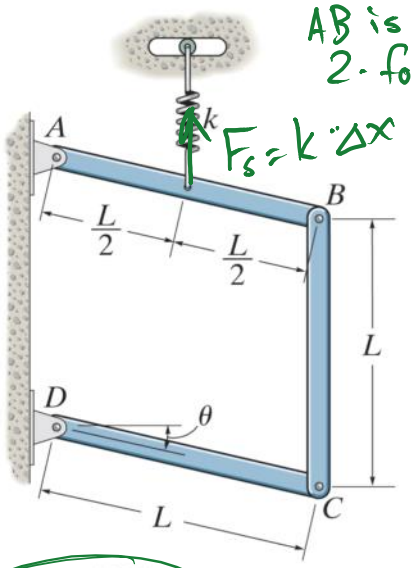
Which example below can be considered a truss problem?

A



No, not loaded only @ joints

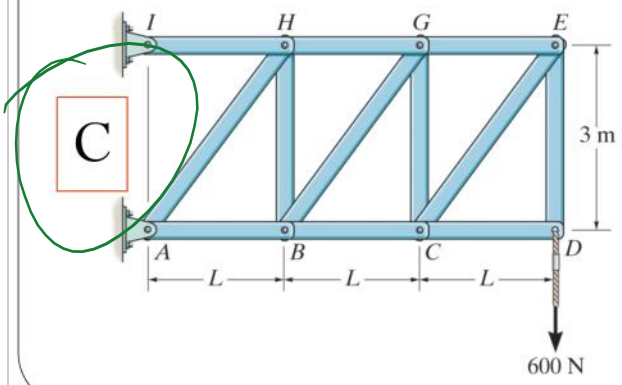
B



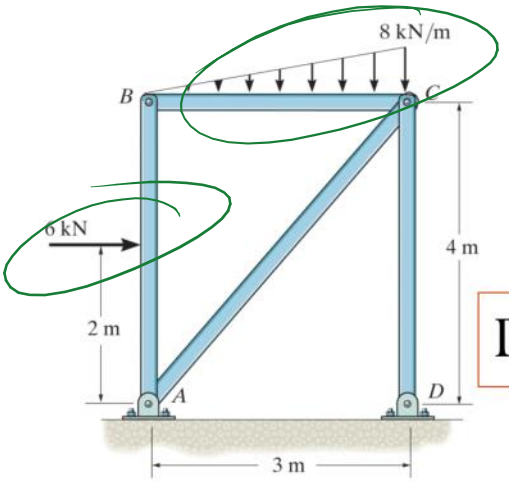
AB is not 2-force

$F_s = k \cdot \Delta x$

C



D



BC & AB are not 2-force members

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Frames and machines

Frames and machines are two common types of structures that have at least **one multi-force member** (Recall that trusses have nothing but two-force members).

3 force or more

Frames are generally **stationary** and used to support various external loads.

Machines contain **moving parts** and are designed to alter the effect of forces

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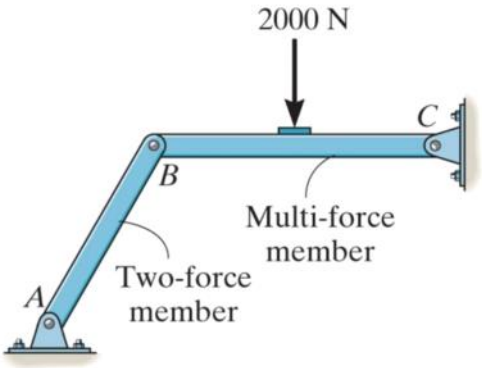
Frames and machines

The general solution method:



1. Do external equilibrium
   – Find reaction forces

2. Identify two-force members

3. Isolate various parts of the structure (draw their FBD) and analyze equilibrium of them. The desired unknowns must appear in at least one FBD!

4. Solve for the requested unknowns.

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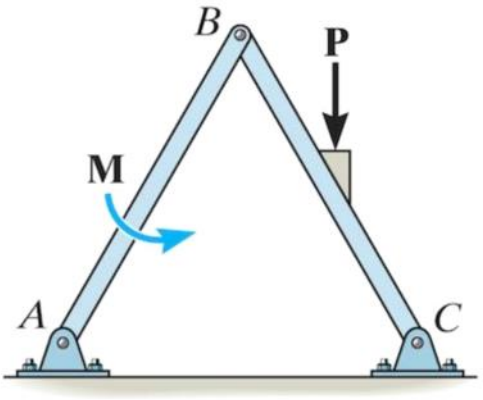
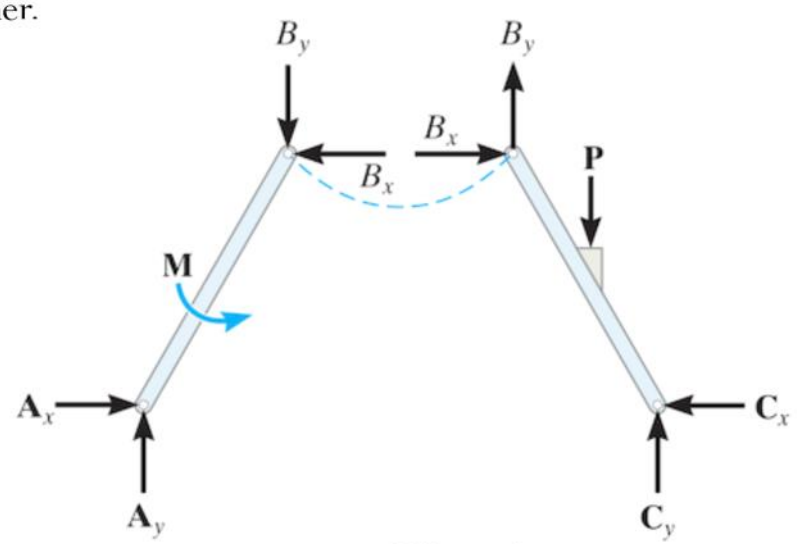
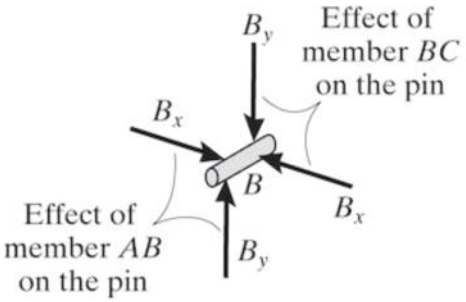
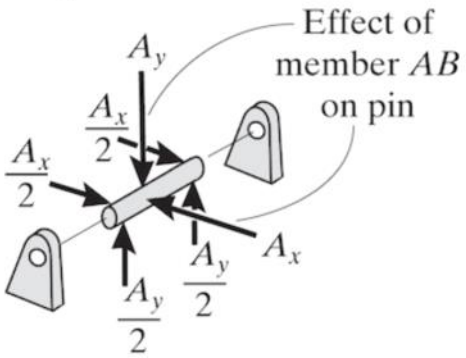
For the frame, draw the free-body diagram of (a) each member, (b) the pins at B and A, and (c) the two members connected together.







Pin B



Pin A