Statics - TAM 210 & TAM 211

Lecture 16

February 21, 2018

Announcements

- Mastering Engineering Tutorials will now be due by 10:00 am Monday.
  - All other deadlines remain the same. **Do not push off your other work.**
  - No change in grading format.
- Concept Inventory: Next week in CBTF. Optional extra credit. Details TBA

- Upcoming deadlines:
- Quiz 3 (2/21-23)
  - Sign up at CBTF
- Monday (2/26)
  - Mastering Engineering Tutorial 7
- Tuesday (2/27)
  - PL HW 6
- Thursday (3/1)
  - WA 3

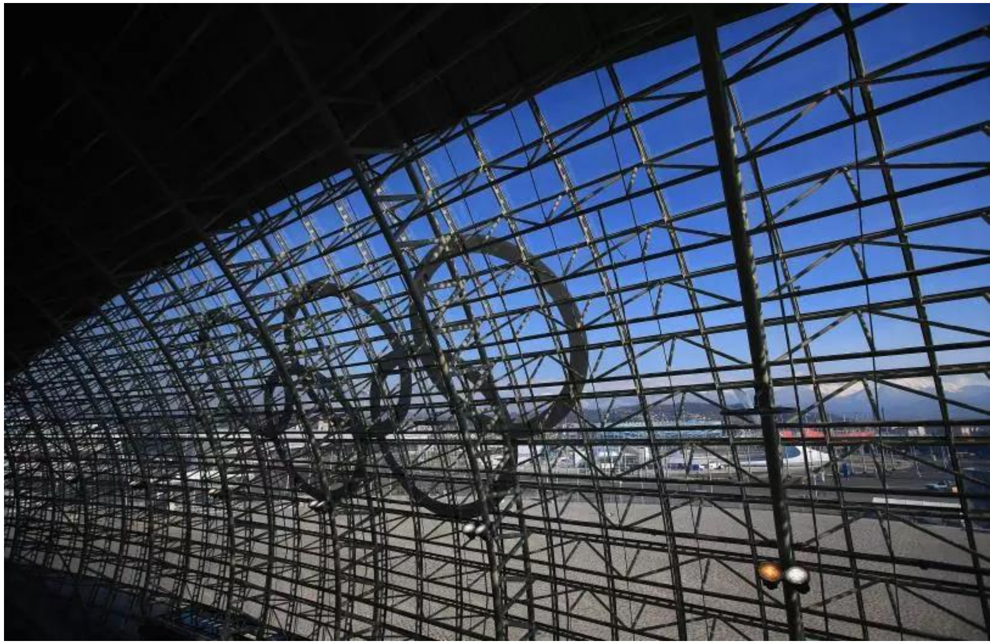


Photo: Richard Heathcote/Getty Images

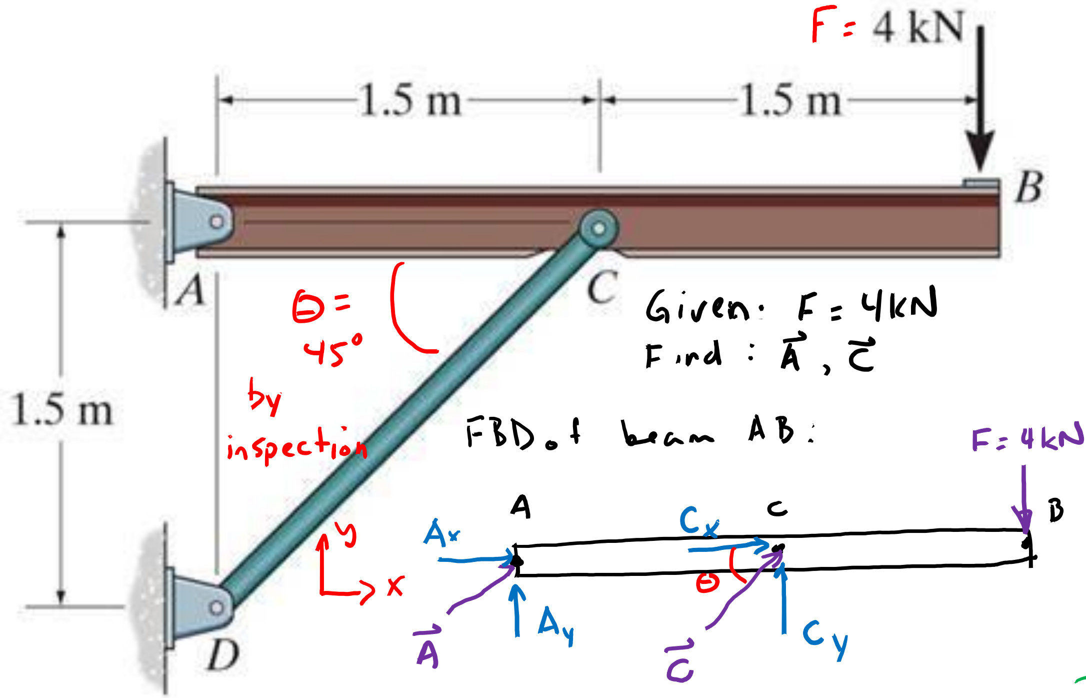
Given the 4kN load at B of the beam is supported by pins at A and C. Find the support reactions at A and C.

- Ignore weight
- use 2 & 3 - force members to simplify problem.

Given: F = 4kN

Find: $\vec{A}$, $\vec{C}$

FBD of beam AB:



ΣF_x: $A_x + C_x = 0 \rightarrow A_x = -C_x$

ΣF_y: $A_y + C_y - 4kN = 0 \rightarrow A_y = 4kN - C_y$

ΣM? Pick point to compute moment about that creates an equation with the least number of unknowns, so either A or C.

$\Sigma M = \vec{r} \times \vec{F}$ or dF if d is ⊥ distance to F

If select A,

$+\circlearrowleft \Sigma M_A$: $\vec{A}_x, \vec{A}_y, \vec{C}_x$ do not contribute to possible rotation about pt. A, since each passes thru A one's line of action

$(1.5m)\,C_y + (3m)(-4kN) = 0 \rightarrow \boxed{C_y = 8kN}$

$\therefore \boxed{A_y = -4kN}$

From FBD: $C_y = C\sin\theta$, $\theta = 45°$

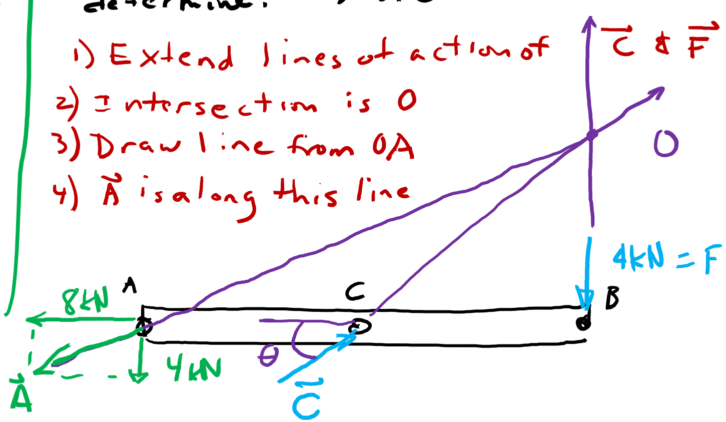
$\Rightarrow C = 11.3\,kN$

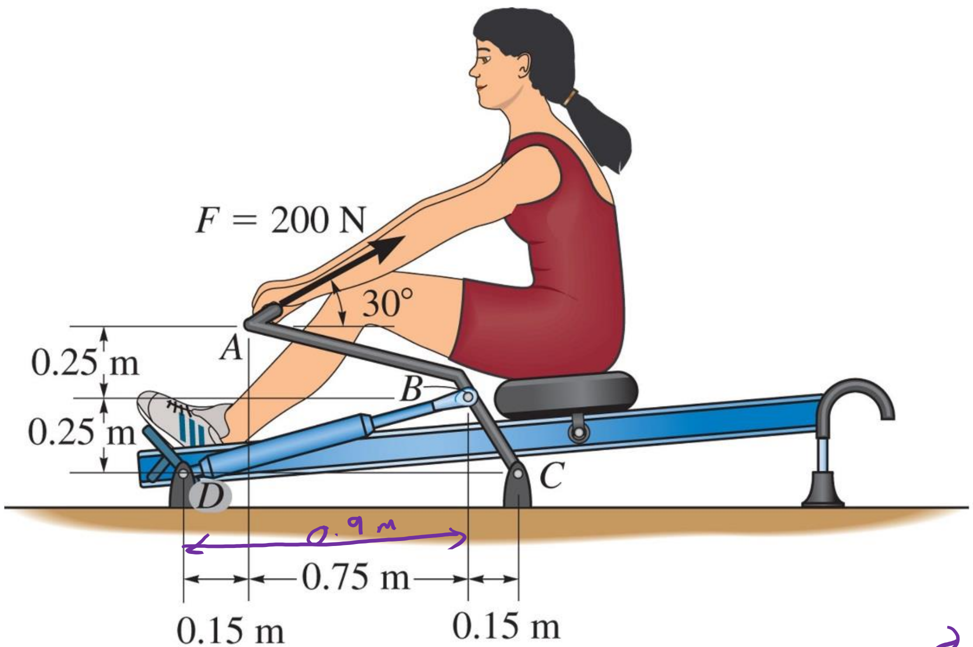
$\therefore C_x = C\cos\theta \rightarrow \boxed{C_x = 8kN}$

$\Rightarrow \boxed{A_x = -8kN}$

What is orientation of $\vec{A}$? use 3-force member principle to determine: "3 forces meet at same pt"

1) Extend lines of action of $\vec{C}$ & $\vec{F}$
2) Intersection is O
3) Draw line from OA
4) $\vec{A}$ is along this line



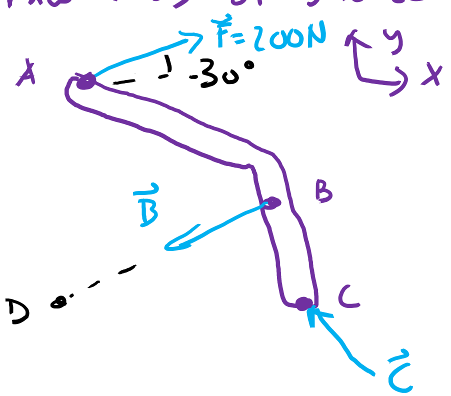


The woman exercises on the rowing machine. If she exerts a holding force of F = 200 N on the handle ABC, determine the reaction force at pin C and the force developed along the hydraulic cylinder BD on the handle.

Sample problem: Not covered in class

Find: $\vec{C}$, $\vec{B}$

① Draw FBD of 3 force members



② Determine x,y components of each force

a) $\vec{F} = 200N(\cos 30°)\hat{i} + 200N(\sin 30°)\hat{j}$

b) $\vec{B} = |B|\,\vec{u}_{BD}$, $\vec{u}_{BD} = \frac{\vec{r}_{BD}}{|\vec{r}_{BD}|}$

$\therefore \vec{B} = B\left[\frac{-0.9\hat{i} - 0.25\hat{j}}{\sqrt{0.9^2 + 0.25^2}}\right]$

Sum moments about C to solve for B

$\Sigma M_C: \vec{r}_{CB} \times \vec{B} + \vec{r}_{CA} \times \vec{F} = 0$

$\Rightarrow \boxed{B = 628\,N}$

Solve for reaction forces at C:

$\Sigma F_x: 200\,N(\cos 30°) + 628N\left(\frac{-0.9}{\sqrt{\quad}}\right) = 0$

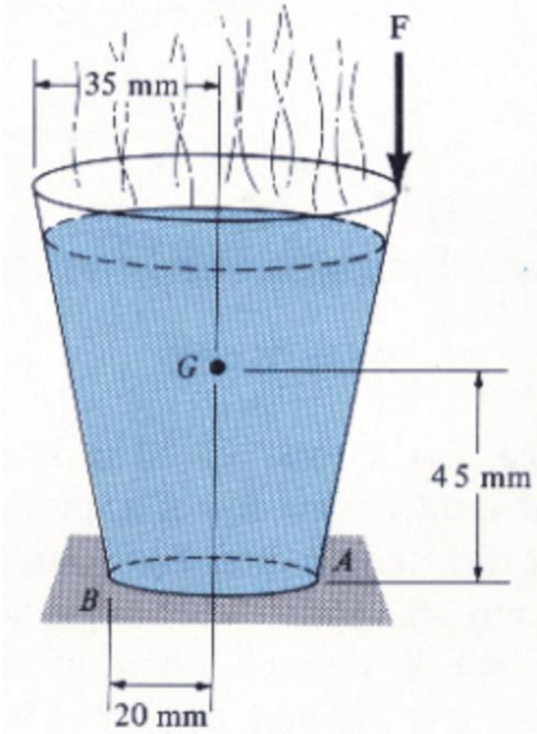
$\rightarrow \boxed{C_x = -432\,N}$

$\Sigma F_y: 200N(\sin 30°) + 628N\left(\frac{-0.25}{\sqrt{\quad}}\right) = 0$

$\rightarrow \boxed{C_y = 68.1\,N}$

$\vec{B} = 628\left(\frac{-0.9}{\sqrt{\quad}}\hat{i} - \frac{0.25}{\sqrt{\quad}}\hat{j}\right)\,N$

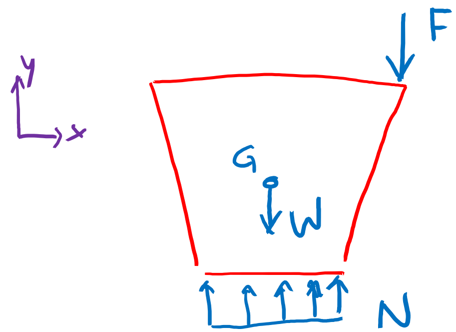
$\vec{C} = -432\hat{i} + 68.1\hat{j}\,N$



The cup is filled with 125 g of liquid. The mass center is located at G. If a vertical force F is applied to the rim of the cup, determine its magnitude so the cup is on the verge of tipping over.

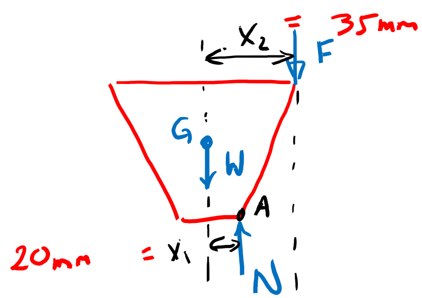
Sample problem: Not covered in class

Draw FBD



The system is not in equilibrium unless $F = 0$.

On verge of tipping means that N acts at a specific point.



$\Sigma F_x: \quad 0$

$\Sigma F_y: \quad N - W - F = 0$

$\Sigma M_A: \quad x_1 W - (x_2 - x_1) F = 0$

$$F = \left(\frac{x_1}{x_2 - x_1}\right) W$$

$$F = \frac{20\ mm}{(35 - 20)\ mm}\left(0.125g \cdot 9.8\frac{m}{s^2}\right)$$

$$\boxed{F = 1.635\,N}$$

iclicker:

Were these written out examples helpful?

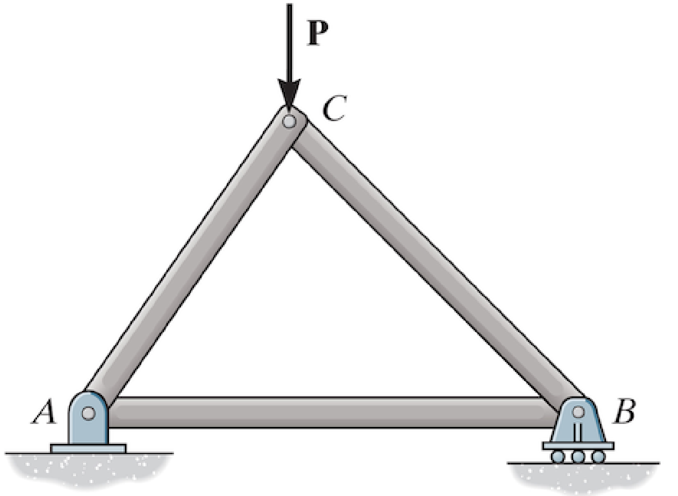
1) yes ok out of class
2) yes, but do it in class
3) no
4) I don't care

Chapter 6: Structural Analysis

Goals and Objectives

- Determine the forces in members of a truss using the method of joints
- Determine zero-force members
- Determine the forces in members of a truss using the method of sections

Recap: Truss Analysis



Assumption of trusses

- Loading applied at joints, with negligible weight (If weight included, vertical and split at joints)
- Members joined by smooth pins
- Pins in equilibrium: $\sum F_x = 0$ and $\sum F_y = 0$

Method of joints

cf. analysis of a particle

Procedure for analysis:

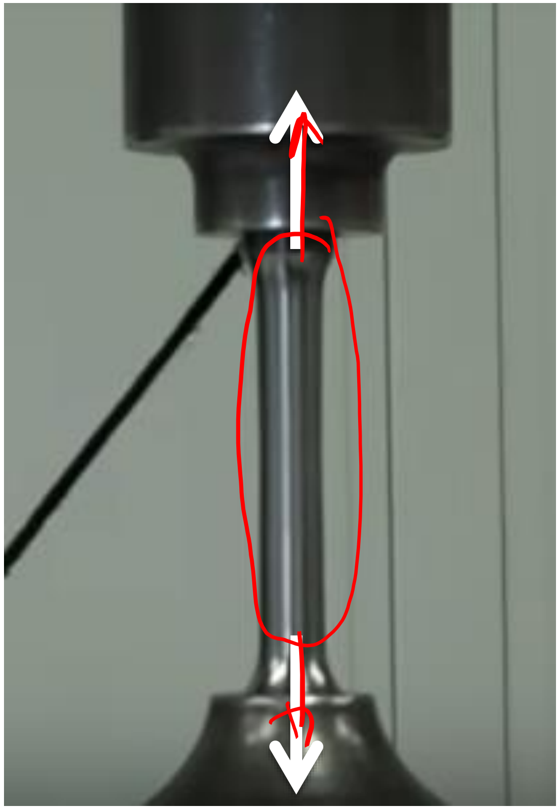
- Free-body diagram for each joint
- Start with joints with at least 1 known force and 1-2 unknown forces
- Assume the unknown force members to be in *tension*

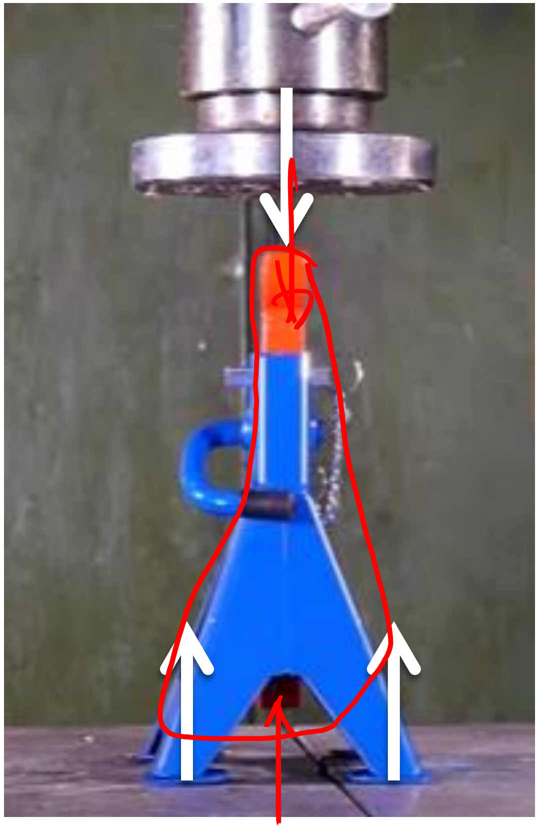
Zero-force members

Two situations:

- Two non-collinear members , no external or support at jt → **Both members are ZFM**
- Two collinear member, plus third non-collinear, no loads on third member → **Non-collinear member is ZFM**.

Tension vs. Compression

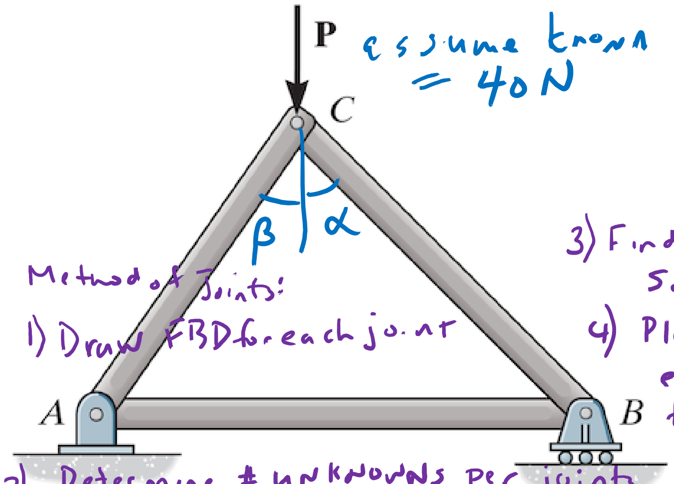




Rigid bodies respond differently to tension versus compression.

https://www.youtube.com/watch?v=67fSwIjYJ-E
https://www.youtube.com/watch?v=Gb9eemosZF8

Create FBDs for each joint and each member.
Assume unknown force members to be in *tension*



P assume known = 40 N

Method of Joints:
1) Draw FBD for each joint
2) Determine # unknowns per joints.
3) Find case with # unk ≤ # eqn
Solve for unknowns.
4) Plug solved values into eqns for other joints to solve for more unknowns

Jt A:
ΣF_x, ΣF_y – 2 eqns.
unk: 4 : A_x, A_y, F_{AC}, F_{AB}
unk > eqn ⇒ look at another jt

plug in value from $F_{AC} = F_{CA}$

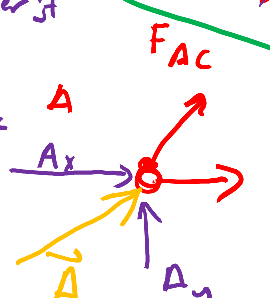
Jt B:
2 eqns ΣF_x ΣF_y
unk: B_y, F_{BA}, F_{BC}
unk > eqn ⇒ look at another jt

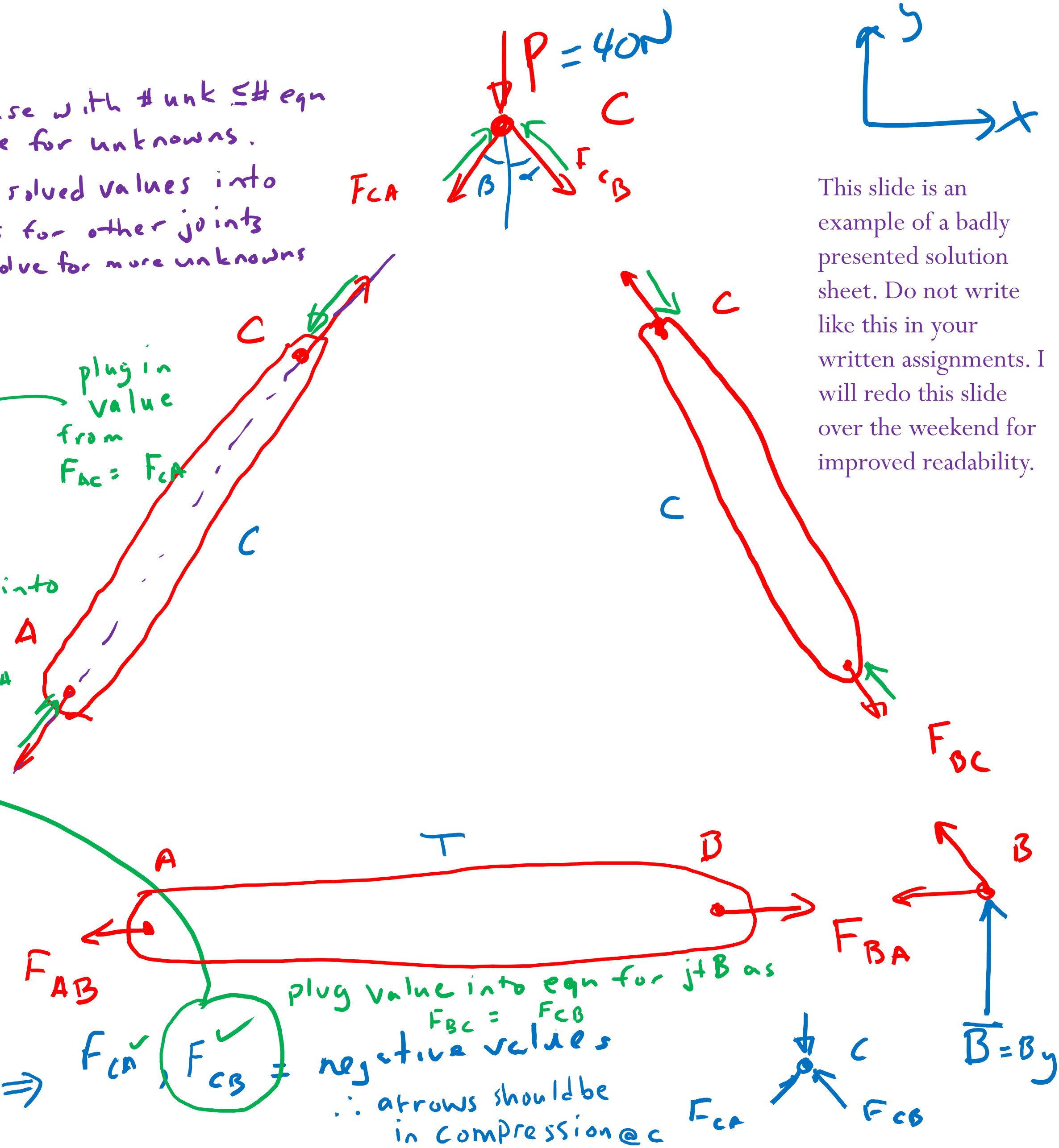
plug value into eqn for jt A as $F_{AB} = F_{BA}$

Jt C:
unk: F_{CA}, F_{CB}
unk = eqn ⇒ solve for unk

ΣF_x:
$-F_{CA}\sin\beta + F_{CB}\sin\alpha = 0$

ΣF_y:
$-40\,kN - F_{CA}\cos\beta - F_{CB}\sin\beta = 0$ ⇒ F_{CA}, F_{CB} = negative values
∴ arrows should be in compression @ c



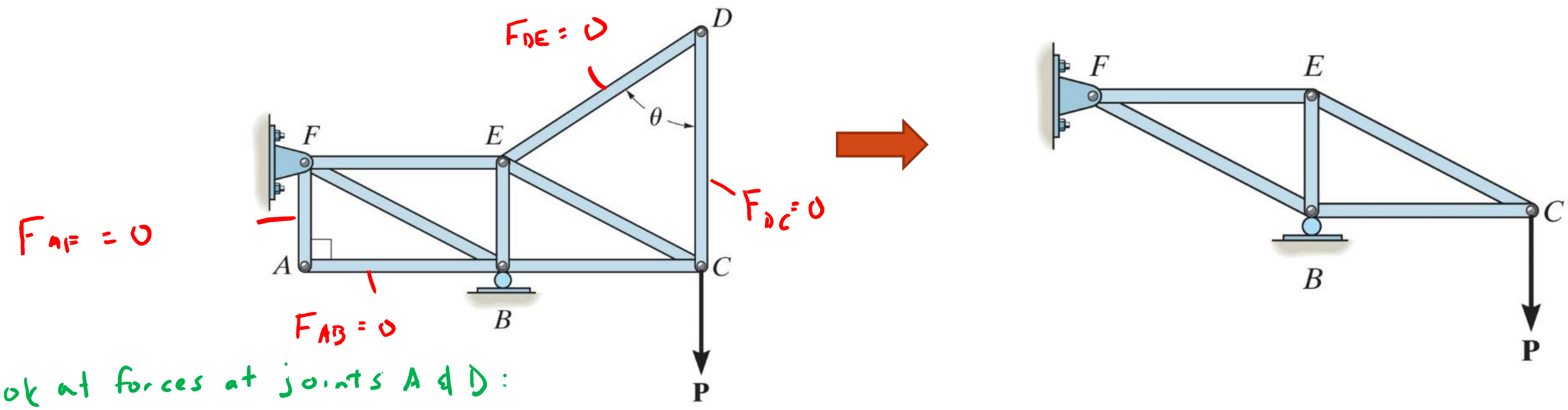


plug value into eqn for jt B as $F_{BC} = F_{CB}$

This slide is an example of a badly presented solution sheet. Do not write like this in your written assignments. I will redo this slide over the weekend for improved readability.

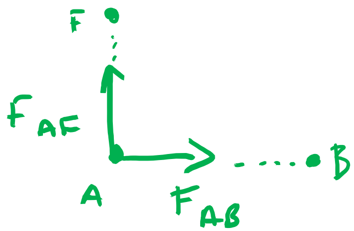
Use Method of joints to prove that members attached to A and D should be FZM:

From lecture 15, we know that the following forces are zero.



Look at forces at joints A & D:

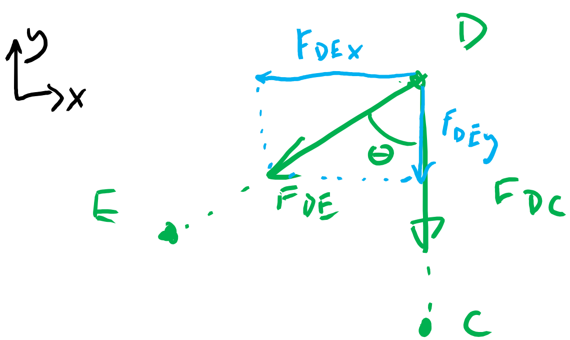
Jt A



$\Sigma F_x: F_{AB} = 0$ ✓

$\Sigma F_y: F_{AF} = 0$ ✓

Jt D:



$\Sigma F_x: \; -F_{DEx} = 0$

$F_{DEx} = |\vec{F}_{DE}| \sin\theta = 0$

since $\theta \neq 0 \; \therefore \; F_{DE} = |\vec{F}_{DE}| = 0$ ✓

$\Sigma F_y: \; -F_{DC} - \cancel{F_{DE}}\cos\theta = 0$

$\cancel{F_{DE}} \to 0$

$\therefore \; F_{DC} = 0$ ✓