Statics - TAM 210 & TAM 211

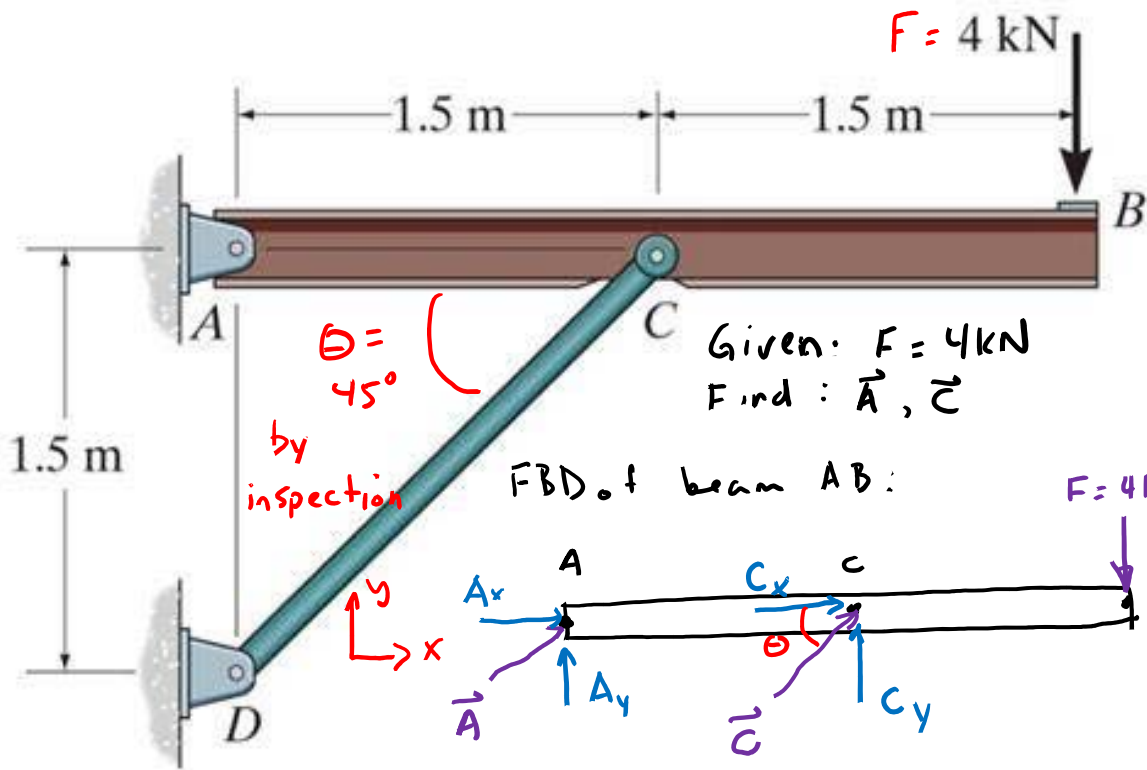**Lecture 16**

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.

❑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

F = 4 kN

$\leftarrow$ 1.5 m $\rightarrow$ | $\leftarrow$ 1.5 m $\rightarrow$

B

A

$\theta = 45°$

by inspection

1.5 m

C

D

Given: F = 4kN
Find : $\vec{A}$, $\vec{C}$

FBD of beam AB:

F = 4kN

A

A_x

$\vec{A}$ $\uparrow A_y$

C_x C

θ

$\vec{C}$ $\uparrow C_y$

B

F = 4kN

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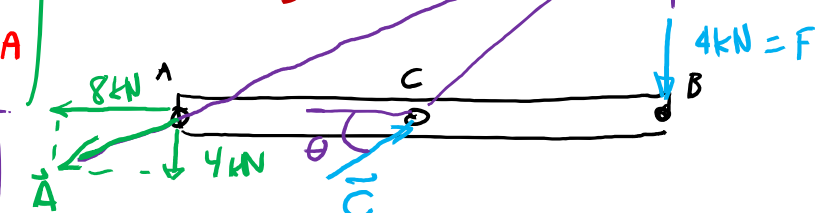
$\therefore \boxed{A_y = -4kN}$

From FBD: $C_y = C\sin\theta$, $\theta = 45°$
$\Rightarrow C = 11.3 kN$

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

$\Sigma F_x:$ $A_x + C_x = 0$ $\rightarrow$ $A_x = -C_x$

$\Sigma F_y:$ $A_y + C_y - 4kN = 0$ $\rightarrow$ $A_y = 4kN - C_y$
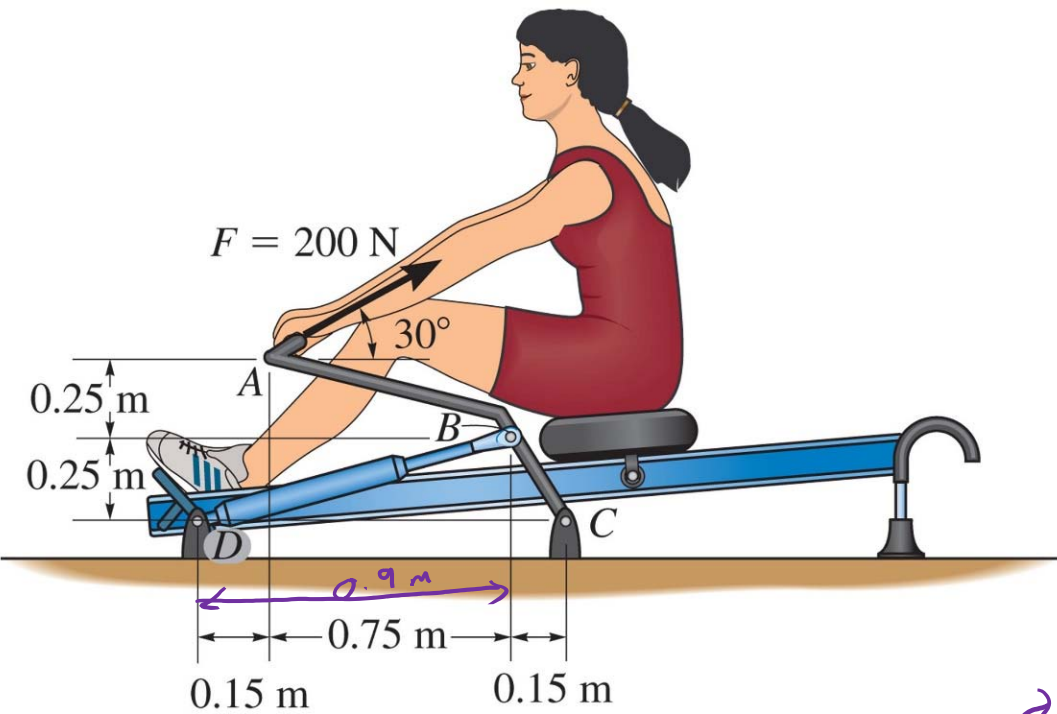
$\Sigma M_?$ Pick point to compute moment about that creates an equation with the least number of unknowns, so either A or C.

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

If select A,

$+) \Sigma M_A:$ $\vec{A_x}, \vec{A_y}, \vec{C_x}$ do not contribute to possible rotation about pt. A, since each passes thru A, one's line of action.

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

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

8kN

4kN = F

C

O

$\vec{A}$ 4kN

θ

$\vec{C}$

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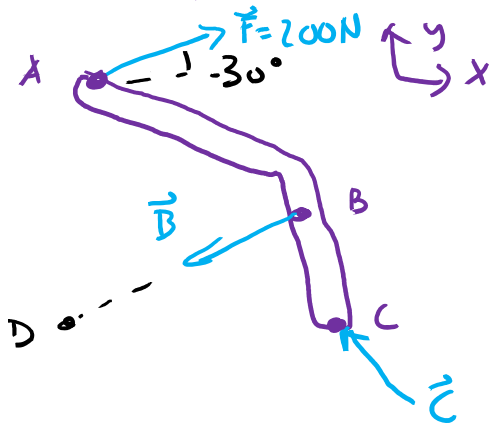
The woman exercises on the rowing machine. If she exerts a holding force of F = 200 N on the handle ABC, determine the reaction force at pin C and the force developed along the hydraulic cylinder BD on the handle.

Sample problem: Not covered in class

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

$F = 200$ N

$30°$

0.25 m A

0.25 m B

D

C

0.9 m

0.75 m

0.15 m   0.15 m

① Draw FBD of 3 force member

$\vec{F} = 200$ N $-30°$

A

$\vec{B}$ B

D

C $\vec{C}$

② Determine x,y components of each force

a) $\vec{F} = 200$ N $(\cos 30°)\,\hat{\imath} + 200$ N $(\sin 30°)\,\hat{\jmath}$

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

∴ $\vec{B} = B\left[\dfrac{-0.9\,\hat{\imath} - 0.25\,\hat{\jmath}}{\sqrt{0.9^2 + 0.25^2}}\right]$

Sum moments about C to solve for B

$\Sigma M_c : \vec{r}_{cB} \times \vec{B} + \vec{r}_{cA} \times \vec{F} = 0$

⇒ $B = 628$ N

Solve for reaction forces at C

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

→ $C_x = -432$ N

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

→ $C_y = 68.1$ N

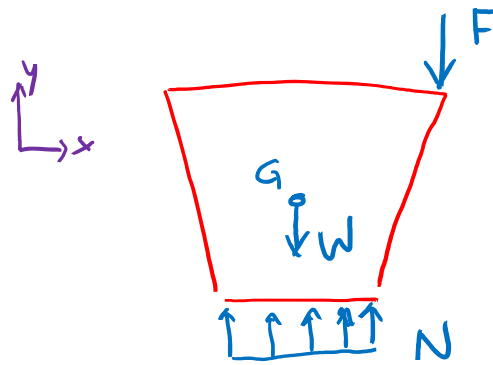$\vec{B} = 628\left(\dfrac{-0.9}{\sqrt{\;}}\hat{\imath} - \dfrac{0.25}{\sqrt{\;}}\hat{\jmath}\right)$ N

$\vec{C} = -432\,\hat{\imath} + 68.1\,\hat{\jmath}$ 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 <u>cup is on the verge of tipping over.</u>
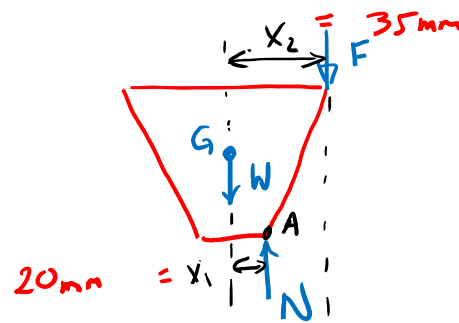
Sample problem: Not covered in class

Draw FBD

The system is <u>not</u> in equilibrium unless $F = 0$.

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

$\Sigma F_x:$ 0

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

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

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

$F = \dfrac{20 \text{ mm}}{(35 - 20) \text{ mm}} \left(0.125 g \cdot 9.8 \tfrac{m}{s}\right)$

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

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

Procedure for analysis:

- Free-body diagram for each joint

- Start with joints with at least 1 known force and 1-2 unknown forces
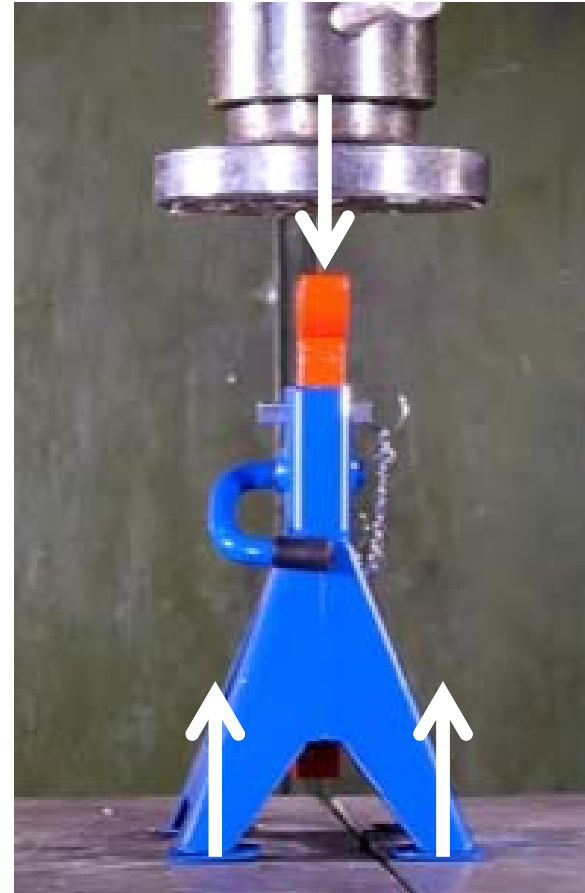
- Assume the unknown force members to be in *tension*

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**.
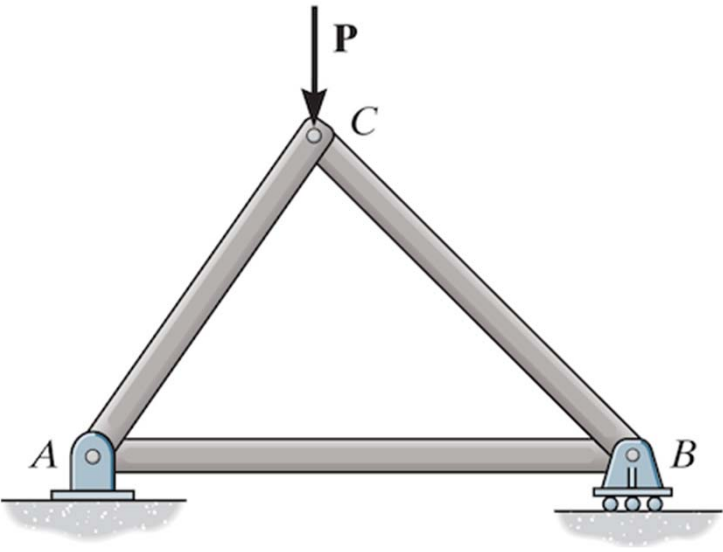
Tension vs. Compression

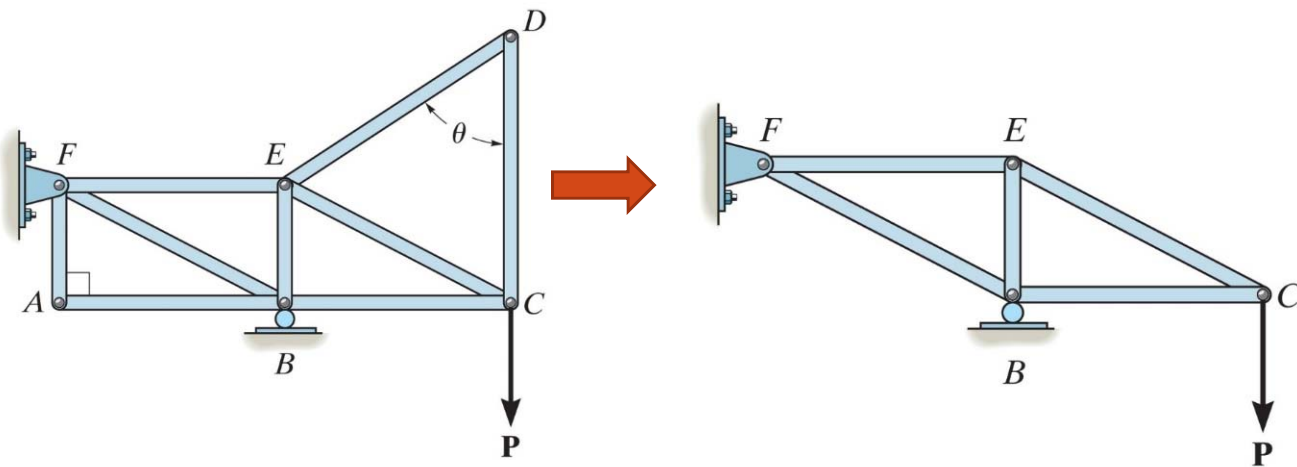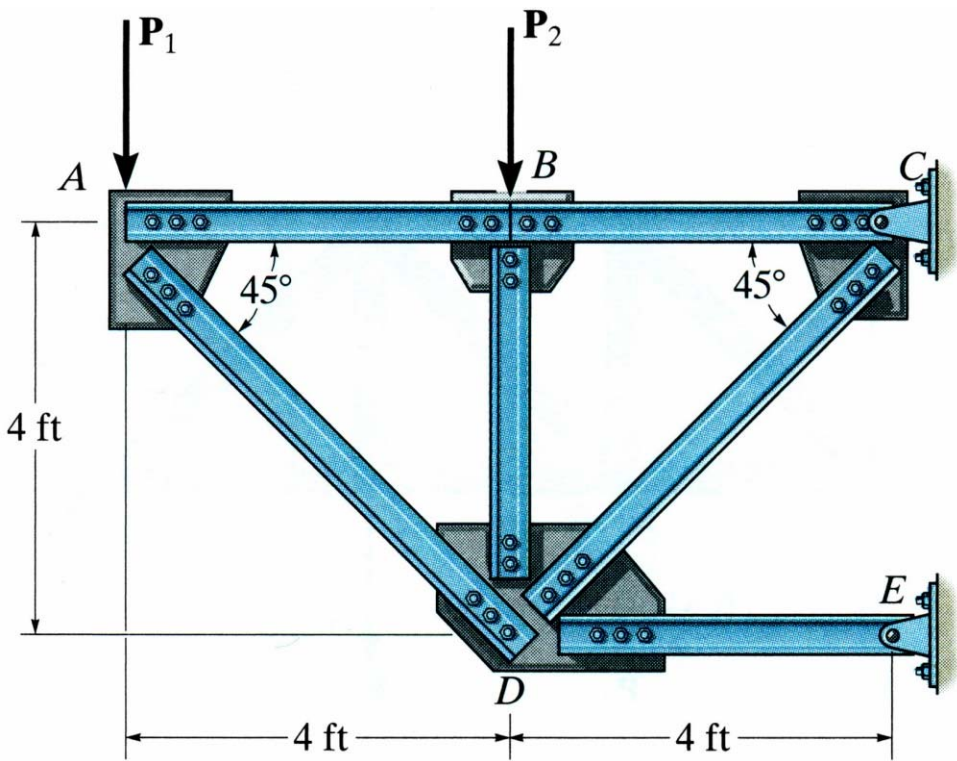Rigid bodies respond differently to tension versus compression.

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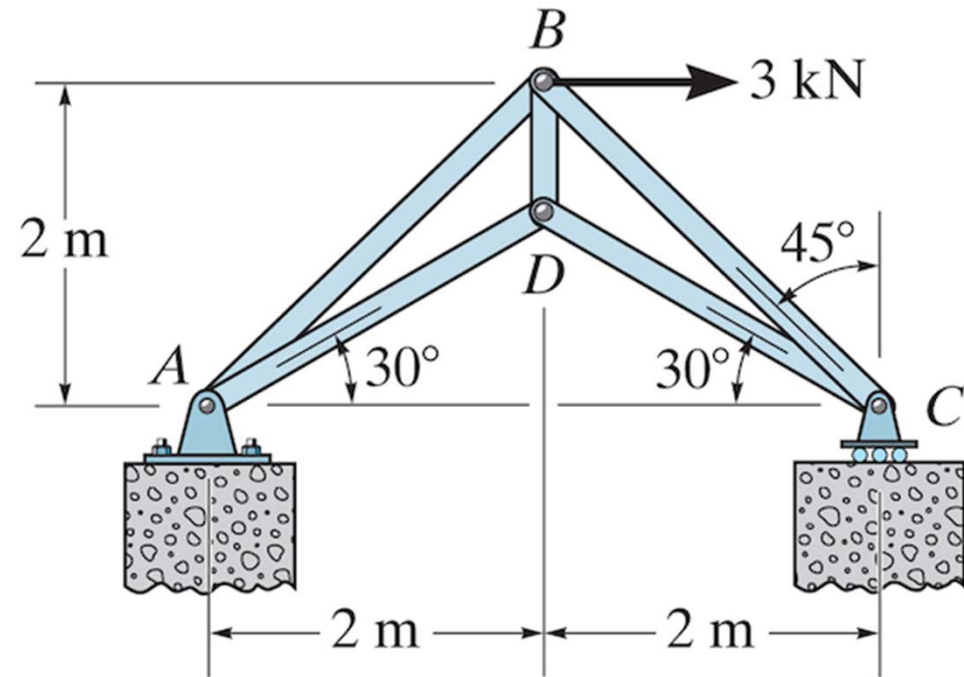Assume unknown force members to be in *tension*

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

The truss, used to support a balcony, is subjected to the loading shown. Approximate each joint as a pin and determine the force in each member. State whether the members are in tension or compression.

Determine the force in each member of the truss and indicate whether the members are in tension or compression.

Determine the force in member *FG* of the truss and state if the member is in tension or compression.