Lecture 20

Monday, October 16, 2017 12:36

To do ...

- Quiz 4 this week!

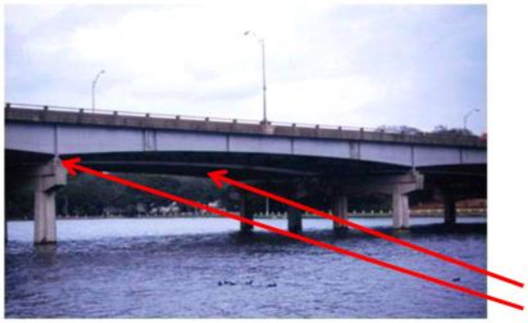
- HW 14 PL due **Wed**
- HW 15 ME due **Thurs**

Chapter 7: Internal Forces

Main goals and learning objectives

- Determine the internal loadings in members using the method of sections
- Generalize this procedure and formulate equations that describe the internal shear and moment throughout a member

Internal loadings developed in structural members

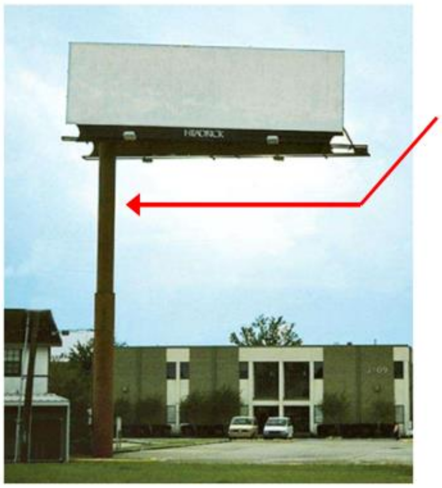


Beams are structural members designed to support loads applied perpendicularly to their axes.

Beams can be used to support the span of bridges. They are often thicker at the supports than at the center of the span.

Why are the beams tapered? Internal forces are important in making such a design decision.

Internal loadings developed in structural members

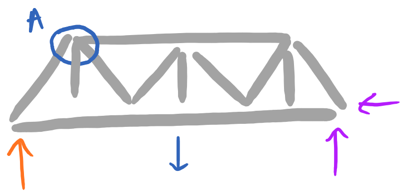


A fixed column supports these rectangular billboards.

Usually such columns are wider/thicker at the bottom than at the top. Why?

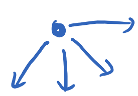
So far:
- External forces on rigid bodies.
- Method of joints/sections - forces on trusses.

FBD of truss



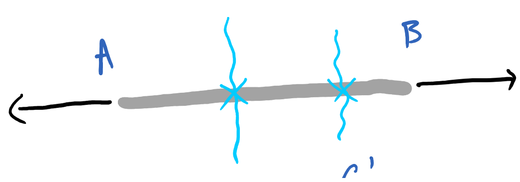
External forces on truss

FBD of A

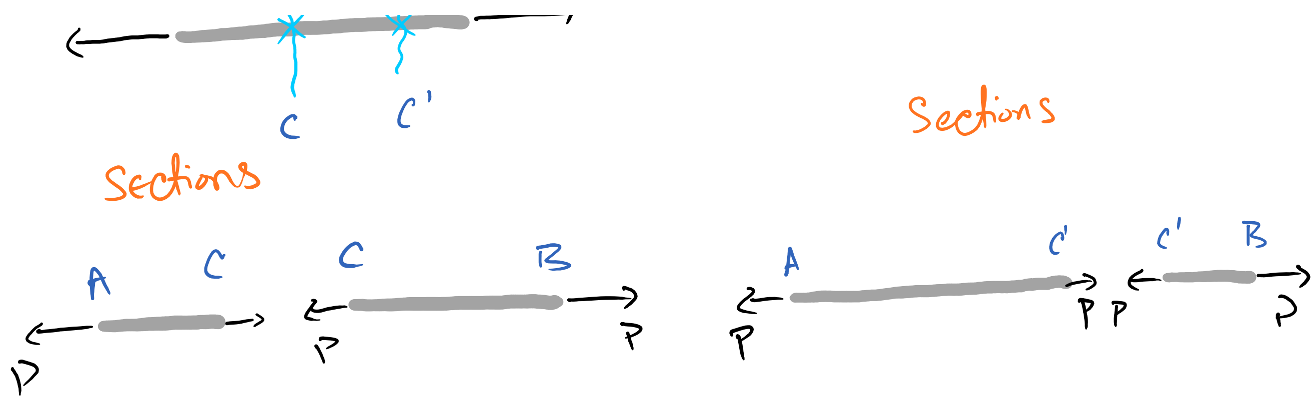


External force on pin/joint.
(internal force on truss)

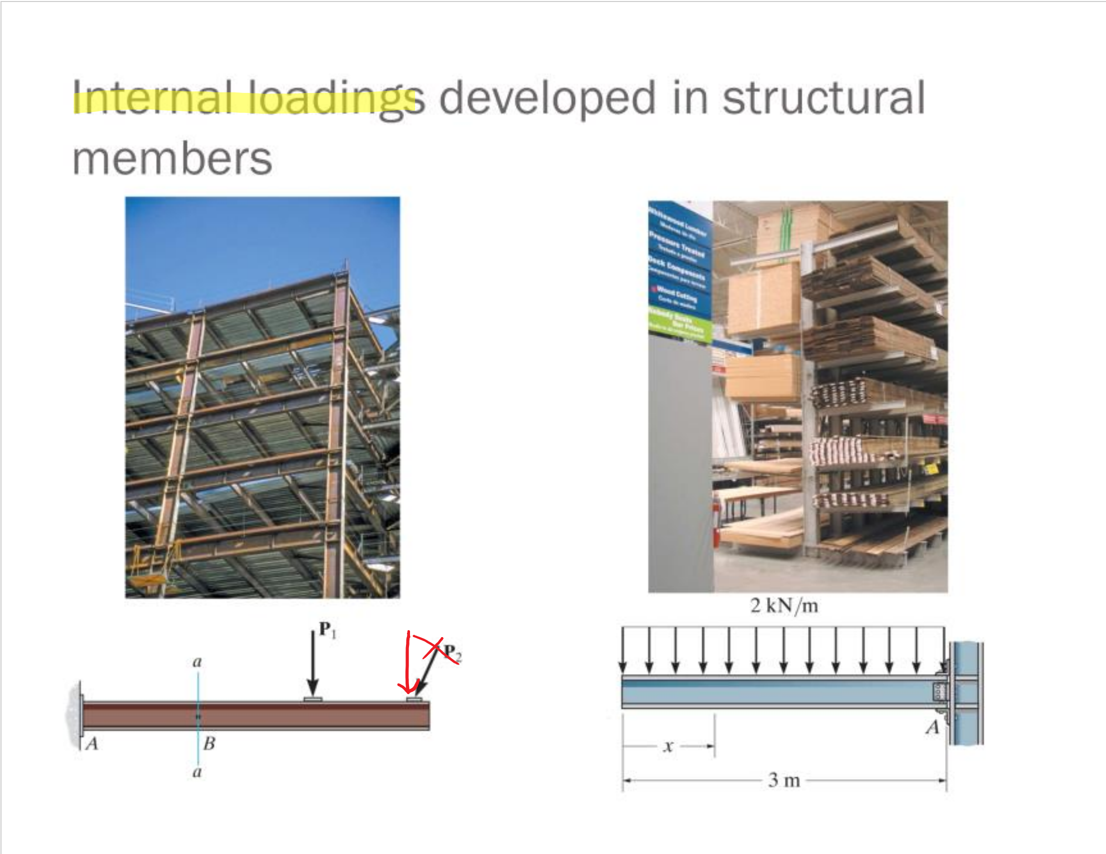
Consider the two force member.



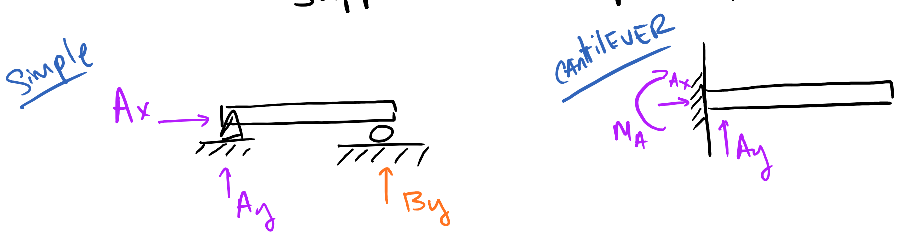
tension (or compression)



important for mechanics of materials, failure, deformation.

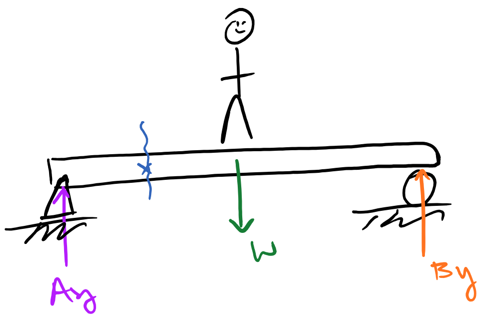


BEAMS –
- Structural members
- length >> cross section
- Supports – Simple support / cantilever → boundary conditions.

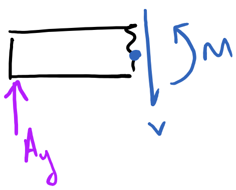


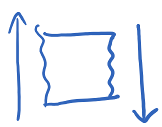
- carry loads perpendicular to axis.
  - concentrated or distributed loads.
- loads create internal forces → normal, shear] translation; bending] rotation

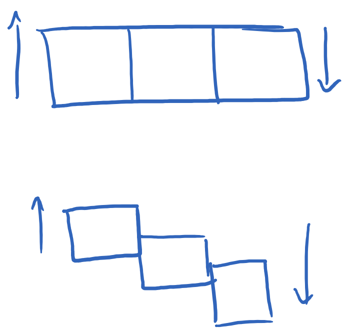
Q: What are shear forces and bending moments?



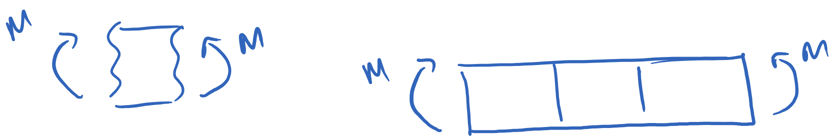
At a specific point, use method of sections to determine internal forces.



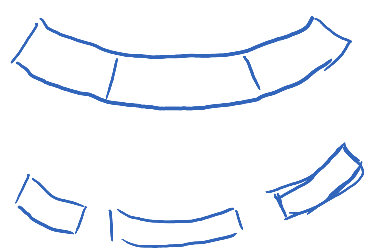




translation (shear)



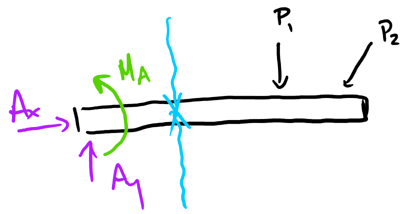
tendency to bend (deform)



- Determine the internal loading at point B of the cantilever beam.

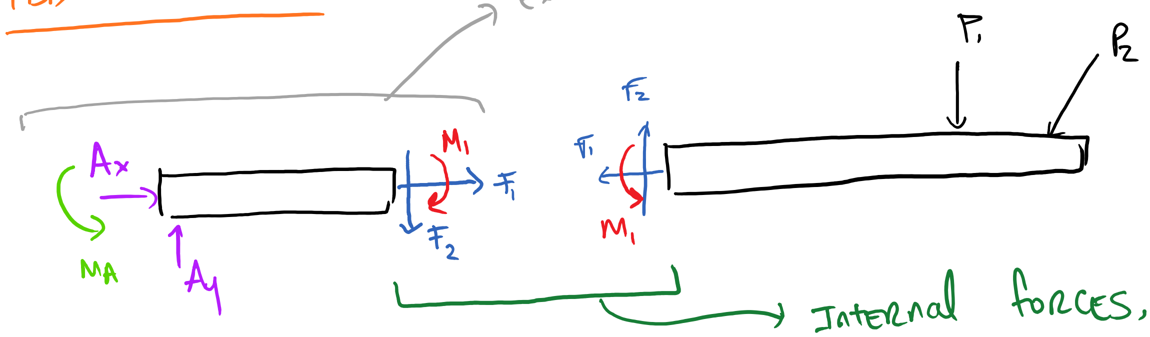
use method of sections!

FBD of Beam



external forces on section!

FBD of sections



Internal forces, cancel out when beam is put together

Section AB is in Rigid body equilibrium

$$\Sigma F_x = 0$$

$$\Sigma F_y = 0$$

$$\Sigma M = 0$$

F_1, F_2, & M have specific names.

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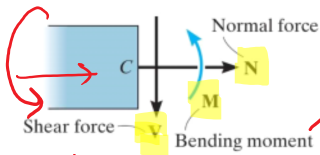
Internal loadings developed in structural members

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.**



→ acts perp to cut/ cross section

→ counter couple moment.

↳ Acts para to cut / tangent to cross section

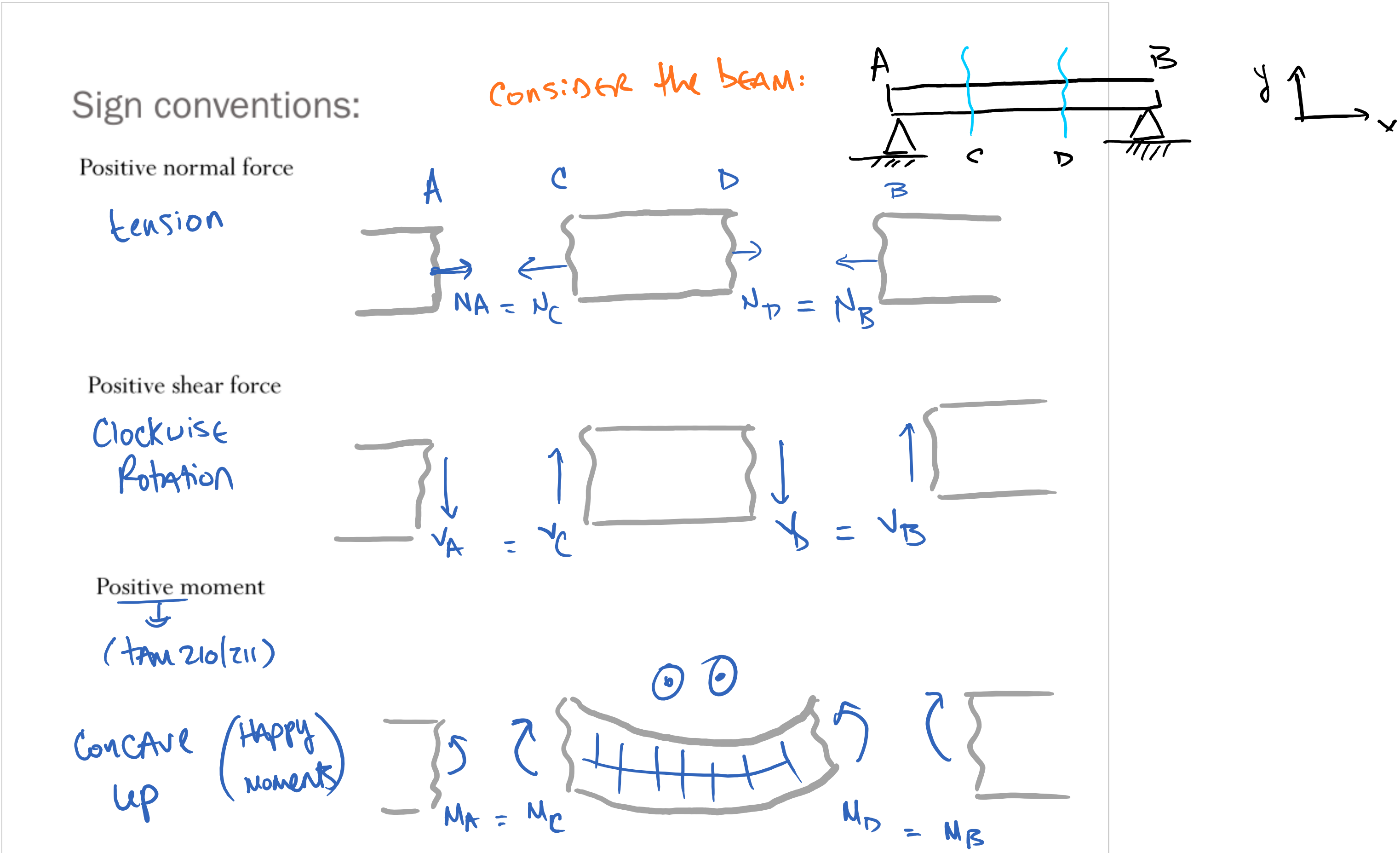
https://www.youtube.com/watch?v=hLfNCAHPL8c BCT540 Truss Test, Group 2

https://www.youtube.com/watch?v=YdqvGGFIbfc Steel Rebar Tensile Test

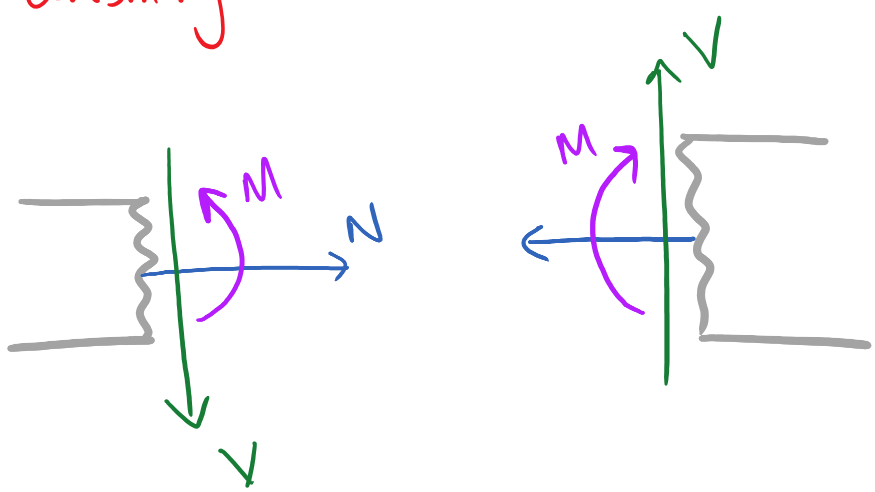
(N, V, M)

* note : in 2D - there are 3 types of internal loading

in 3D there ARE 4 types + torsion/twisting moment.


Sign conventions:
Consider the beam:
A
B
C
D
y
x
Positive normal force
tension
$N_A = N_C$
$N_D = N_B$
Positive shear force
Clockwise Rotation
$V_A = V_C$
$V_D = V_B$
Positive moment
(TAM 210/211)
Concave up
(Happy moments)
$M_A = M_C$
$M_D = M_B$

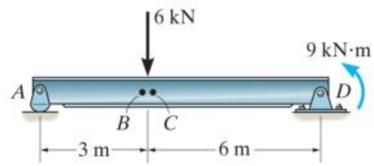
Combining…


M
N
V
V
M
V

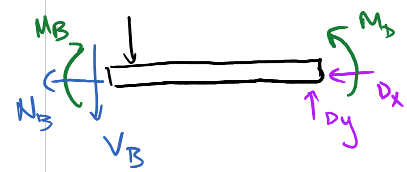
Procedure for analysis:

1. Find support reactions (free-body diagram of entire structure)
2. Pass an imaginary section through the member
3. Draw a free-body diagram of the segment that has the least number of loads on it
4. Apply the equations of equilibrium

Find the internal forces and moments at B (just to the left of P) and at C (just to the right of P)

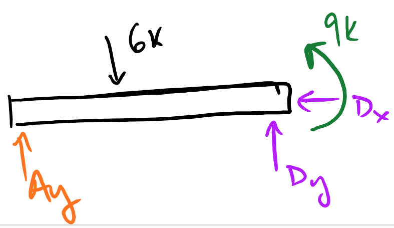


FBD of section BD

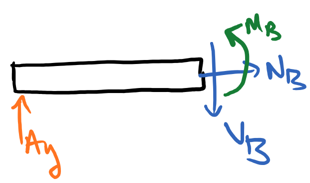


(5 unknowns)

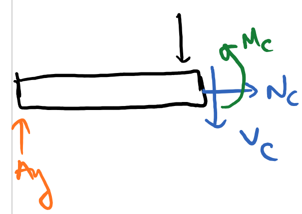
FBD of BEAM AD



FBD of section AB



FBD of section AC



(3 unknowns)

Eqns of Eq.

$\Sigma F_x: 0 \quad N_B = 0$

$\Sigma F_y: \quad A_y = V_B$

$\Sigma M_B: \quad M_B - xA_y = 0$

$M_B = xA_y$

$\Sigma F_x = \quad N_c = 0$

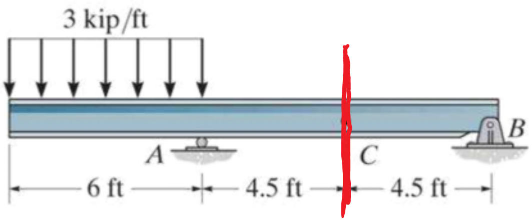
$\Sigma F_y: \quad A_y - V_c - 6k = 0$

$\Sigma M_c: \quad M_c - xA_y = 0$

$M_c = xA_y$

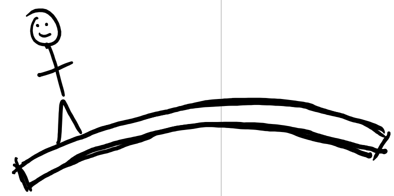
Q: Could you use section BD or CD?

-Sure!

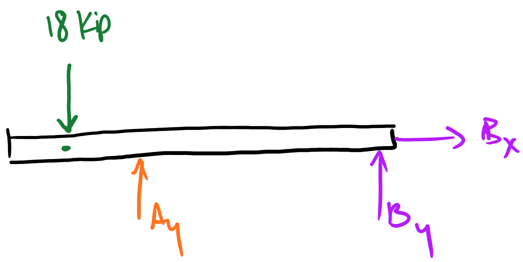


Find the internal forces at point C.

1. DRAW FBD of beam
2. TAKE cut.

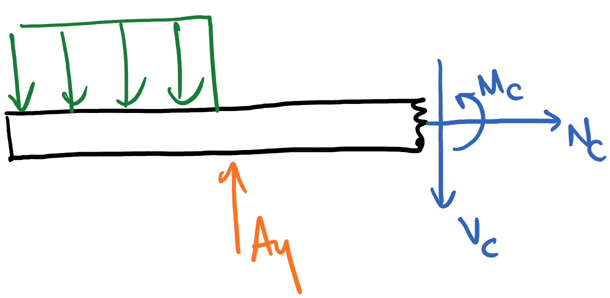


FBD of beam:



FBD of left section:

FBD of right section:



4 unknowns!

5 unknowns!

use eqns. of equilibrium:

ΣF_x: $-\underline{N_c} = 0$

ΣF_y: $\underline{V_c} + B_y = 0$

ΣM_c: $-\underline{M_c} + (4.5)B_y = 0$