Statics - TAM 210 & TAM 211

Lecture 20

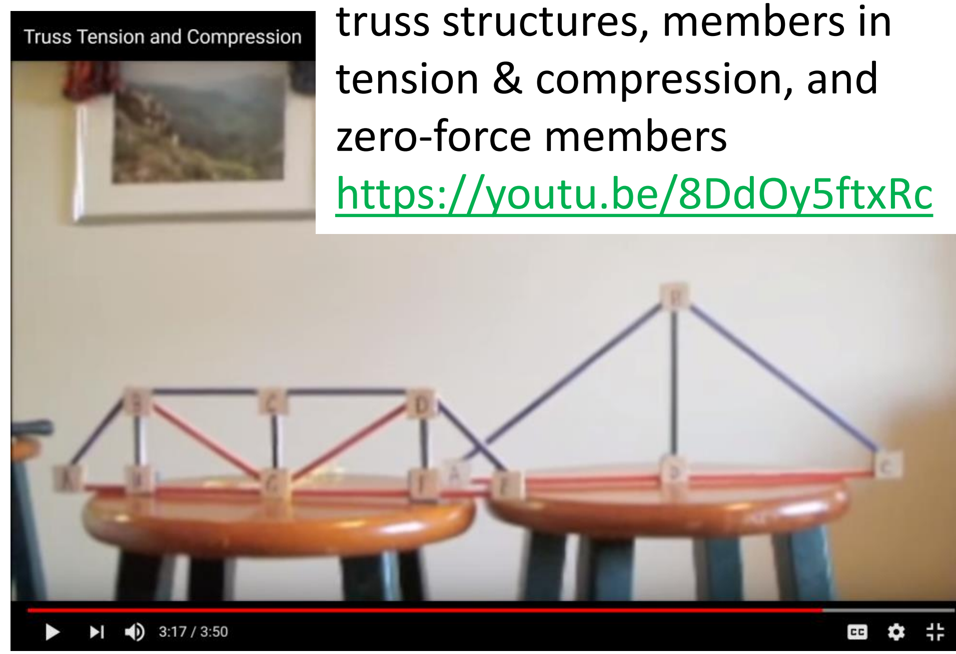
March 2, 2018

Chap 7.1

Announcements

- Structured office hours of working through practice problems will be held during Sunday office hours in 429 Grainger
  - 3:00 - 4:30 pm
  - Starting this Sunday March 4
- Written Assignments:
  - TAs are NOT accepting late WA submissions
- Upcoming deadlines:
- Monday (3/5)
  - Mastering Engineering Tutorial 8
- Tuesday (3/6)
  - PL HW 6
- Quiz 4 (3/7-9)
  - Sign up at CBTF

The following short video provides simple explanations of truss structures, members in tension & compression, and zero-force members
https://youtu.be/8DdOy5ftxRc



Recap: Procedure for solving for forces/moment in frames and machines

1. Identify two-force member(s) and zero-force members to simplify direction of unknown force(s).
2. Identify external support reactions on entire frame or machine. Draw FDB of entire structure.
3. Draw FDBs of individual subsystems (members). (Solve respective equations of equilibrium $\sum F_x = 0, \sum F_y = 0$, $\sum M_{most\ efficient\ pt} = 0$.)
4. Solve for the requested unknown forces or moments. (Look for ways to solve efficiently and quickly.)

Chapter 7: Internal Forces

Goals and 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

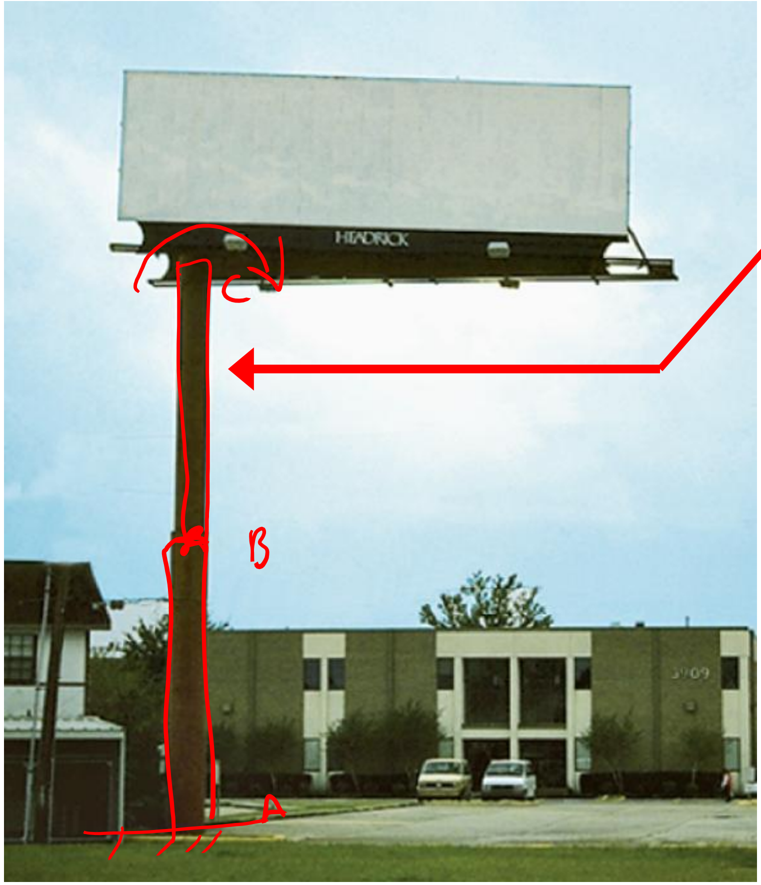
Internal loadings developed in structural members

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.

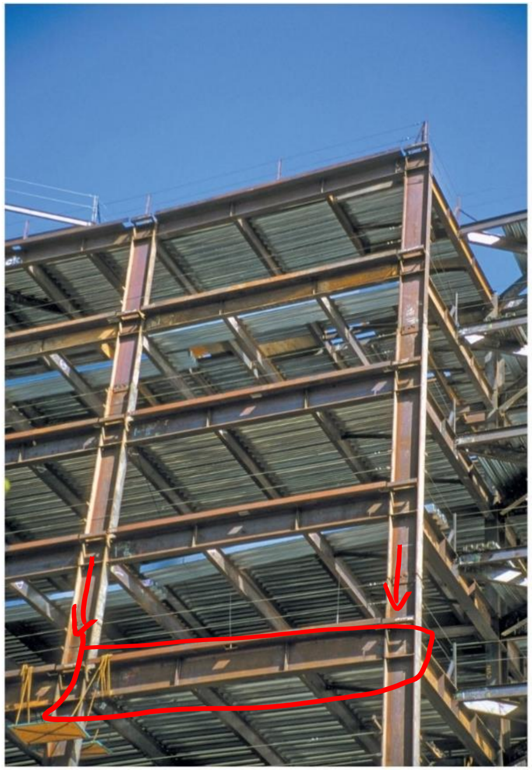
Internal loadings developed in structural members



A fixed column supports these rectangular billboards.

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

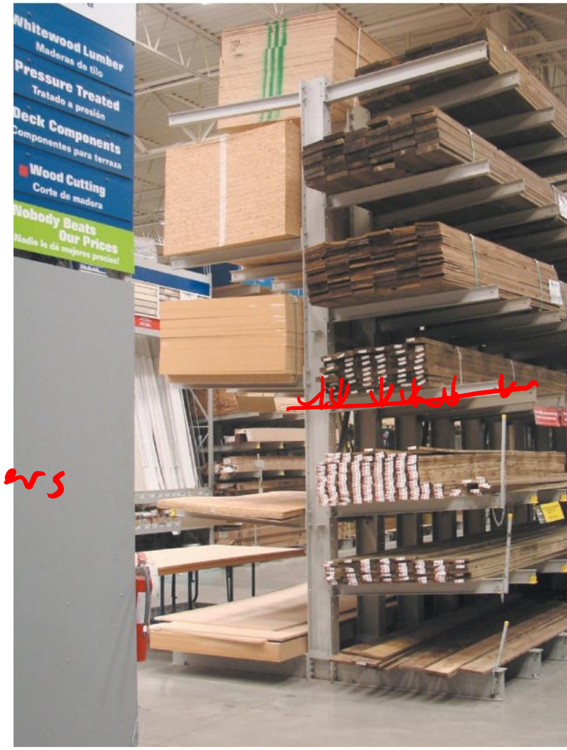
Internal loadings developed in structural members

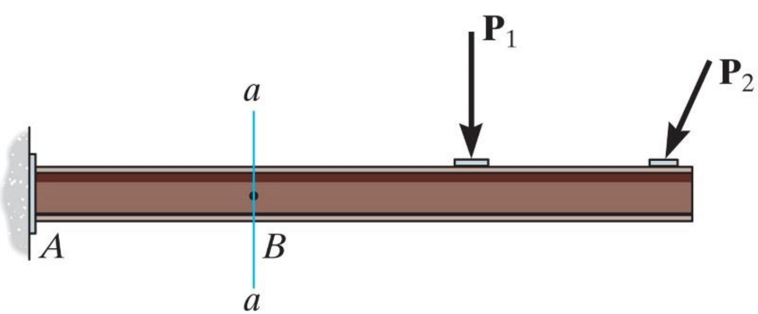


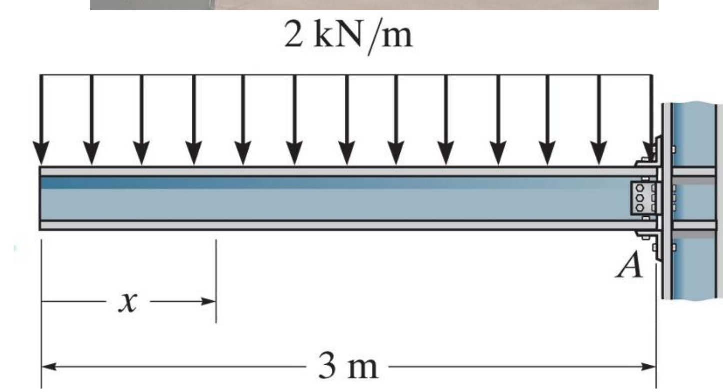
Beams:
Length >> x section

Loads:
⊥ to beams

Supports:
simple supports: pin, rollers
cantilever (fixed)



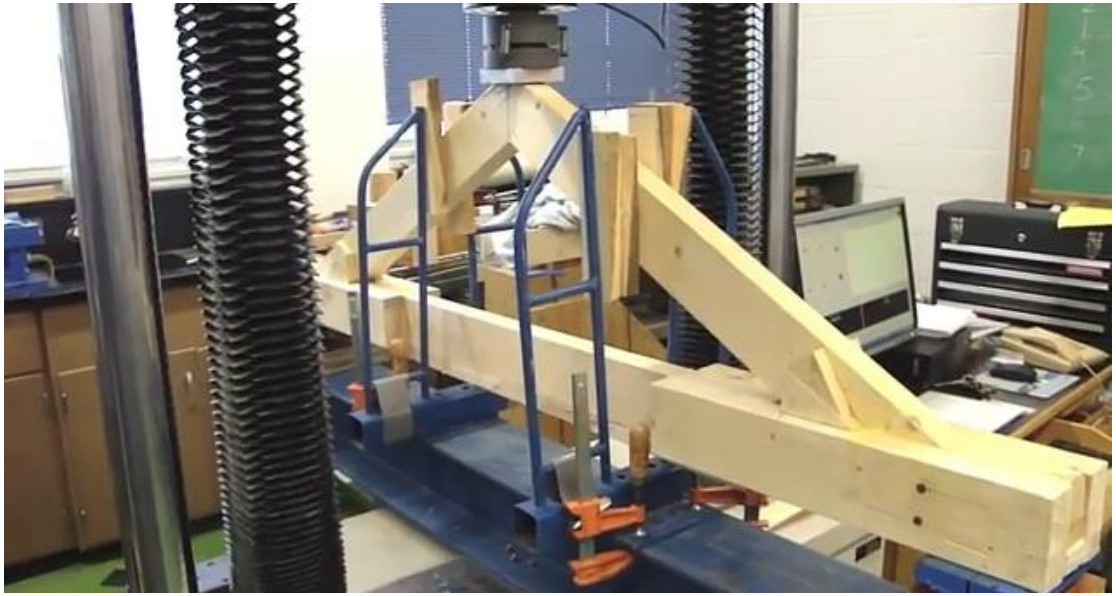




Internal loadings developed in structural members

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.** ⟹ use Method of Sections



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

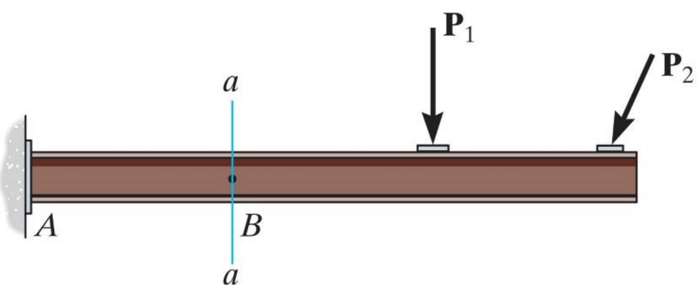
https://www.youtube.com/watch?v=YdqvGGFlbfc Steel Rebar Tensile Test

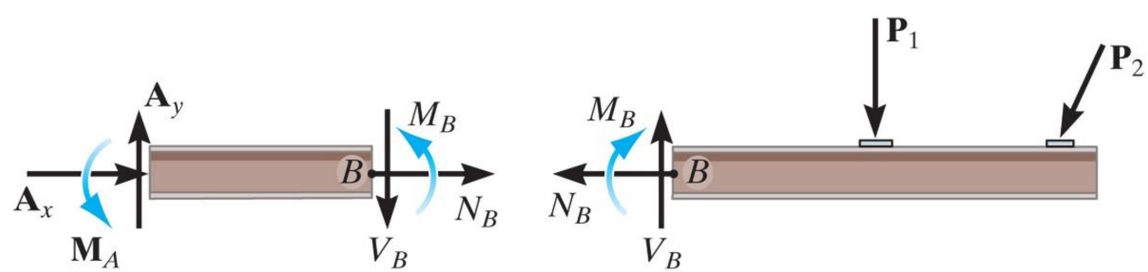
Internal loadings developed in structural members

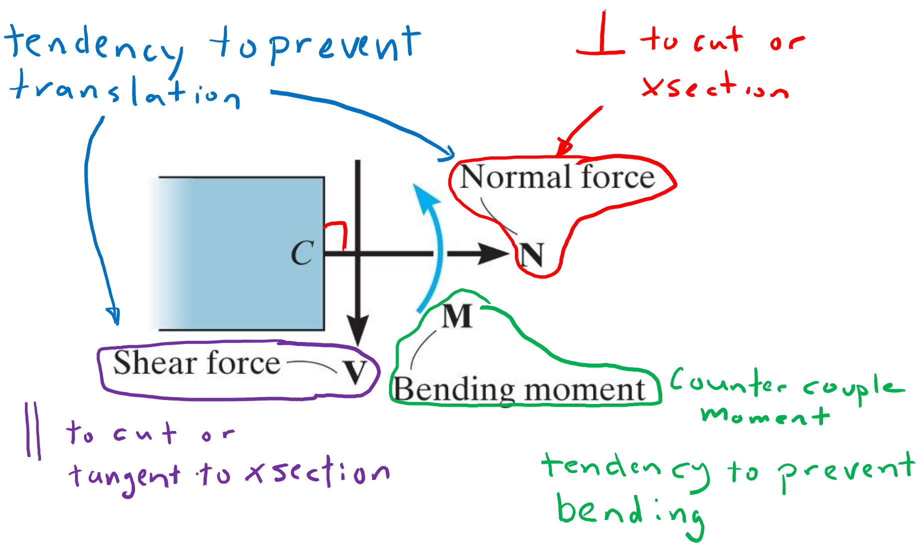
N, V, M ← key labels to learn

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

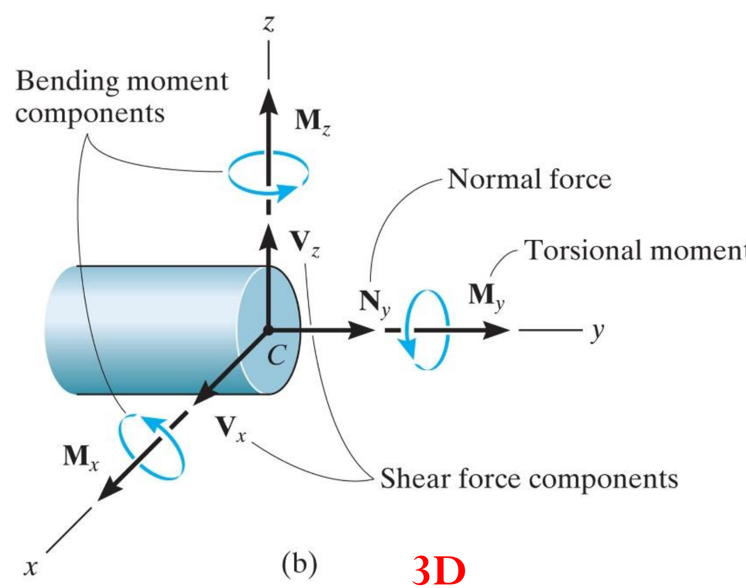
Cutting members at internal points reveal **internal forces and moments.**







2D

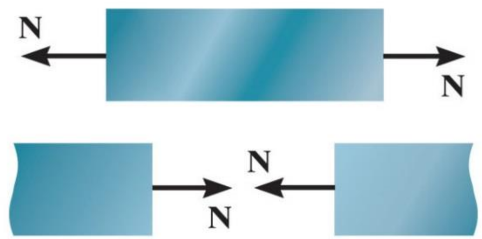


3D

Sign conventions:

Positive normal force

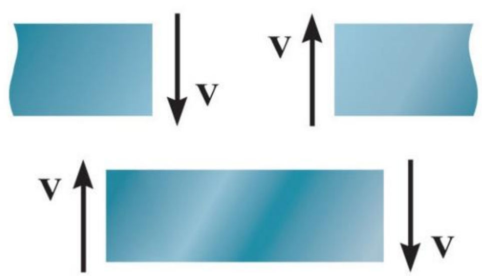
Tension



Positive normal force

Positive shear force

Clockwise rotation

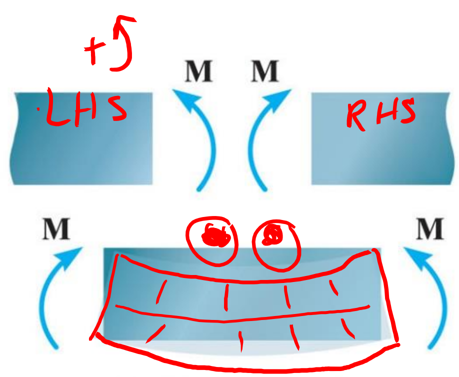


Positive shear

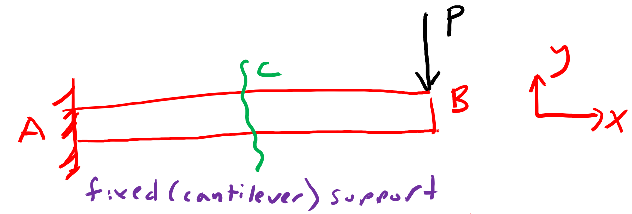
Positive moment

Concave up

"happy moment"

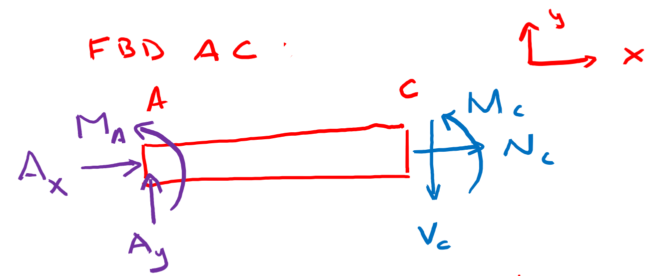


Positive moment

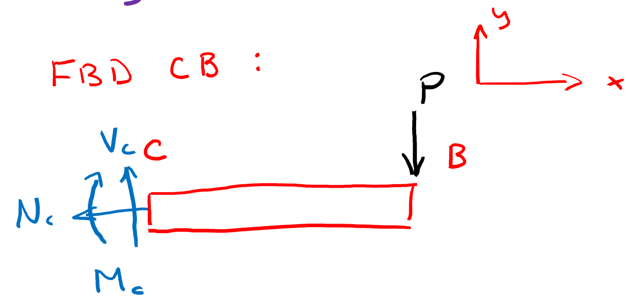


If beam AB is cut at C, draw FBDs of sections AC, CB illustrating assumptions of N, V, M drawn in positive directions.

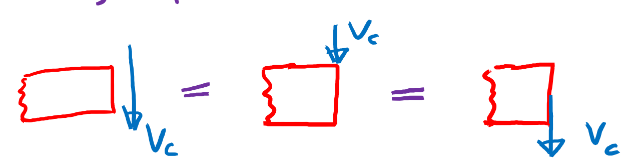
FBD AC:



FBD CB:



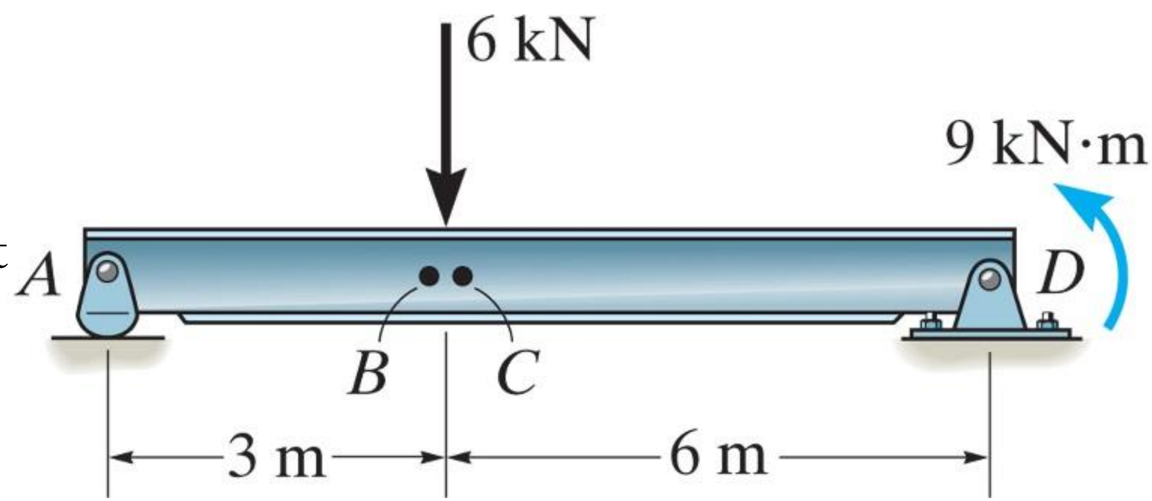
Note: although draw V off the side of the cut section, V is actually applied at the cut.



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 load P) and at C (just to the right of load P)



Procedure for analysis:

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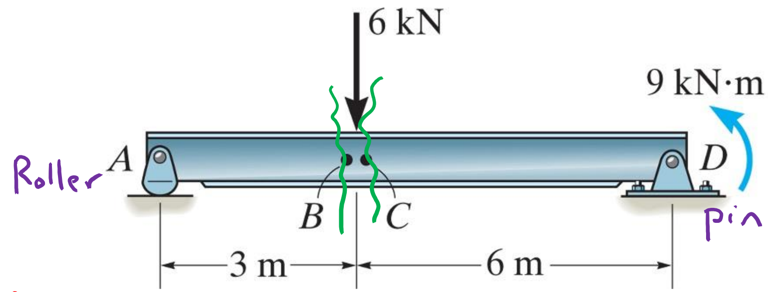
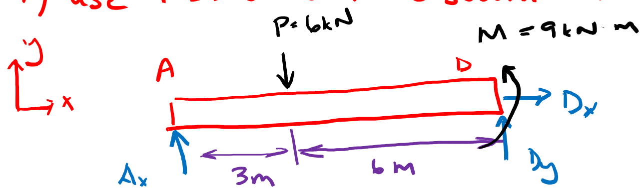
4. Apply the equations of equilibrium

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



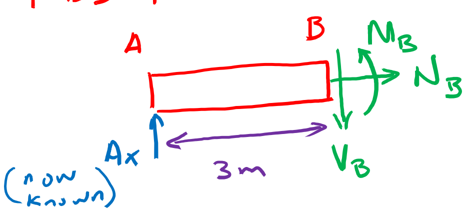
1) use FBD of entire beam AD to find unknown rxn forces



3 unknowns (A_x, D_x, D_y) → 3 eqns ΣF_x, ΣF_y, ΣM
can solve for unkn rxns

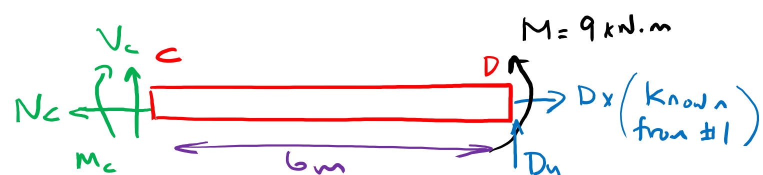
Steps 2, 3, 4:

FBD for AB

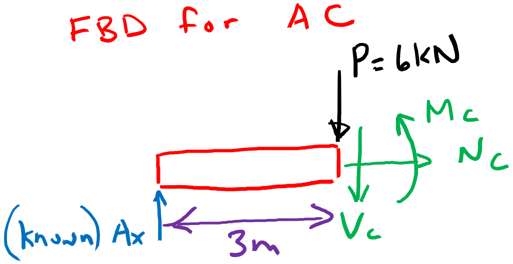


3 unknowns (N_B, V_B, M_B) → 3 eqns: ΣF_x, ΣF_y, ΣM_B
can solve for unknown internal forces

Note: Could have also used FBDs of CD or BD



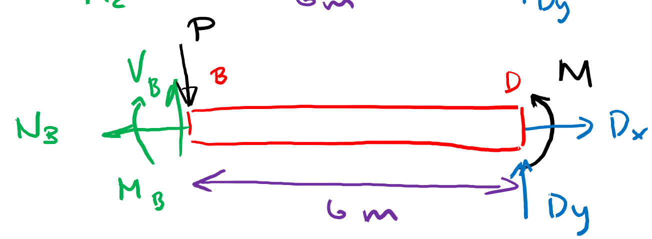
FBD for AC



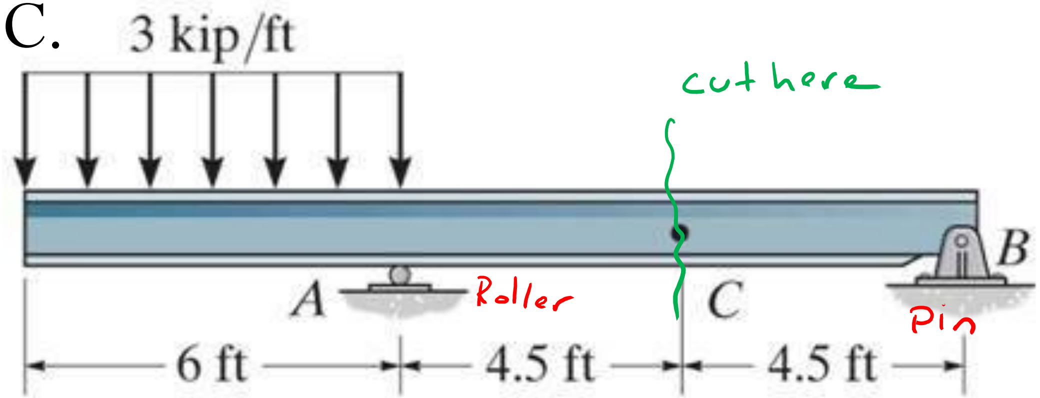
3 unknowns (N_c, V_c, M_c)

3 eqns: ΣF_x, ΣF_y, ΣM_c

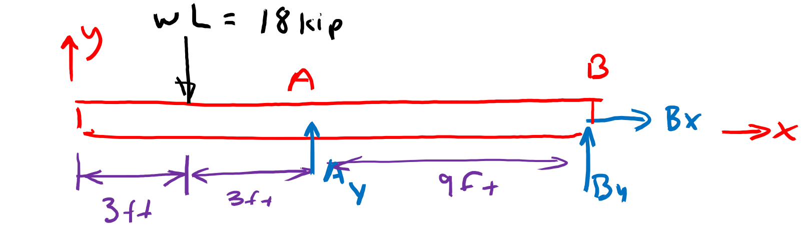
solve for unknowns



Find the internal forces at point C.



FBD of entire beam



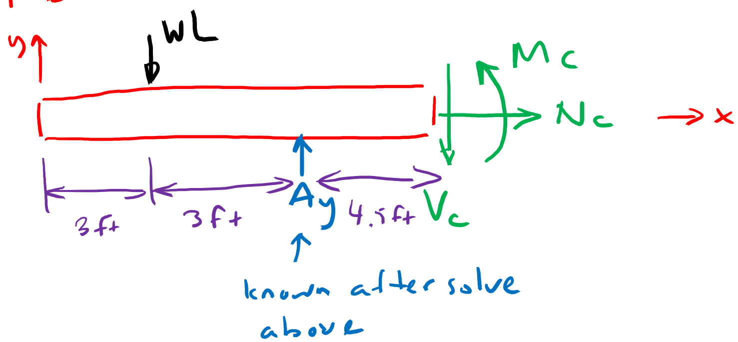
3 unknowns (A_y, B_x, B_y)

use 3 EoE to solve for A_y, B_x, B_y.

ΣF_x : $\boxed{B_x = 0}$, ΣF_y : $A_y + B_y - wL = 0$ → $\boxed{B_y = -6 \text{ kip}}$

$+\circlearrowleft \Sigma M_B$: $(12 ft)\, wL - (9 ft)\, A_y = 0$ → $\boxed{A_y = 24 \text{ kip}}$

FBD of left section:



3 unknowns (N_c, V_c, M_c), assuming know A_y

use EoE:

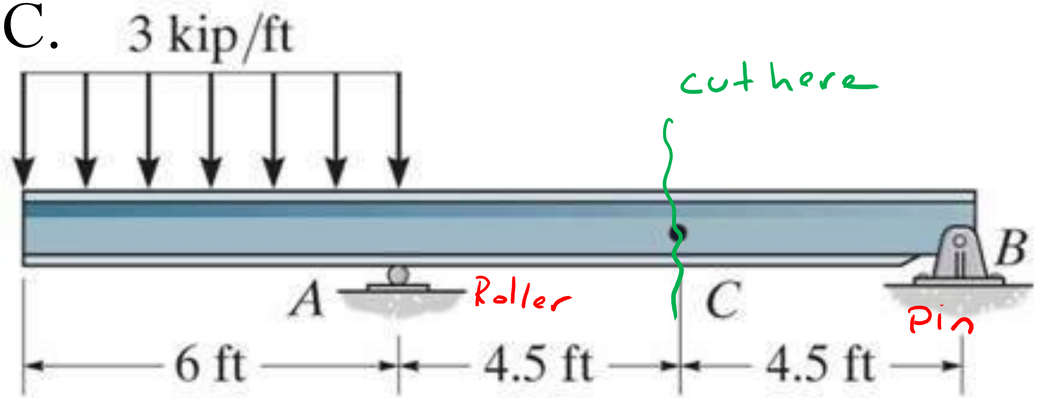
ΣF_x : $\boxed{N_c = 0}$

ΣF_y : $A_y - wL - V_c = 0$ ⇒ $\boxed{V_c = 6 \text{ kip}}$

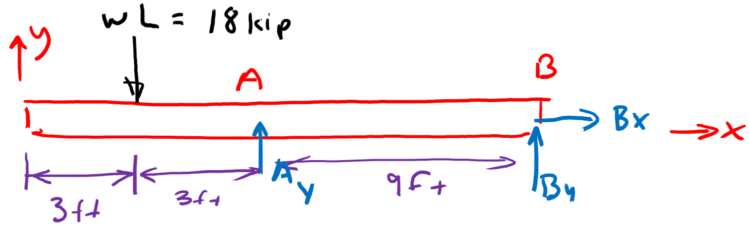
$+\circlearrowleft \Sigma M_c$: $M_c - (4.5 ft)\, A_y + (7.5 ft)\, wL = 0$

⇒ $\boxed{M_c = -27 \text{ kip} \cdot ft}$

Find the internal forces at point C.



FBD of entire beam

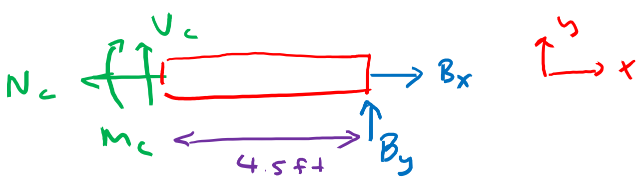


3 unknowns (A_y, B_x, B_y)

use 3 EoE to solve for A_y, B_x, B_y. $A_y = 24$ kip $B_x = 0$ $B_y = -6$ kip

Alternatively, could examine right section:

FBD of right section



3 unknowns (N_c, V_c, M_c) assuming know B_x, B_y

use EoE:

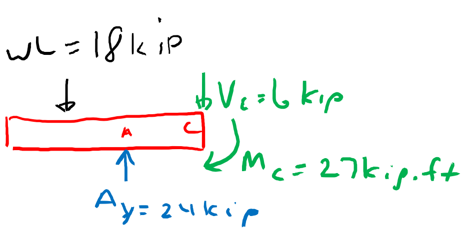
ΣF_x: $B_x - N_c = 0 \Rightarrow N_c = 0$

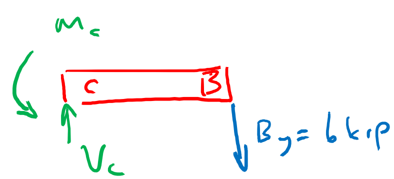
ΣF_y: $B_y + V_c = 0 \rightarrow V_c = 6$ kip

$+\circlearrowleft \Sigma M_c$: $-M_c + (4.5\,ft) B_y = 0$

$\rightarrow M_c = -27$ kip·ft

∴ Actual Forces & Moments:





Note changes in directions of arrows for B_y & M_c from original FBDs due to negative values in solutions.