Statics - TAM 210 & TAM 211

Lecture 21

March 5, 2018

Chap 7.2

Announcements

- Upcoming deadlines:

- Monday (3/5)
  - Mastering Engineering Tutorial 8
- Tuesday (3/6)
  - PL HW 6
- Quiz 4 (3/7-9)
  - Sign up at CBTF
  - Up thru and including Lecture 19 (Frames & Machines). Note that quiz and lecture material always builds on earlier fundamental concepts.
- No class Friday March 9, enjoy EOH!

Chapter 7: Internal Forces

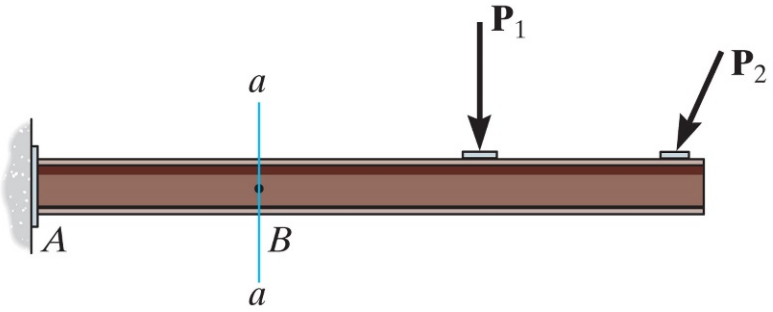
Goals and Objectives

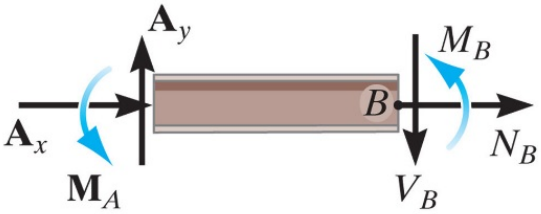
- Determine the internal loadings in members using the method of sections
- Generalize this procedure and formulate equations that describe the internal shear and bending moment throughout a member
- Be able to construct or identify shear and bending moment diagrams for beams when distributed loads, concentrated forces, and/or concentrated couple moments are applied

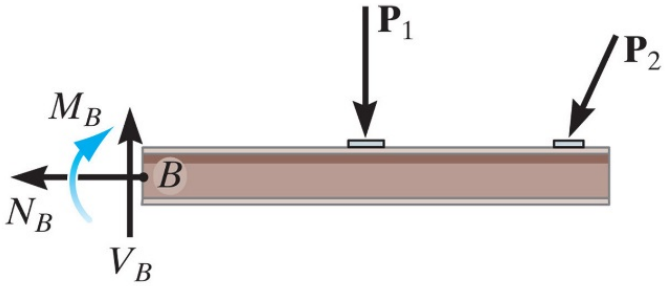
Recap: Internal loadings in structural members

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

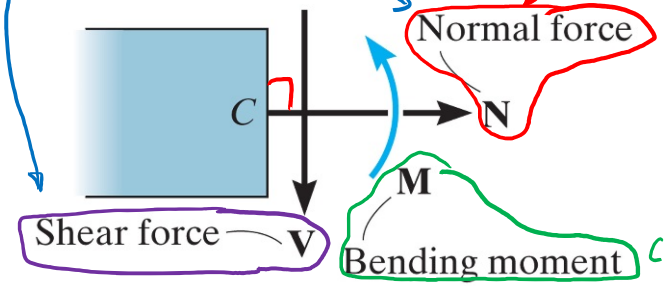






tendency to prevent translation

⊥ to cut or xsection



Counter couple moment

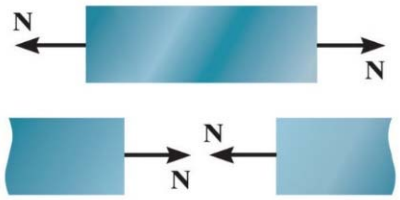
|| to cut or tangent to xsection

tendency to prevent bending

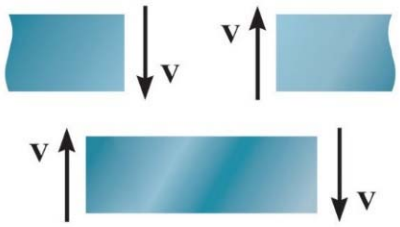
2D

N, V, M ← key labels to learn

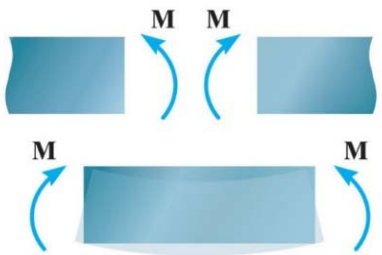
Recap: Sign conventions:



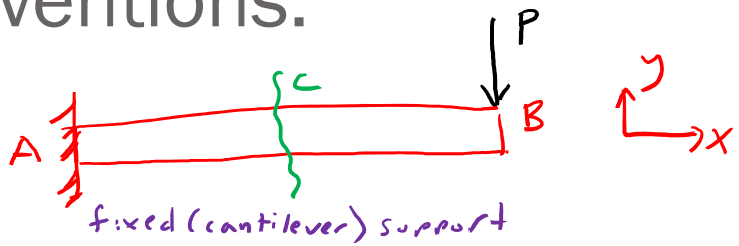
Positive normal force



Positive shear

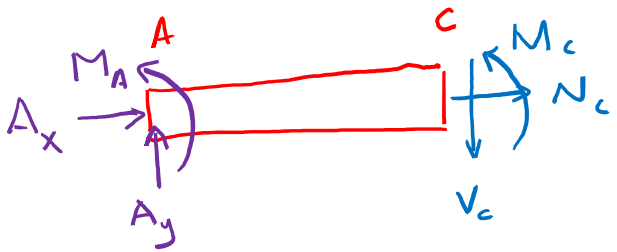


Positive moment

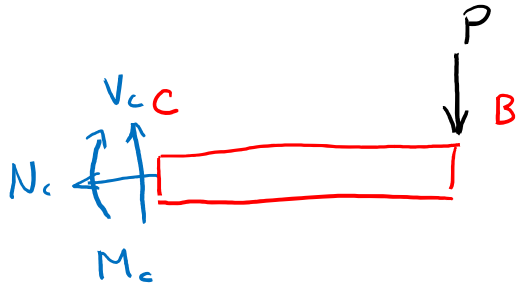


If beam AB is cut at C, draw FBDs of sections AC, CB illustrating assumptions of N, V, M drawn in positive directions.

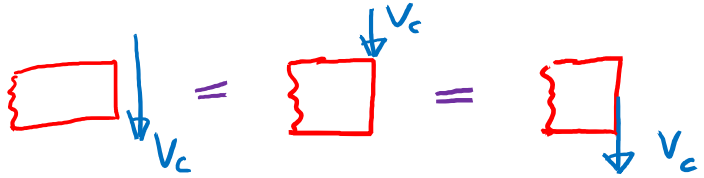
FBD AC:



FBD CB:



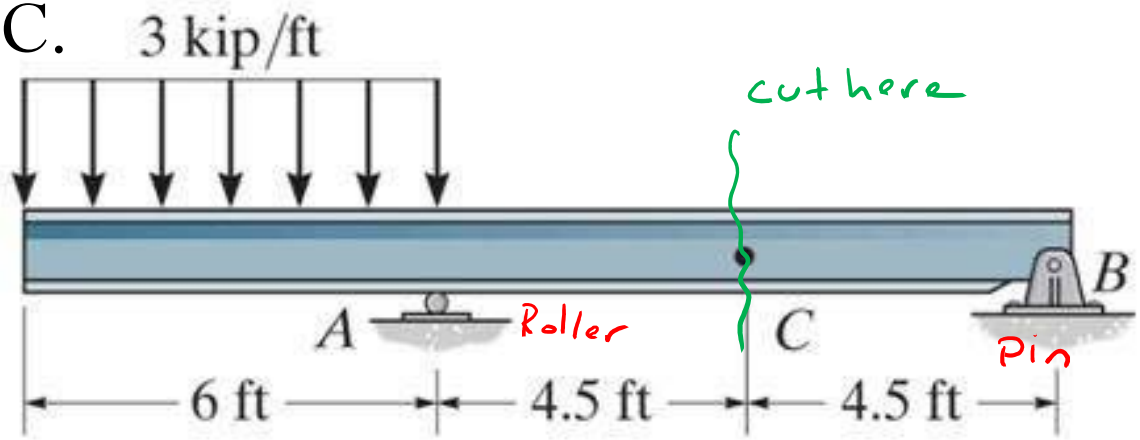
Note: although draw V off the side of the cut section, V is actually applied at the cut.



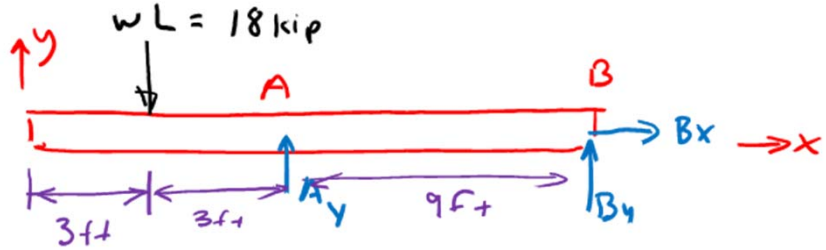
Procedure for analysis:

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 at point C.



FBD of entire beam

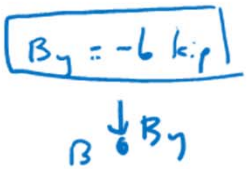


3 unknowns (A_y, B_x, B_y)

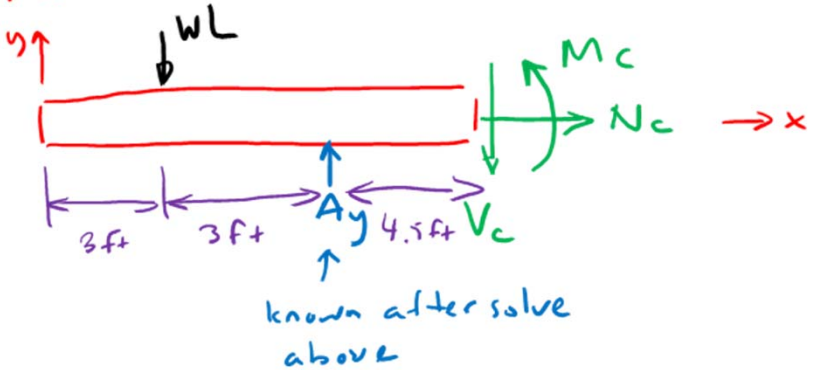
use 3 EoE to solve for A_y, B_x, B_y.

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

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



FBD of left section:



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

use EoE:

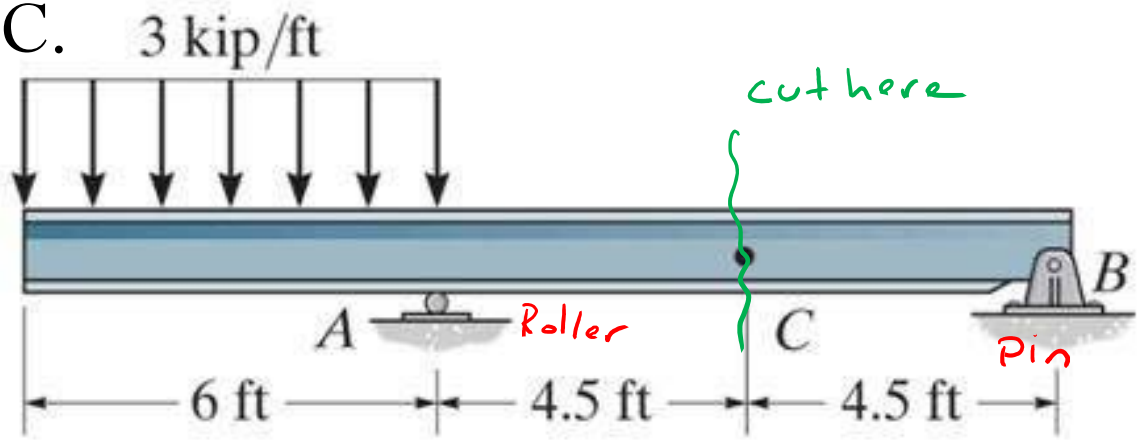
ΣF_x : $\boxed{N_c = 0}$

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

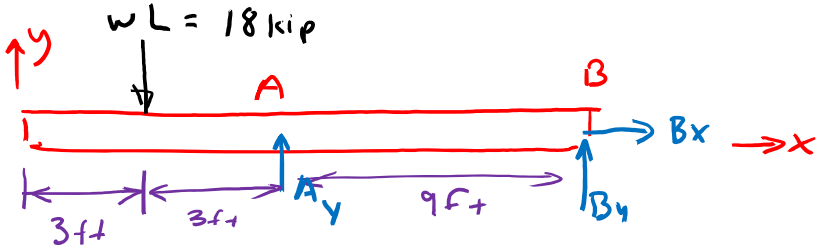
$+\circlearrowleft \Sigma M_c$: $M_c - (4.5\text{ft})\,A_y + (7.5\text{ft})\,wL = 0$

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

Find the internal forces at point C.



FBD of entire beam

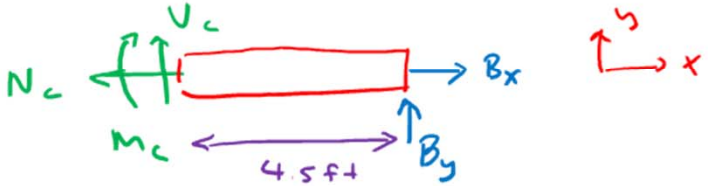


3 unknowns (A_y, B_x, B_y)

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 known B_x, B_y

use E o E:

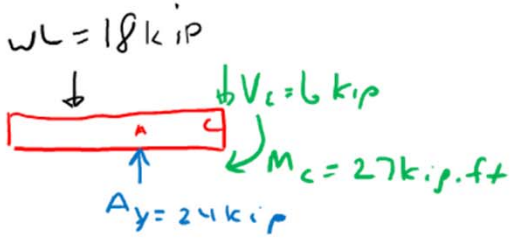
ΣF_x : $B_x - N_c = 0 \Rightarrow N_c = 0$

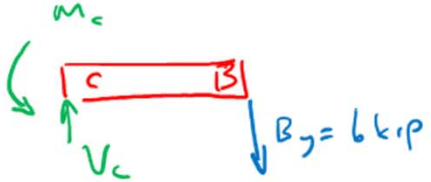
ΣF_y : $B_y + V_c = 0 \rightarrow V_c = 6$ kip

$+\circlearrowleft \Sigma M_c$: $-M_c + (4.5\text{ft})B_y = 0$

$\rightarrow M_c = -27$ kip.ft

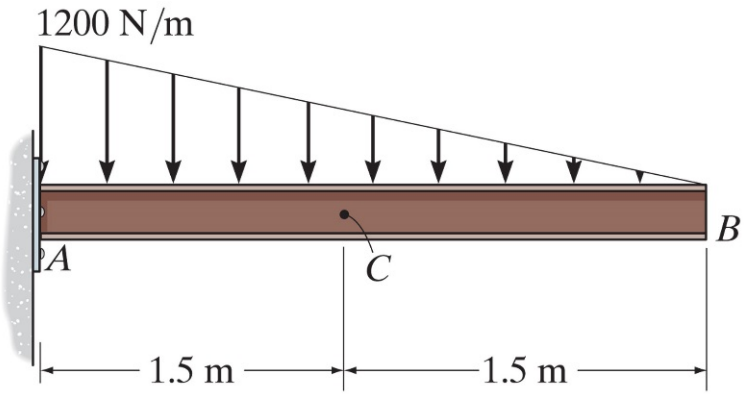
∴ Actual Forces & Moments:





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

Find the internal forces and moments at C

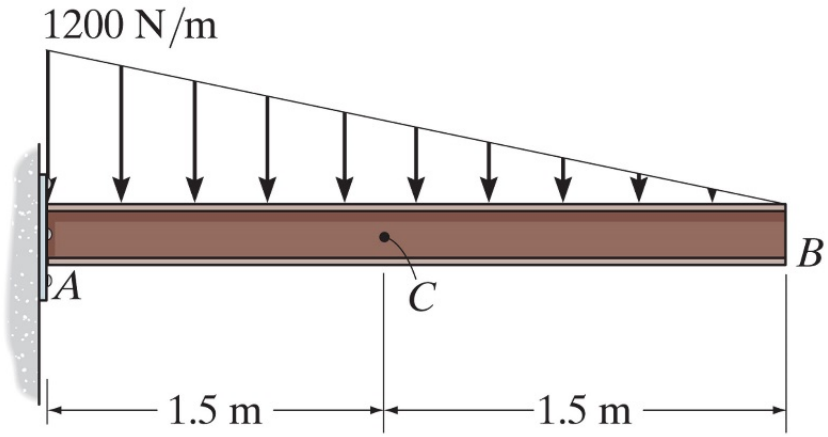


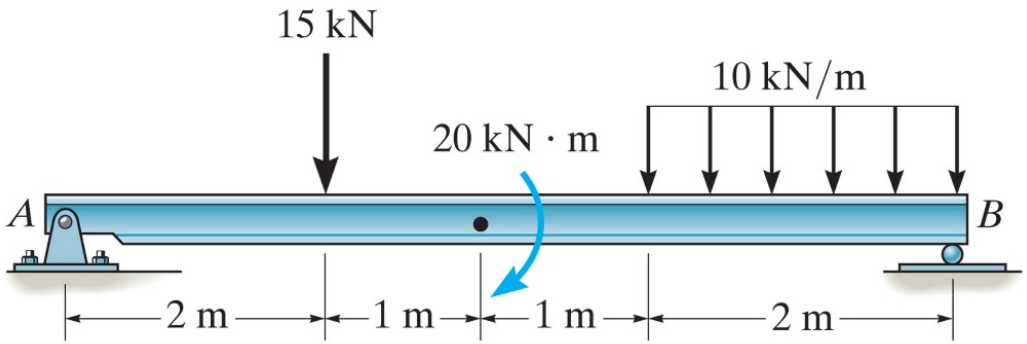
Shear and Bending Moment Diagram

Goal: provide detailed knowledge of the variations of internal shear force and bending moments (V and M) throughout a beam when perpendicular distributed loads, concentrated forces, and/or concentrated couple moments are applied.

Procedure

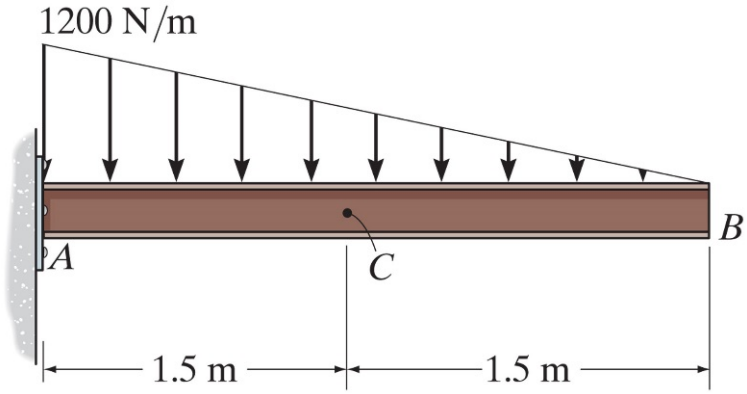
1. Find support reactions (free-body diagram of entire structure)
2. Specify coordinate x (start from left)
3. Divide the beam into sections according to loadings
4. Draw FBD of a section
5. Apply equations of equilibrium to derive V and M as functions of x: V(x), M(x)





Shear and Bending Moment Diagram

Draw the shear and bending moment diagrams for the beam.



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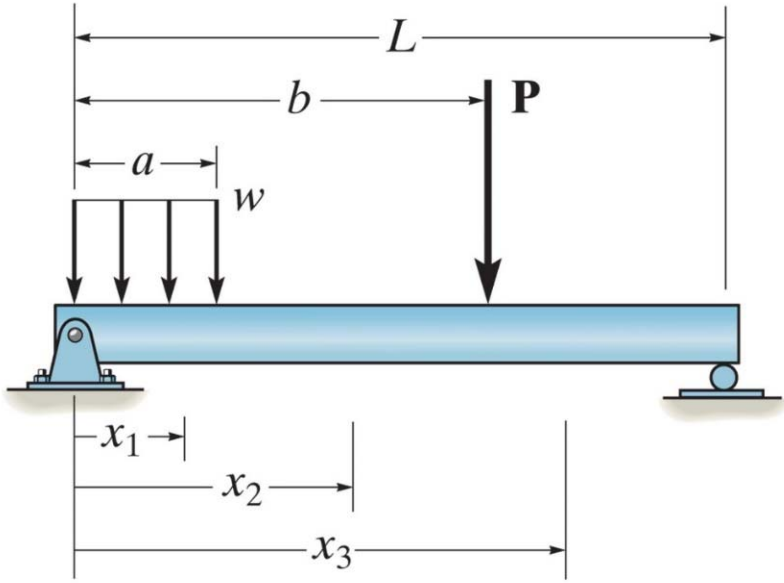

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