# Statics - TAM 211

**Lecture 21**

**November 12, 2018**

**Chap 7.2**

# Announcements

- Upcoming deadlines:

- Tuesday (11/12)
  - Prairie Learn HW 8
- Friday (11/16)
  - Written Assignment 8
- Quiz 4
  - Wednesday Nov 14
  - 9:00am-9:50am (class time)
  - Try to arrive early to log in to computer
  - Instructional Lab Building: D211 (ME), D331 (CEE)
  - 3D rigid body (Chap 4)
  - Structural Analysis (Chap 5)

# Chapter 7: Internal Forces

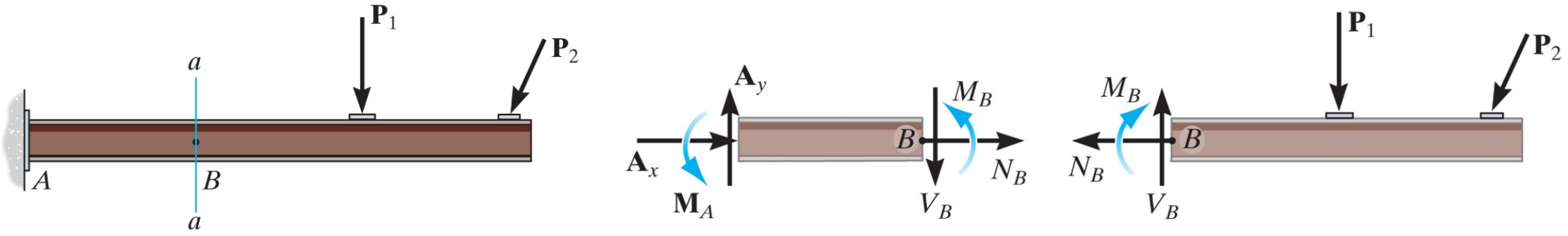
# Goals and Objectives

- 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

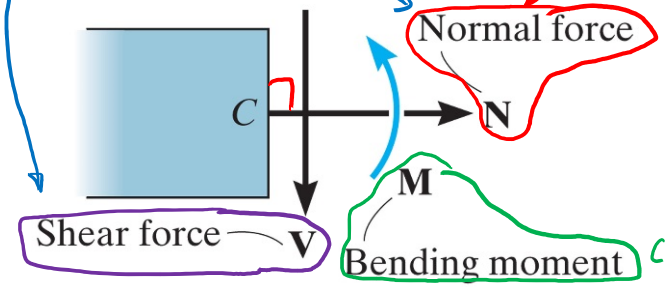
Structural Design: need to know the loading acting within the member in order to be sure the material can resist this loading

**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

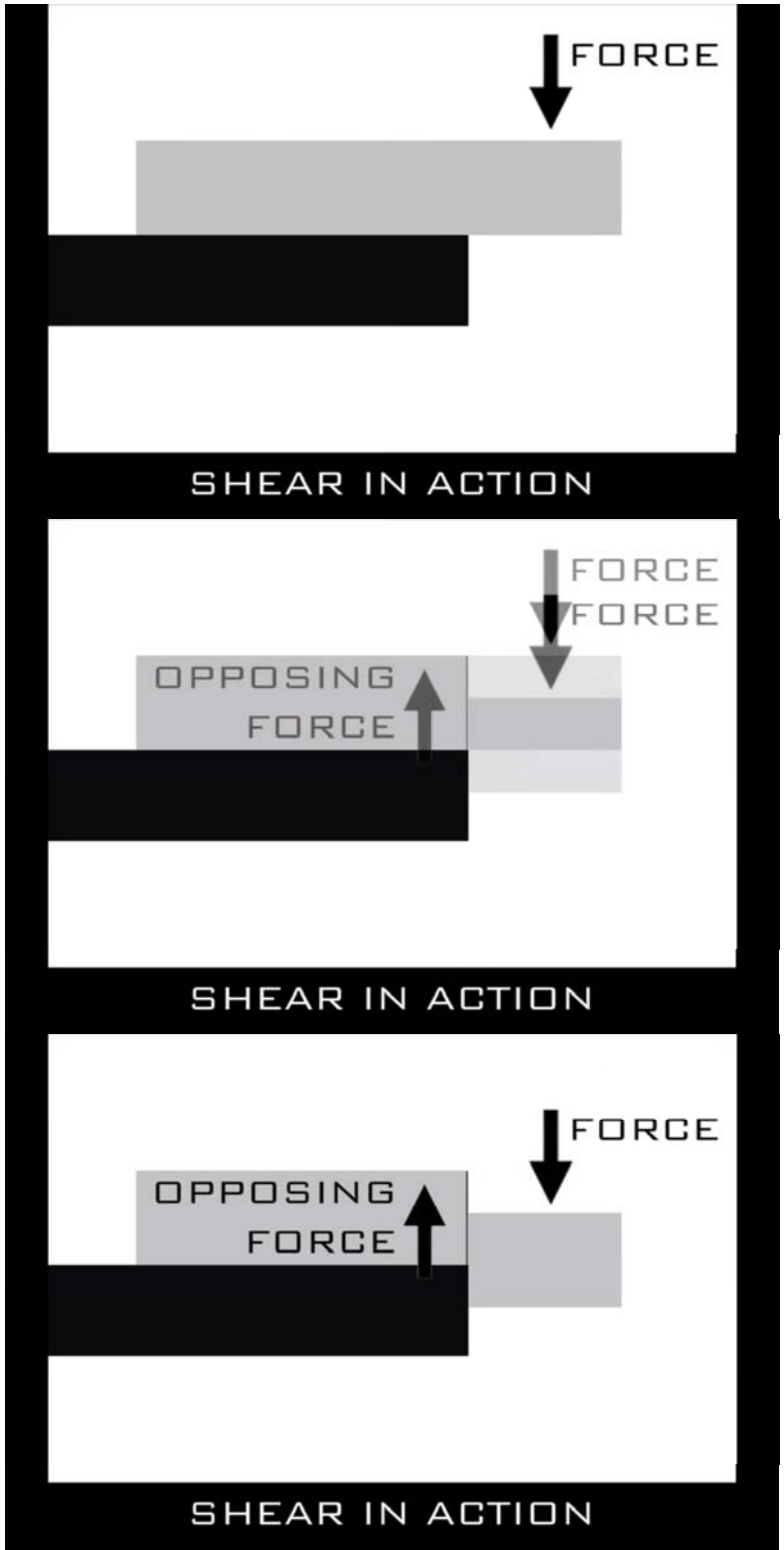
tendency to prevent bending

∥ to cut or tangent to xsection

N, V, M ← key labels to learn

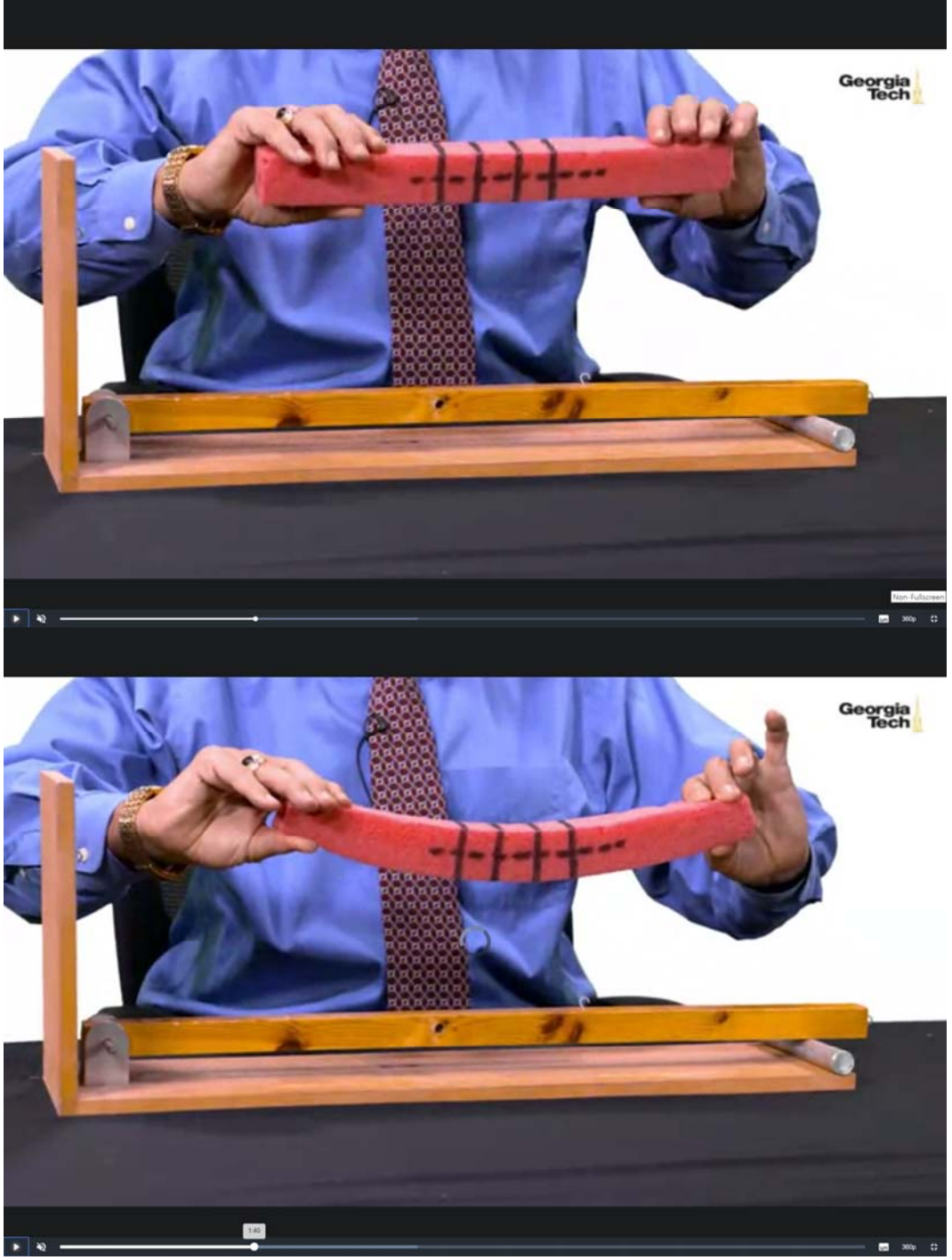
2D

Positive Shear Force



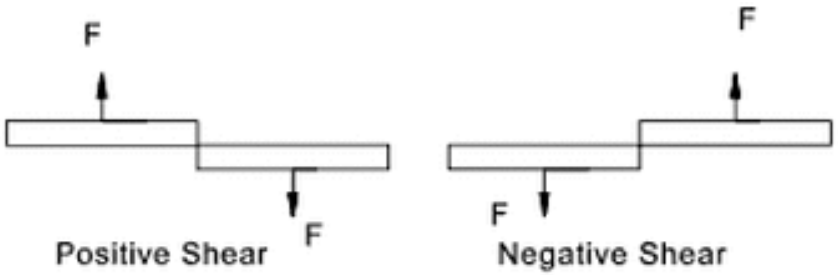

https://youtu.be/-Jbdofrbt6Y

Positive Bending Moment

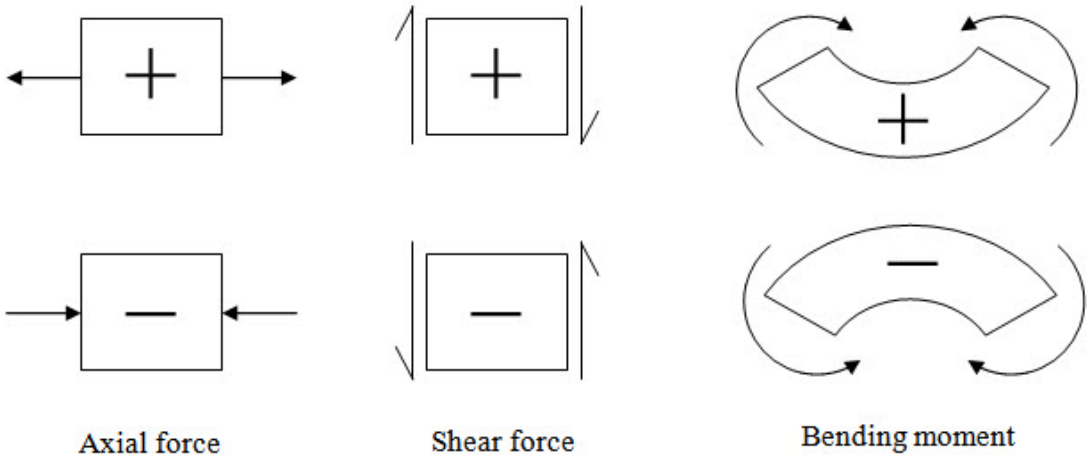



https://fr.coursera.org/lecture/beam-bending/module-2-real-world-beam-bending-examples-c9r68

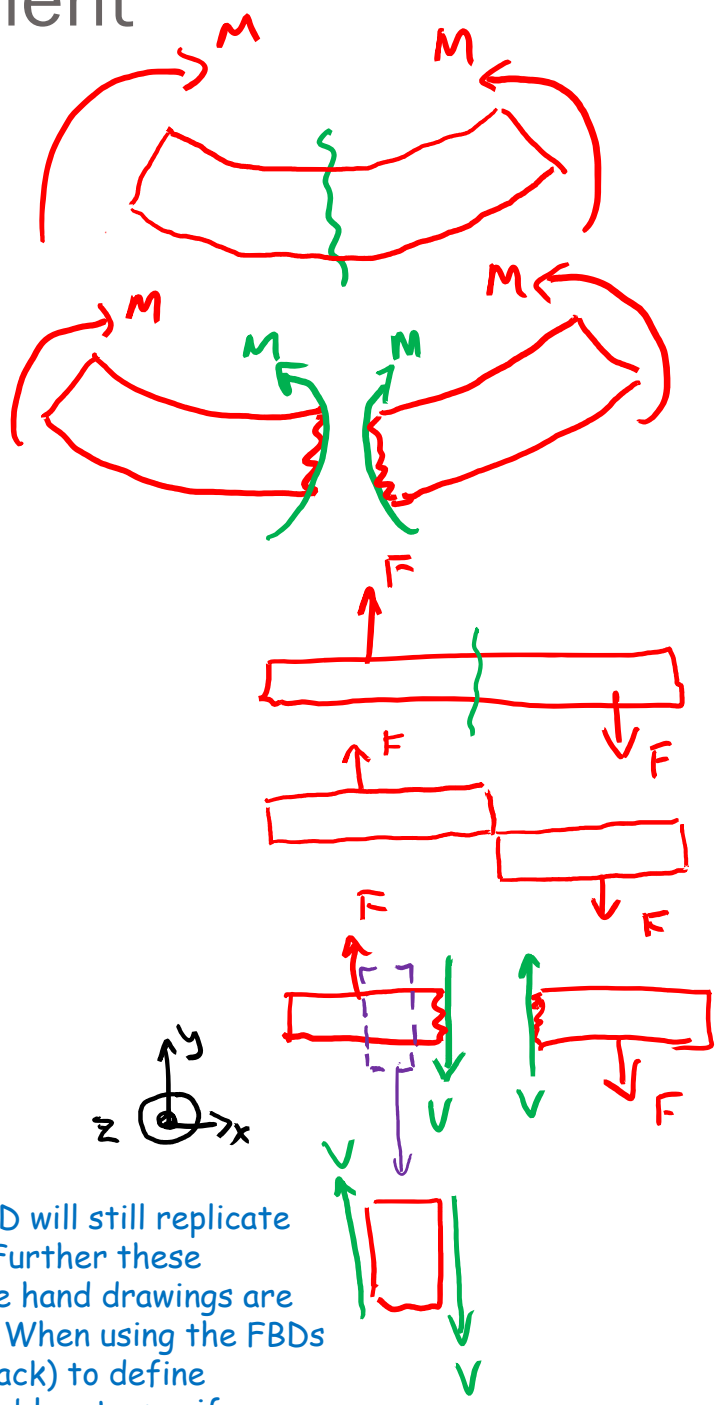
# Recap: Shear Force and Bending Moment




http://structureanalysis.weebly.com/bending-moment--shear-force.html

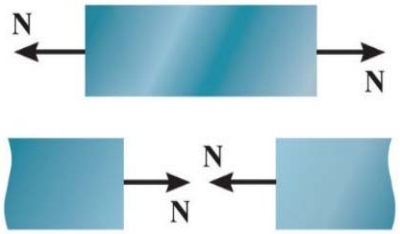



https://ecoursesonline.icar.gov.in/mod/page/view.php?id=125191



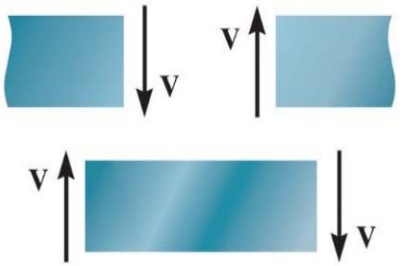

Notes about hand-drawn material: even when cutting a beam (green), the new smaller FBD will still replicate the bending moments or shear forces on the cut surfaces on the left or right segment. Further these replicated moments/forces should be drawn to be equal and in opposite directions. These hand drawings are for when the bending moments and shear forces are drawn to be in the "positive" sense. When using the FBDs to write out the eqns of equilibrium, use the axes of your coordinate system diagram (black) to define whether the vectors are pointing in a positive or negative direction – see any example problem to see if a particular force or moment is + or – in the eqn.

# Recap: Sign conventions:



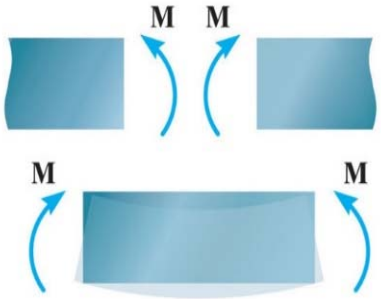

Positive normal force

**Tension**



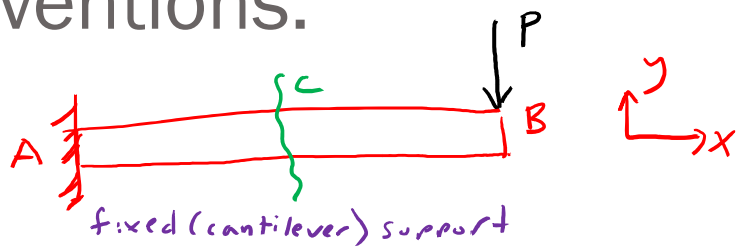

Positive shear

**Clockwise rotation**



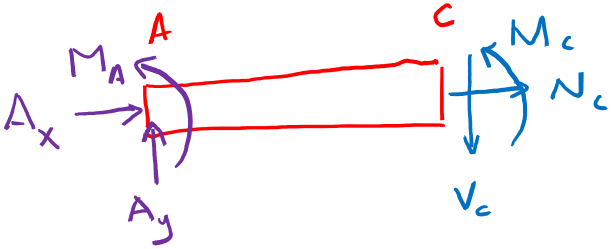

Positive moment

**Concave up**

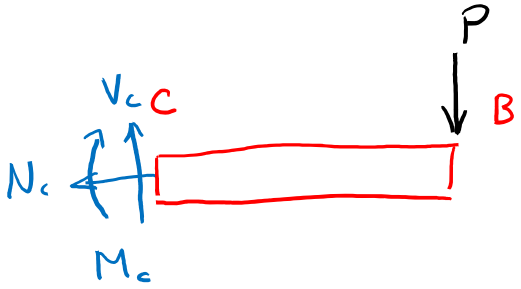



If beam AB is cut at C, draw FBDs of sections AC, CB illustrating assumptions of N, V, M drawn in positive directions.

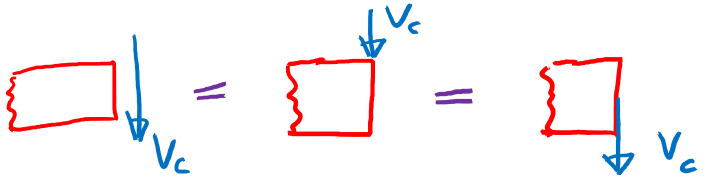
FBD AC:


FBD CB:

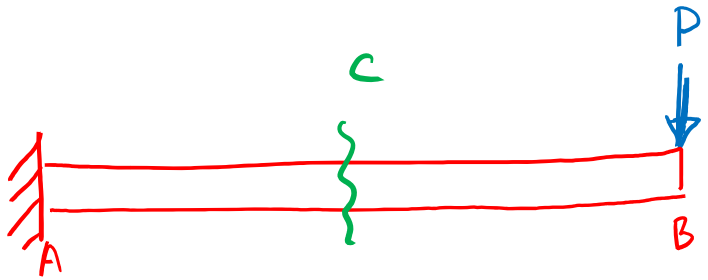



Note: although draw V off the side of the cut section, V is actually applied at the cut.



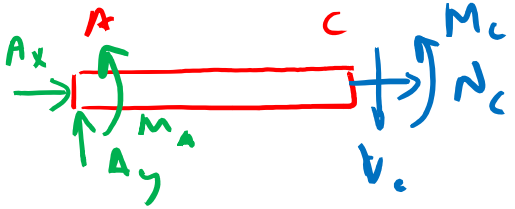
# Recap: What sign to give N, V and M terms in equations of equilbrium?

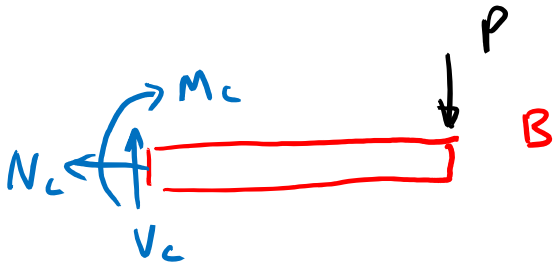
Follow the positive orientations of the coordinate system.

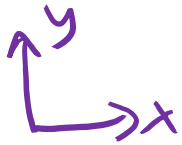




FBD




$+\rightarrow \Sigma F_x : A_x + N_c = 0$

$+\uparrow \Sigma F_y : A_y - V_c = 0$

$+\circlearrowleft \Sigma M_A : M_A + M_c - r_{Ac} V_c = 0$

$+\rightarrow \Sigma F_x : -N_c = 0$

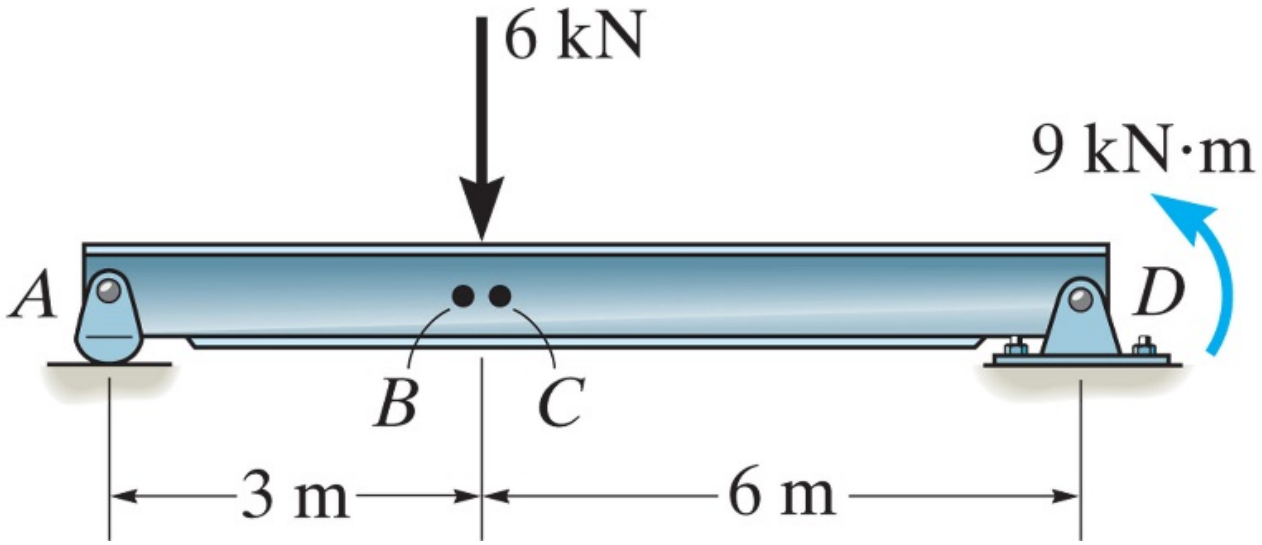
$+\uparrow \Sigma F_y : V_c - P = 0$

$+\circlearrowleft \Sigma M_B : -M_c - r_{cB} V_c = 0$

# 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)



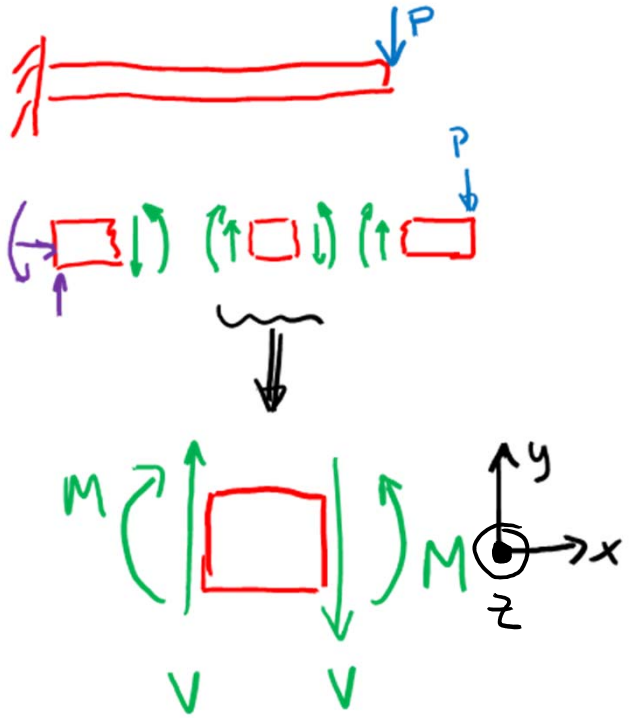
# How to orient positive V and M on a FBD?

"Positive" sign convention:

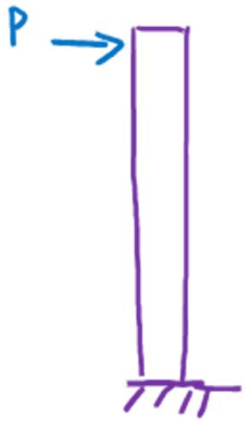
"Positive shear will create a clockwise rotation" ⟹ Draw V arrows to create CW rotation

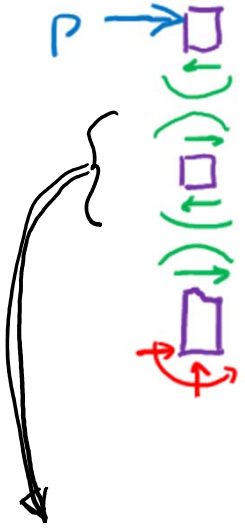
"Positive bending moment will create bend that is concave upward"

Horizontal Beam

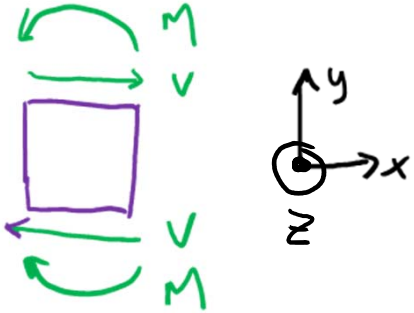



Vertical Beam

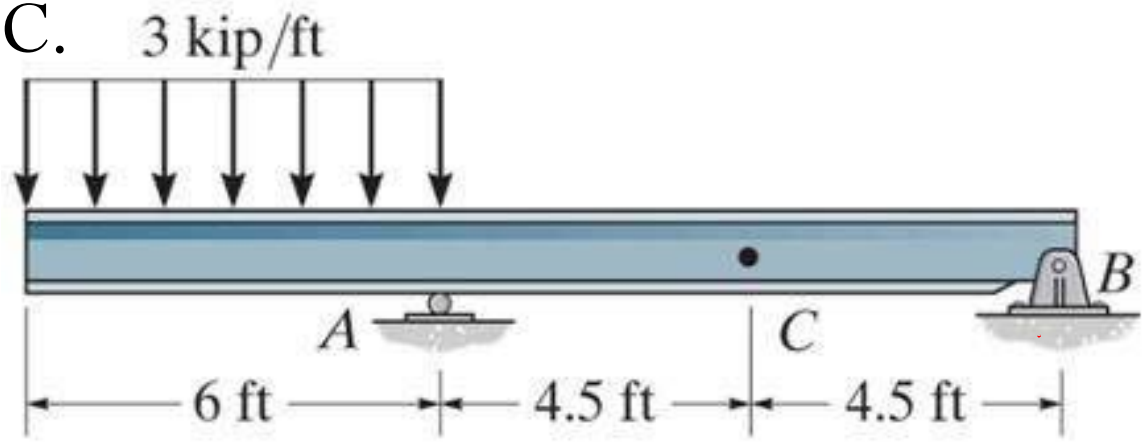


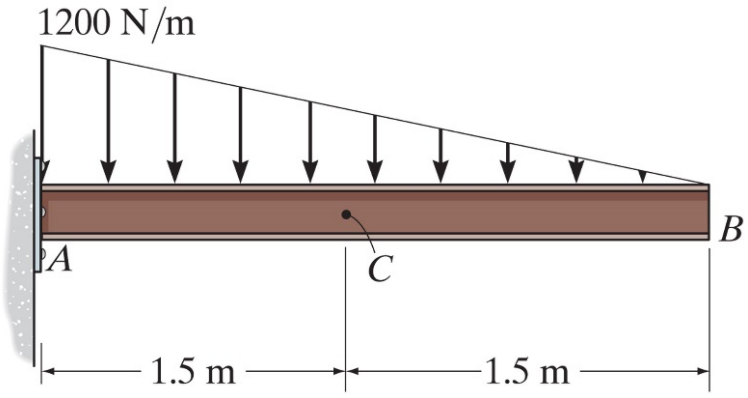

Which direction of the arrow for M?



Find the internal forces at point C.



Find the internal forces and moments at C



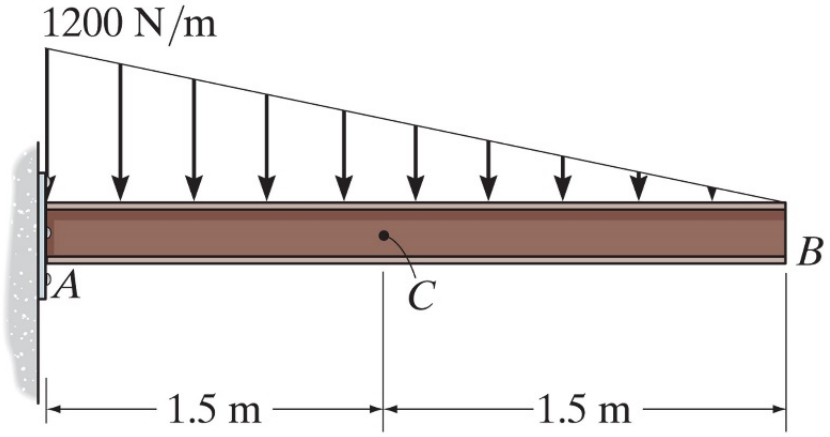
# Shear Force and Bending Moment Diagrams

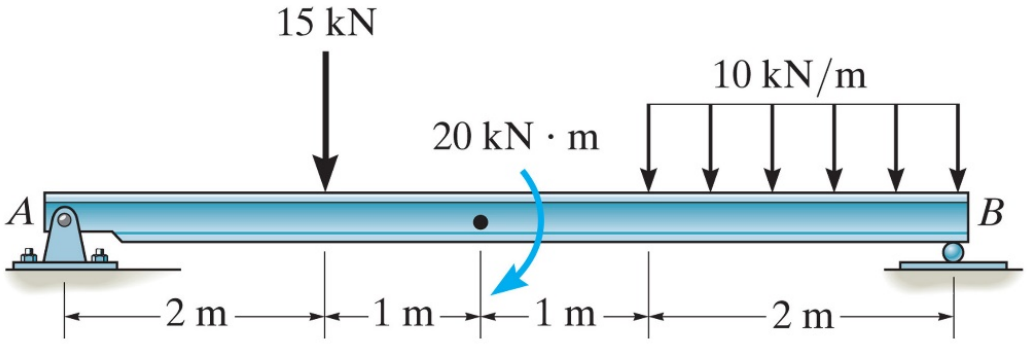
Goal: provide detailed knowledge of the variations of internal shear force and bending moments (V and M) throughout a beam when perpendicular distributed loads, concentrated forces, and/or concentrated couple moments are applied.

Normal forces (N) in such beams are zero, so we will not consider normal force diagrams.

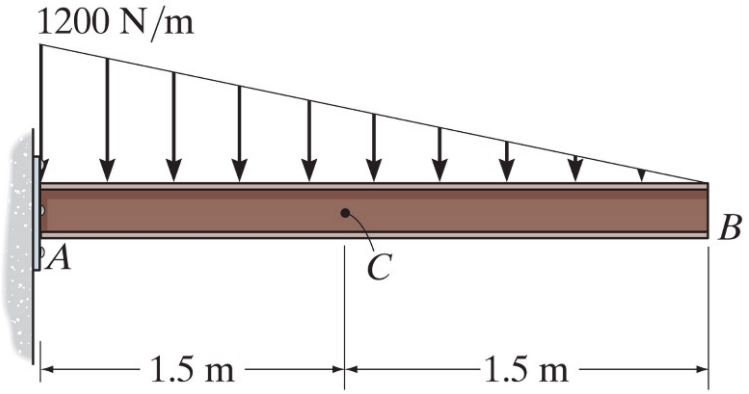
Procedure

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($x$)

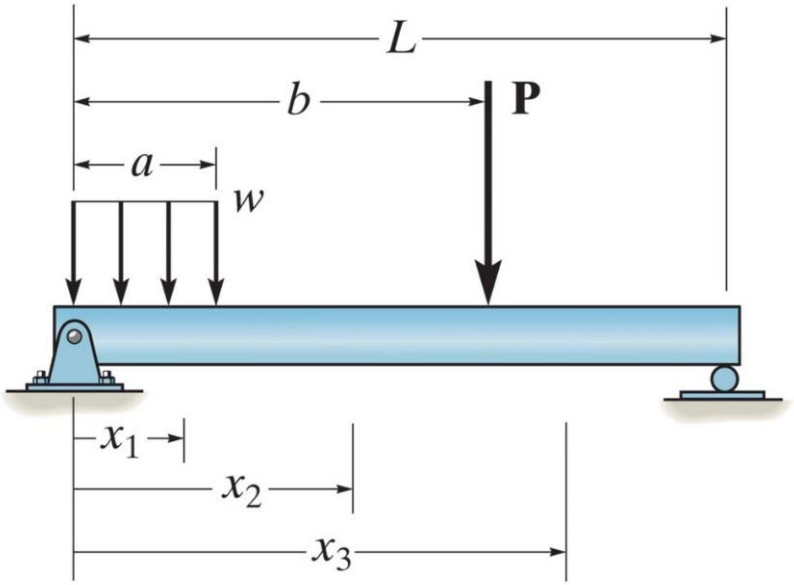


Draw the shear and bending moment diagrams for the beam.



Draw the shear and bending moment diagrams for the beam.



Draw the shear and bending moment diagrams for the beam.