# Lecture 21

Wednesday, October 18, 2017 11:54

## To do …

- Quiz 4 this week!
- Quiz 3 pick up at Grainger OH
  - Wed 4-9 pm
  - Thurs 4-9 pm
- HW 14 PL due **Wed (today)**
- HW 15 ME due **Thurs**

The careful text-books measure
  (let all who build beware!)
The load, the shock, the pressure
  Material can bear.
So when the buckled girder
  Lets down the grinding span,
The blame of loss, or murder,
  Is laid upon the man.
Not on the stuff – the Man!

Rudyard Kipling (1865-1936)
"Hymn of Breaking Strain"

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# 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

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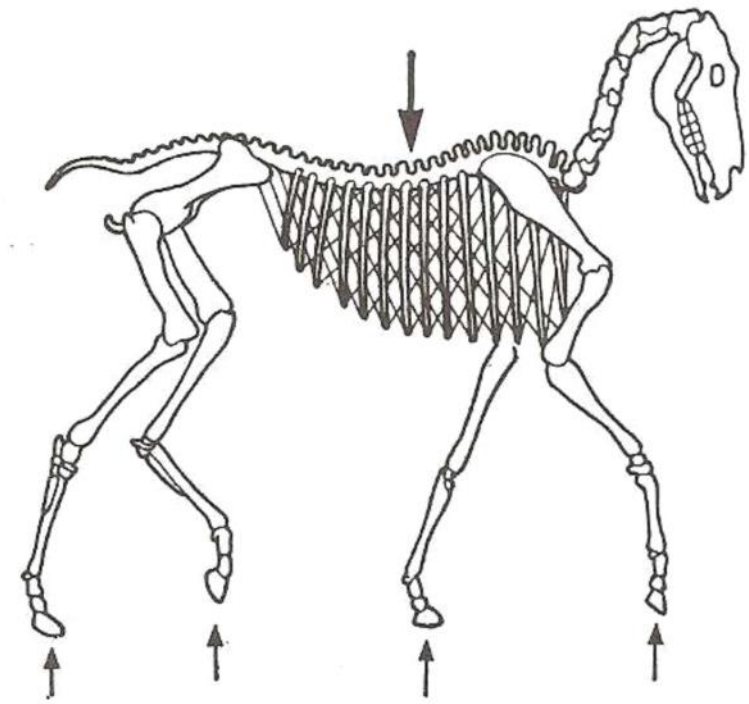
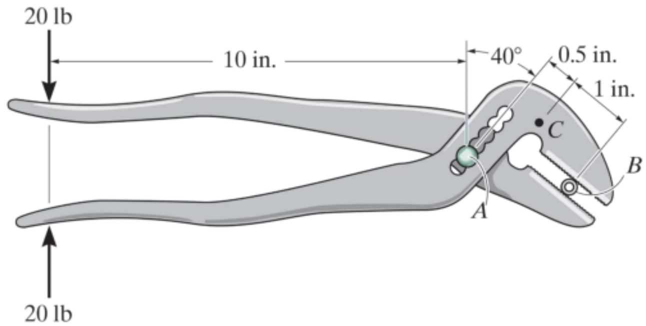


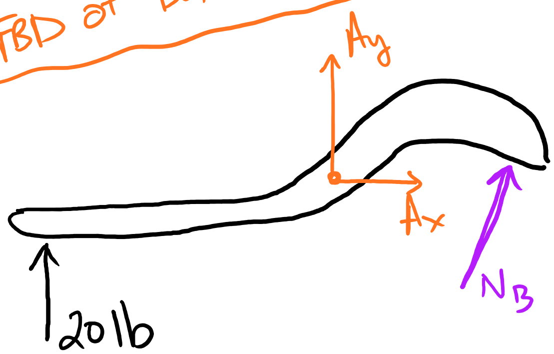
# Chapter 7: Internal Forces

## Main goals and learning objectives




If a force of 20 lb is applied to the handles, determine the internal shear force and moment at point C.

FBD of bottom member

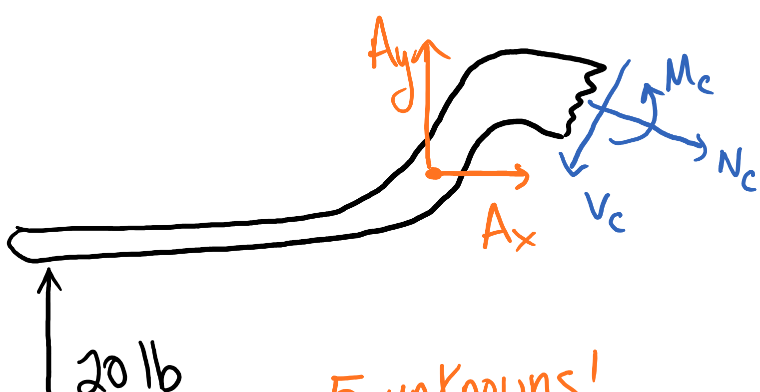



3 unknowns!

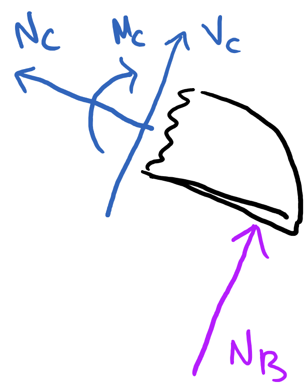
$\Sigma M_A = 0$

$(-20)(10) + N_B(1.5) = 0$

$$N_B = 133.3 \text{ lb}$$




5 unknowns!




3 unknowns!

use this segment.

$$\sum F_x = 0$$

$$-N_c = 0$$

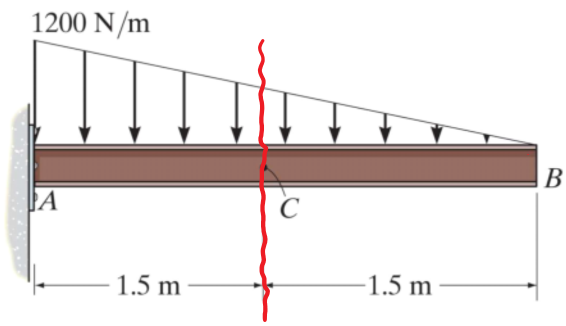
$$\sum F_y = 0$$

$$V_c + N_B = 0 \quad \therefore \quad \boxed{V_c = -N_B = -133.3 \text{ lb}}$$

$$\sum M_c = 0$$

$$-M_c + (133.3)(1) = 0 \quad \therefore$$

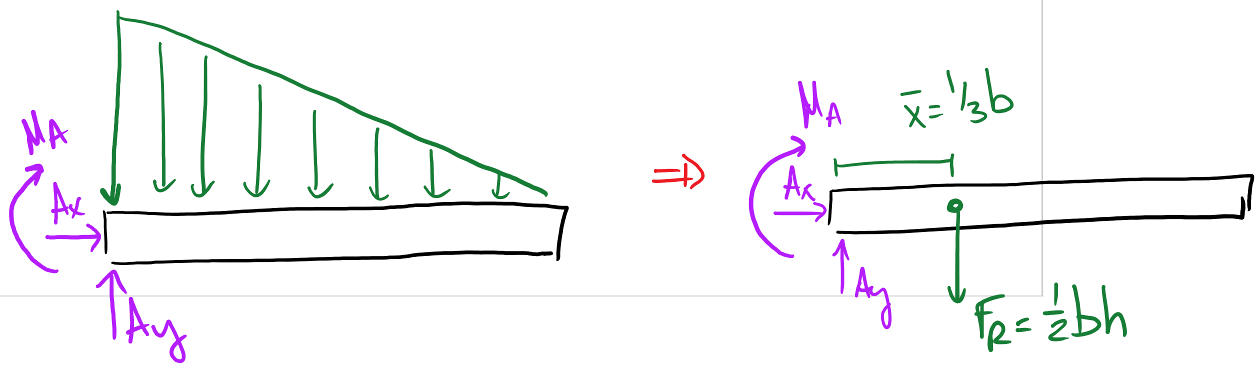
$$\boxed{M_c = 133.3 \text{ lb} \cdot \text{in}}$$



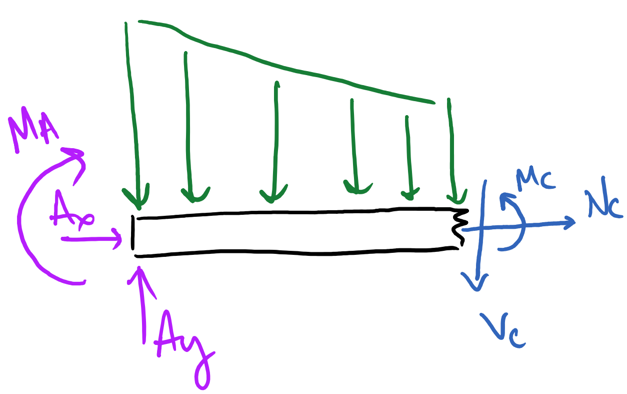

Determine the normal force, shear force, and bending moment at *C* of the beam.

1. DRAW FBD of beam
2. TAKE section

## FBD of beam:

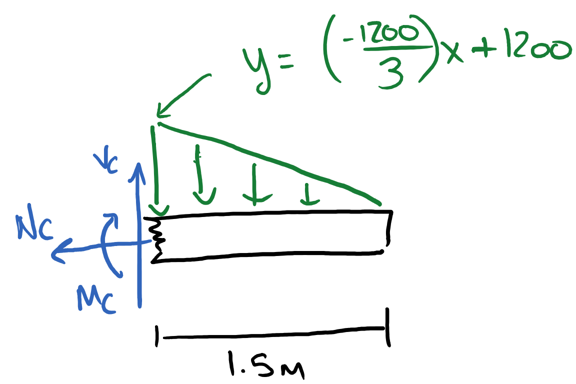



## FBD of left Section

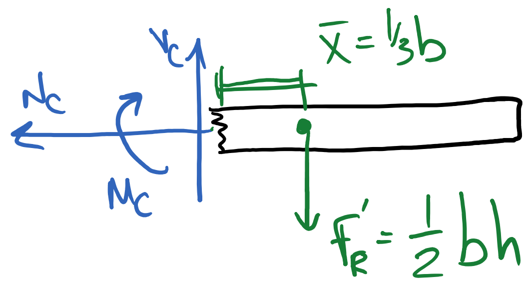



6 unknowns!

## FBD of right section




3 unknowns! use this section and reduce dist. load.




## Eqns. of Equilibrium:

$\Sigma F_x: \quad -N_c = 0$

$\Sigma F_y: \quad V_c - F_R' = 0$

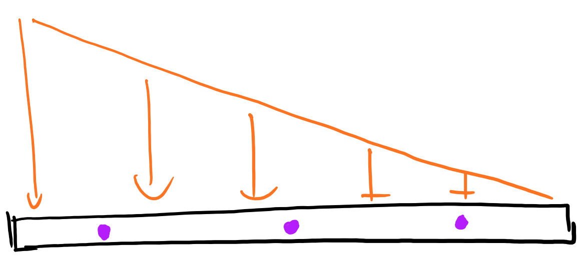
$$\underline{V_c} = \frac{1}{2}bh$$

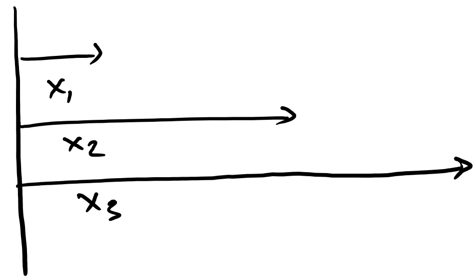
$\Sigma M_c: \quad -M_c - \bar{x}F_R' = 0$

$$M_c = -\left(\frac{1}{3}b\right)\left(\frac{1}{2}bh\right)$$

$$\underline{M_c} = -\frac{1}{6}b^2h$$

**Q: How do these forces vary along the beam?**





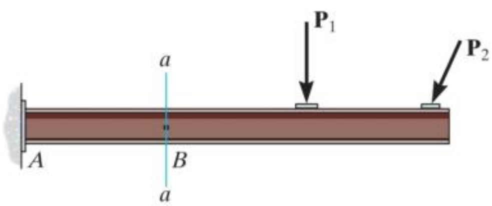

$N_1 = 0$ $\quad N_2 = 0$ $\quad N_3 = 0$

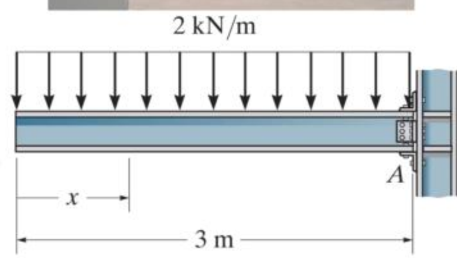
$V_1 > V_2 > V_3$

$M_1 > M_2 > M_3$

Q: which is greatest?

# Internal loadings developed in structural members




Concentrated loads

Continuous loads

Q: How do internal forces vary along the beam?

↳ provide graphical description of V and M as a function of x

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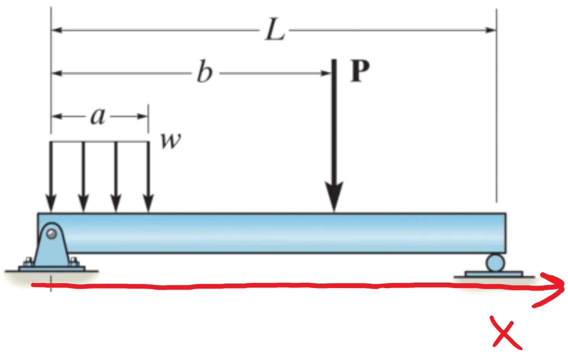
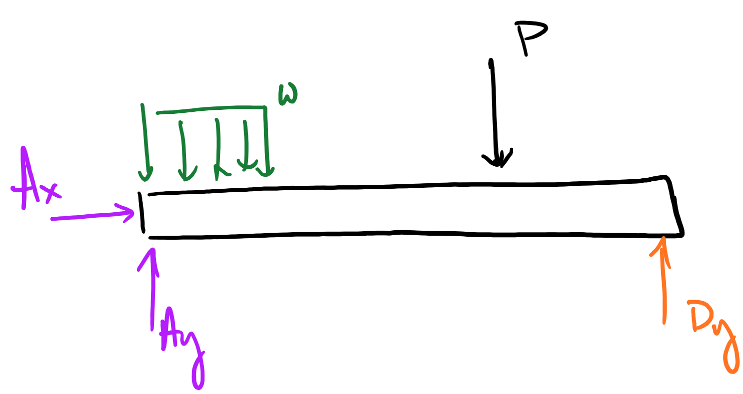



Draw the shear and moment diagrams for the simply supported beam.

1. Determine reactions and moment.
2. Specify coordinate system - start from left.
3. Section beam, draw FBD with V and M in positive sense
4. Apply eqns. of equilibrium

FBD of BEAM:




3 unknowns! Can solve!

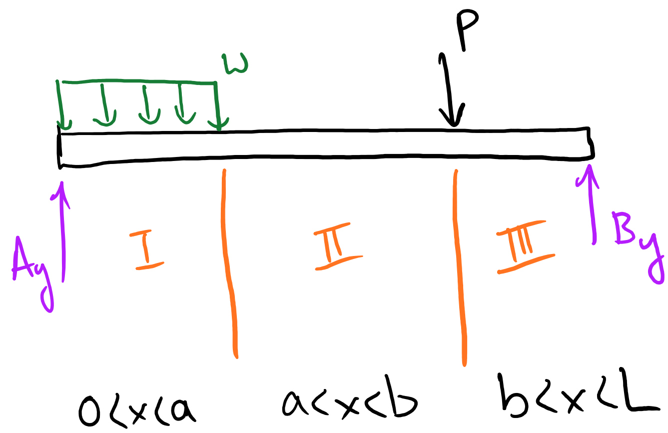
$\Sigma F_x$: $A_x = 0$

$\Sigma F_y$: $A_y + B_y - P - aw = 0$

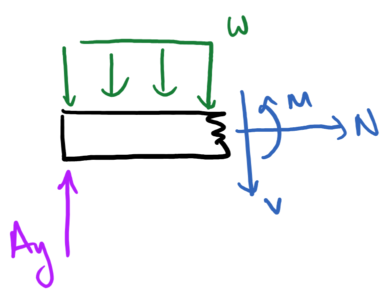
$\Sigma M_A$: $LB_y - bP - \left(\frac{a}{2}\right)aw = 0$

$$B_y = \frac{bP}{L} + \frac{a^2 w}{2L}$$

Identify Regions to Section




Region I: $0<x<a$




$\Sigma F_x = 0 \quad \therefore \quad N = 0$

$\Sigma F_y = 0$

$A_y - V(x) - xw = 0$

$$V(x) = A_y - xw$$

$$V(x) = A_y - xw$$

$$\Sigma M = 0$$

$$M(x) - xA_y + \frac{x}{2}(xw) = 0$$

$$M(x) = xA_y - \frac{1}{2}wx^2$$