Statics - TAM 210 & TAM 211

Lecture 22

March 7, 2018

Chap 7.2

Announcements

- No physical lecture. View online video recording of lecture.
- Upcoming deadlines:
- 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!
- No Prof. H-W office hours on Friday March 9
- Monday (3/12)
  - Mastering Engineering Tutorial 9
- Tuesday (3/13)
  - PL HW 7
- Quiz 5 (3/14-16)

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

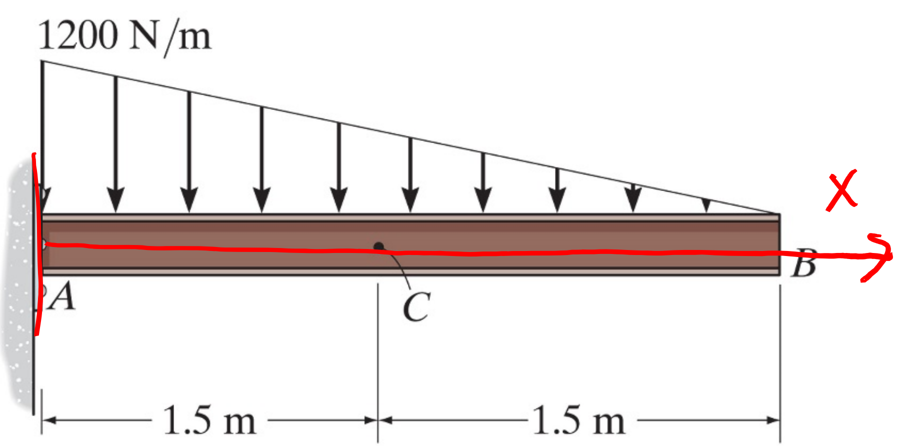
Recap: Shear Force and Bending Moment Diagrams

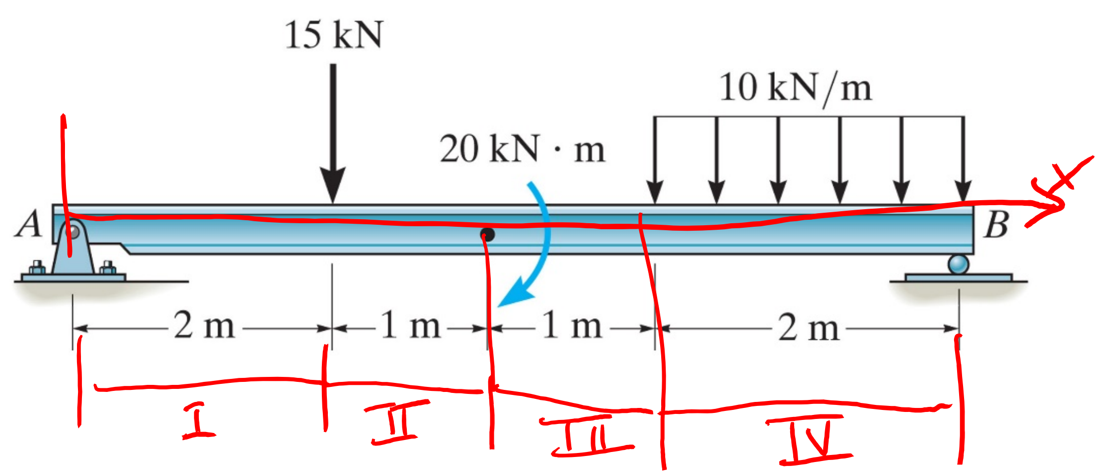
Goal: provide detailed knowledge of the variations of internal shear force and bending moments (V and M) throughout a beam when perpendicular distributed loads, concentrated forces, and/or concentrated couple moments are applied.

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

Procedure

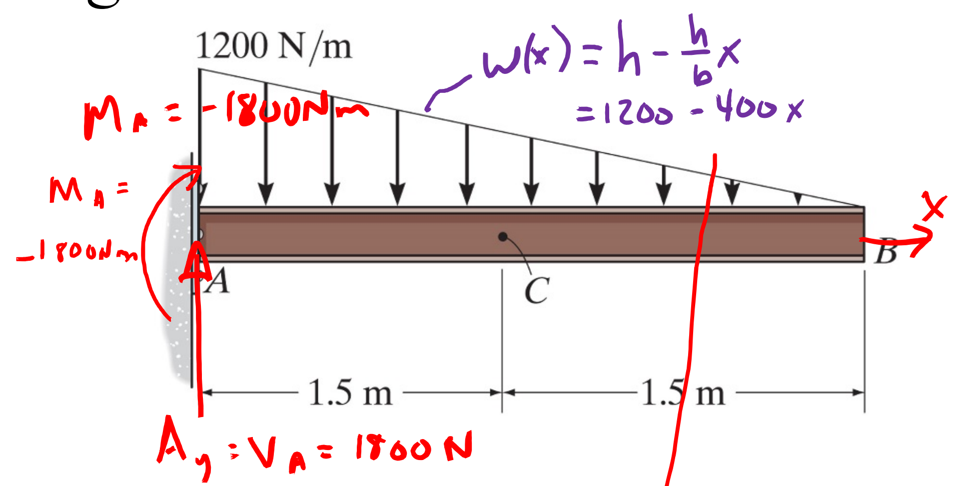
1. Find support reactions (free-body diagram of entire structure)
2. Specify coordinate x (start from left)
3. Divide the beam into sections according to loadings
4. Draw FBD of a section
5. Apply equations of equilibrium to derive V and M as functions of x: $V(x)$, $M(x)$





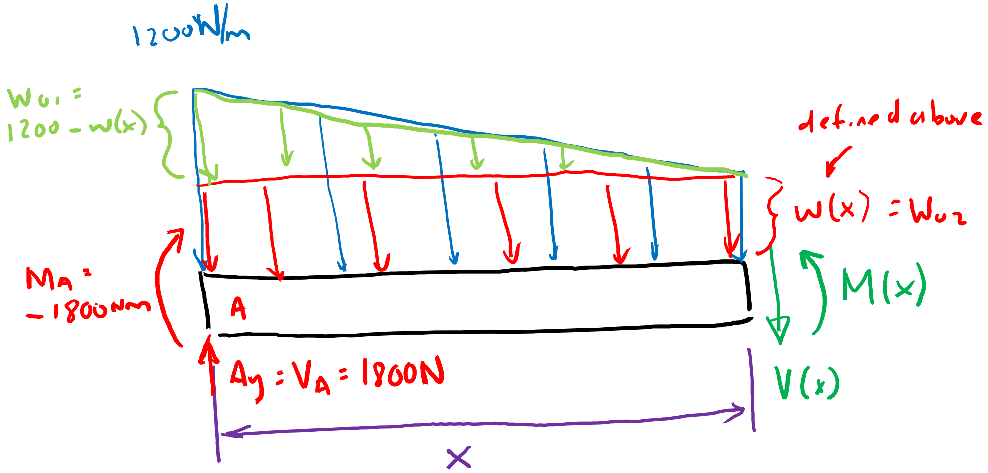
Draw the shear and bending moment diagrams for the beam.

From previous example, we know that the support reactions are: $A_x = 0$, $A_y = 1800\,N \uparrow$, $M_A = -1800\,Nm$



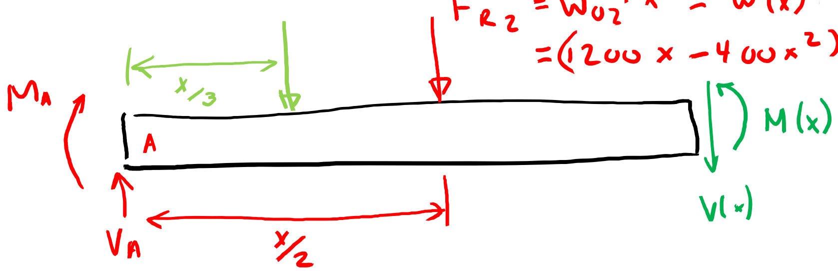
We are interested in finding $V(x)$ & $M(x)$ as these vary along the length of the beam.

So for any length x of the beam, we get the following generic FBD as a function of x.



$F_{R_1} = w_{0_1} \frac{L}{2} = [1200 - w(x)]\frac{x}{2} = (200x^2)\,N$

$F_{R_2} = w_{0_2} \cdot x = w(x) \cdot x$
$= (1200x - 400x^2)\,N$



$\Sigma F_x: A_y - F_{R1} - F_{R2} - V(x) = 0$

$$\boxed{V(x) = (200x^2 - 1200x + 1800)\,N}$$

Quadratic

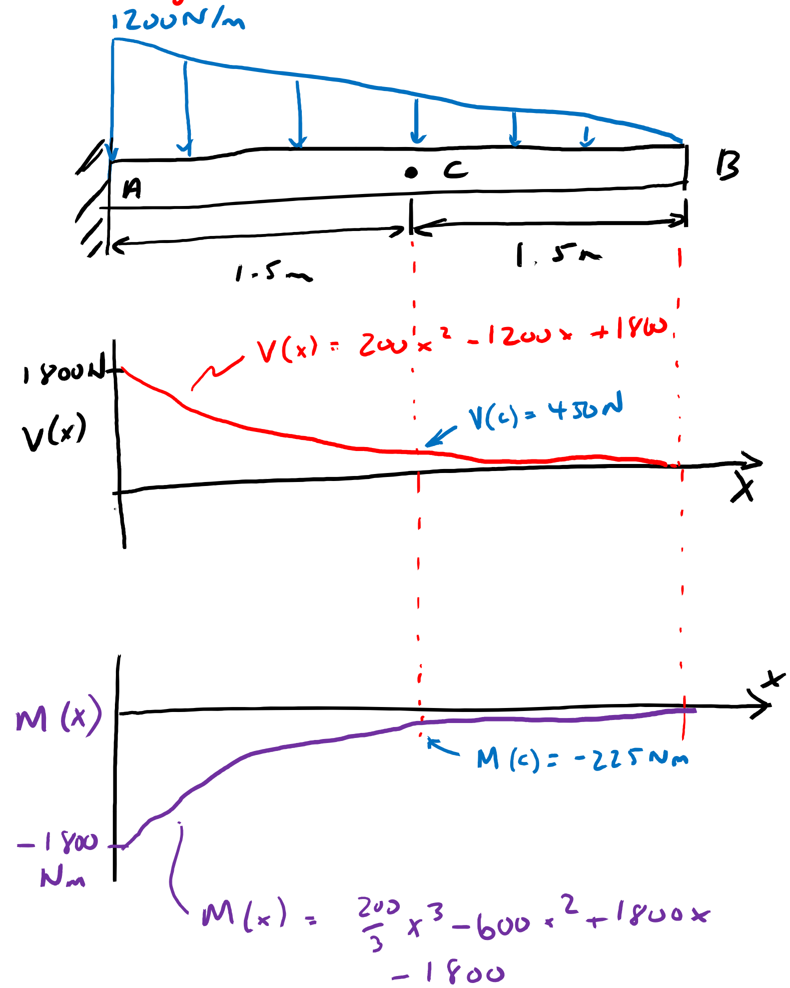
Boundary conditions:

$V(x=0) = 1800N = A_y$

$V(x=L=3m) = 0\,N$

cf. $V(@C=1.5m) = 450\,N$ ✓ w/ previous example

Draw Shear Force V(x) & Bending Moment M(x) diagrams



$+\circlearrowleft \Sigma M_A: -M_A - \left(\frac{x}{3}\right)F_{R1} - \left(\frac{x}{2}\right)F_{R2} - x\cdot V(x) + M(x) = 0$

$$\boxed{M(x) = \left(\frac{200}{3}x^3 - 600x^2 + 1800x - 1800\right)\,Nm}$$

3rd Order Polynomial

B.C.

$M(0) = -1800\,Nm = M_A$

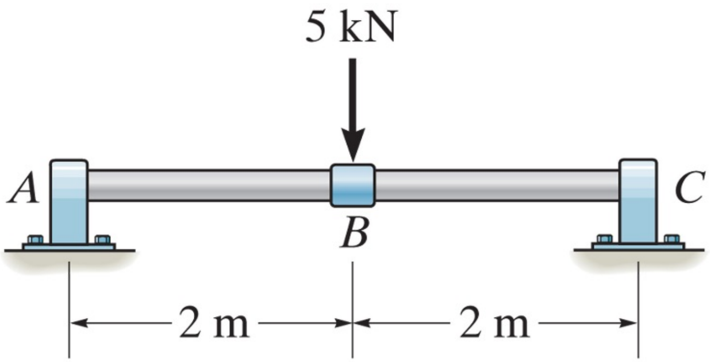
$M(L) = 0$

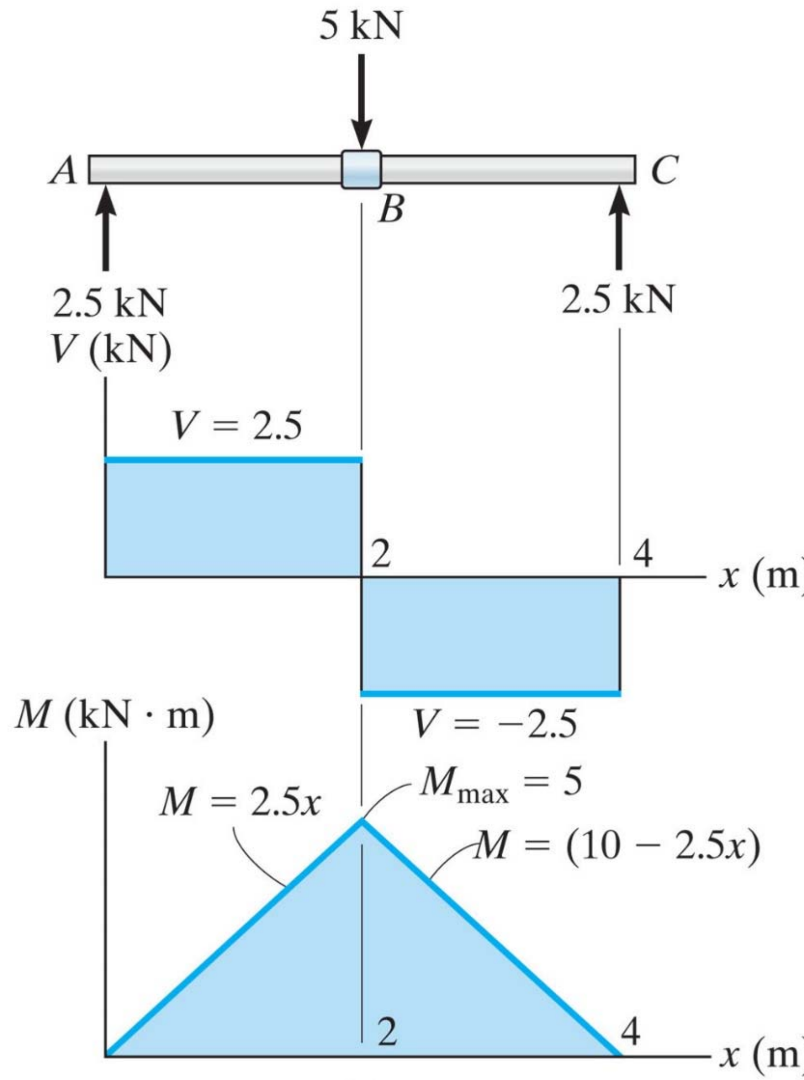
cf. $M(@C=1.5m) = -225\,Nm$ ✓ w/ previous

Note that since the applied load is a single distributed load along the entire length of the beam, then V(x) and M(x) are continuous functions. We will see that V(x) and M(x) will be discontinuous functions when multiple loads are applied to a beam, and these discontinuities will happen at the transitions between loading regions.

Explore and re-create the shear force and bending moment diagrams for the beam.

Example: single concentrated load

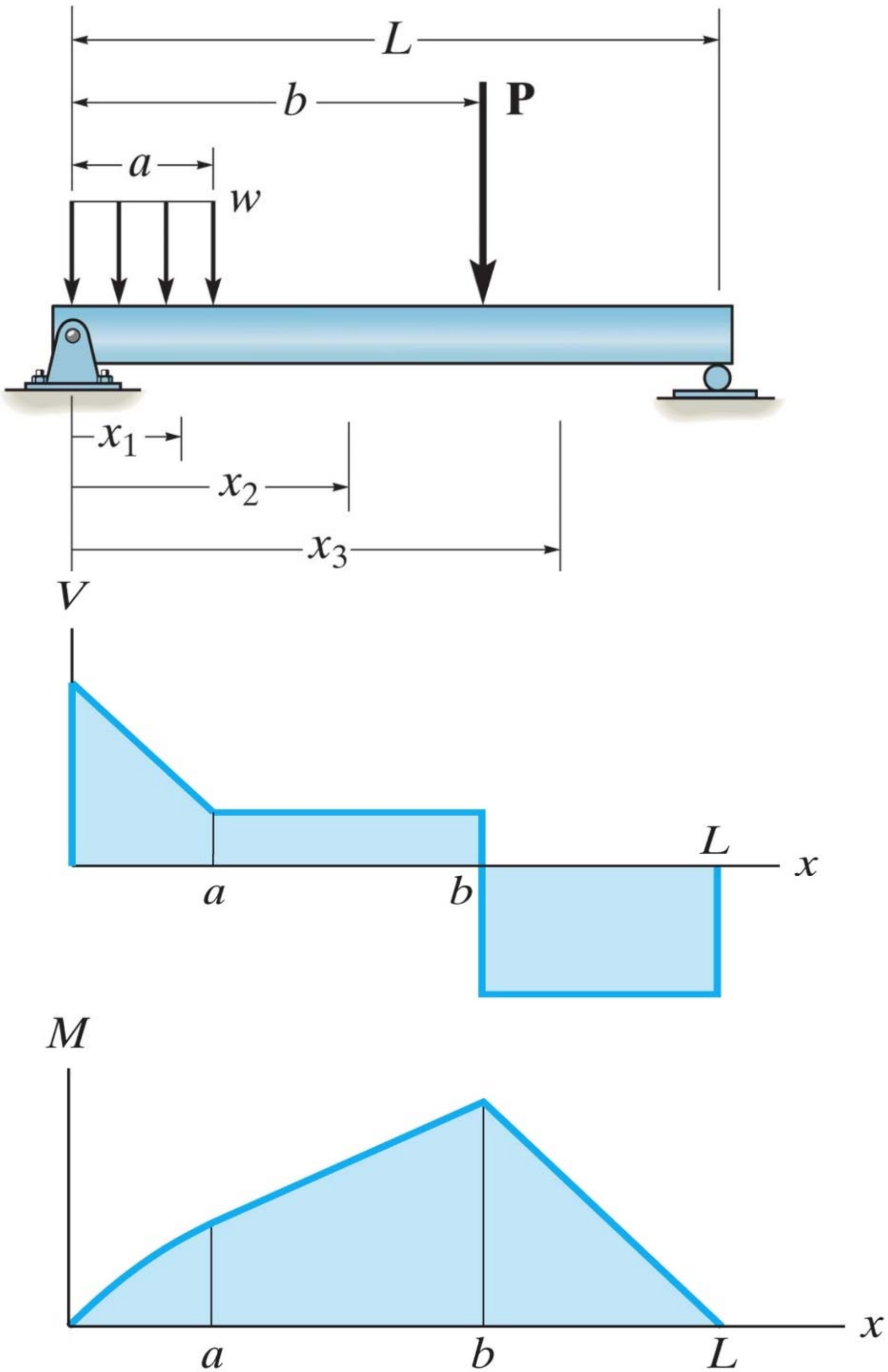




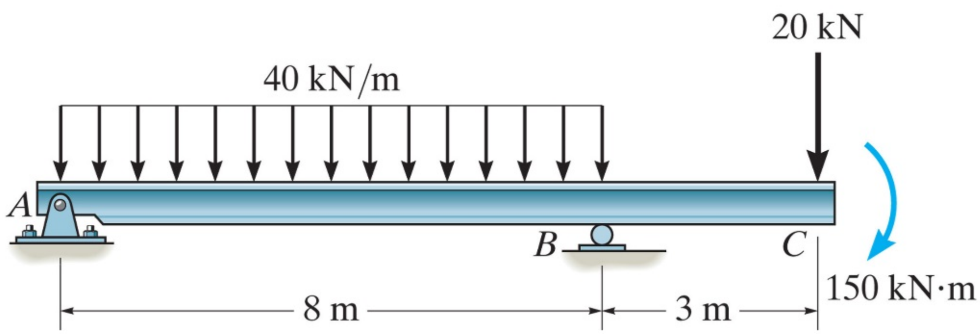
(d)

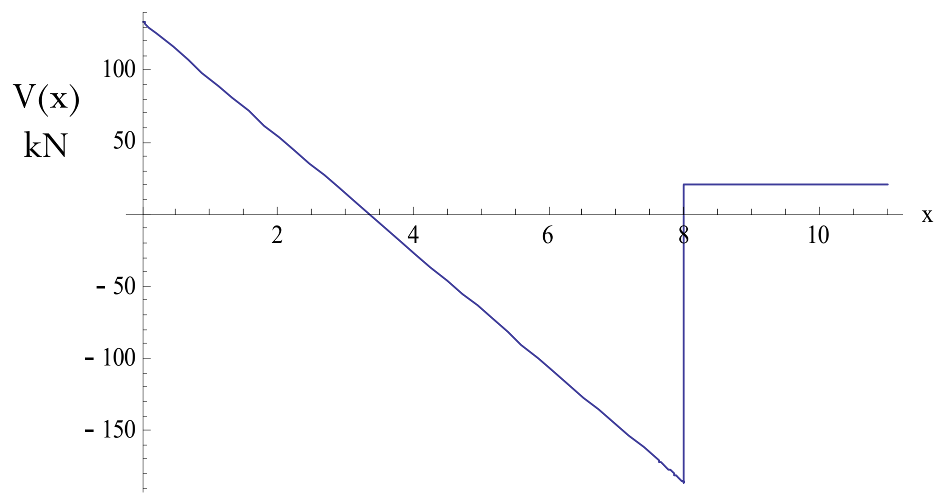
Explore and re-create the shear force and bending moment diagrams for the beam.

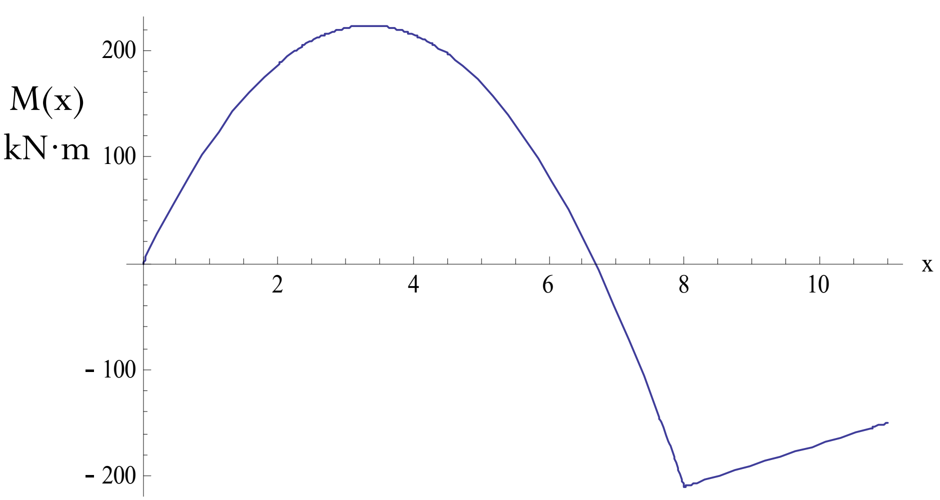
Example: single concentrated load, rectangular distributed load



Explore and re-create the shear force and bending moment diagrams for the beam.
Example: concentrated load, rectangular distributed load, concentrated couple moment







Draw the shear force and bending moment diagrams for the beam.

Example: concentrated load, rectangular distributed load, concentrated couple moment