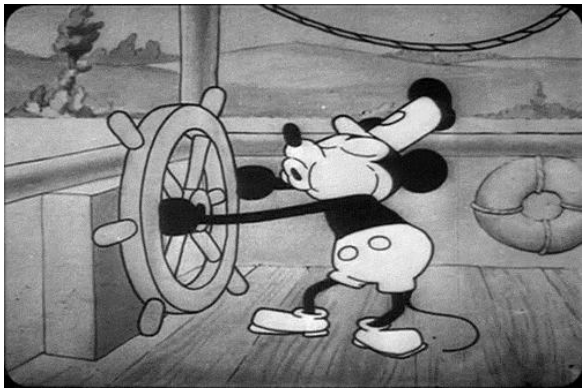
WORCESTER POLYTECHNIC INSTITUTE
MECHANICAL ENGINEERING DEPARTMENT

STRESS ANALYSIS
ES-2502, B'2025

We will get started soon...



25 November 2025

WORCESTER POLYTECHNIC INSTITUTE
MECHANICAL ENGINEERING DEPARTMENT

STRESS ANALYSIS
ES-2502, B'2025

Lecture 20:
Unit 15, 16: Bending of beams::
MV diagrams & MV general relationship

25 November 2025

General information

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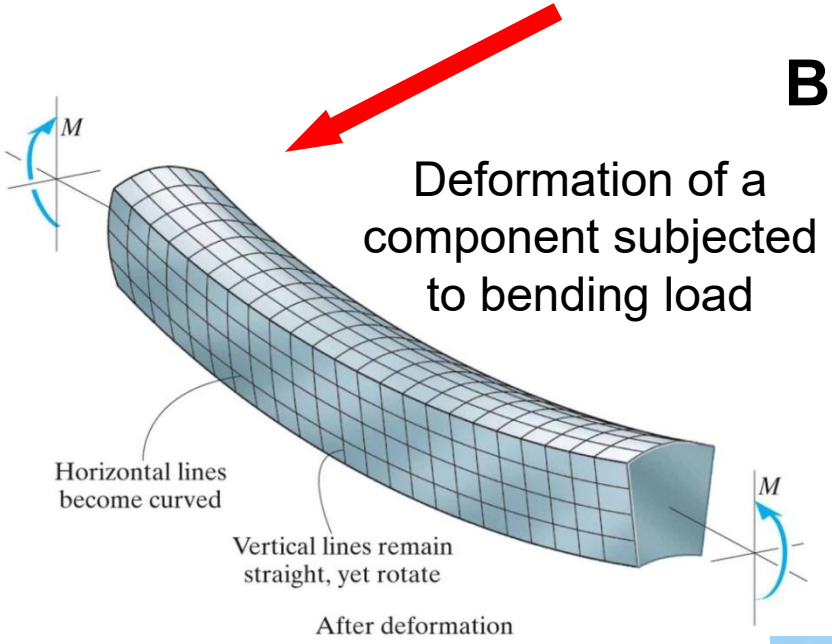
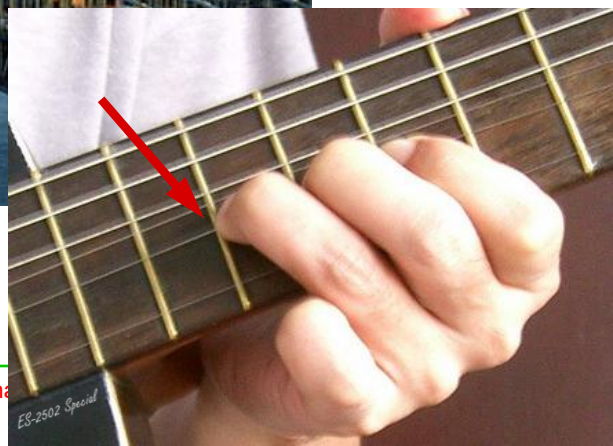
Bending

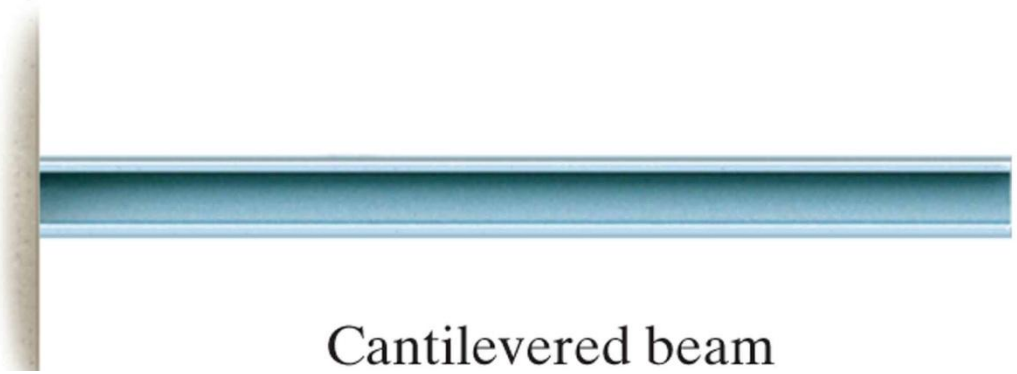
Deformation of a component subjected to bending load





Bending: many real components are modeled as “beams”

Simply supported beam

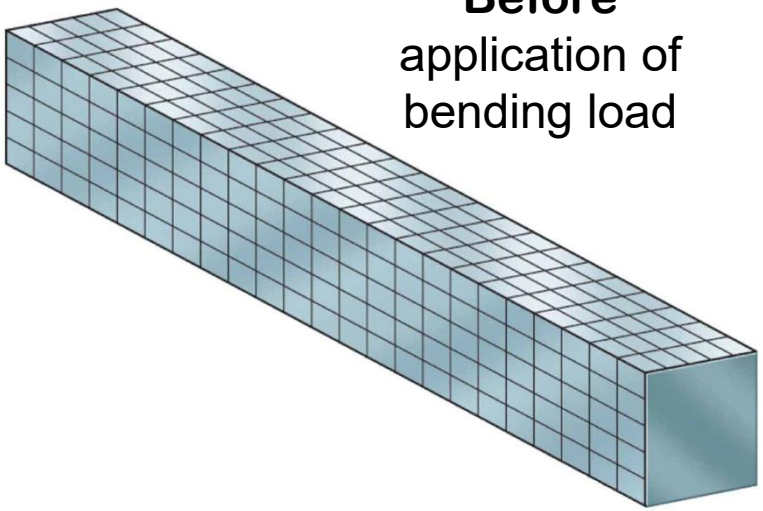


Cantilevered beam

Overhanging beam

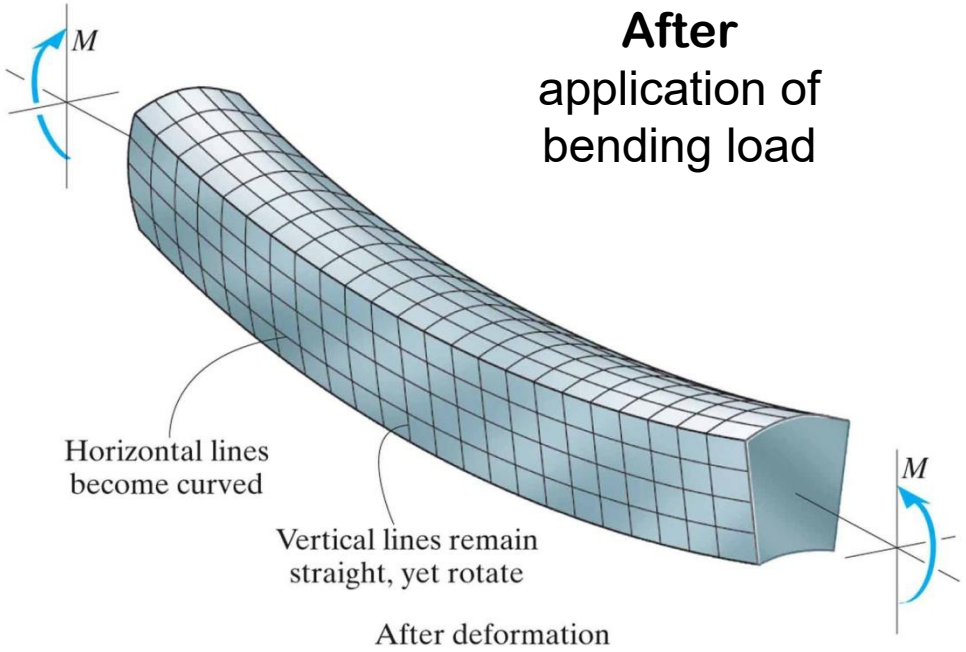
Bending

Before application of bending load

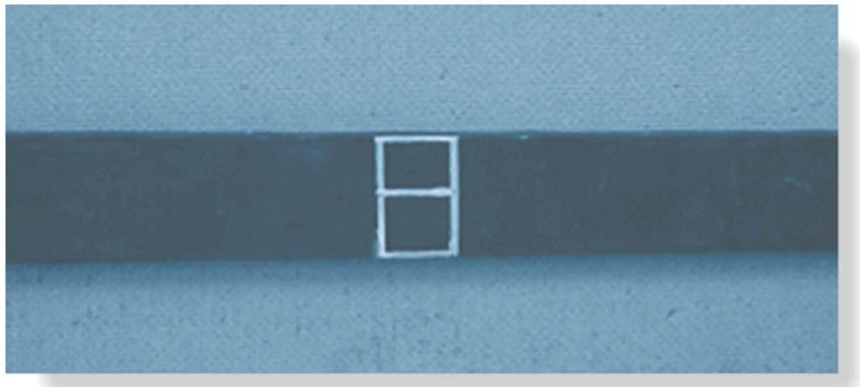


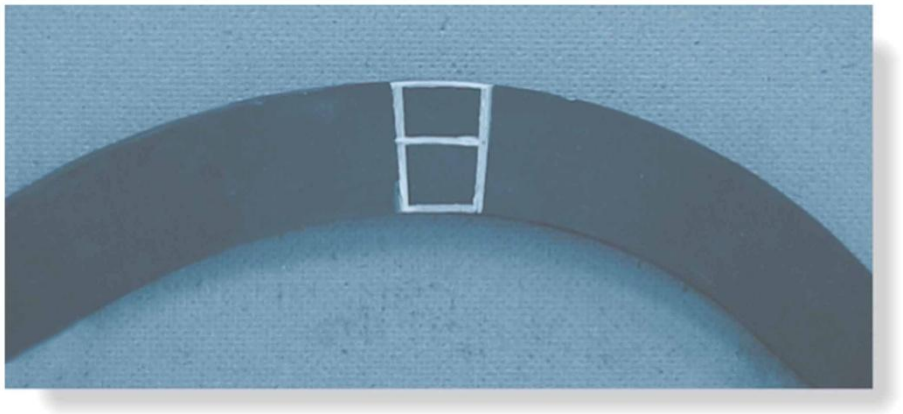
Before deformation

After application of bending load



After deformation

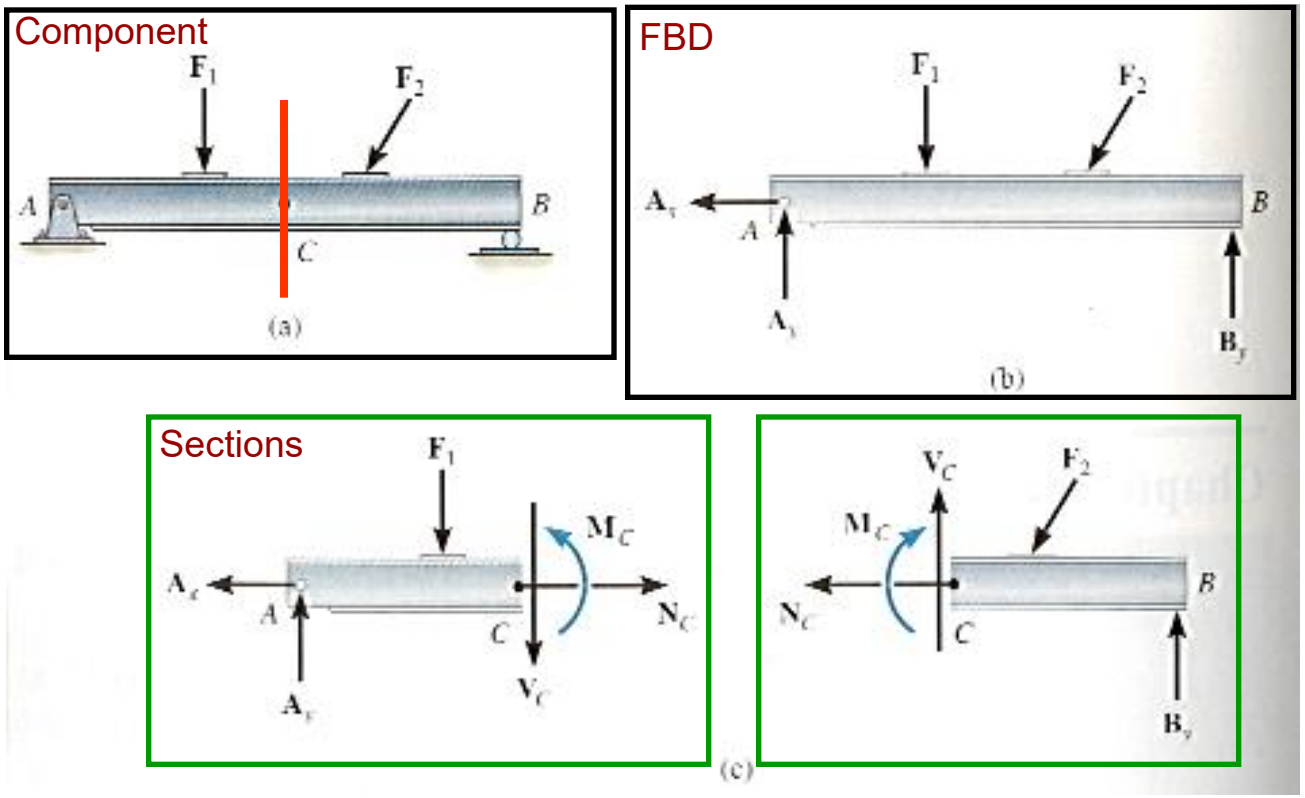




Internal forces and moments

Shear and bending moments

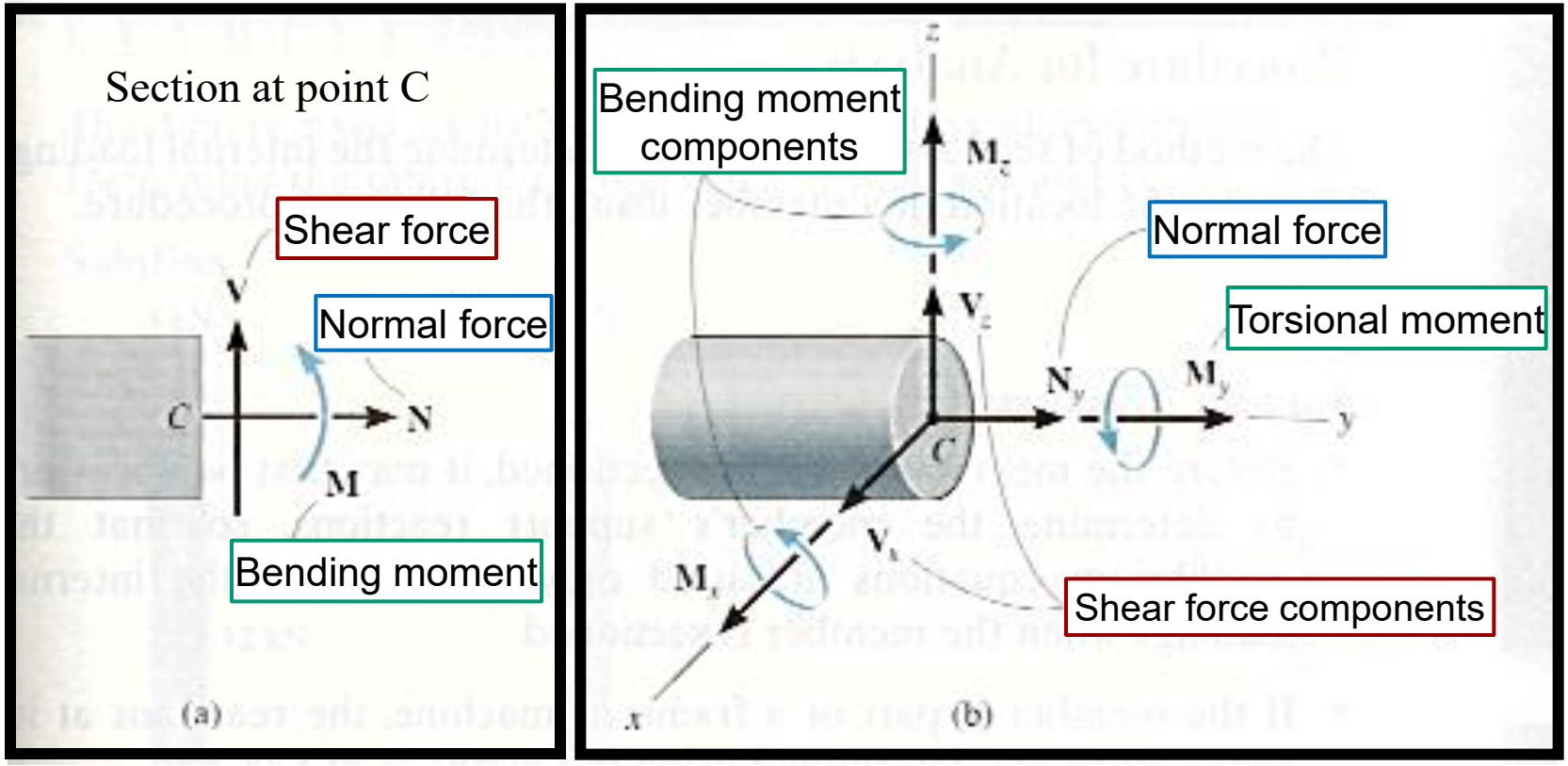
Internal forces (determination of shear and moment diagrams)



Internal: moments, shear, and normal forces at point C

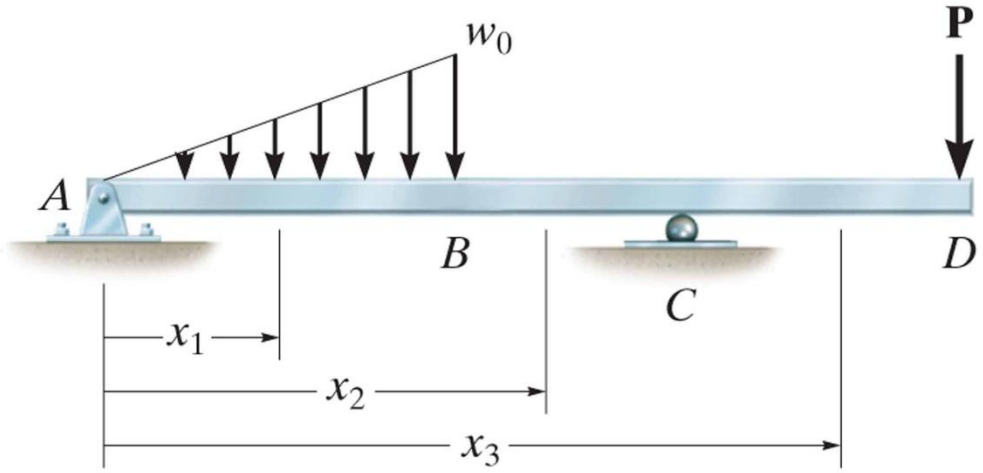
Internal forces and moments

Shear and bending moments

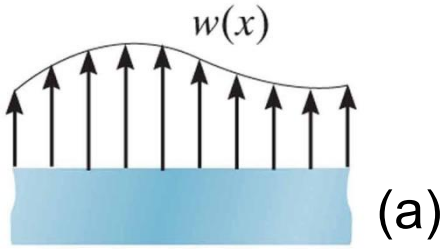


Shear and bending diagrams

Diagrams are determined for *each region* of the beam *between* any two discontinuities of loading

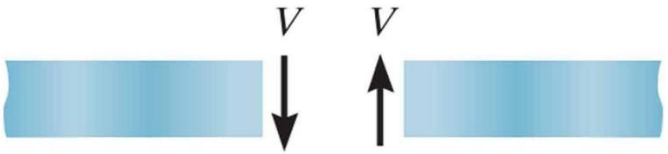


Beam sign convention



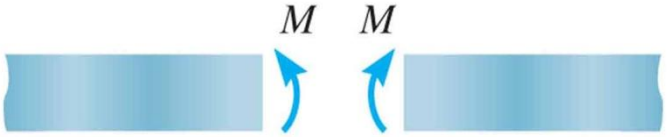
(a)

Positive external distributed load



(b)

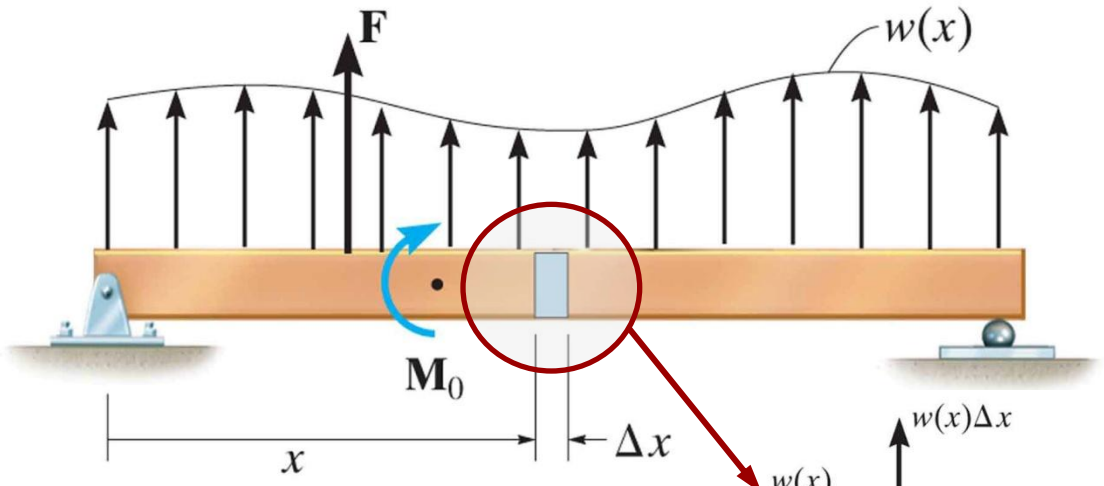
Positive internal shear



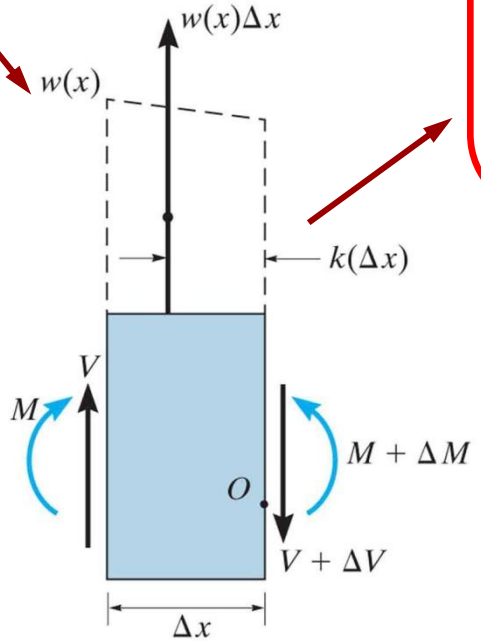
(c)

Positive internal moment

Shear and bending diagrams: regions with distributed load



Free body diagram of element Δx:



Free-body diagram of segment Δx

Important to remember!!

$$\frac{dV}{dx} = w(x);$$

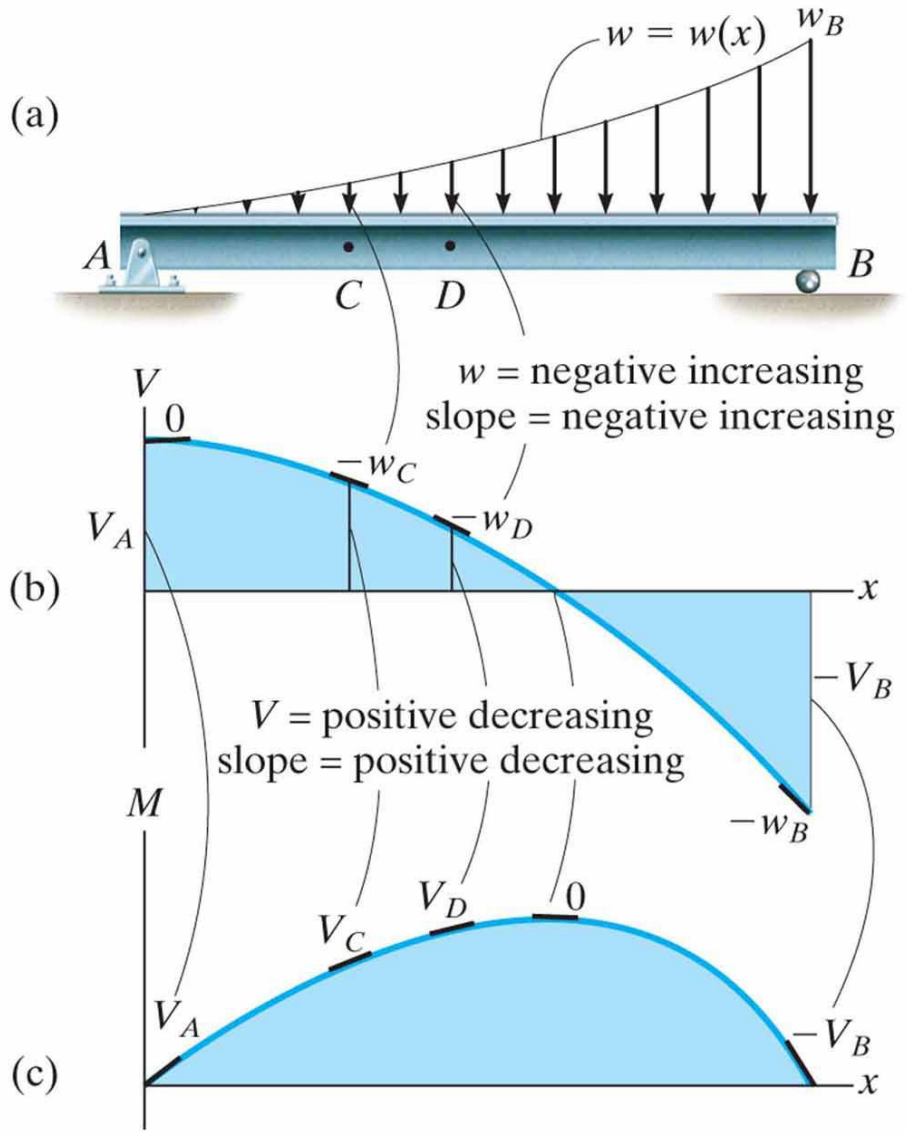
$$\frac{dM}{dx} = V(x)$$

Shear and bending diagrams: regions with distributed load

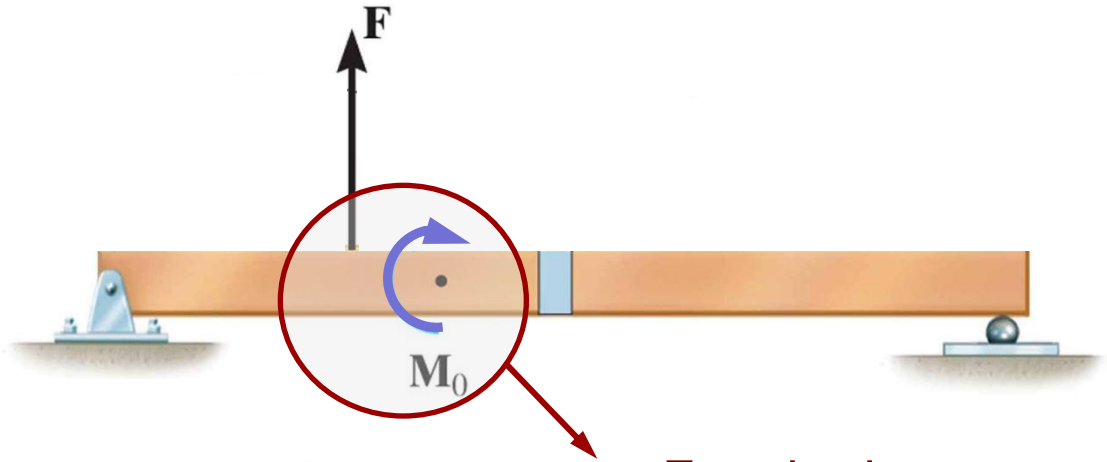
Important to remember!!

$$\frac{dV}{dx} = w(x);$$

$$\frac{dM}{dx} = V(x)$$



Shear and bending diagrams:
regions with concentrated force and moment

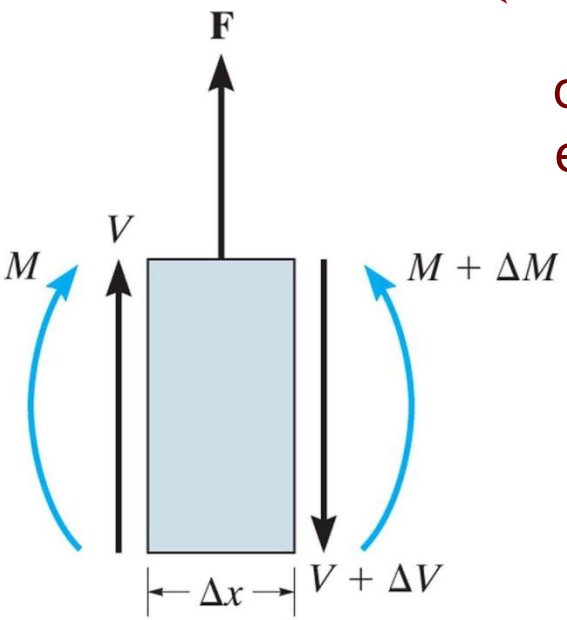


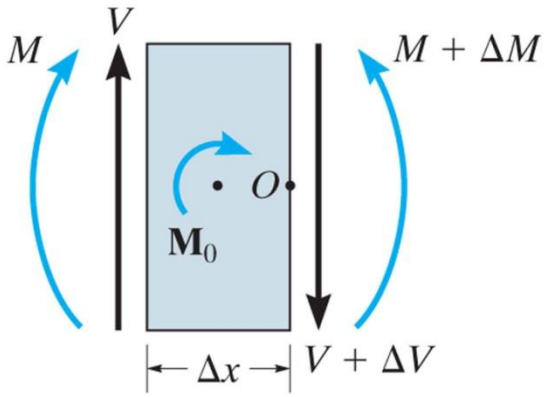
Important to remember!!

$$\Delta V = F\ ;$$

$$\Delta M = M_0$$

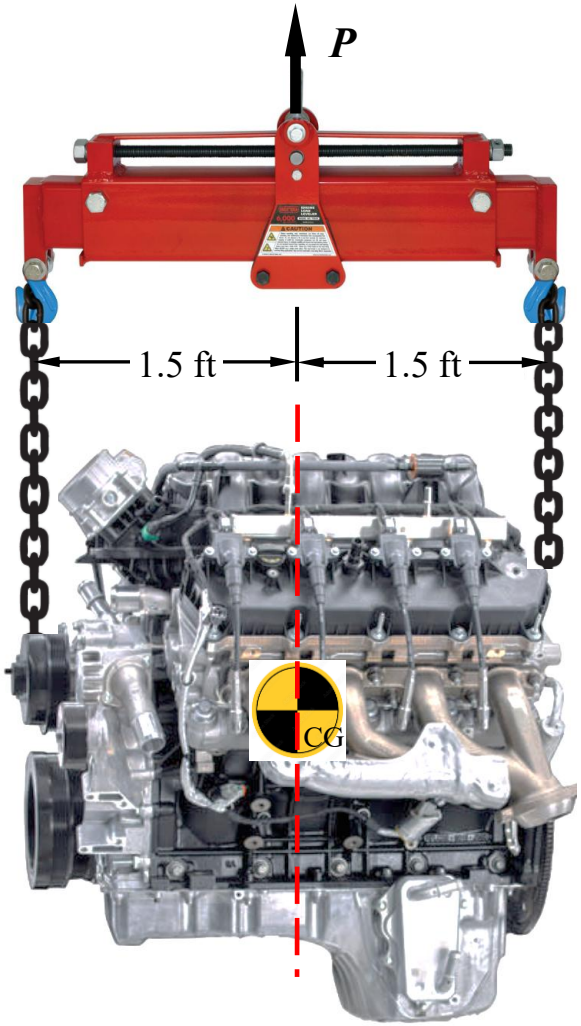
Free body diagrams of element Δx:





Shear and bending diagrams: example A

A suspended bar supports a 600-lb engine. Plot the shear and moment diagrams for the bar



Shear and bending-moment diagrams

Method of sections: *plot using step functions + MathCad*

S-M Diagrams – Bar: ES 2502

A suspended bar supports a 600-lb engine.
Plot the shear and moment diagrams for the bar.

Input:

$L := 3$

$a := 1.5$

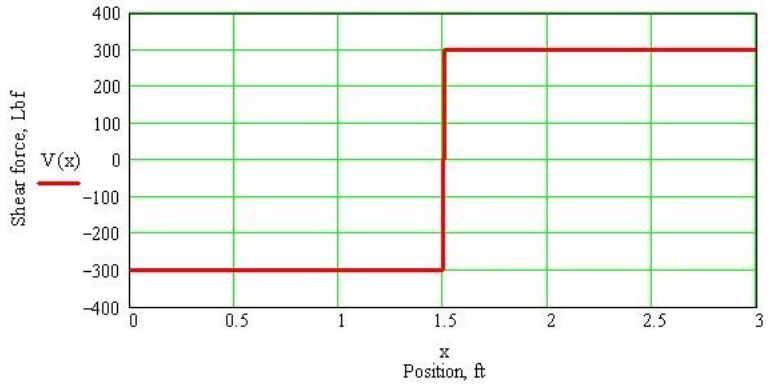
$x := 0, 0.001 \cdot L .. L$

Define unit step function:

$S(x, z) := \text{if}(x \geq z, 1, 0)$

Define shear function:

$V(x) := -300 \cdot S(x, 0) + 600 \cdot S(x, 1.5)$

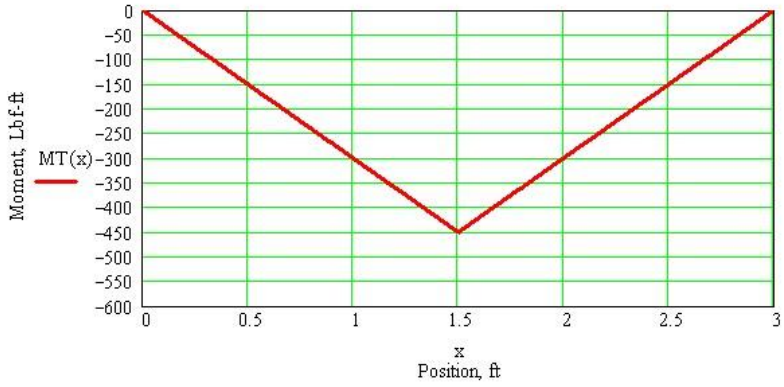


Define moments function:

$M1(x) := -300 \cdot x$

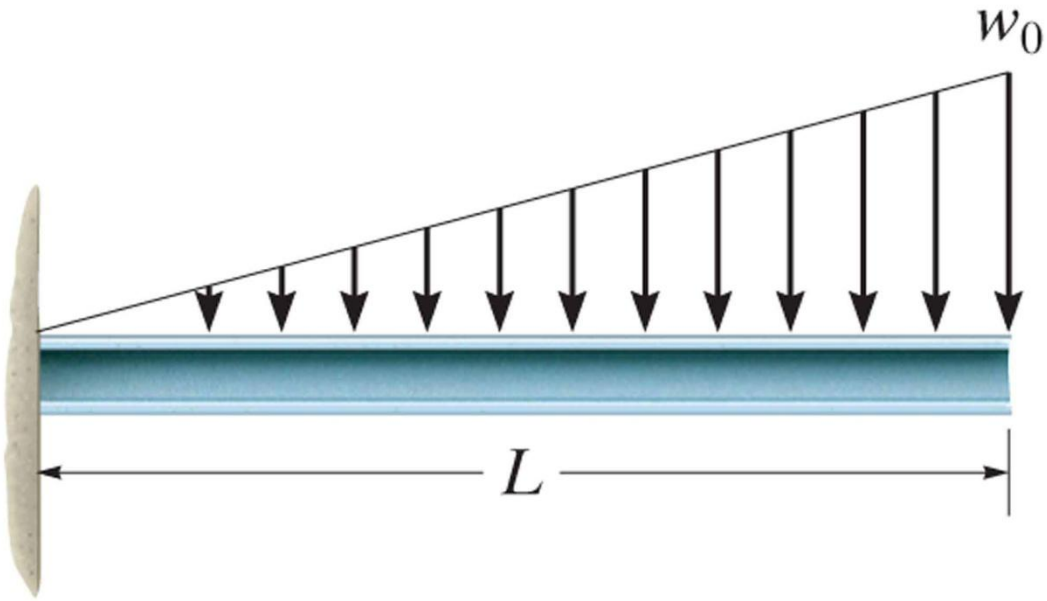
$M2(x) := 300 \cdot x - 900$

$MT(x) := S(x, 0) \cdot M1(x) - S(x, 1.5) \cdot M1(x) + S(x, 1.5) \cdot M2(x)$



Shear and bending diagrams: example B

Determine the shear and moment diagrams for the beam shown



Reading assignment

- Chapter 6 of textbook
- Review notes and text: ES2001, ES2501

Homework assignment

- As indicated on webpage of our course