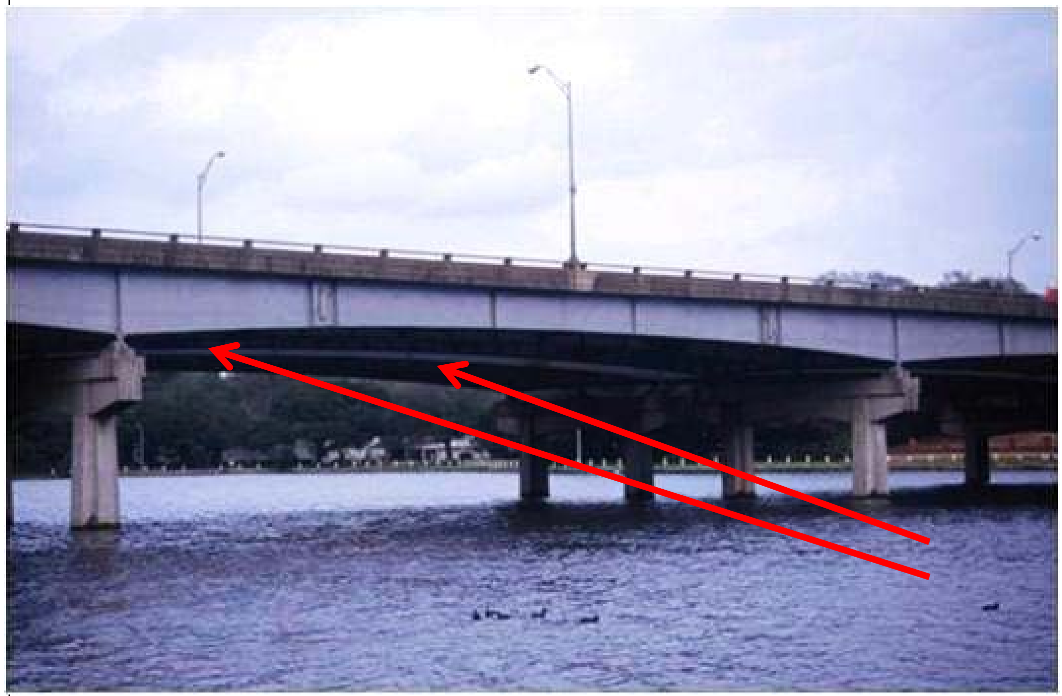
Chapter 7: Internal Forces

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 moment throughout a member

Internal loadings developed in structural members

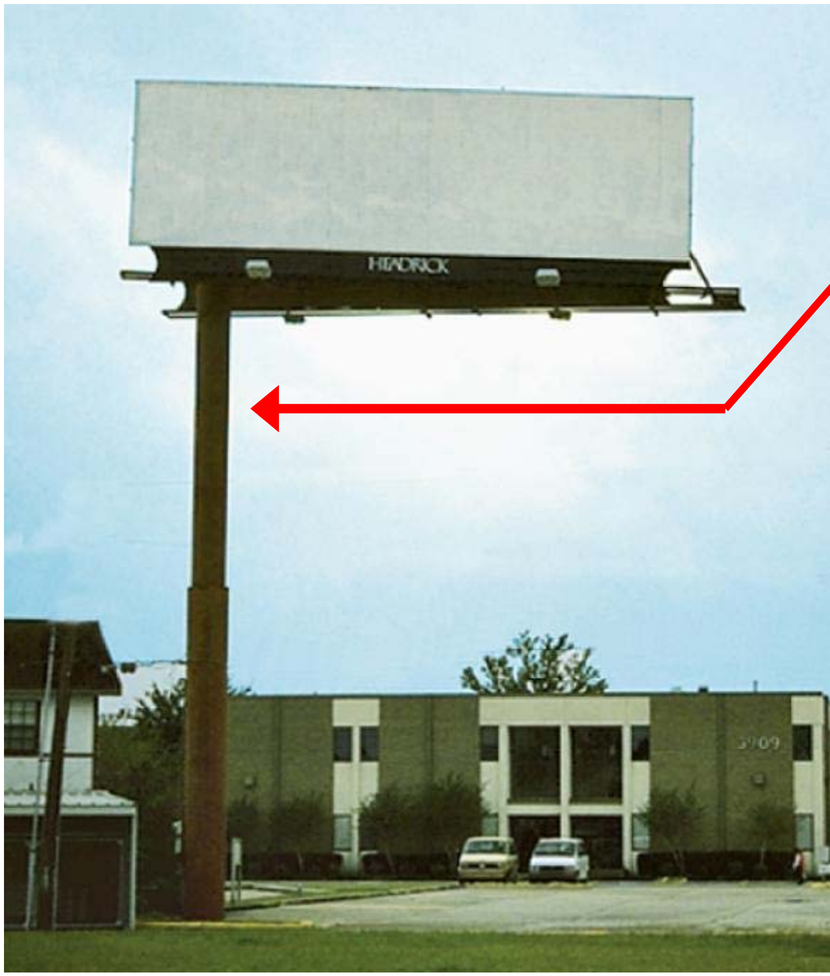


Beams are structural members designed to support loads applied perpendicularly to their axes.

Beams can be used to support the span of bridges. They are often thicker at the supports than at the center of the span.

Why are the beams tapered? Internal forces are important in making such a design decision.

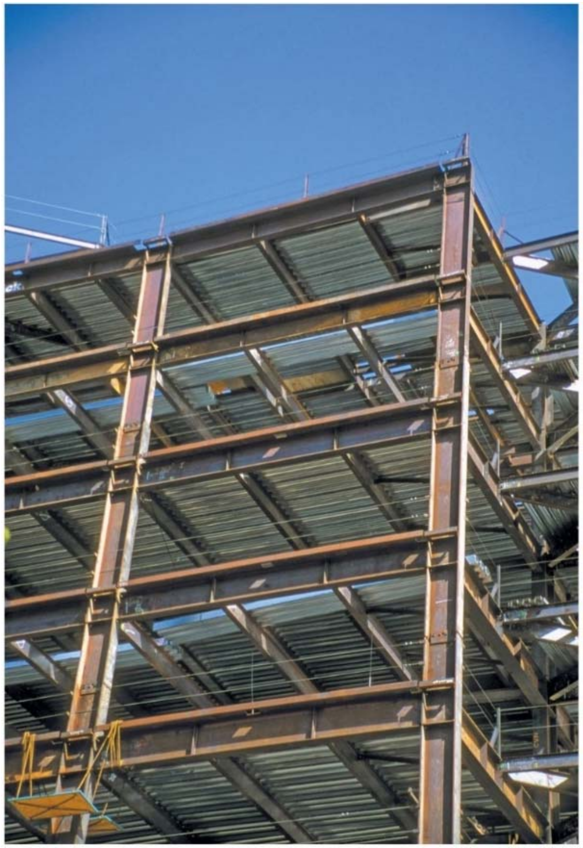
Internal loadings developed in structural members

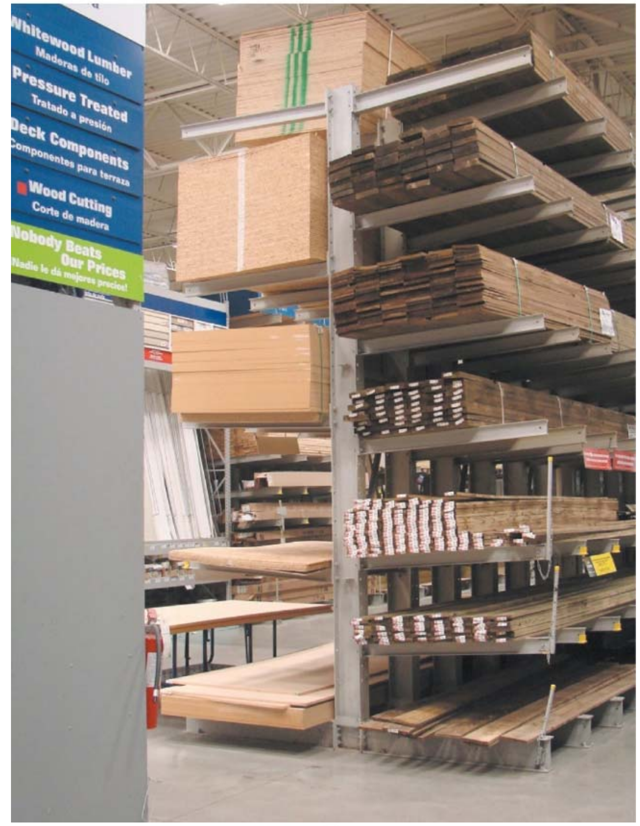


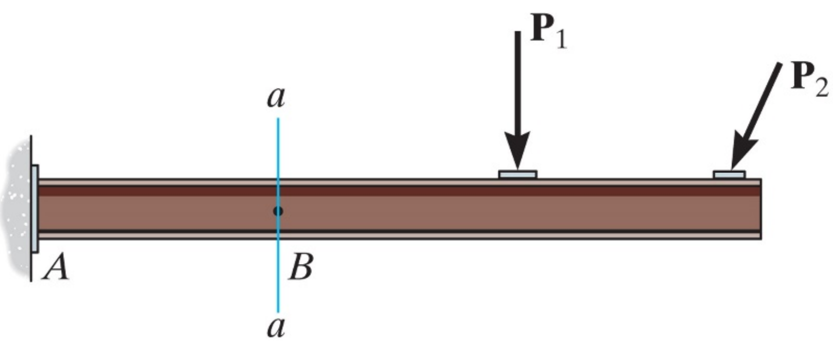
A fixed column supports these rectangular billboards.

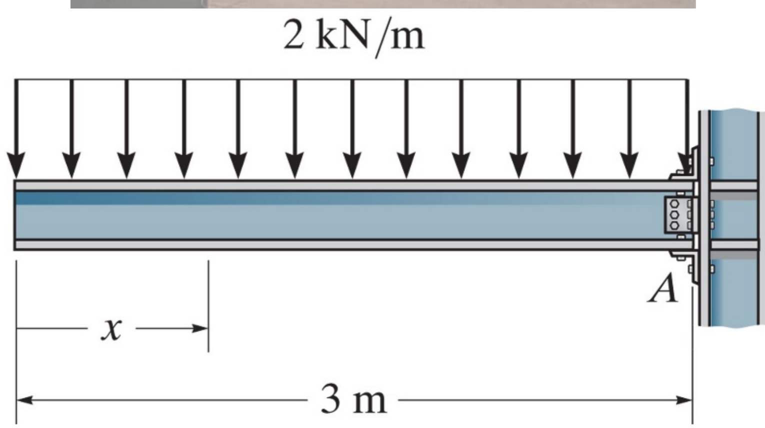
Usually such columns are wider/thicker at the bottom than at the top. Why?

Internal loadings developed in structural members





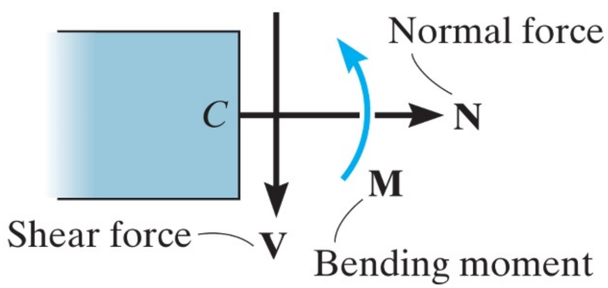




Internal loadings developed in structural members

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.**



https://www.youtube.com/watch?v=hLfNCAHPL8c BCT540 Truss Test, Group 2

https://www.youtube.com/watch?v=YdqvGGFIbfc Steel Rebar Tensile Test

Internal loadings developed in structural members

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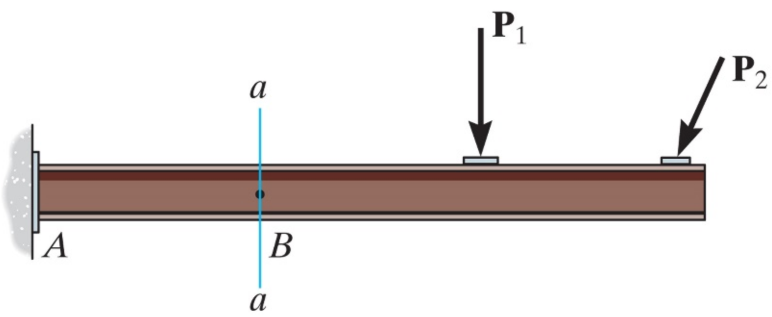
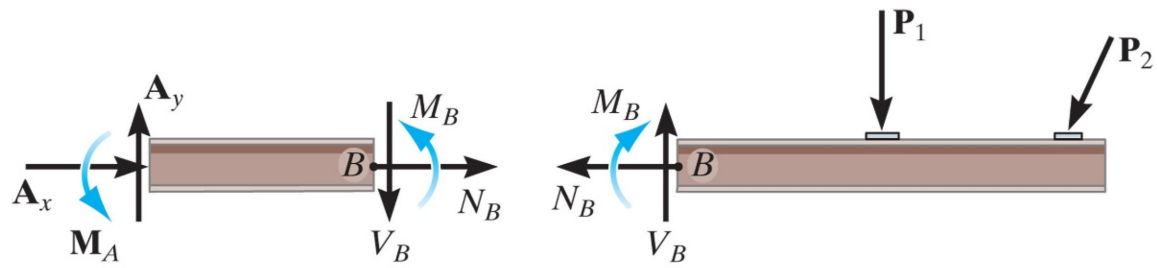
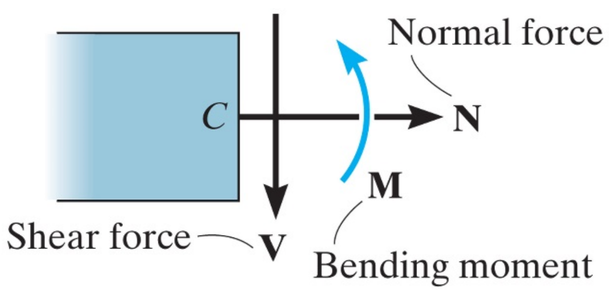
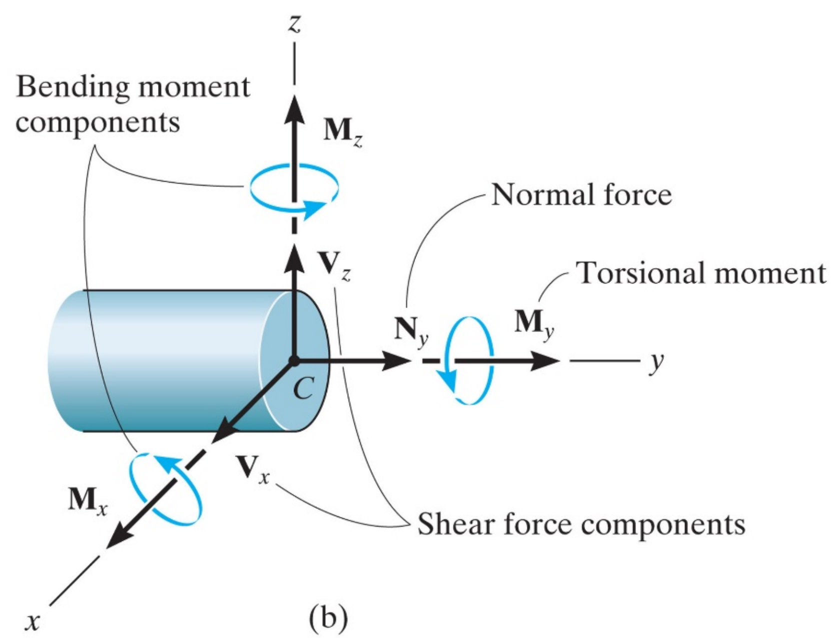


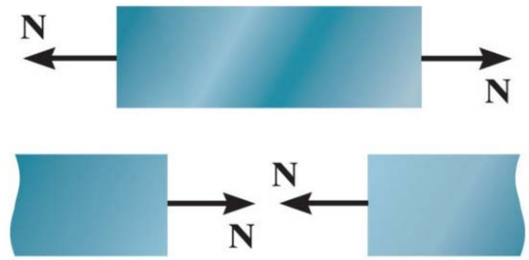




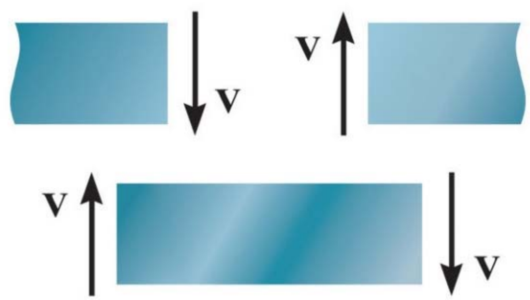


(b)

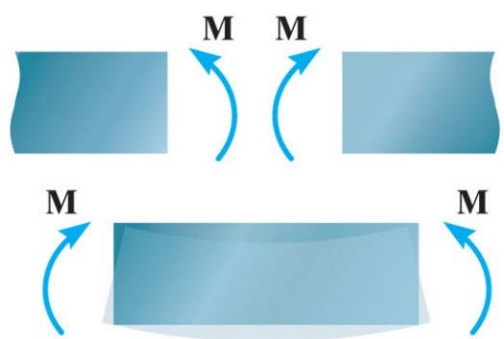
Sign conventions:



Positive normal force



Positive shear

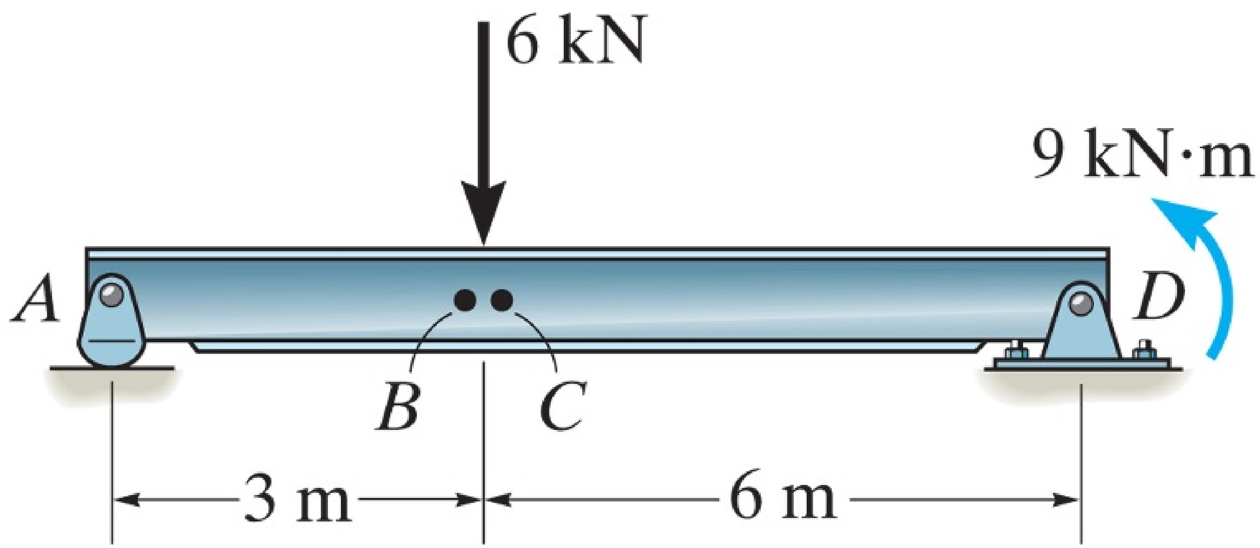


Positive moment

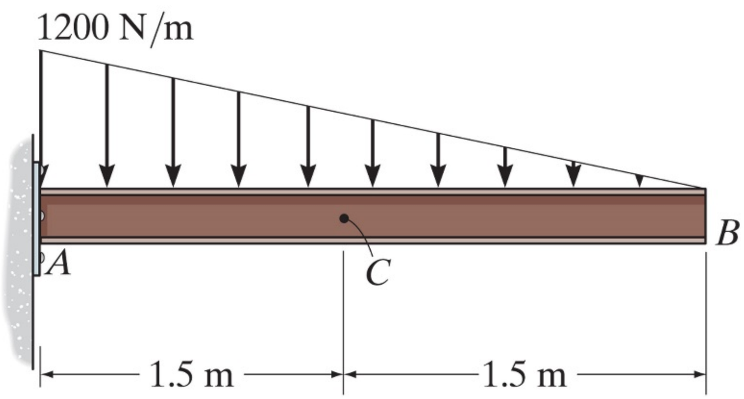
Procedure for analysis:

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

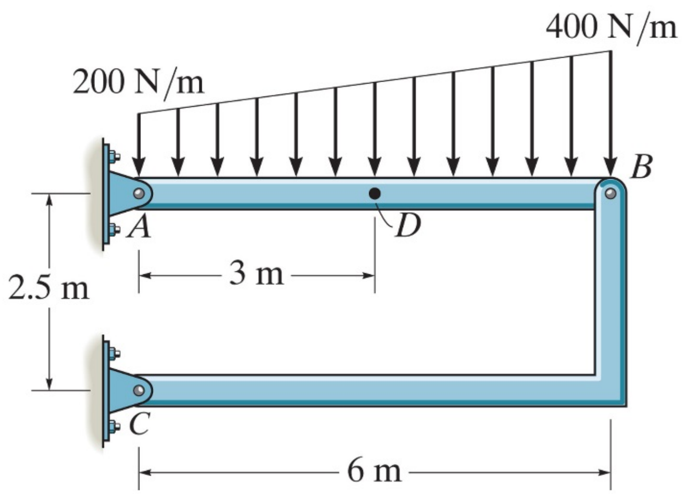
Find the internal forces and moments at B (just to the left of load P) and at C (just to the right of load P)



Find the internal forces and moments at C

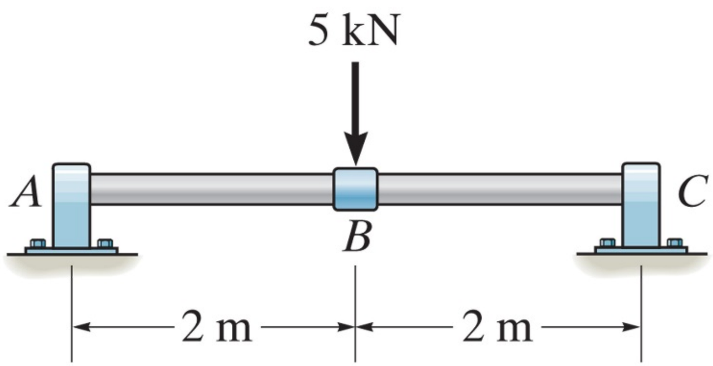


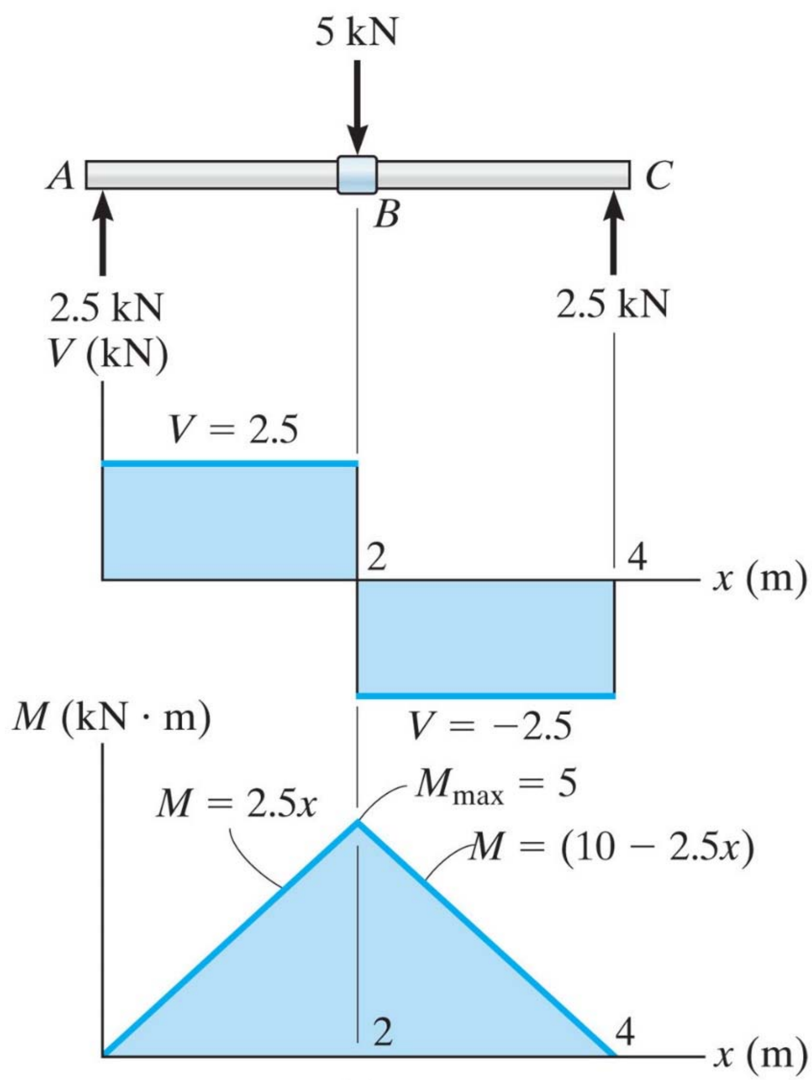
Find the internal forces and moments at D



Shear and Moment Equations and Diagrams

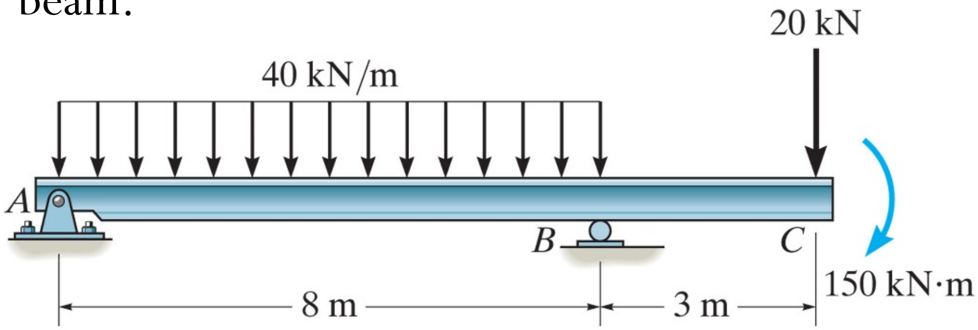
The variation in shear force *V(x)* and bending moment *M(x)* along a beam is often of interest. The relations for *V(x)* and *M(x)* are found from force and moment equilibrium, respectively



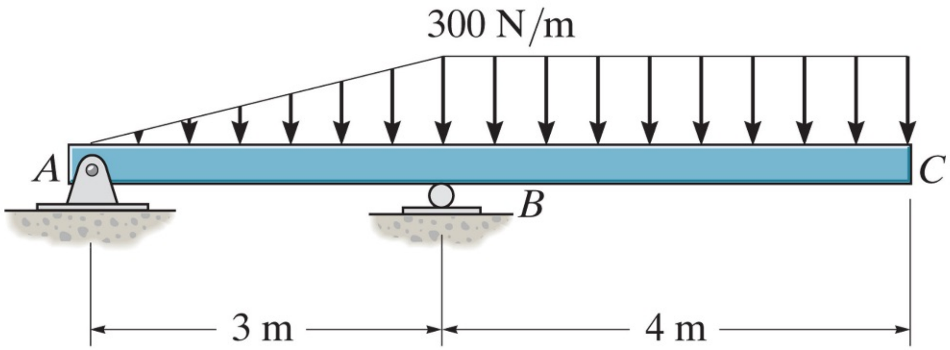


(d)

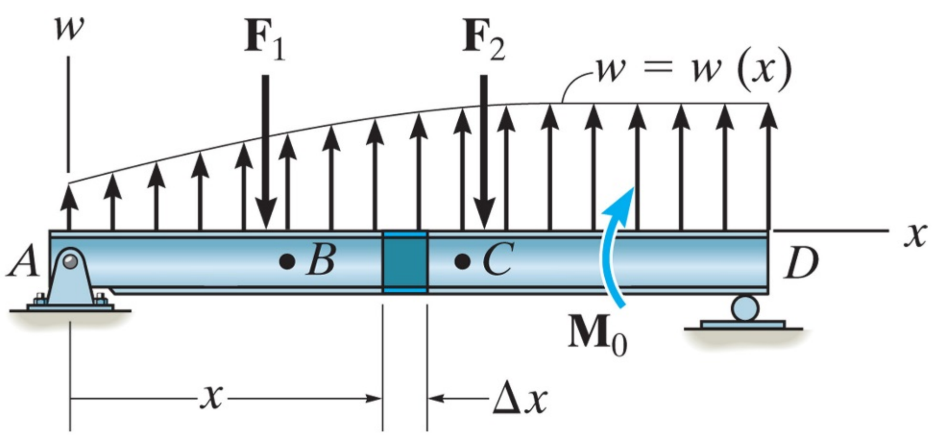
Obtain the expressions for V(x) and M(x) and draw the shear and bending moment diagram for the beam.

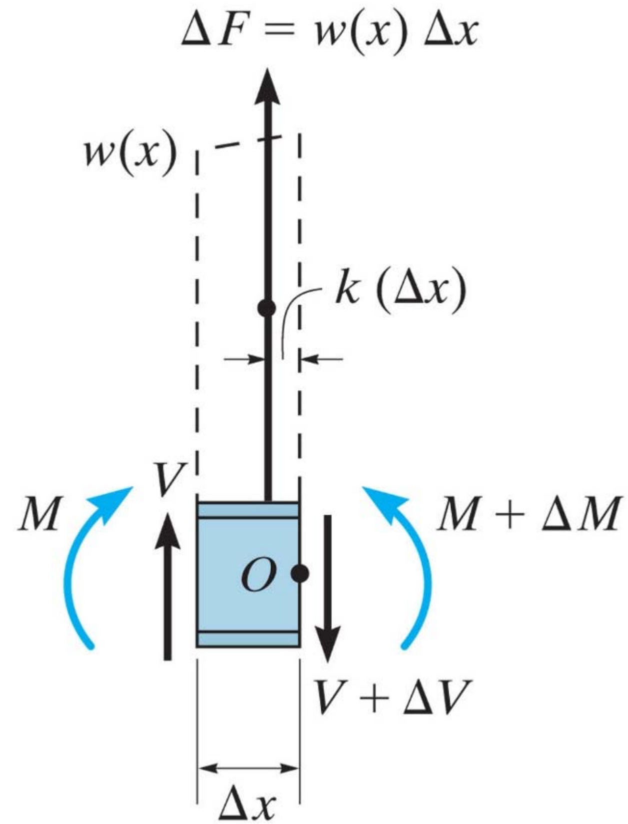


Obtain the expressions for V(x) and M(x) and draw the shear and bending moment diagram for the beam.



Relations Among Load, Shear and Bending Moments





Relationship between load and shear:

$$\sum F_y = 0: \quad V - (V + \Delta V) + w\Delta x = 0$$
$$\Delta V = w\Delta x$$

Dividing by Δx and letting $\Delta x \rightarrow 0$, we get:

$$\frac{dV}{dx} = w \qquad \Delta V = \int w\, dx$$

Relationship between shear and bending moment:

$$\sum M_O = 0: \quad (M + \Delta M) - M - V\,\Delta x - w\Delta x\,(k\,\Delta x) = 0$$
$$\Delta M = V\,\Delta x + wk(\Delta x)^2$$

Dividing by Δx and letting $\Delta x \rightarrow 0$, we get:

$$\frac{dM}{dx} = V \qquad \Delta M = \int V\, dx$$

Wherever there is an external concentrated force, or a concentrated moment, there will be a change (jump) in shear or moment respectively.

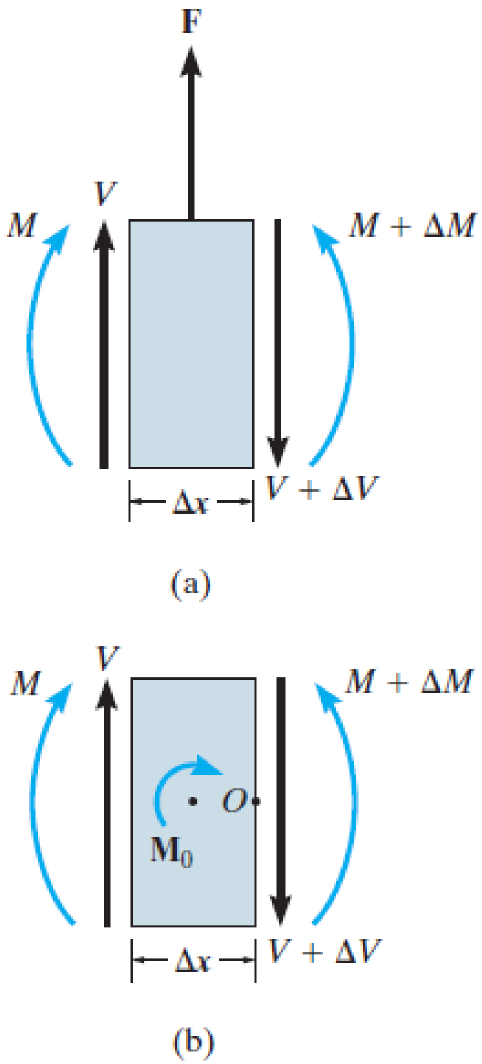
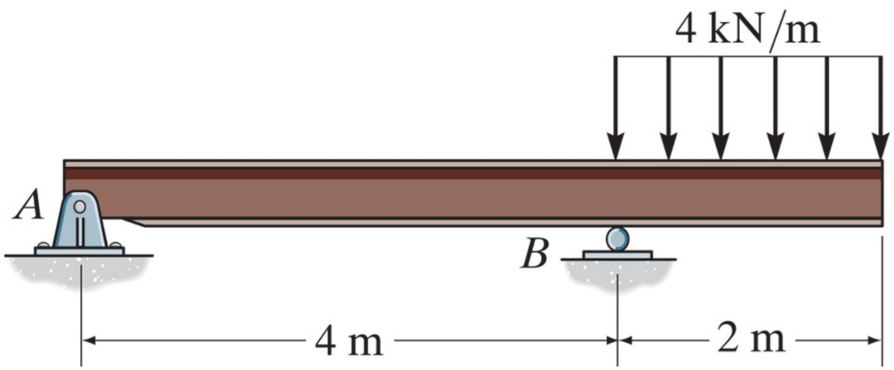


Fig. 6–10

$$V + F - (V + \Delta V) = 0$$
$$\Delta V = F$$

$$M + \Delta M - M_0 - V\Delta x - M = 0$$
$$\Delta M = M_0$$

Draw the shear and bending moment diagrams for the beam and loading shown.



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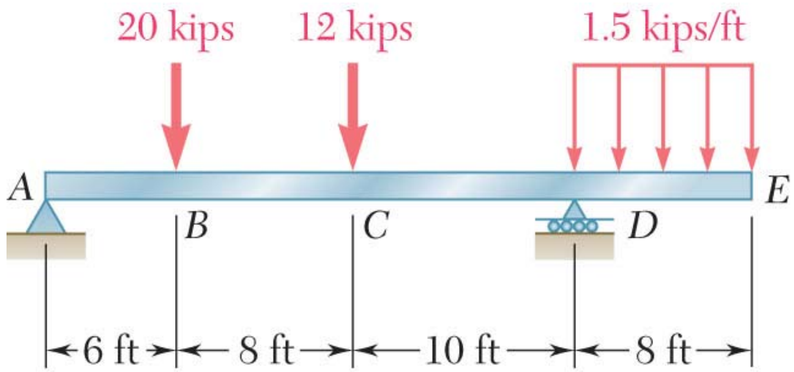

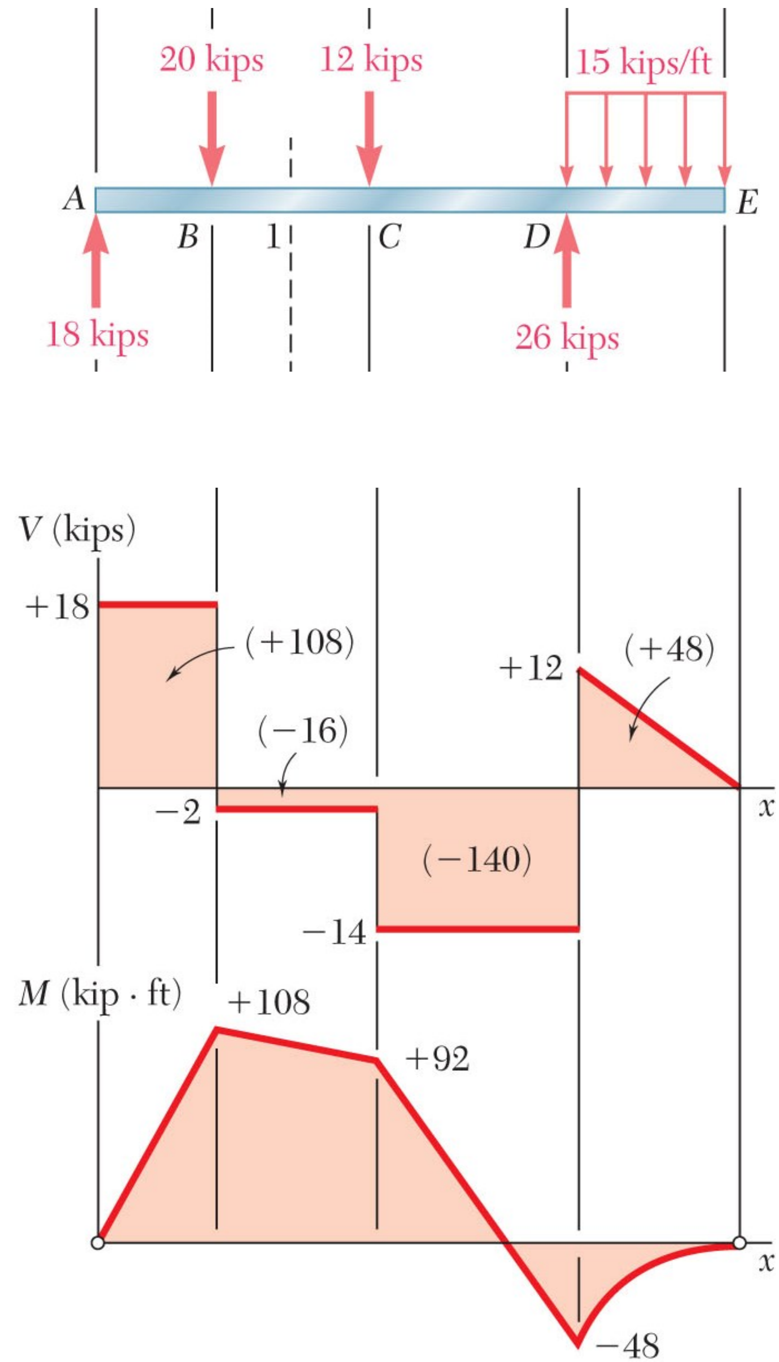

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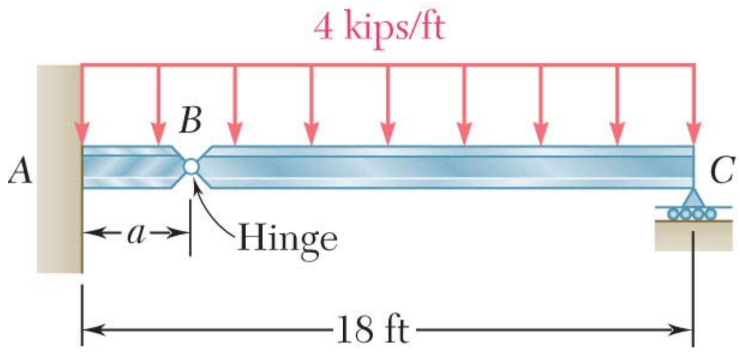

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