

### Internal Loads

Before you can design a structural member, it is necessary to understand the forces and moments that act on it.

**Force**  
acting on the beam

**Compression**  
Pushes the material together

**Tension**  
Stretches the material

### Internal Loads

**Axial Force - Buckling**

### Internal Loads

**Axial Buckling Force**

### Internal Loads

**Shear Force**

### Internal Loads

**Horizontal Shear Force**

### Internal Loads

**Compression and Tension Forces**  
**Bending Moment**

### Internal Loads

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- Internal Loadings Developed in Structural Members
- Before a structural member can be sized or designed, the forces and moments that act on the member must be determined.
- In this section, we will develop methods to calculate the forces and moment at any point along the member's axis.

### Internal Loads

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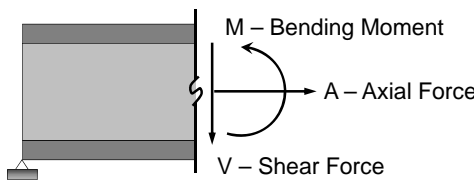
#### Internal Loadings at a Specified Point

- In general, the internal load at a specified point can be determined by the **method of sections**
- Typically, coplanar structures are subject to internal loadings that may consist of an axial force **A**, a shear force **V**, and the bending moment **M**

### Internal Loads

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#### Internal Loadings at a Specified Point

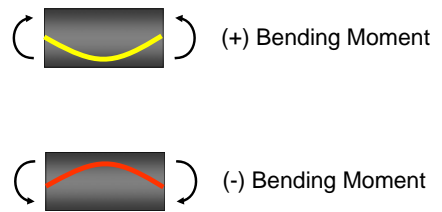


The diagram shows a vertical structural member with a pin support at the bottom. At a specific point, three internal forces are shown: a curved arrow labeled 'M - Bending Moment', a horizontal arrow pointing to the right labeled 'A - Axial Force', and a vertical arrow pointing downwards labeled 'V - Shear Force'.

### Internal Loads

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#### Internal Loadings at a Specified Point

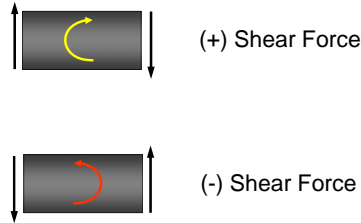


Two diagrams illustrate bending moments. The top diagram shows a yellow curve concave upwards, labeled '(+) Bending Moment'. The bottom diagram shows a red curve concave downwards, labeled '(-) Bending Moment'.

### Internal Loads

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#### Internal Loadings at a Specified Point



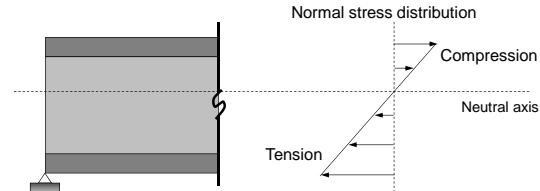
Two diagrams illustrate shear forces. The top diagram shows a yellow curved arrow pointing clockwise, labeled '(+) Shear Force'. The bottom diagram shows a red curved arrow pointing counter-clockwise, labeled '(-) Shear Force'.

### Internal Loads

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#### Internal Loadings at a Specified Point

- These three types of loadings are used to represent the **stress distribution** acting over the member cross-section



The diagram shows a structural member with a pin support at the bottom. To its right, a cross-section is shown with a 'Normal stress distribution' graph. The graph is a straight line passing through a horizontal dashed line labeled 'Neutral axis'. The top part of the graph is labeled 'Compression' and the bottom part is labeled 'Tension'.

### Internal Loads

**Procedure for analysis** - the following is a procedure for determining the internal forces in a member using the method of sections:

1. Before the member is "cut" or sectioned, determine the support reactions for the structure.
2. Keeping all external loadings in their exact locations, make an imaginary "cut" through the member at the point where the internal loading is desired.

Draw the corresponding free-body diagram of one of the "cut" segments indicating the unknown reactions **A**, **V**, and **M** acting in their positive (+) directions

### Internal Loads

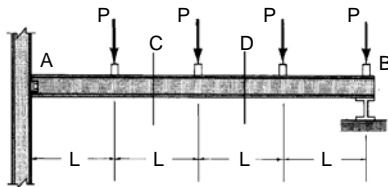
**Procedure for analysis** - the following is a procedure for determining the internal forces in a member using the method of sections:

3. Apply the three equations of equilibrium.

In most cases, the moment equation should be summed at the cut section about the *centroid* of the member cross-section to eliminate the unknowns **A** and **V**.

### Internal Loads

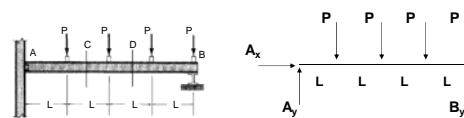
**Example:** Consider the following beam



Determine the shear and moment in the floor girder at points C and D (both points are at the center of each span L).

### Internal Loads

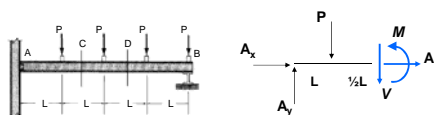
**Example:** Consider the following beam



$$\begin{aligned} \sum^+ M_A = 0 &= -P(L + 2L + 3L + 4L) + B_y(4L) & B_y &= 2.5P \\ \sum^+ F_y = 0 &= A_y + B_y - 4P & A_y &= 1.5P \\ \sum^+ F_x = 0 &= A_x \end{aligned}$$

### Internal Loads

Cut the beam at point C



$$\begin{aligned} \sum^+ M_{cut} = 0 &= M + P\frac{L}{2} - A_y\frac{3L}{2} & M &= 1.75PL \\ \sum^+ F_y = 0 &= A_y - V - P & V &= 0.5P \\ \sum^+ F_x = 0 &= A_x \end{aligned}$$

### Internal Loads

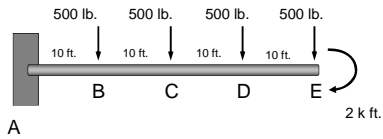
Cut the beam at point D



$$\begin{aligned} \sum^+ M_{cut} = 0 &= M + P\frac{L}{2} + P\frac{3L}{2} - A_y\frac{5L}{2} & M &= 1.75PL \\ \sum^+ F_y = 0 &= A_y - V - P - P \\ \sum^+ F_x = 0 &= A_x \end{aligned}$$

### Internal Loads

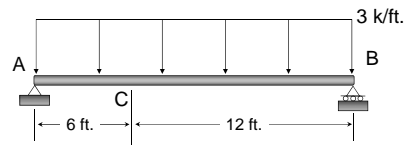
**Example:** Consider the following beam



Determine the internal shear and moment in the cantilever beam shown above at a section passing through point C.

### Internal Loads

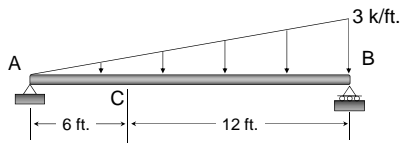
**Example:** Consider the following beam



Determine the internal shear and moment at a section passing through point C.

### Internal Loads

**Example:** Consider the following beam



Determine the internal shear and moment in the at a section passing through point C.

### End of Internal Loads – Part 1

Any questions?

