Summary: Stress analysis in beams

• For most problems, you will need the external support reactions
  • Draw an FBD and enforce equilibrium to find the reactions

• To calculate stresses, you need the internal shear force and bending moment
  • Method 1: Make a cut, draw an FBD, and use equilibrium to find \( V \) and \( M \)
    • Most useful if you are asked to find stresses at a particular location on the beam
  • Method 2: Draw the shear force and bending moment diagrams for the beam
    • You can use integration or inspection to draw the diagrams (see Lecture Book Ch. 9, Pg. 7 and 9)
    • Most useful if you need to find the maximum flexural stress or transverse shear stress in the beam

• Recall our sign convention:
Summary: Stress analysis in beams

- Distributions of flexural stress and transverse shear stress on a cross section

\[
\sigma_x = \frac{-My}{I_{O,z}}
\]

\[
\tau_{xy} = \frac{VQ}{I_{O,z}t} = \frac{V\bar{y}^*}{I_{O,z}t}
\]
Summary: Stress analysis in beams

• Assumptions:
  • Long beams ($L > 4h$) $\rightarrow$ neglect deformation due to shear (plane sections remain plane)
  • Thin beams ($h > 2b$) $\rightarrow$ transverse shear stress is constant in the $z$ direction

• Other reminders
  • The normal stress is a maximum at top/bottom surface. It is zero at the neutral surface.
    • If the cross section is not symmetric about the neutral surface, the maximum tensile stress and maximum compressive stress will be different.
  • The transverse shear stress is a maximum at the neutral surface if the cross section is symmetric about the neutral surface, OR the minimum thickness of the cross section is at the neutral surface (e.g. a T-shaped cross section)
    • Solid rectangular section: $\tau_{\text{max}} = \frac{3V}{2A}$  
      Solid circular section: $\tau_{\text{max}} = \frac{4V}{3A}$ where $A =$ area of the entire cross section
  • The transverse shear stress is zero at the top and bottom surface
  • The transverse shear stress acts in the same direction as the shear force