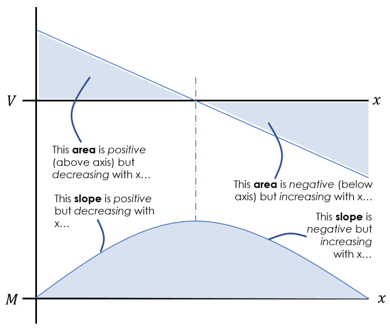
STUDENT SUCCESS CENTER
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

MECHANICS OF MATERIALS: NORMAL & SHEAR STRESS

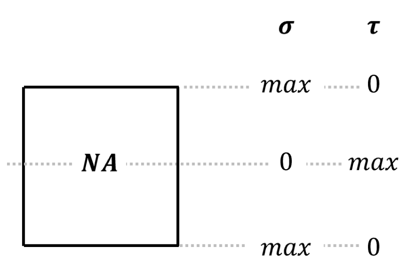
Normal Stress Caused by Bending:

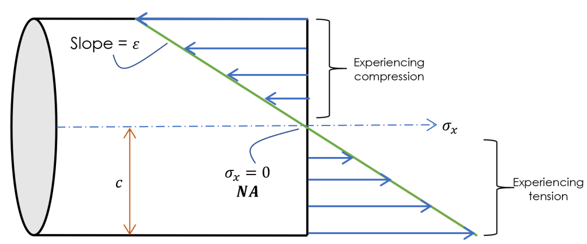
- Recall shear and moment calculation and graphing techniques:



Load (w)	**Shear (V)**	**Mon (M**
0	0	(
$-w$ (constant)	wx (linear)	w (para
$-wx$ (linear)	wx^2(parabolic)	w
$-wx^2$ (parabolic)	wx^3	w

- The Neutral Axis is the axis at which a member in bending experiences no normal stress:





- When bending, we observe how stress varies as a point moves away from the Neutral Axis.

$$\varepsilon = -\frac{y}{c}\cdot\varepsilon_{max} \quad such\ that\ \ \sigma_x = E\left(-\frac{y}{c}\right)\cdot\varepsilon_{max} \quad and \quad \sigma_x = -\frac{y}{c}\cdot\sigma_{max}$$

$$I = \int y^2 dA = \frac{Mc}{\sigma_{max}} \quad or \quad \sigma_x = -\frac{My}{I}\ for\ any\ y$$

The negative sign is necessary because for a positive point, the beam experiences compression

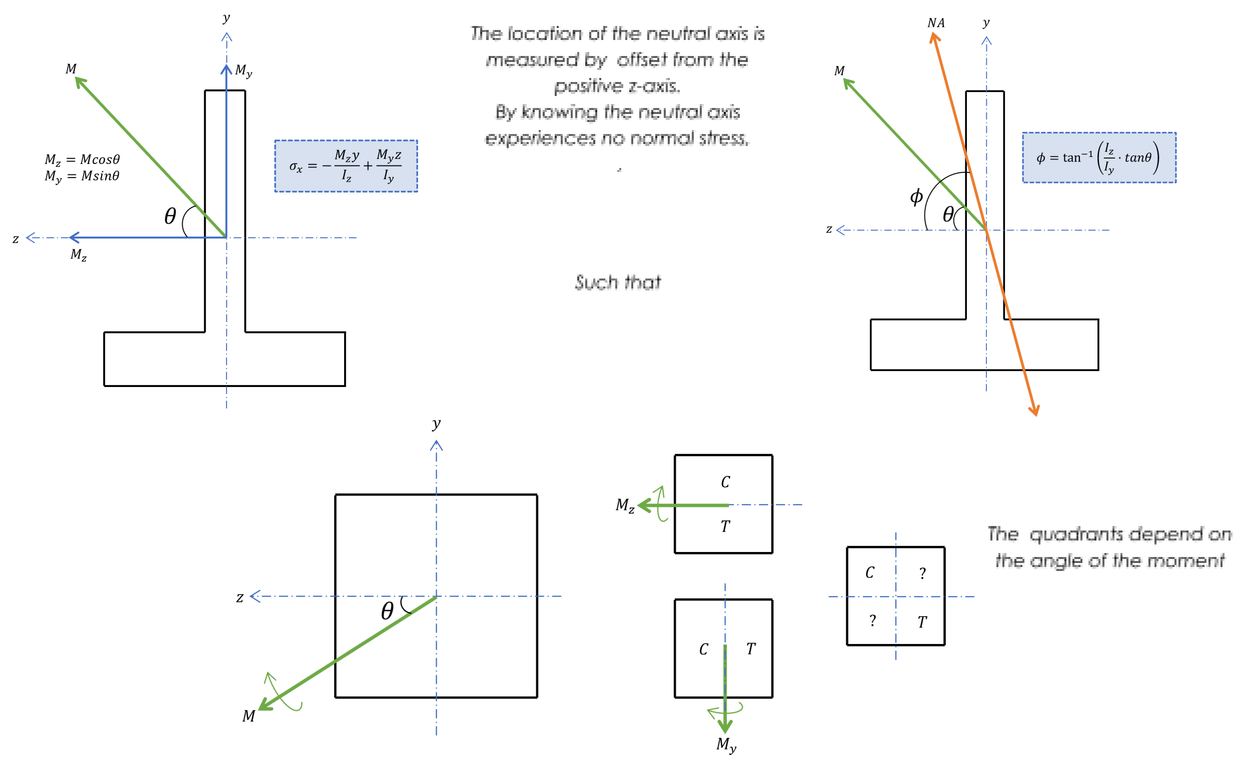
Rectangle	$I_{rectangle} = \frac{1}{12}bh^3$
Circle	$I_{circle} = \frac{1}{4}\pi R^4$
Triangle	$I_{triangle} = \frac{1}{36}bh^3$

- The Parallel Axis Theorem is often used for objects that are not strictly rectangular or circular, but rather are comprised of several shapes:

Semi-circle	$I_{semicircle} = \frac{1}{8}\pi R^4$
b is in the direction parallel (‖) to the NA	
h is in the direction perpendicular (⊥) to the NA	

$$I_i = I' + A_i d_i^2$$

- Unsymmetrical bending due to moments at angles requires the moment vector be decomposed:



Shear Stress Caused By Shear Force:

$\bar{y}$	Distance from NA to the centro of A
A	Area above the point or above Shear Plane (opposite side of N

- There are two directions in which shear force acts: longitudinal (along the length of the beam) and transverse (on cut plane)
    1. Horizontal shear (longitudinal): $\Delta H = \frac{VQ}{I}\Delta x$
    2. Transverse shear: $\tau_{avg} = \frac{VQ}{It}$ and $\tau_{max} = 1.5 \cdot \frac{V_{max}}{A}$
- Shear flow (shear force per unit length): $q = \frac{\Delta H}{\Delta x} = \frac{VQ}{I}$

I	Moment of inertia of entire obje (independent of A or $\overline{y}$)
V	Transverse force applied
t	Thickness of the object at the point observed or Shear Plane

How to determine Q: