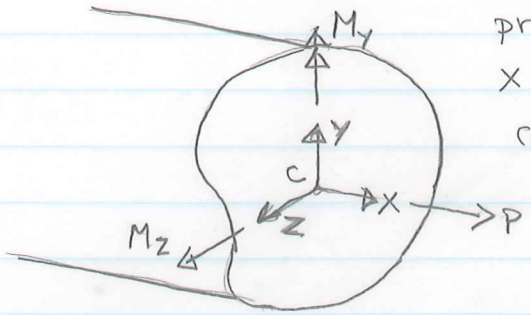
20. Combined axial load and bending
(linearly elastic, homogeneous, isotropic material)

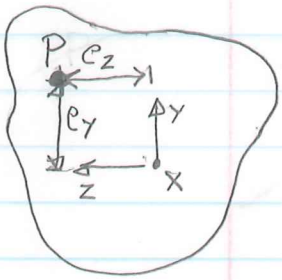
We will consider the following section resultants: axial force P and bending moments M_y and M_z. y and z are principal centroidal axes. P is in the x direction and is applied at the centroid.



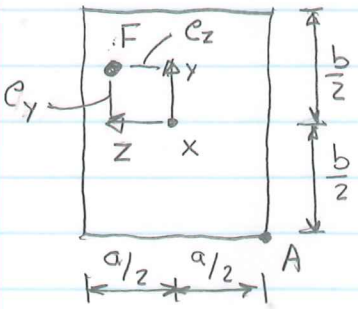
The St. Venant solution for stresses is

$$\sigma_x = \frac{P}{A} - \frac{M_z y}{I_z} + \frac{M_y z}{I_y}$$

If P is not applied at the centroid, then move it to the centroid and compensate by adding moments Pe_z about y and $-Pe_y$ about z.



Example: A compressive force F is applied to a rectangular cross-section. Determine under what conditions, if any, tensile stress σ_x can exist.



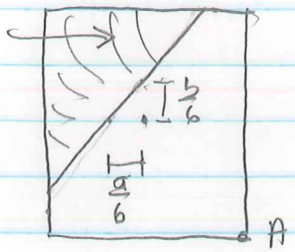
Tensile stress will most likely exist at A.

If true, $\sigma_{xA} = \frac{-F}{ab} + \frac{F \cdot e_z \cdot \frac{a}{2}}{\frac{1}{12}a^3 b} + \frac{F \cdot e_y \cdot \frac{b}{2}}{\frac{1}{12}ab^3} > 0$

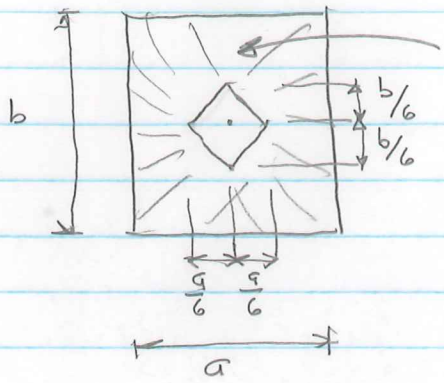
or $\frac{6e_z}{a} + \frac{6e_y}{b} \geq 1$

So tension at A is possible if F is located as shown below.

Tension at A if F located in this area.



The complete region is



Tension somewhere on the cross-section if F is applied outside the inner diamond.