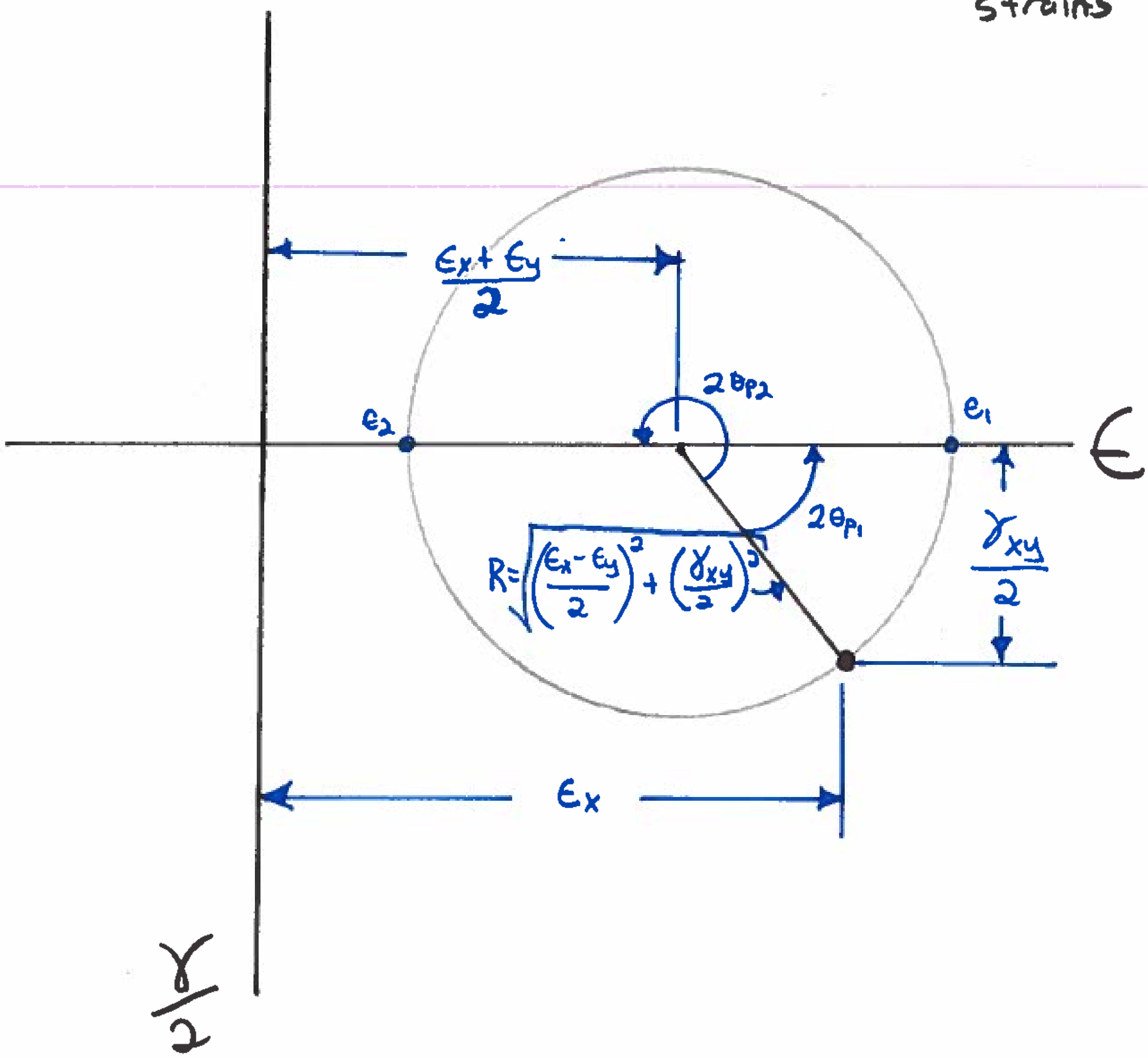
Mohr's Circle For Plane Strain

$\epsilon_1, \epsilon_2 \Rightarrow$ principal strains



Curved Beams in ~~Beats~~ Bending

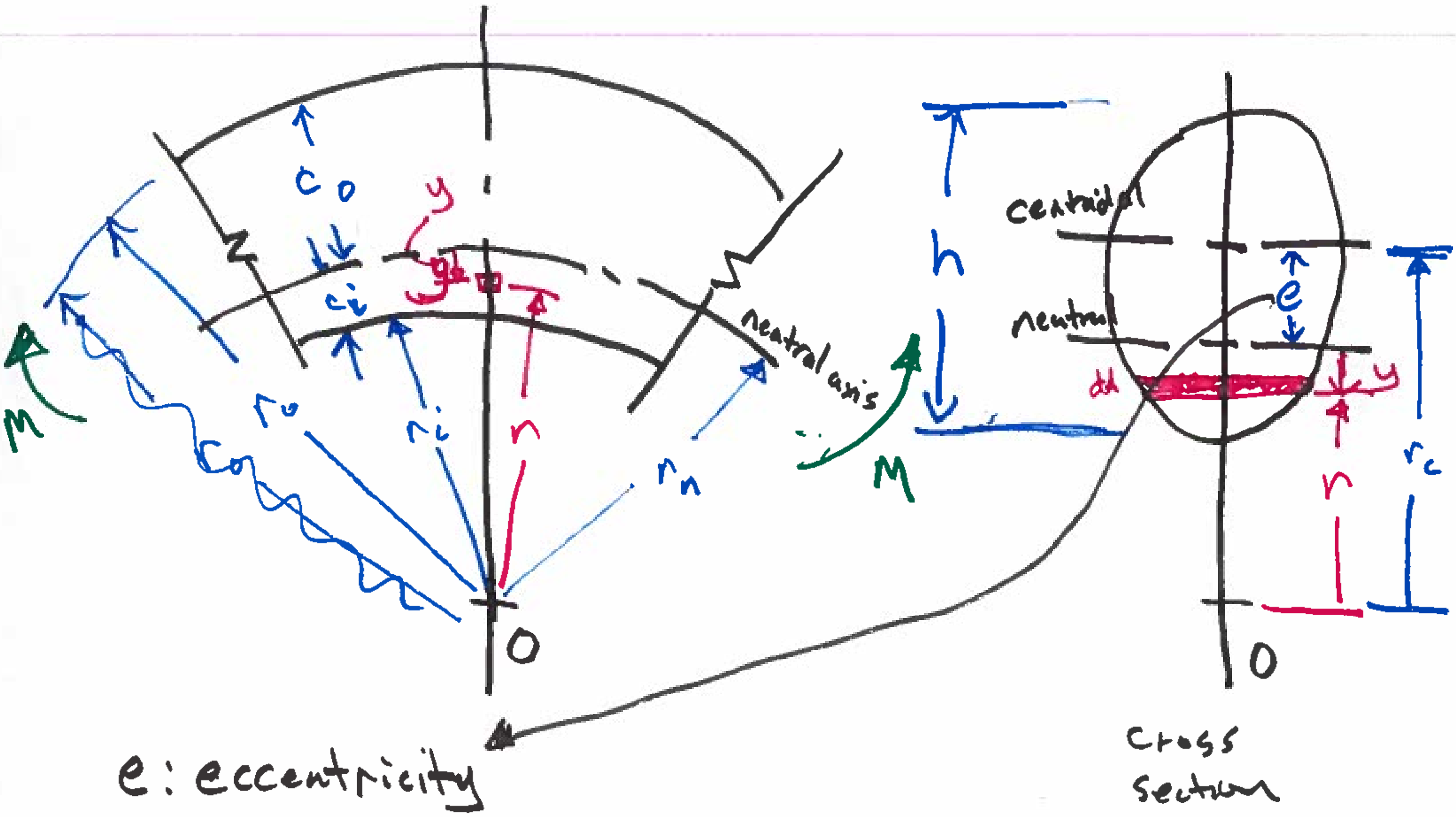
Can't use same analysis as straight beams!

Centroidal axis $\neq$ neutral axis

Assumptions

- cross section has axis of symmetry in the plane of bending
- plane cross sections remain plane
- modulus of elasticity is same tension and compression

M : decrease the curvature



e : eccentricity

③

neutral axis

$$r_n = \frac{A}{\int_{r_i}^{r_o} \frac{dA}{r}}$$

centroidal axis

$$r_c = \frac{\int_{r_i}^{r_o} r\,dA}{A}$$

Normal Stress Distributions

$$\sigma(y) = \frac{My}{Ae(r_n - y)}$$ hyperbolic function in y

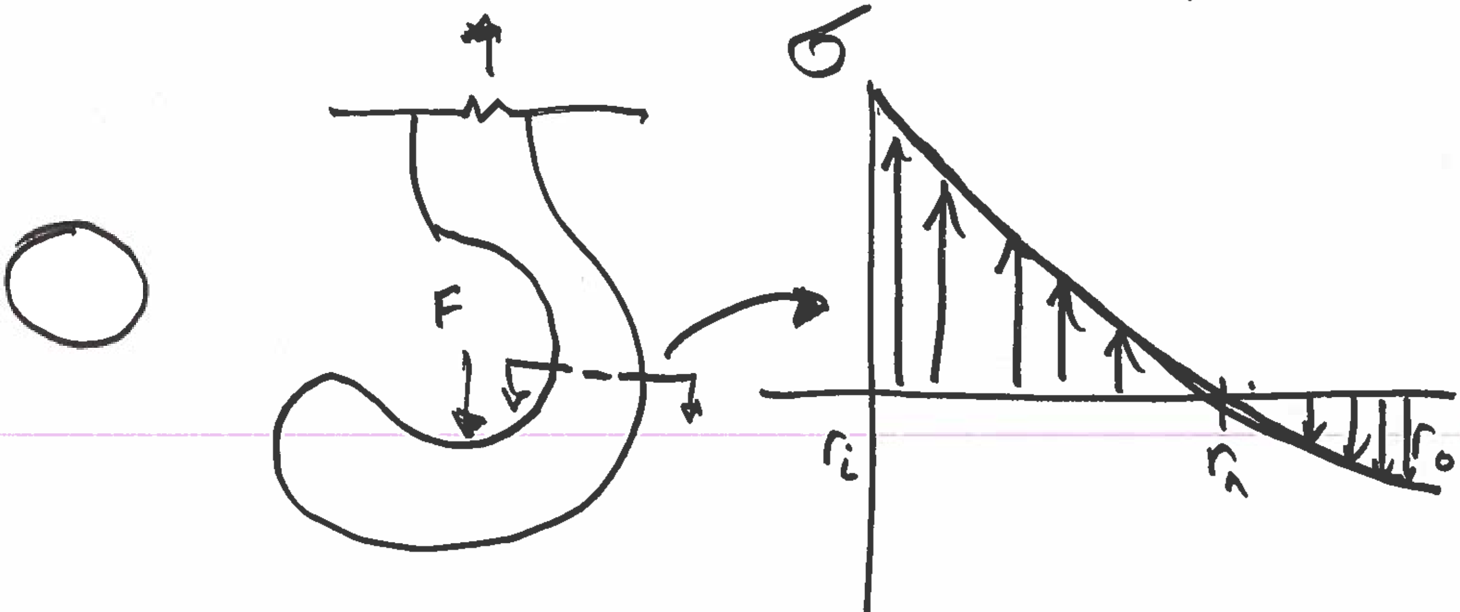
$$\sigma_i = \frac{\boxed{Mc_i}}{Ae r_i} \qquad \sigma_o = -\frac{Mc_o}{Ae r_o}$$

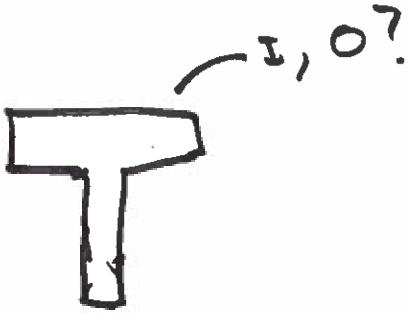
+ : tension

− : compression

Fig 3.35

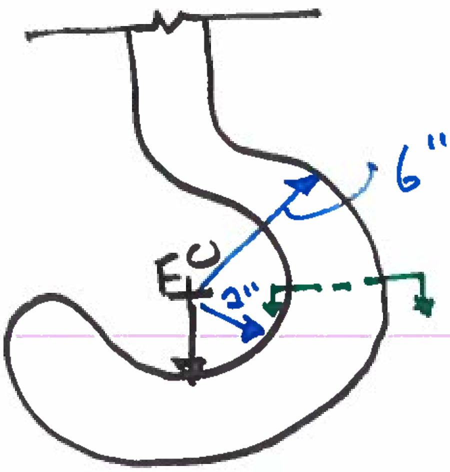
$\sigma_i > \sigma_o$

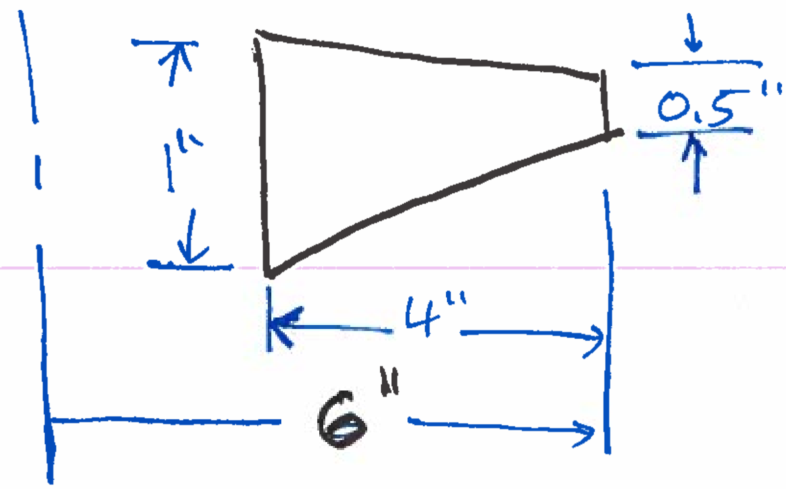




Example

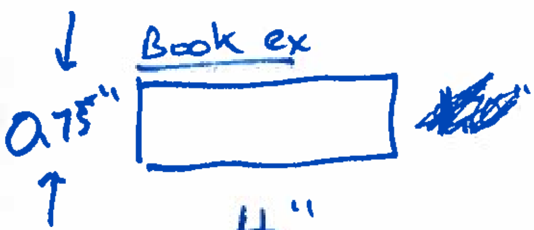
$F = 5000\,\text{lb}$





center

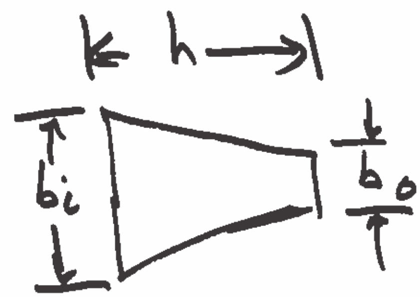
O



$\sigma_i = 16.9\ \text{kpsi}$

$\sigma_o = -5.63\ \text{kpsi}$

Table 3-4



$$r_c = r_i + \frac{h}{3}\,\frac{b_i + 2b_o}{b_i + b_o}$$

$$r_n = \frac{A}{b_o - b_i + \left[(b_i r_o - b_o r_i)/h\right]\ln\left(\frac{r_o}{r_i}\right)}$$

$$\sigma_i = \frac{M c_i}{A e r_i}$$

$$A = b_i h - \frac{(b_i - b_o)}{2} h$$

$$A \approx 3 \text{ in}^2$$

$r_i = 2"$

$h = 4"$

$b_i = \cancel{\#}\ 1"$

$b_o = 0.5"$

$r_o = 6"$

$c_i = r_n - r_i$

$r_n \approx 3.44"$

$c_i \approx 1.44"$

$e \approx 0.34"$

$$\sigma_i = \frac{(20000 \text{ in lb})(1.44")}{(3 \text{ in}^2)(0.34")(2")}$$

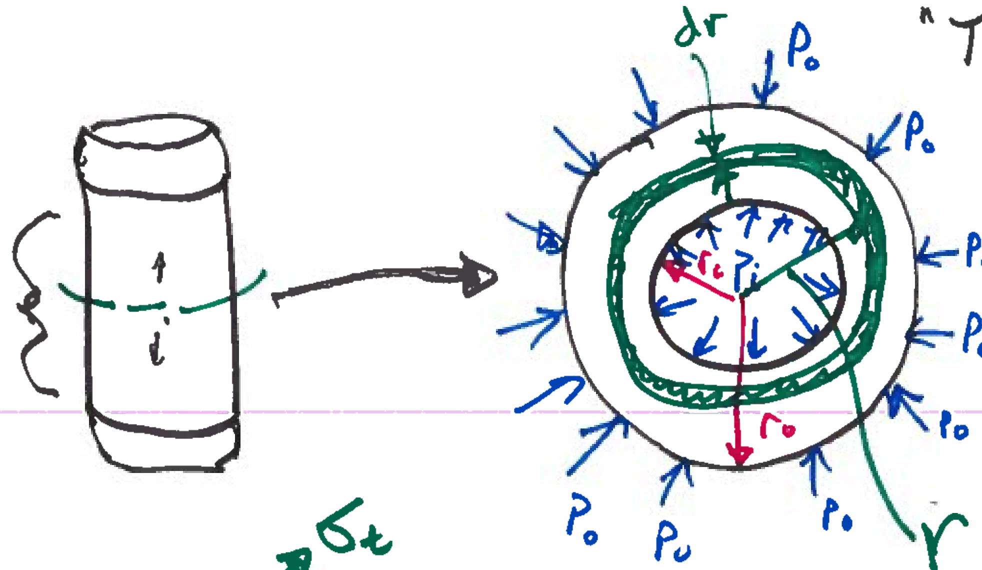
$$\sigma_i \simeq 14.1 \text{ Kpsi} < 16.9 \text{ Kpsi}$$

$\sigma_o = -7.3$ Kpsi

$\sigma_{o_{rect}} \Rightarrow -5.63$ Kpsi

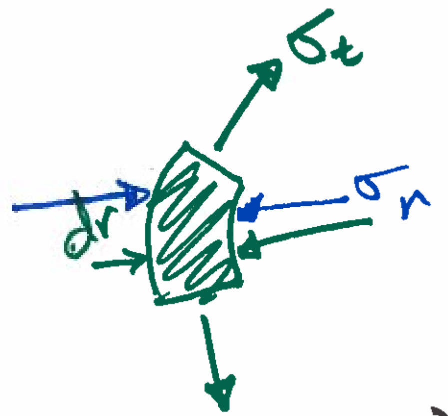
increased compression stress

Stress in Pressure Vessels



"Thick walled" vessel

wall thickness $> \frac{\text{radius}}{10}$



σ_r = radial stress

σ_t = tangential

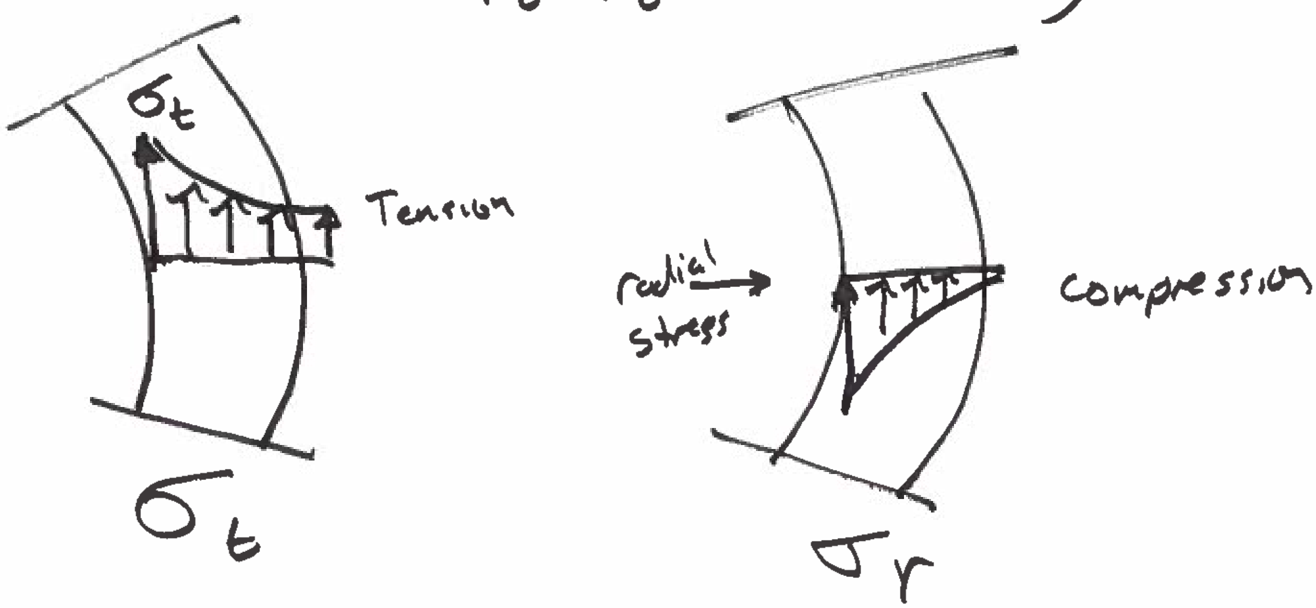
$$\sigma_t = \frac{p_i r_i^2 - p_o r_o^2 - r_i^2 r_o^2 (p_o - p_i)/r^2}{r_o^2 - r_i^2}$$

$$\sigma_r = \frac{p_i r_i^2 - p_o r_o^2 + r_i^2 r_o^2 \frac{(p_o - p_i)}{r^2}}{r_o^2 - r_i^2}$$

$P_o = 0$ Special Case

$$\sigma_t = \frac{r_i^2 p_i}{r_o^2 - r_i^2}\left(1 + \frac{r_i^2}{r^2}\right)$$

$$\sigma_r = \frac{r_i^2 p_i}{r_o^2 - r_i^2}\left(1 - \frac{r_o^2}{r^2}\right)$$



$P_o = 0$

Longitudinal stress

$$\sigma_l = \frac{p_i r_i^2}{r_o^2 - r_i^2}$$