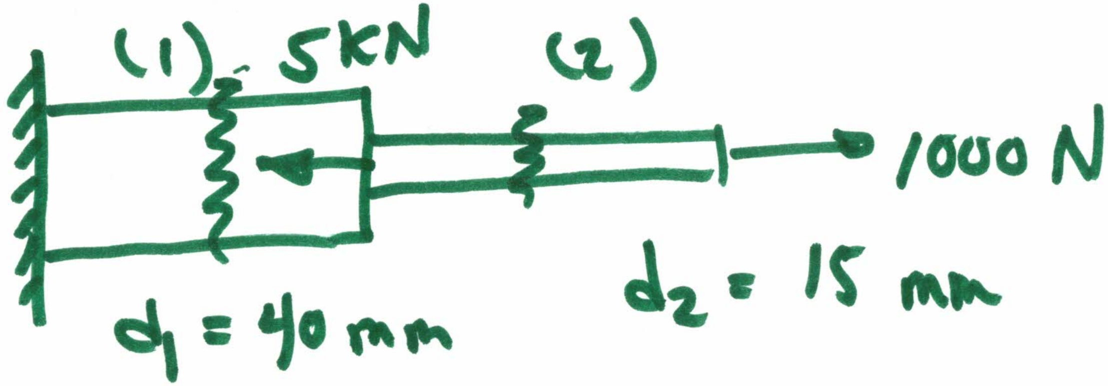
EXAMPLE:

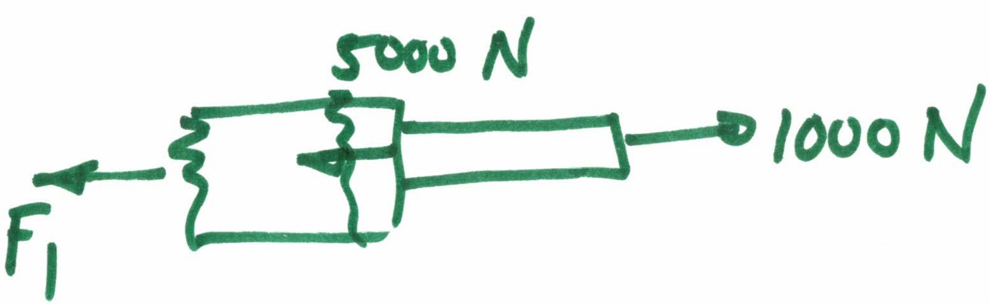
Find σ_1 & σ_2 (axial stresses)



$$\sigma = \frac{F}{A}$$

$\xrightarrow{+}$ $\sum F_x$ $\quad -F_2 + 1000 = 0 \quad F_2 = 1000$ N

$$\sigma_2 = \frac{1000\ \text{N}}{\frac{\pi}{4}\left(15 \times 10^{-3}\right)^2 \text{m}^2} = \underbrace{5.695}_{\text{3 or 4 sig. digits}} \text{ MPa}$$



$\xrightarrow{+}$ $\sum F$ $\quad -F_1 - 5000 + 1000 = 0$

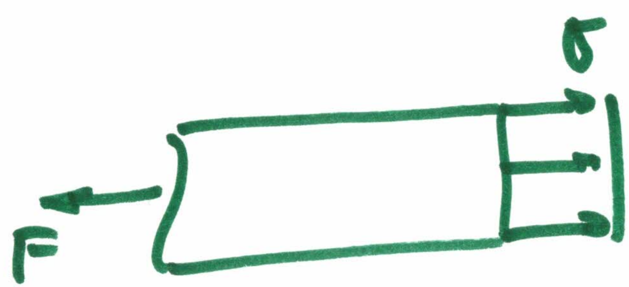
$F_1 = -4000$ N

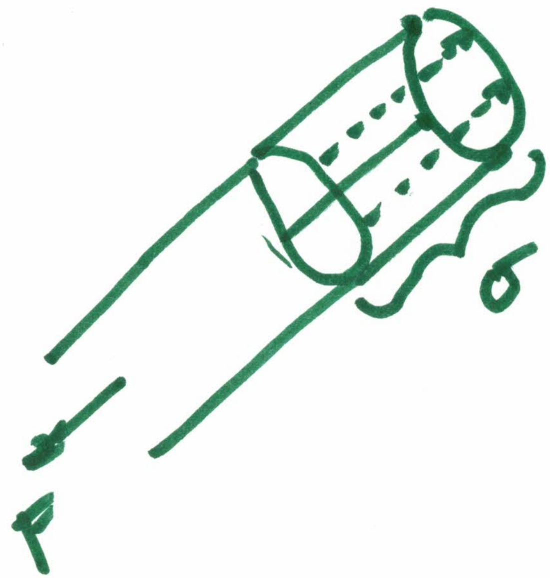
$$\sigma_1 = \frac{-4000\ \text{N}}{\pi/4\left(40 \times 10^{-3}\right)^2 \text{m}^2} = -3.183 \text{ MPa}$$

or

3.183 MPa (C)

3. Stress distribution – indicates how the stress varies on the cross-section





If the stress is the same everywhere on the x-section, then there is a <u>uniform</u> <u>stress</u> distribution.

To use $\sigma = \frac{F}{A}$, the axial force needs to be applied at the centroid of the x-section.

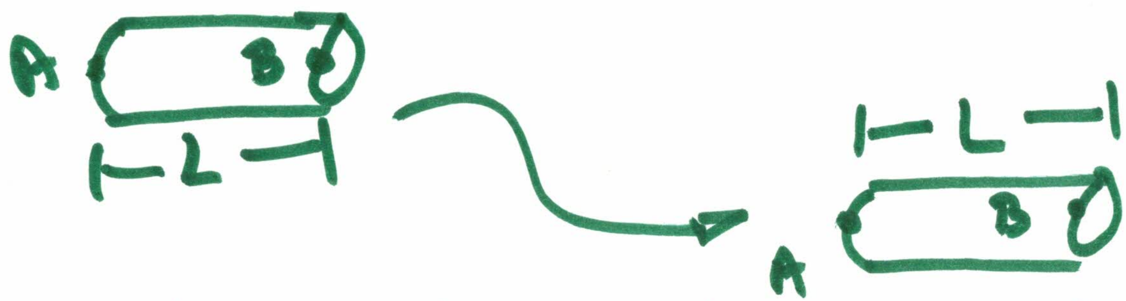
4. The resultant force is the volume of the stress distribution.

$$\text{Volume} = \sigma \cdot A_{base} = F_{RES}$$

$$\sigma = \frac{F}{A} \qquad F = \sigma \cdot A$$

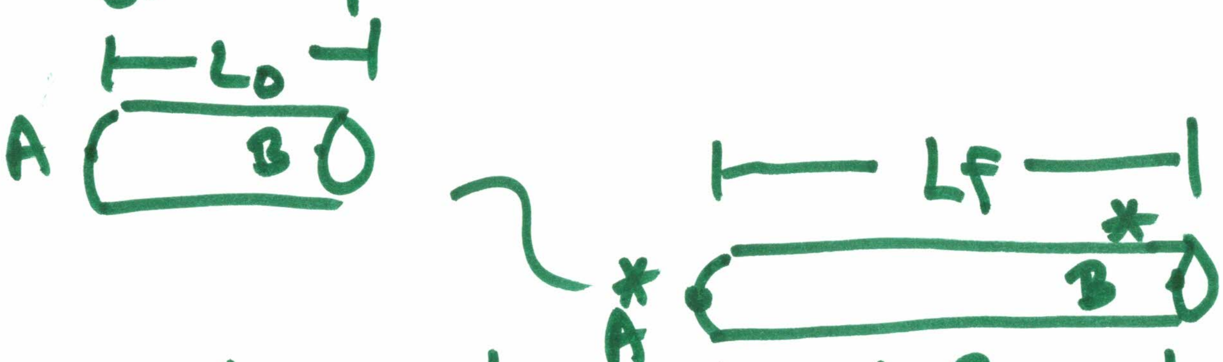
C. Concept of Strain

When structures are loaded, they may move (displace) or they can stretch / deform.



displacement

Displacement is the amount of movement of a point on the bar.



Displacement with deformation.
(stretching)

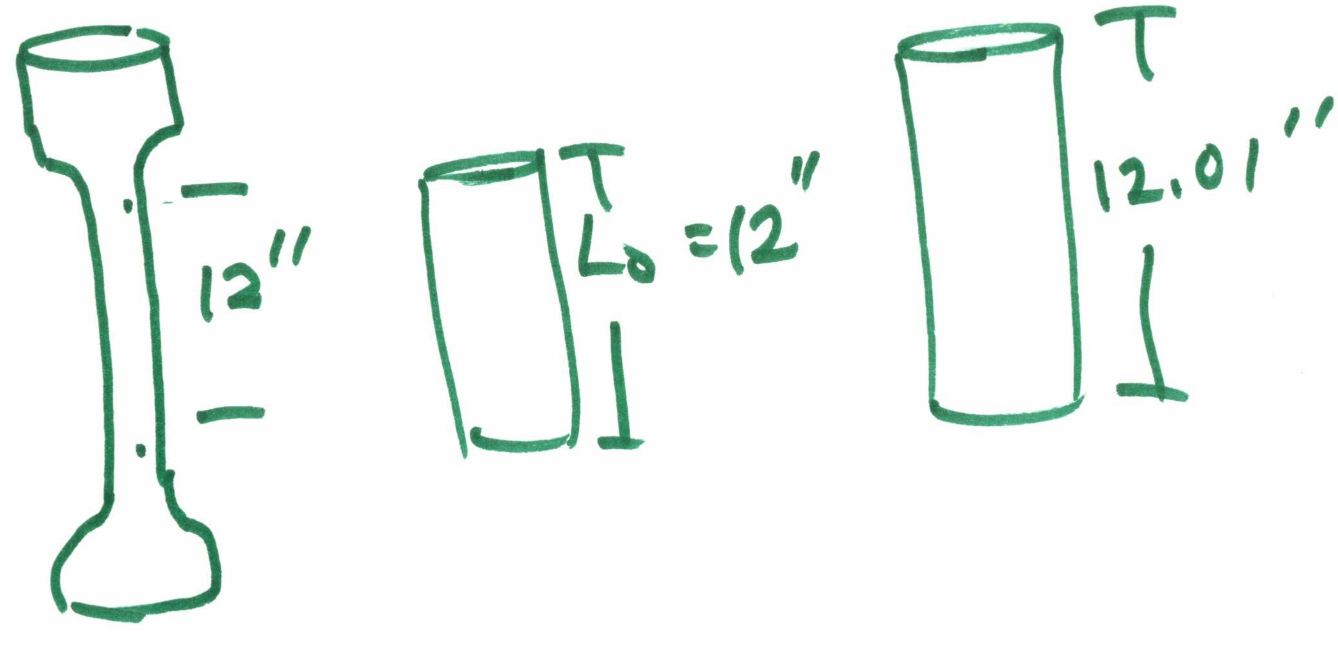
$\Delta L = L_f - L_0 = e$ deformation

1. normal or axial strain

$$\epsilon = \frac{\Delta L}{L_0}$$

if $\Delta L > 0$ $\epsilon > 0$ (unitless)

if $\Delta L < 0$ $\epsilon < 0$



$$\epsilon = \frac{\Delta L}{L_o} = \frac{12.01 - 12}{12} = \frac{0.01}{12} \frac{in}{in}$$

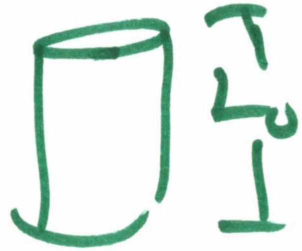
$$= 0.000833 \frac{in}{in} = 833 \times 10^{-6} \frac{in}{in}$$

$$= 833\mu \frac{in}{in}$$

$$= 833\mu$$

2. Thermal Strain

α - coefficient of thermal expansion



$$\epsilon^t = \alpha \Delta T$$

↳ thermal strain

Steel : $\alpha = 8 \times 10^{-6} \frac{1}{°F}$

$\epsilon = \frac{\Delta L}{L_o}$ $\Delta L = \epsilon L_o$

Boiler tube $L_o = 150$ ft

$\Delta L = \epsilon L_o$

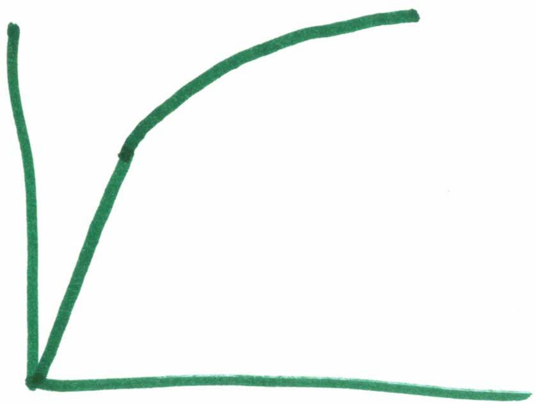
$= [\alpha \Delta T] L_o$

$\Delta L = \left(8 \times 10^{-6} \frac{1}{°F}\right)(1000 °F)(150 \text{ ft})$

$\Delta L = \underline{1.2 \text{ ft}}$

D. Stress-strain Diagrams

F



ΔL

Force - Deflection diagram

$\sigma = \frac{F}{A_0}$

$\epsilon = \frac{\Delta L}{L_0}$

stress-strain diagram