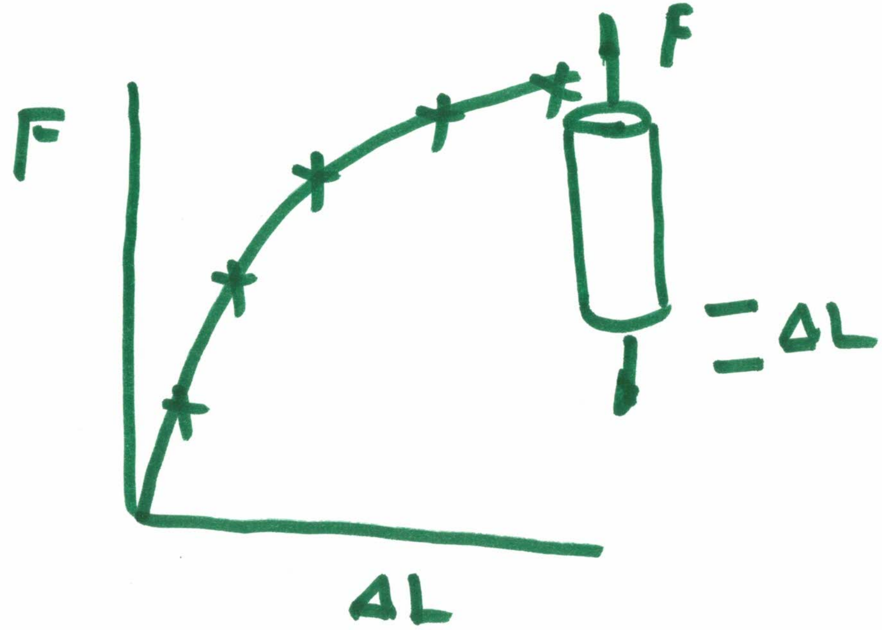
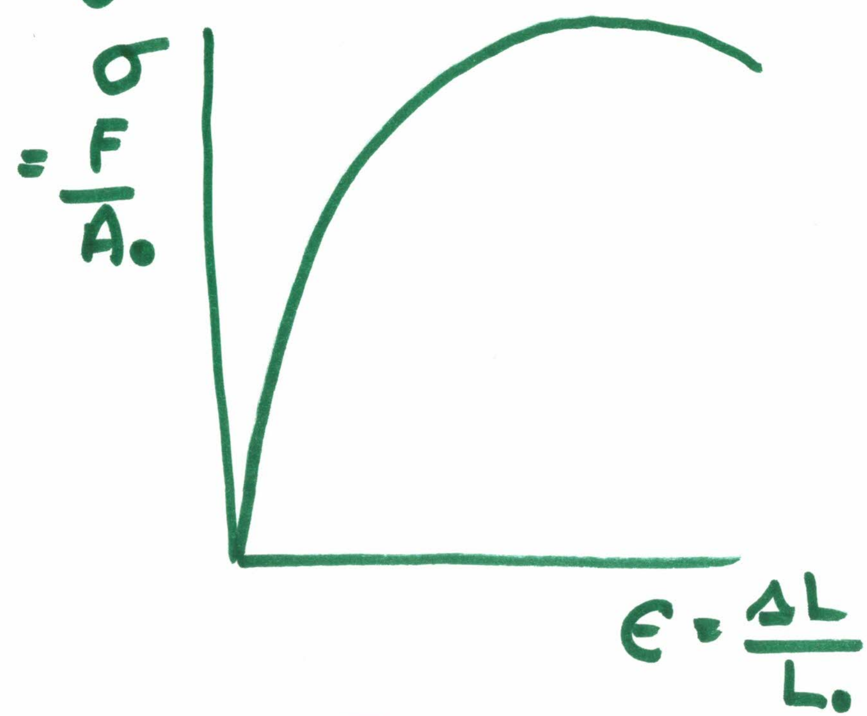
Free body diagram

- sketch of the structure that you draw where supports have been replaced by the appropriate reactions

D. Stress-Strain Diagrams





$F - \Delta L$ depends on size as well as material

$\sigma - \epsilon$ curve is a material property.

Engineering Stress

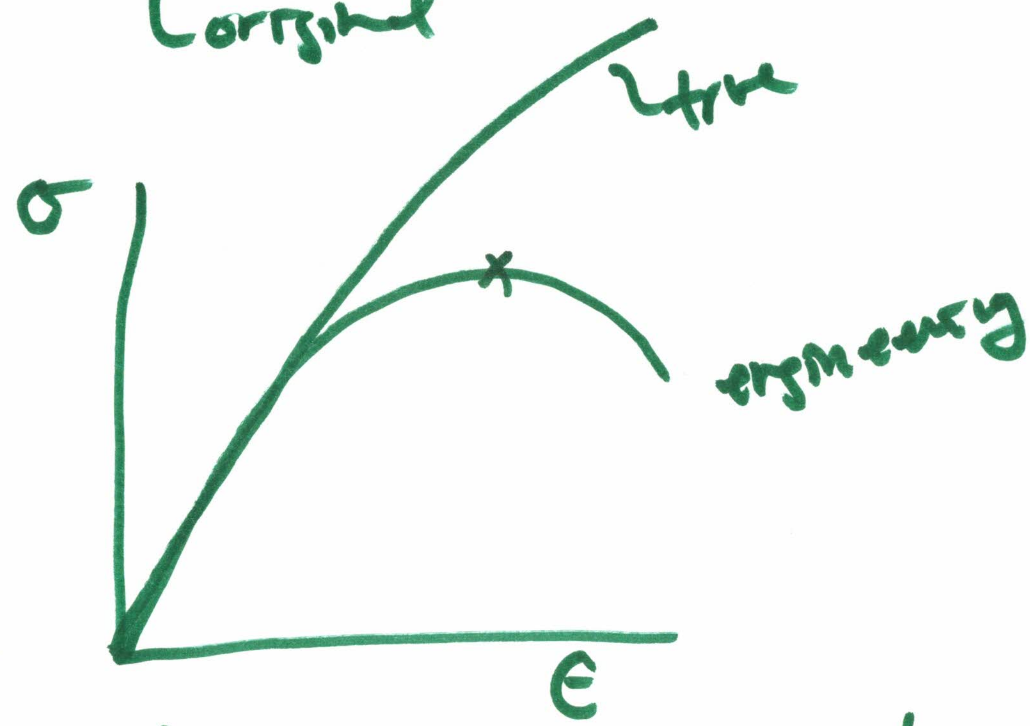
$$\sigma_{eng} = \frac{F}{A_o}$$

original

True Stress

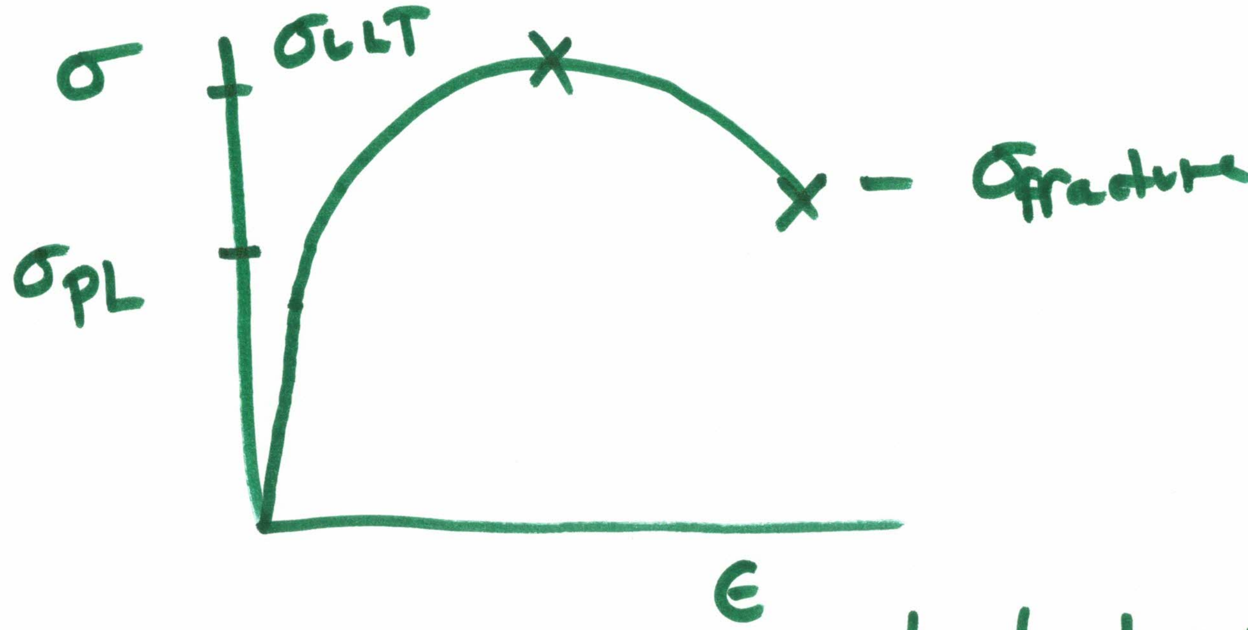
$$\sigma_{true} = \frac{F}{A_i}$$

instantaneous



We will use engineering stress & strain in AEM 250

1. Important parts of $\sigma - \epsilon$ curve



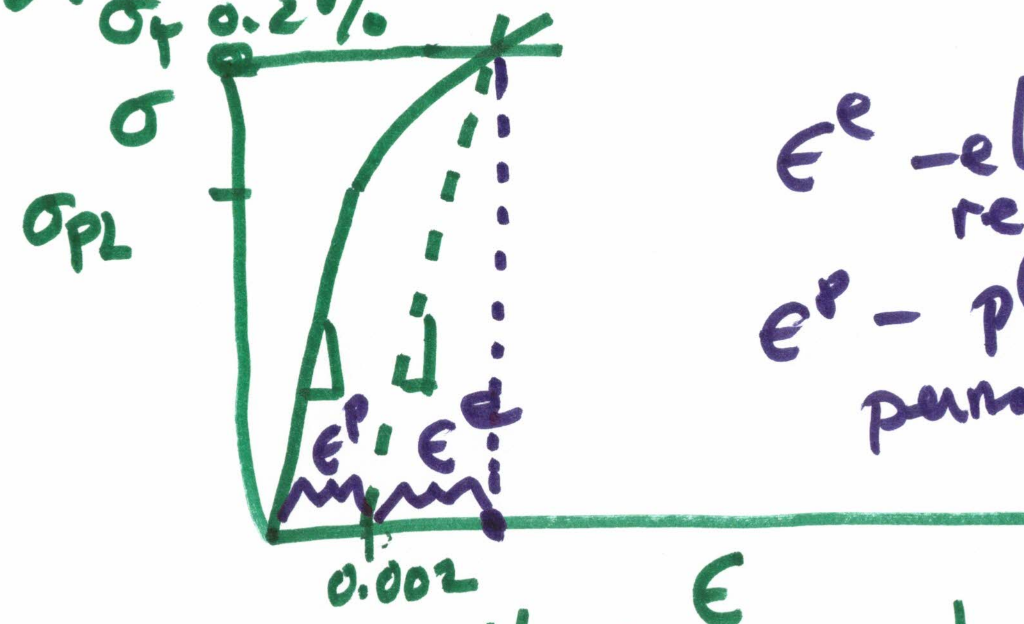
σ_{ULT} – ultimate stress – highest point on $\sigma - \epsilon$ curve

$\sigma_{fracture}$ – stress level at fracture

σ_{PL} – proportional limit stress

$\sigma_{PL} \sim \sigma_{y.s.}$ (yield stress)

2. Initial $\sigma - \epsilon$ curve



ϵ^{e} – elastic strain
recovered deformation

ϵ^{p} – plastic strain
permanent deformation

$\sigma_{Y.S.}$ – yield stress is where you have permanent deformation

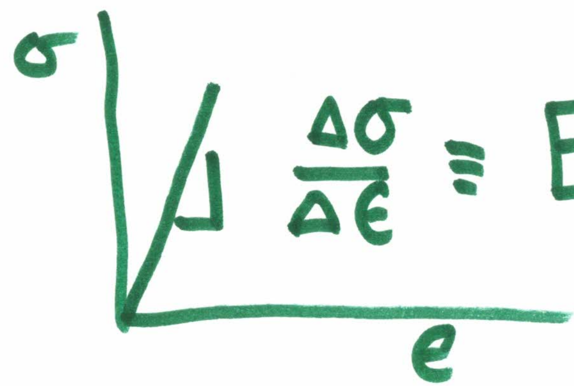
0.2% offset yield stress

$$0.2\% = 0.002 \ \frac{mm}{mm}$$

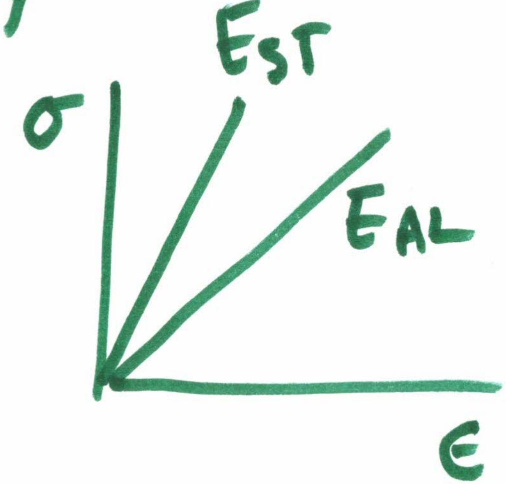
To find σ_Y 0.2%,

- start at 0.002 strain
- draw line parallel to initial σ-ϵ curve
- intersection of line & curve is σ_Y 0.2%

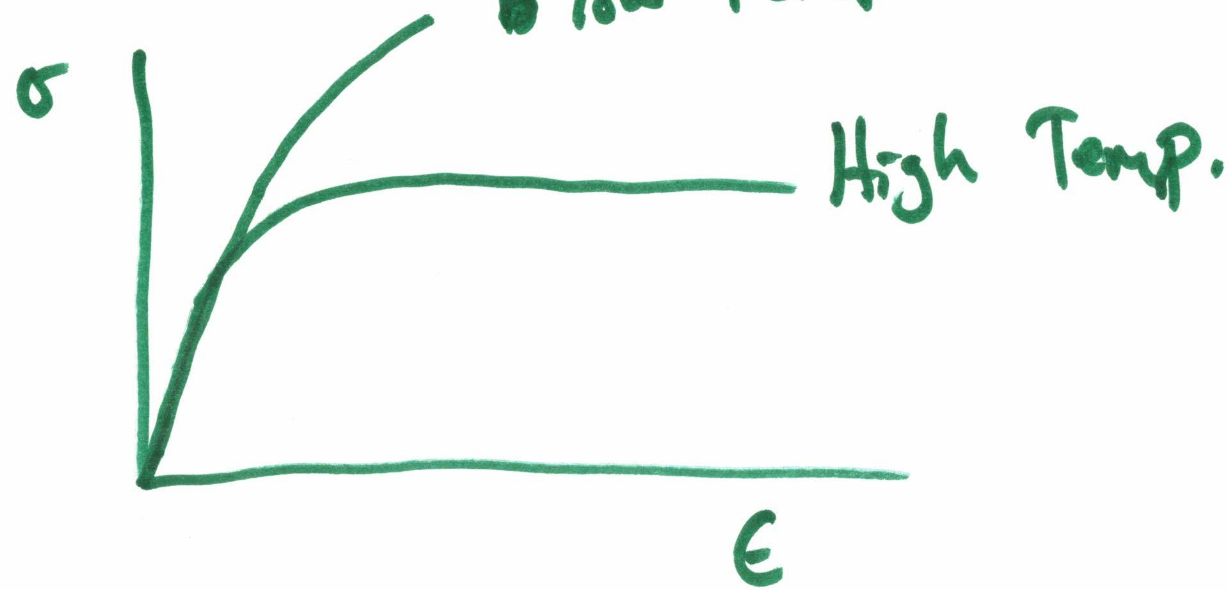
3. Modulus of Elasticity



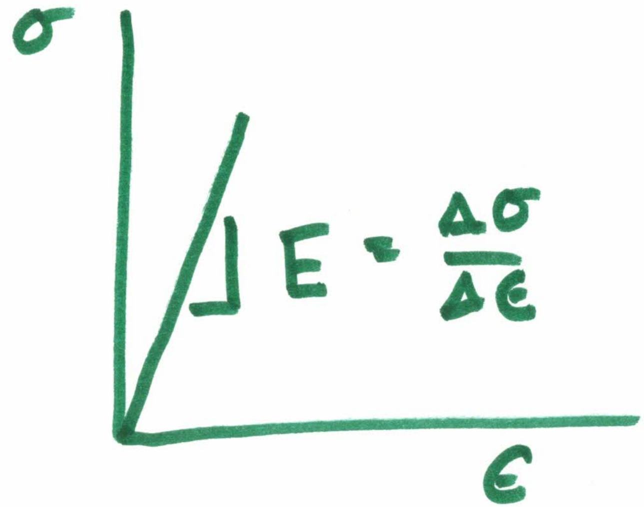
$$\frac{\Delta\sigma}{\Delta\epsilon} \equiv E$$



4. $\sigma - \epsilon$ curves depend on temperature



E. Hooke's Law

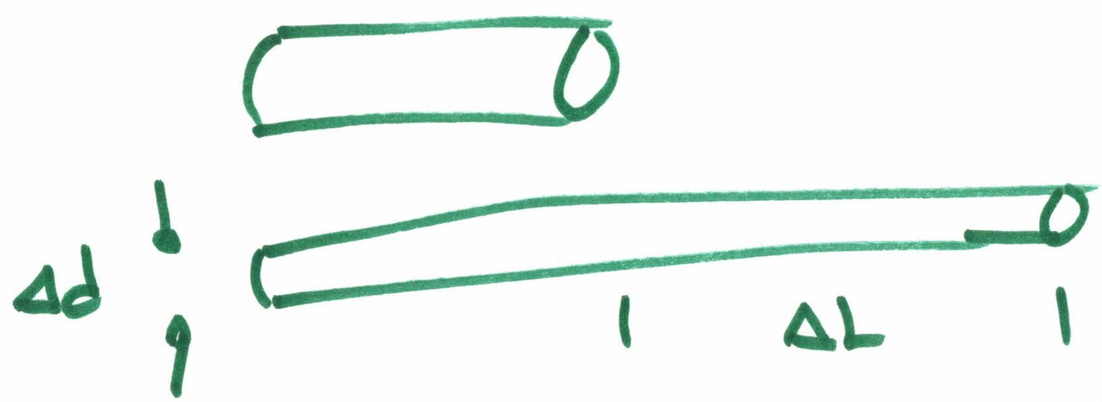


$$y = mx + b$$

$$\underbrace{\sigma = E\epsilon}_{\text{Hooke's Law}}$$

$$F = Kx$$

F. Poisson's Ratio



$$\epsilon_{axial} = \frac{\Delta L}{L_o}$$ positive

$$\epsilon_{dia} = \frac{\Delta d}{d_o}$$ negative value

$$\nu \equiv -\frac{\epsilon_{dia}}{\epsilon_{axial}}$$ } Poisson's Ratio

0.25 ~ 0.35 metals
0.50 ~ Rubber
0.0 ~ Cork

EXAMPLE: Steel bar

$E = 30 \times 10^{3}$ ksi $\quad \nu = 0.3 \quad \sigma_T = 50$ ksi

$= 30 \times 10^{6}$ psi

$L_0 = 4$ ft $\quad d_0 = 1.0$ in

Find ΔL, Δd if $P = 10$ kips

$$\sigma = E\,\epsilon$$

$$\frac{F}{A_0} = E\,\frac{\Delta L}{L_0} \qquad \Delta L = \frac{F}{A_0}\,\frac{L_0}{E}$$

$$\Delta L = \frac{10{,}000}{\pi/4\,(1)^2}\,\frac{(4)(12)}{30 \times 10^{6}} = 20.4 \times 10^{-3} \text{ in.}$$

$$\epsilon_{dia} = \frac{\Delta d}{d_o} \qquad \nu = \frac{-\epsilon_{dia}}{\epsilon_{axial}}$$

$$\epsilon_{dia} = -\nu\, \epsilon_{axial}$$

$$-\nu\, \epsilon_{axial} = \frac{\Delta d}{d_o}$$

$$\Delta d = -\nu\, \epsilon_{axial}\, d_o = -\nu \frac{\Delta L}{L_o} d_o$$

$$\Delta d = -0.3\, \frac{20.4 \times 10^{-3}}{48} (1.0) = -127.5 \times 10^{-6} \text{ in}$$