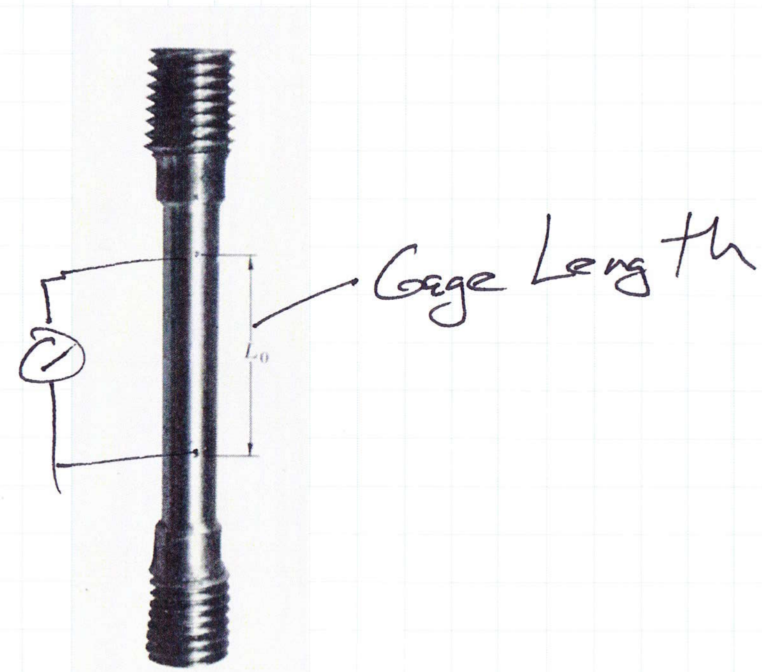
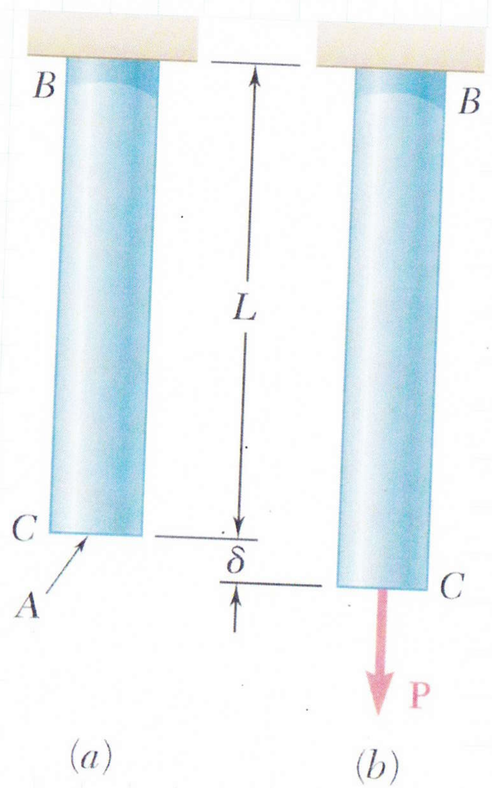
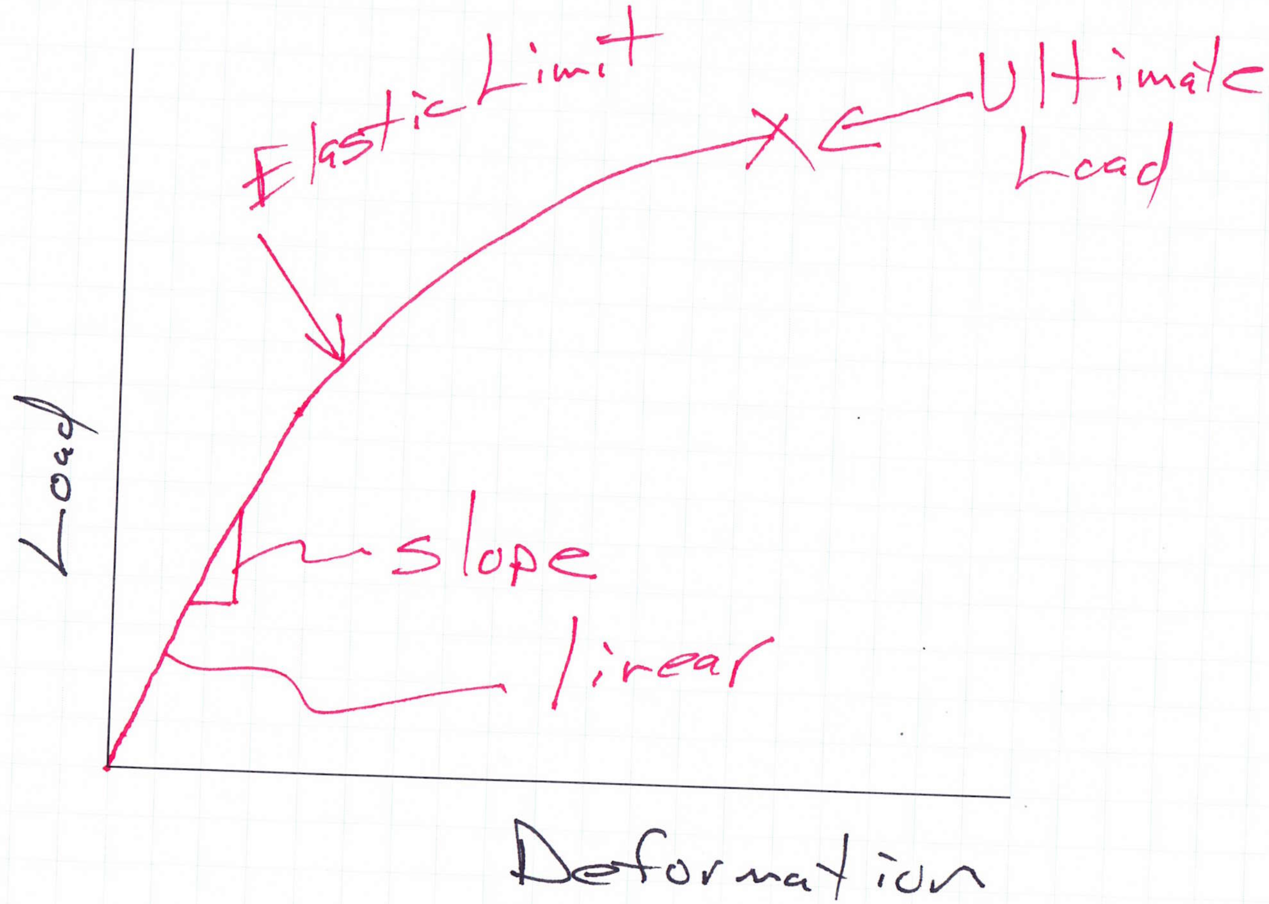
# Load vs Deformation

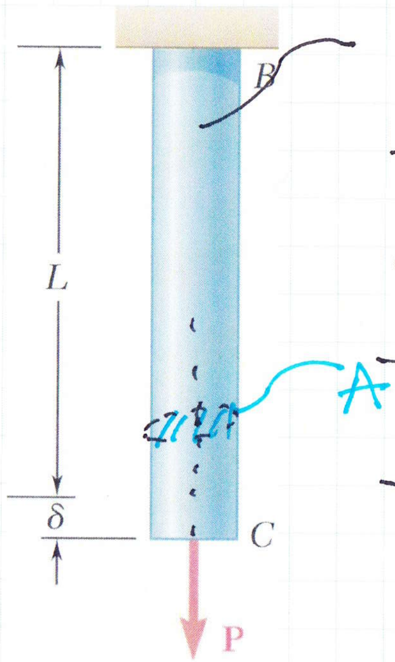


# Load vs Deformation



# Stress and Strain




Prismatic
Homogeneous
Centrically Loaded
Straight
Small deformations

Engineering Stress

$$\sigma_{AVG} = \frac{P}{A_{original}}$$

$\frac{lb}{in^2}$ $\frac{N}{m^2}$

Engineering Strain – by definition

$$\epsilon = \frac{\delta}{L_{original}}$$

$\frac{in}{in}$ $\frac{m}{m}$

PerCentage

$\mu\epsilon$ – micro strain $\times 10^{-6}$

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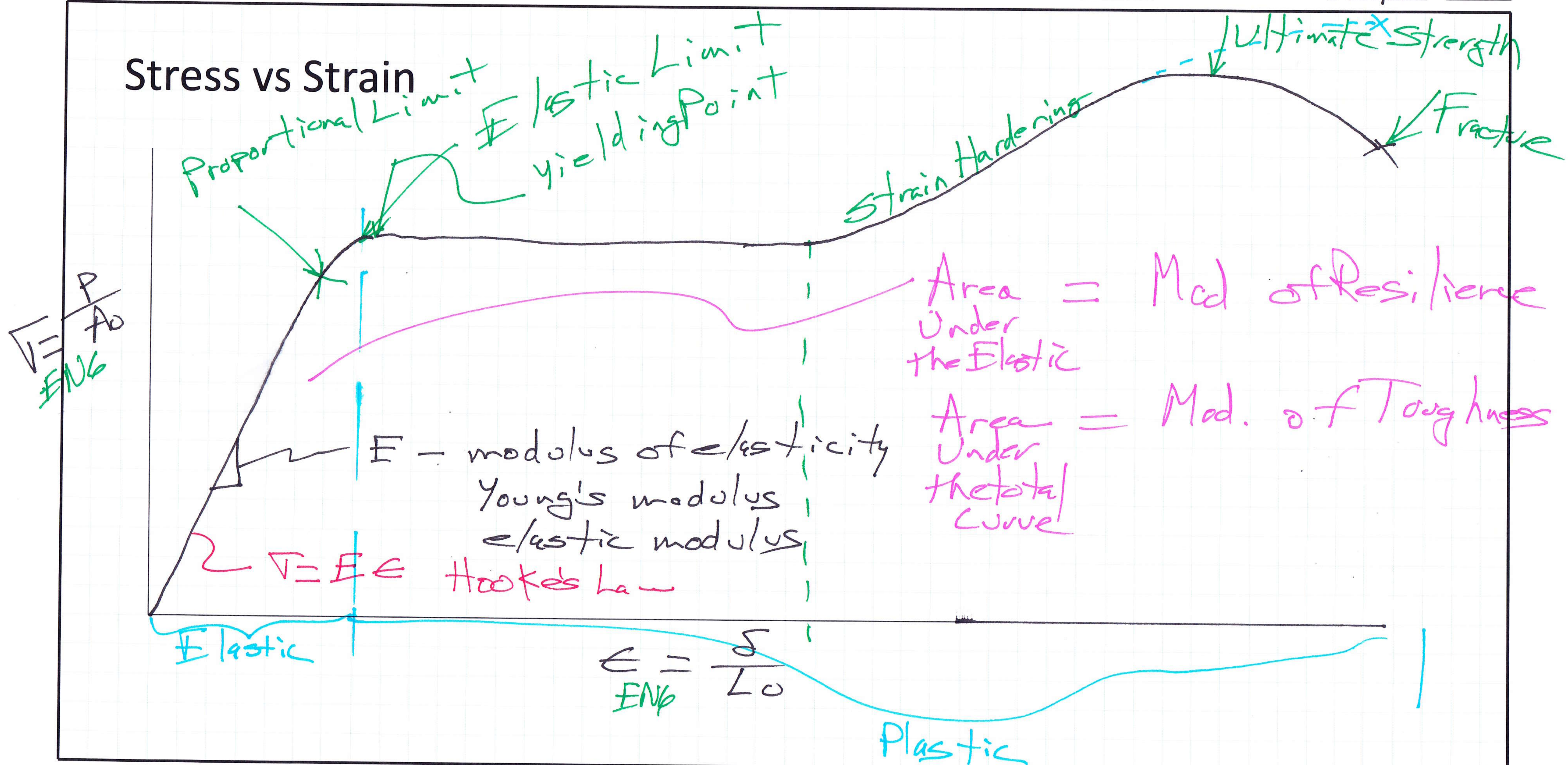


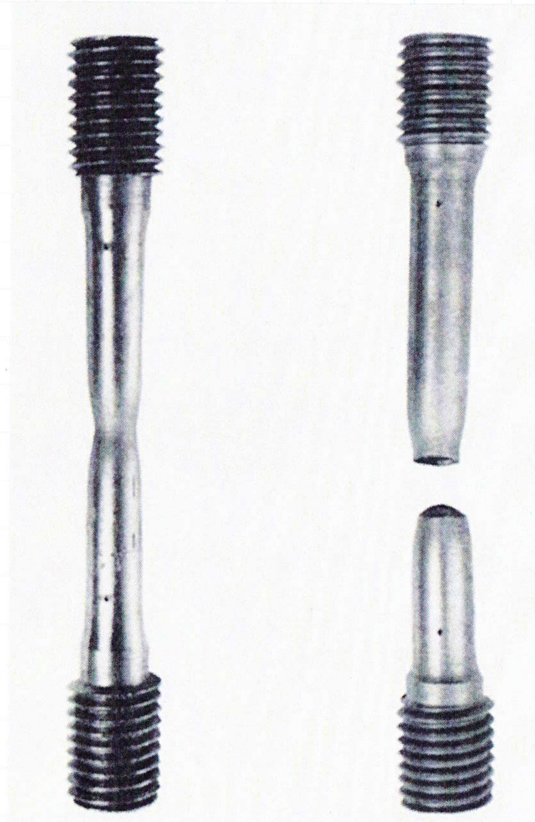
Elastic — when the load is removed the bar returns to its original length

Plastic — some of deformation is not recoverable

Linear — straight line relationship between load and deformation or stress and strain

NonLinear — No straight line relationship between load and deformation

# Behavior of Ductile Materials



(a) (b)

Experience Plastic Deformation

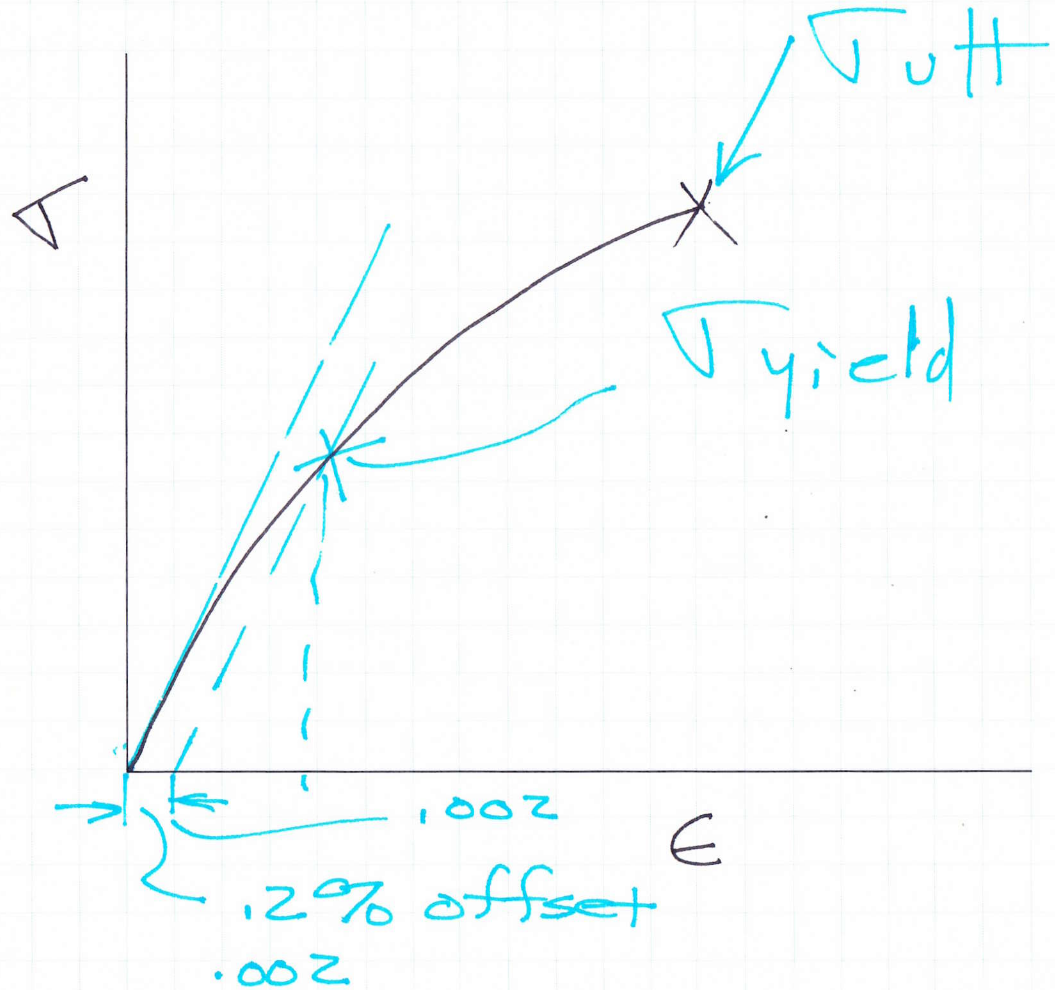
$$\text{Percent Elongation} = \frac{L_{final} - L_{orig}}{L_{orig}} \times 100\%$$

$$\text{Percent Reduction in Area} = \frac{A_{orig} - A_{final}}{A_{orig}} \times 100\%$$

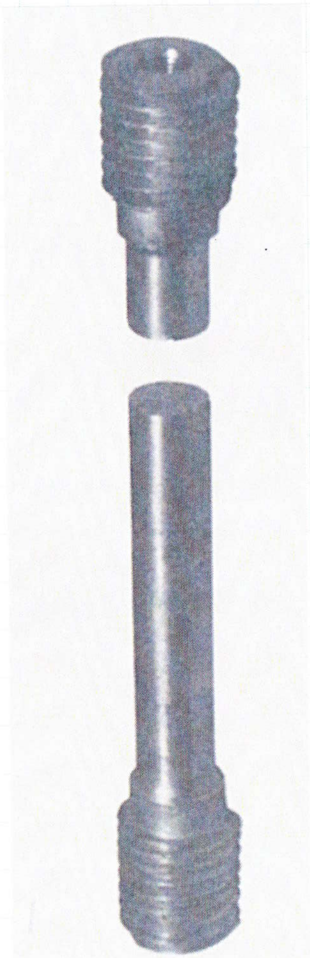
Modulus of Resilience – Area under the elastic portion

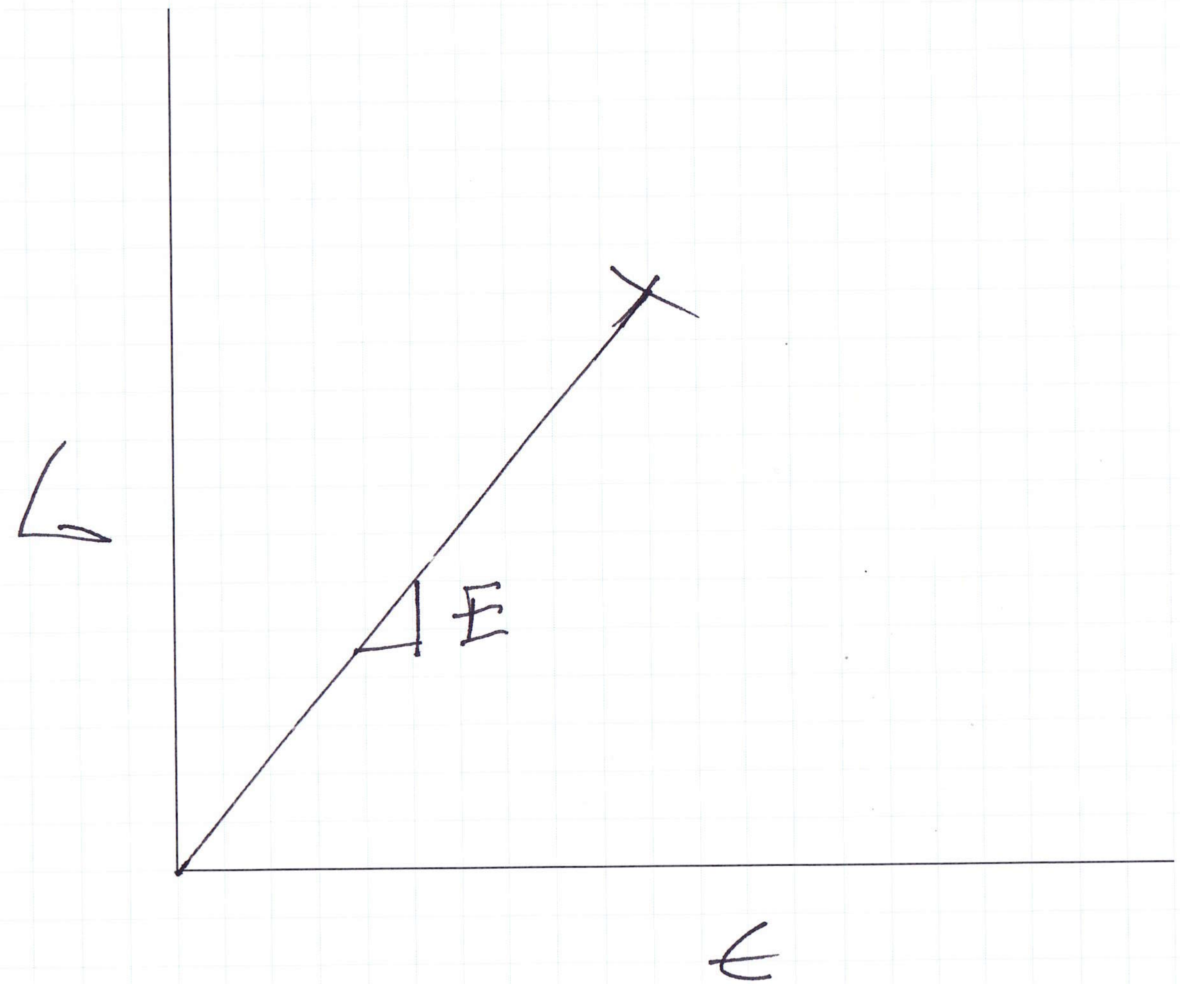
Modulus of Toughness – Area under the entire stress strain diagram

# Tangent Offset Method

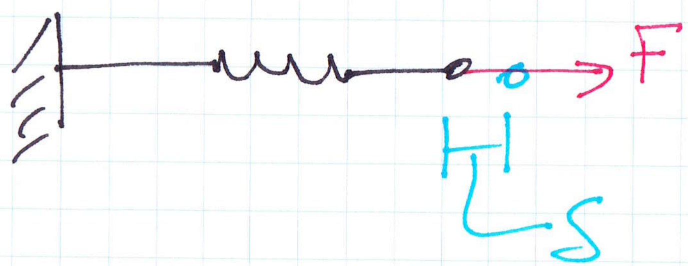


# Behavior of Brittle Materials



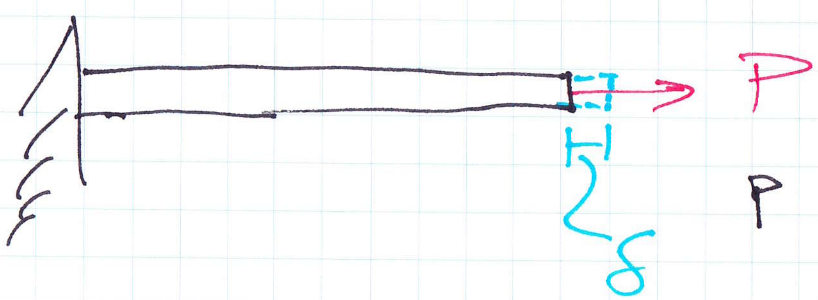


# Hooke's Law

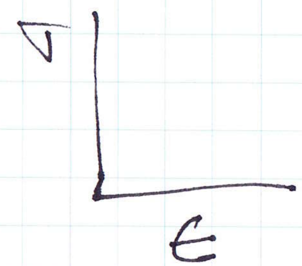



$F = k\,\delta$

k = spring constant




$P = k\,\delta$

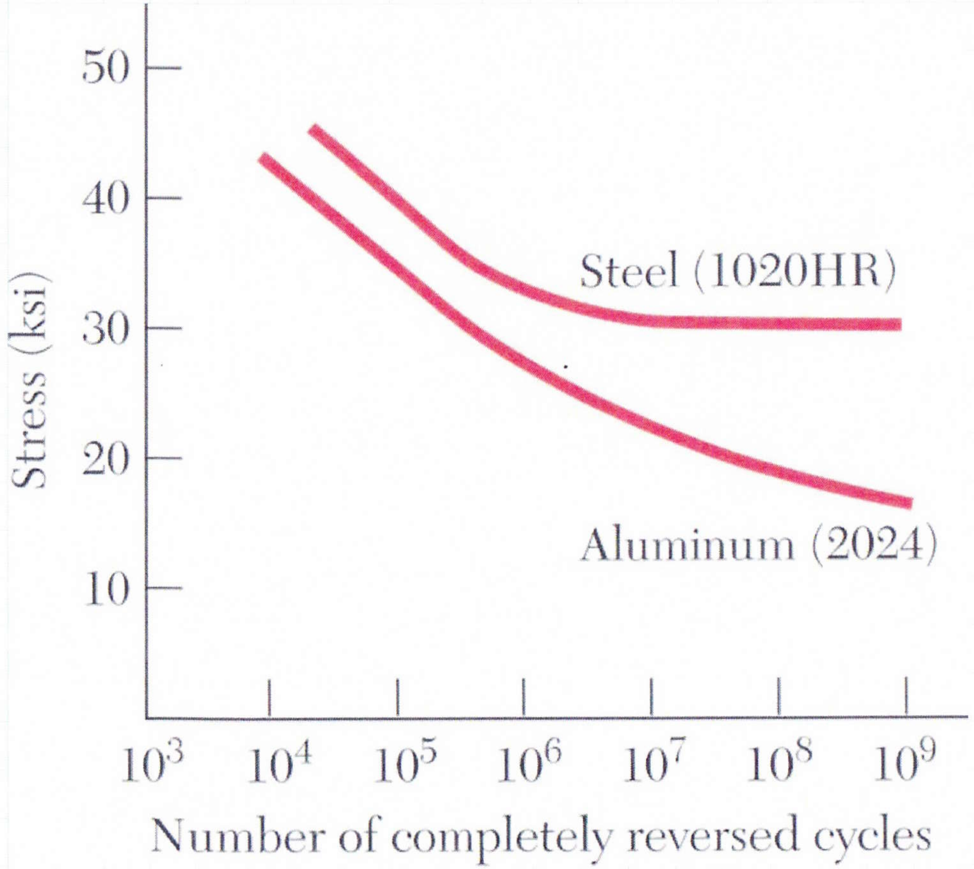



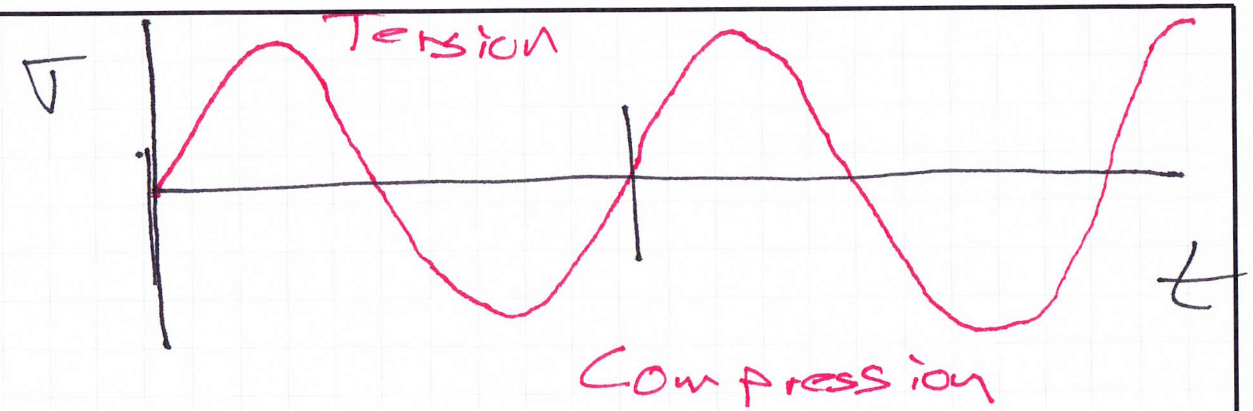

$\sigma = E\,\epsilon$

Hooke's Law

For Uniaxial Loading Only

# Repeated Loadings and Fatigue



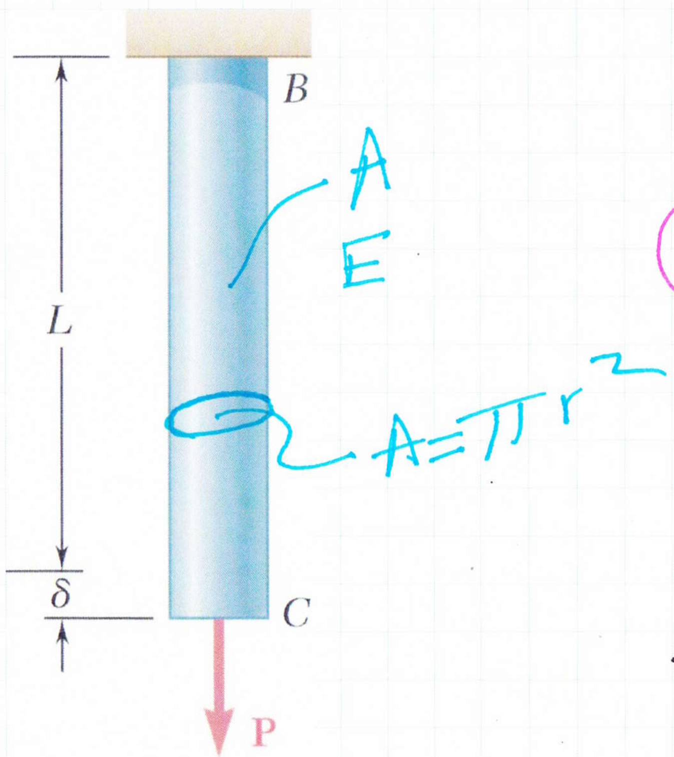

Car Engine

$$(3000 \text{ rpm})\left(60 \frac{\text{m}}{\text{hr}}\right) = 180{,}000 \text{ rph}$$

$$\frac{100000 \text{ mi}}{60 \text{ mi/hr}} = 1667 \text{ hrs}$$

$$(180{,}000)(1667) = 3 \times 10^8 \text{ cycles}$$

# Load Deformation Relationships for Axially Loaded Member




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

$$\epsilon = \frac{\delta}{L}$$

$$\sigma = E\epsilon$$

$$\frac{P}{A} = E\frac{\delta}{L}$$

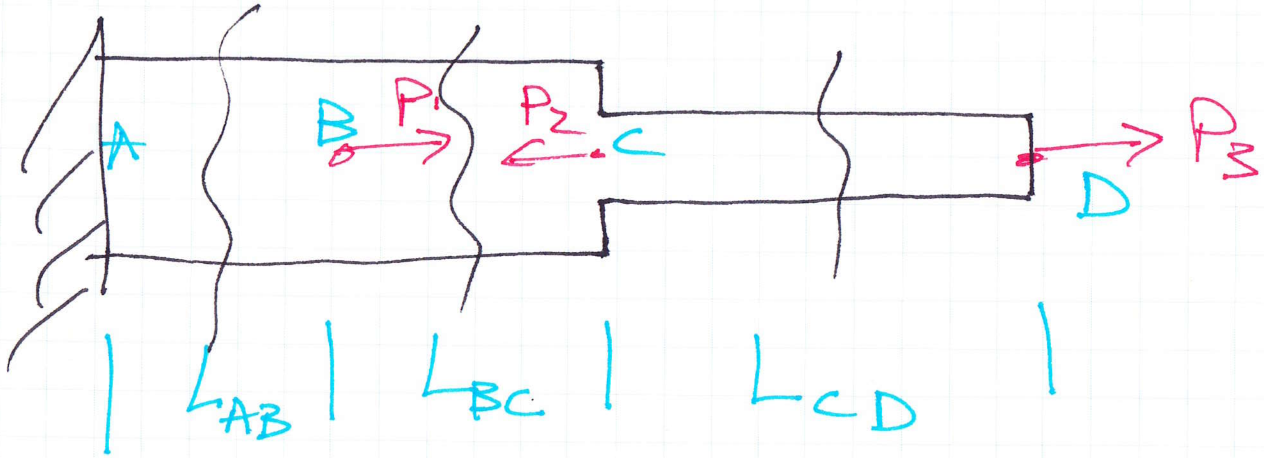
$$\delta = \frac{PL}{AE}$$

Cross-Sectional Area

$$F = k\,\delta$$

$$P = \frac{AE}{L}\,\delta$$

Spring Constant

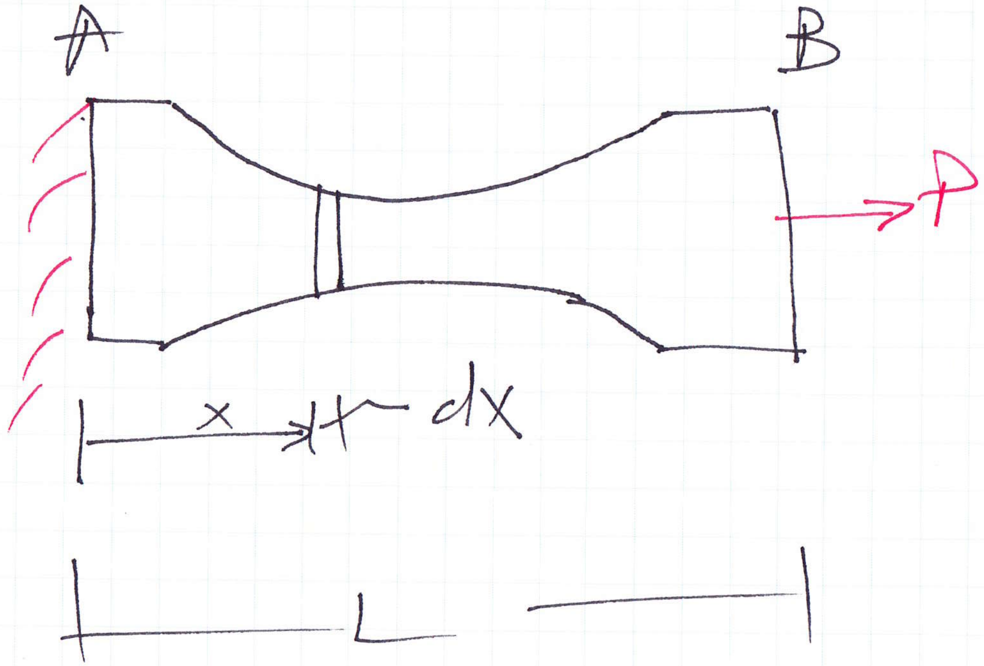



P is the internal Force

$$\delta_{AD} = \delta_{AB} + \delta_{BC} + \delta_{CD}$$

$$\delta_{AD} = \frac{P_{AB} L_{AB}}{A_{AB} E_{AB}} + \frac{P_{BC} L_{BC}}{A_{BC} E_{BC}} + \frac{P_{CD} L_{CD}}{A_{CD} E_{CD}}$$

$$\delta = \sum_{i=1}^{n} \frac{P_i L_i}{A_i E_i}$$




$$\delta = \int_0^L \frac{P}{AE}\,dx$$

P(x)

A(x)

E(x)