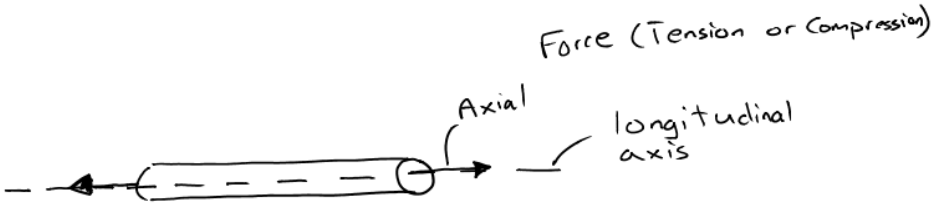
ENGR 2243 – Mechanics of Materials
Introductory Concepts

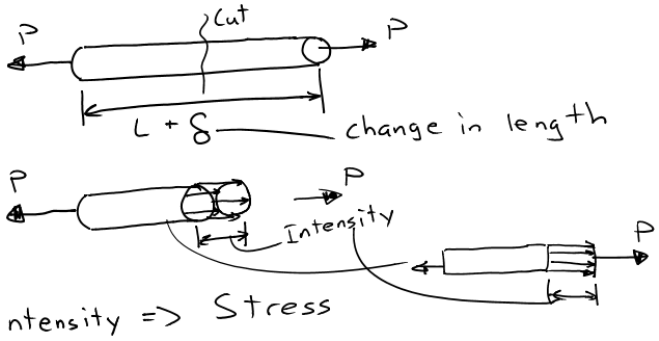
Normal Stress and Strain

- Prismatic Bar: Straight member with a constant cross-section
- Axial Force: A force that is directed along the longitudinal axis



- Prior to Loading

- After Loading



- Stress (σ)
  - Distribution of the force across the cross-sectional area
  - Intensity of the distribution
  - Units: Force per unit area (Pascals and psi)
  - Note on force units: 1 k = 1 kip = 1 kilopound

- For a uniform stress distribution

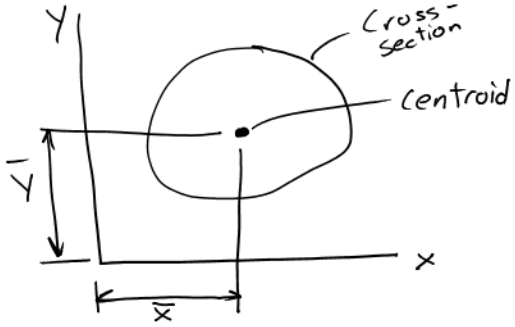
$$\sigma = \frac{P}{A}$$

  - Tensile Stress is positive
  - Compressive stress is negative

- Application of the resultant force for a uniform stress distribution

$$\bar{x} = \frac{\int \tilde{x}\,dA}{\int dA}$$

$$\bar{y} = \frac{\int \tilde{y}\,dA}{\int dA}$$



- Normal Stress: Direction is perpendicular to the cross-sectional area

Normal Strain (ε)

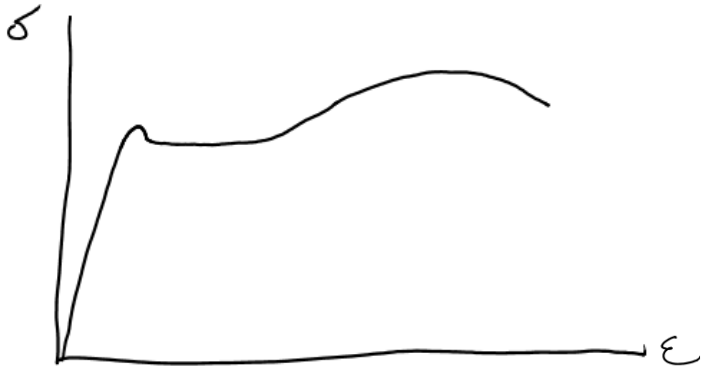
$$\varepsilon = \frac{\delta}{L}$$

Change in Length
Original Length

- Normal Strain: Change in length is perpendicular to the cross-section
- Elongation (tension): Positive
- Shortening (compression): Negative
- Units: Unitless (can be represented as a percentage)

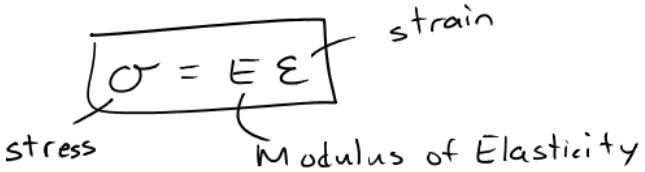
Materials

- Homogeneous Material: Material is the same throughout all parts of the member
- Mechanical Properties of Materials
  - Determined experimentally
  - Measure force and elongation, which is then used to calculate stress and strain
- Stress-Strain Curve

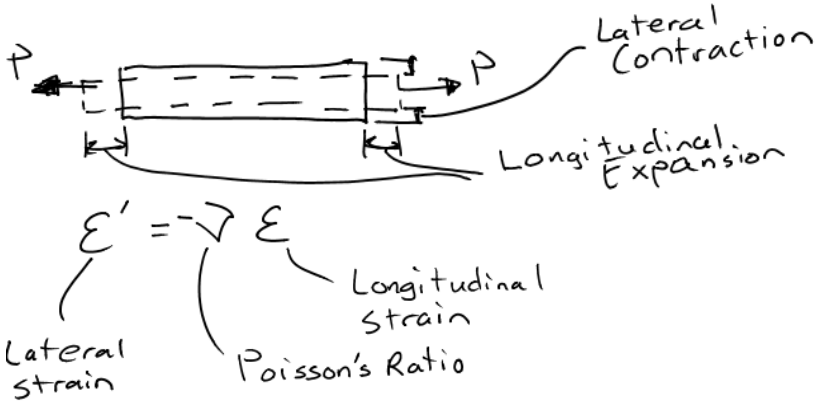


- Modulus of Elasticity
  - The slope of the linear region of the stress-strain curve
- Linear Elastic Material
  - Elastic
  - The stress-strain curve is linear in the elastic region

- Hooke's Law for a linear elastic material

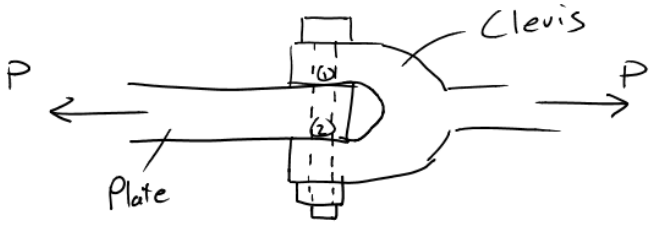


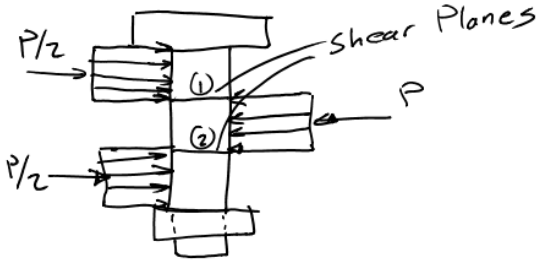
- Poisson's Ratio
  - Relates longitudinal strain to axial strain



- Appendix I: Mechanical Properties of Materials

<u>Shear Stress and Strain</u>
- Directed parallel to the cross-section
- Caused by a change in the bearing stress





- Bearing Stress
  - Assume the bearing stresses are uniform

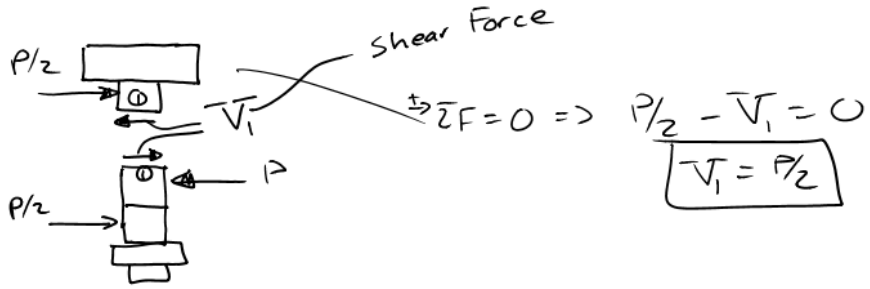
$$\sigma_b = \frac{F_b}{A_b}$$ — F_b: Bearing Force; A_b: Projected Bearing Area

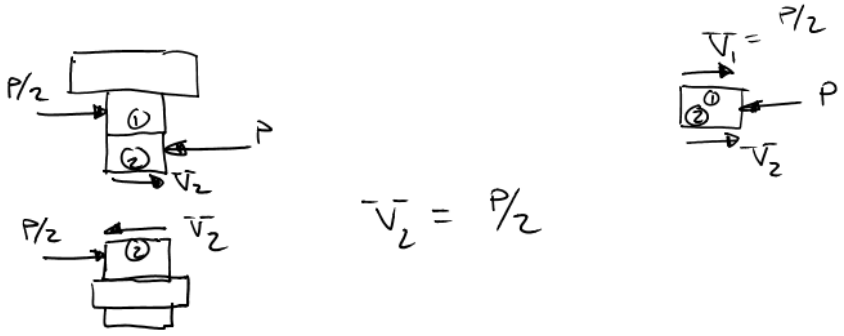
$$A_b = dt$$

Plate $F_b = P$

Each Clevis Arm $\Rightarrow F_b = P/2$

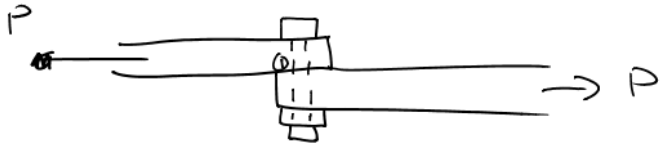
- Shear Stress
  - Cuts are made at each shear plane

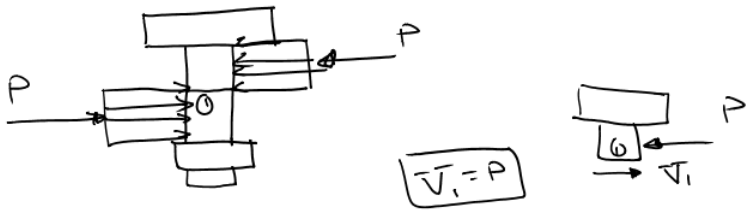




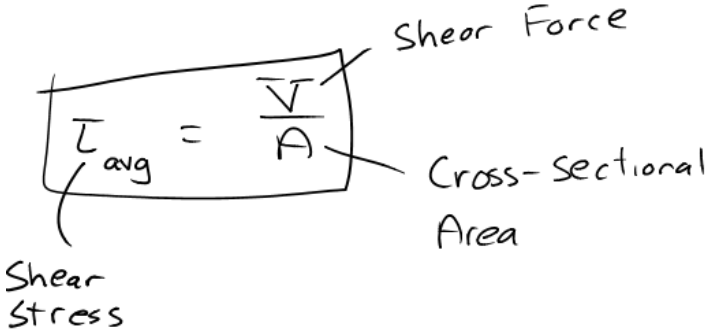
Double Shear => Two shear planes

- For single shear

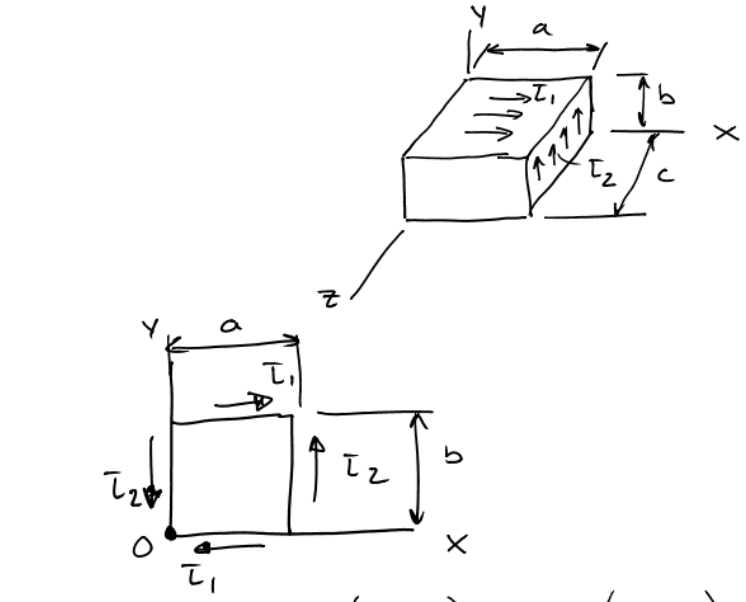




- Shear Stress

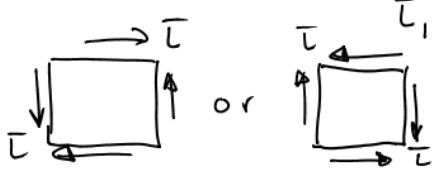


- Shear on different faces

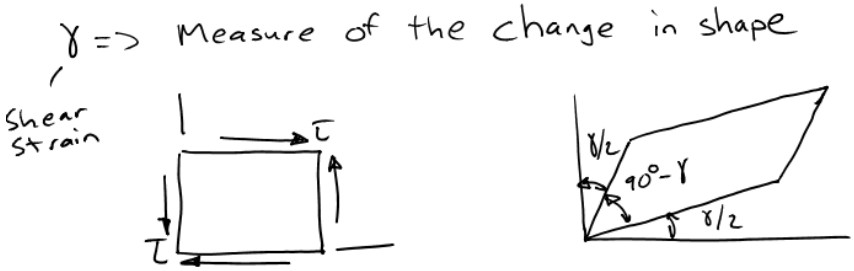


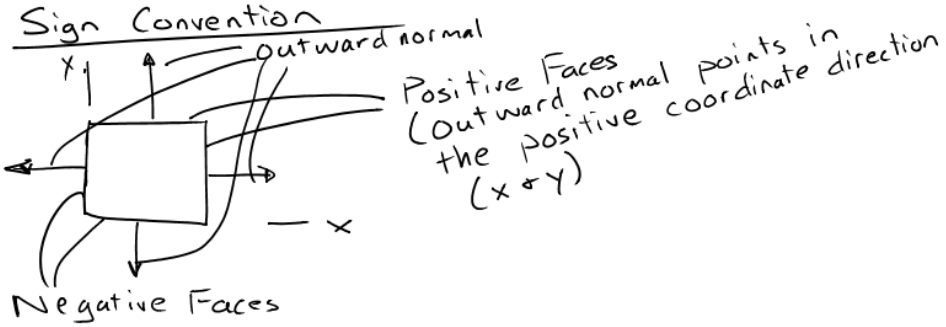
$$+\circlearrowleft \Sigma M_o = 0 \Rightarrow -\underbrace{(\bar{\tau}_1 ac)}_{\bar{V}_1} \underbrace{b}_{\text{Moment Arm}} + \underbrace{(\bar{\tau}_2 bc)}_{\bar{V}_2} a = 0$$

$$\bar{\tau}_1 = \bar{\tau}_2 = \bar{\tau}$$

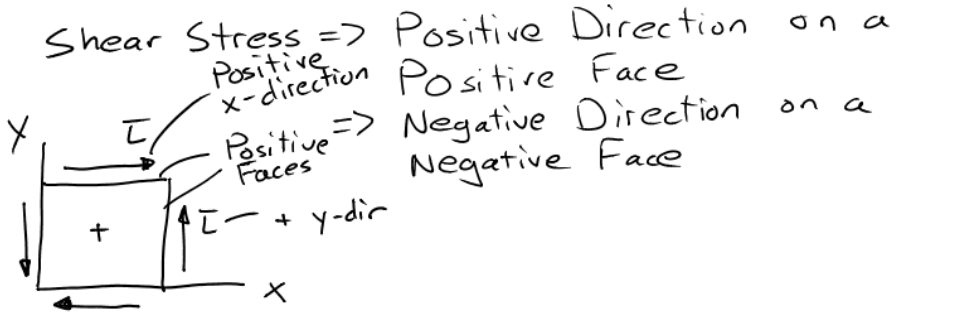


- Shear Strain



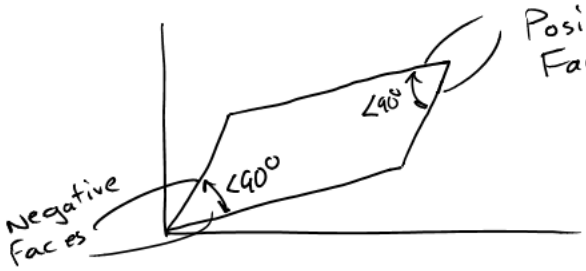


- Positive Shear

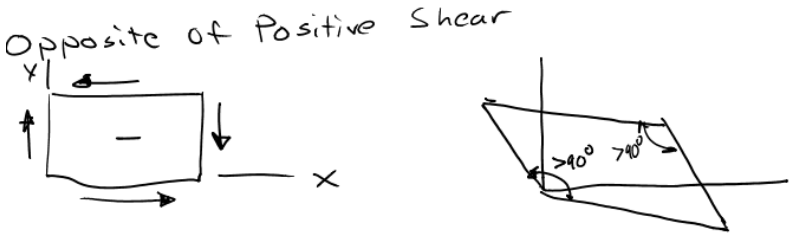


Shear Strain

Positive => Angle between two positive faces or two negative faces is reduced ($< 90°$)



- Negative Shear



- Hooke's Law for Shear

$$\tau = G\gamma \quad \text{(Linear Elastic Material)}$$

τ: shear stress; γ: shear strain; G: Shear Modulus of Elasticity

$$G = \frac{E}{2(1+\nu)}$$

E: Modulus of Elasticity; ν: Poisson's Ratio