Mechanics of Materials II:

Thin-Walled Pressure Vessels and Torsion

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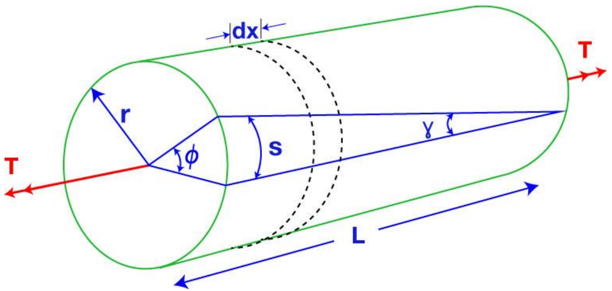
Module 11 Learning Outcome

- Develop the expression for Torsional Shearing Stress

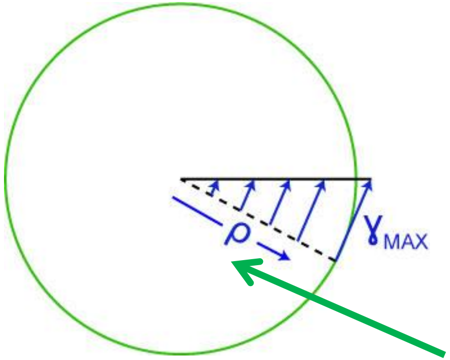
Circular Bar Torsion



Torsional Shear Strain at Outer Surface

$$\gamma_{MAX} = \frac{r\phi}{L} = \frac{r\,d\phi}{dx} = r\theta$$

Shear Strains vary linearly with ρ



$$\gamma = \rho\theta = \frac{\rho}{r}\gamma_{MAX}$$

radial distance from center

Note: So far we haven't specified any material properties:

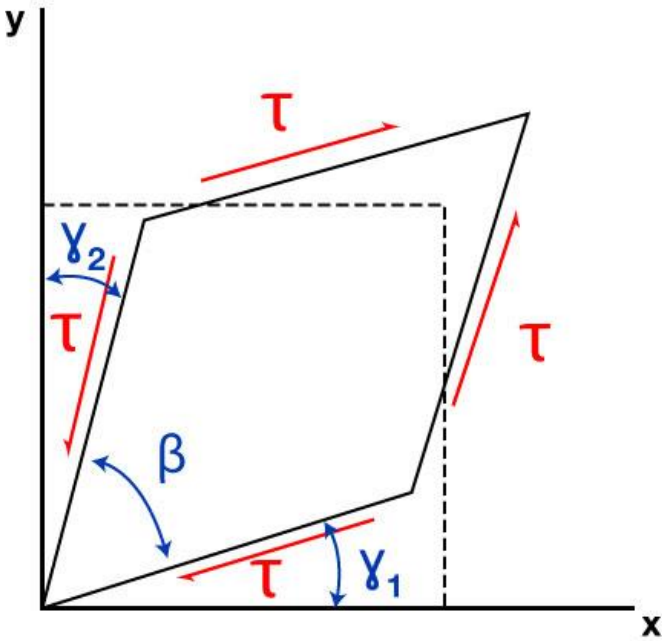
material could be in elastic or inelastic region

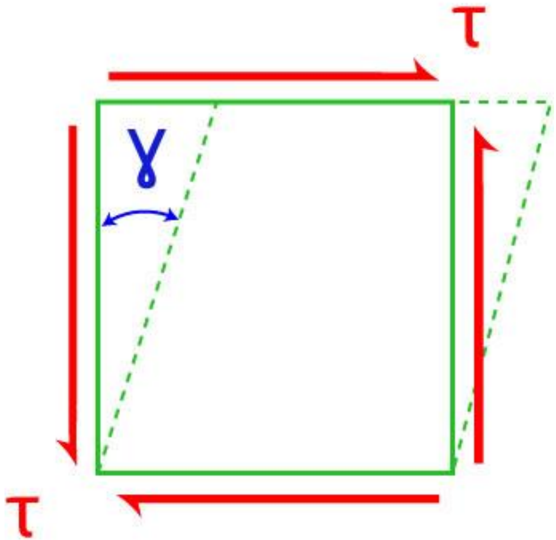
material could homogeneous or heterogeneous

we have specified small angles: $\tan\gamma \approx \gamma = \frac{s}{L}$

Recall Pure Shear
Shear Strain, γ

Change in the angle between perpendicular reference axes; Angular Distortion (Shear Distortion)





$\gamma \equiv Shear \quad Strain$ [dimensionless]

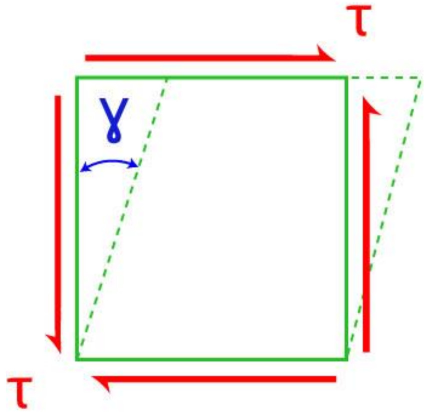
$$\gamma = \gamma_1 + \gamma_2 = \frac{\pi}{2} - \beta$$

Hooke’s Law in Shear

(valid for linear elastic region):

$$\tau = G\gamma$$

G = Modulus of Rigidity
(Shear Modulus)



$$\gamma_{MAX} = \frac{r\phi}{L} = \frac{r\,d\phi}{dx} = r\theta$$

$$\gamma = \rho\theta = \frac{\rho}{r}\gamma_{MAX}$$

$$\tau_{MAX} = G\gamma_{MAX}$$

$$\tau_{MAX} = Gr\theta$$

$$\theta = \frac{\tau_{MAX}}{Gr}$$

$$\tau = G\rho\theta$$

$$\tau = \frac{\rho}{r}\tau_{MAX}$$

Shear Stresses also vary linearly with ρ