Mechanics of Materials II:

Thin-Walled Pressure Vessels and Torsion

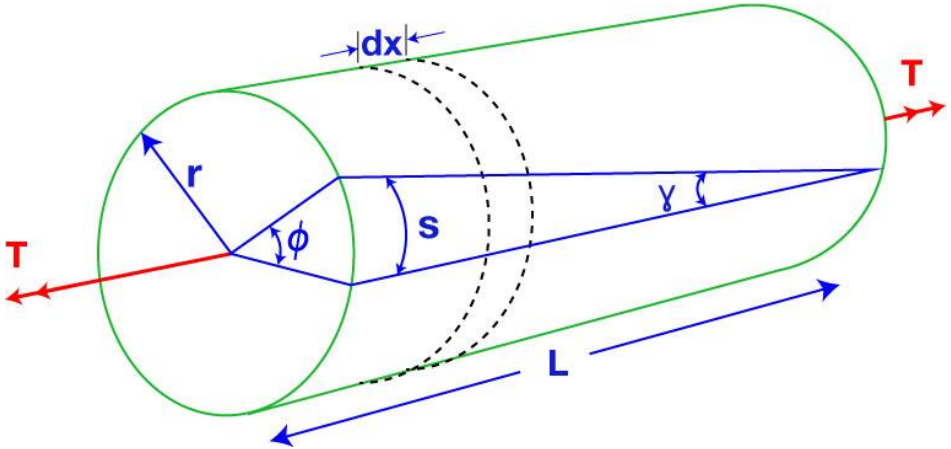
Dr. Wayne Whiteman
Senior Academic Professional and Director of the Office of Student Services
Woodruff School of Mechanical Engineering

Georgia Institute of Technology

Module 10 Learning Outcome

- Develop the expression for Torsional Shearing Strain

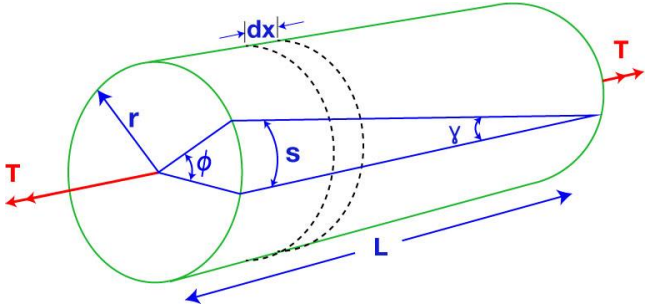
Circular Bar Torsion

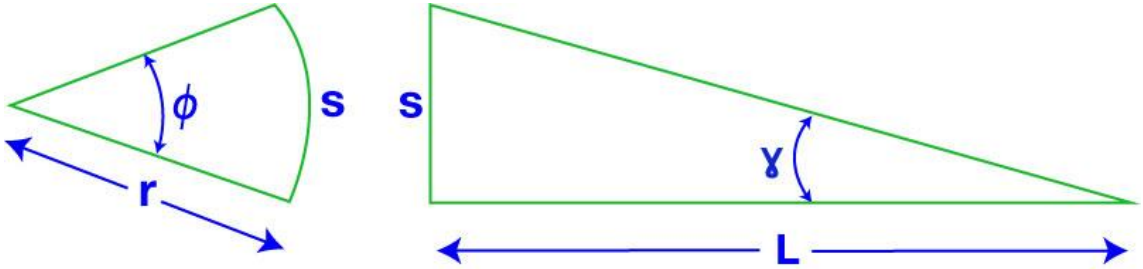


Assumptions:

- **Pure torsion**
- **Circular cross-section**
  - **Therefore cross-sections remain plane (other cross-sections warp)**
- **Small angles**

Circular Bar Torsion





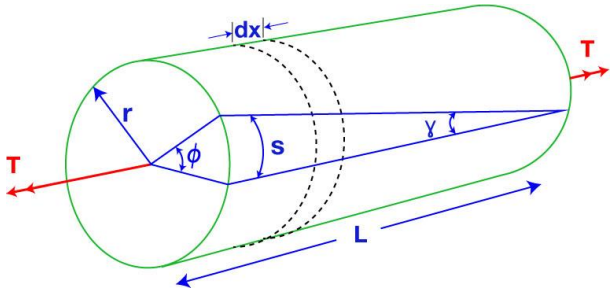
$$s = r\phi$$

$$\tan\gamma \approx \gamma = \frac{s}{L}$$

Torsional Shear Strain at Outer Surface

$$\gamma_{MAX} = \frac{r\phi}{L}$$

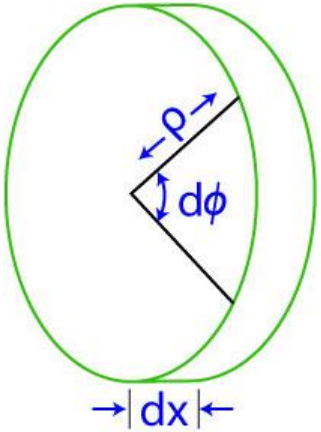
Circular Bar Torsion



Torsional Shear Strain at Outer Surface

$$\gamma_{MAX} = \frac{r\phi}{L}$$

Let's look at a small element



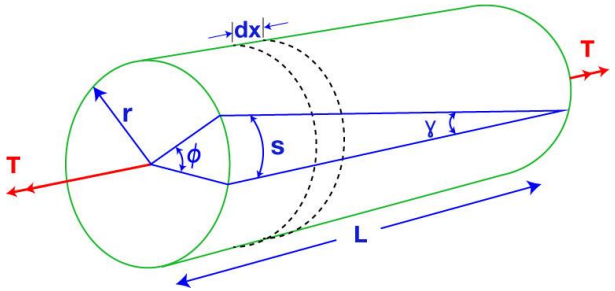
Rate of Twist, θ

(angle of twist per unit length)

$$\theta = \frac{d\phi}{dx}$$

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

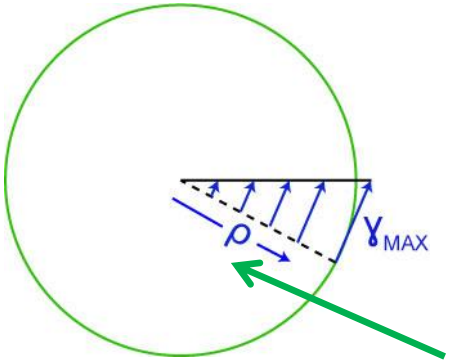
Circular Bar Torsion



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: $\tan\gamma \approx \gamma = \frac{s}{L}$