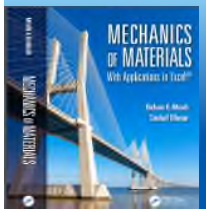
MECHANICS OF MATERIALS: WITH APPLICATIONS IN EXCEL

CHAPTER 2: TORSIONAL LOADS

LECTURE 11

2.6 STRESSES UNDER COMBINED LOADS



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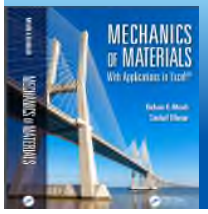
Lecture Outline

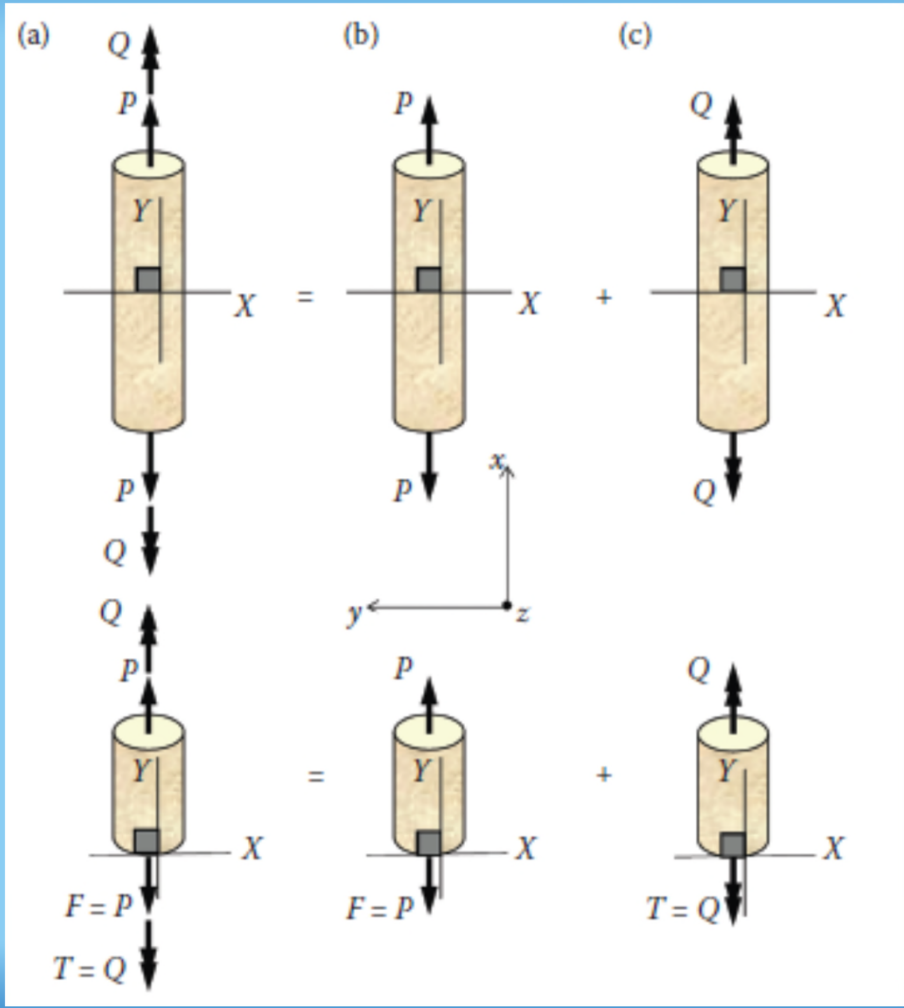
- Superposition
- Hooke's Law in two dimensions
- Examples

Superposition

- Analysis of combined axial and torsional loads is most conveniently accomplished by using the principle of superposition.
- The method of superposition is equally applicable to any cross-sectional form as long as the material is not stressed beyond the elastic limit.



Combined Axial Force and Torque

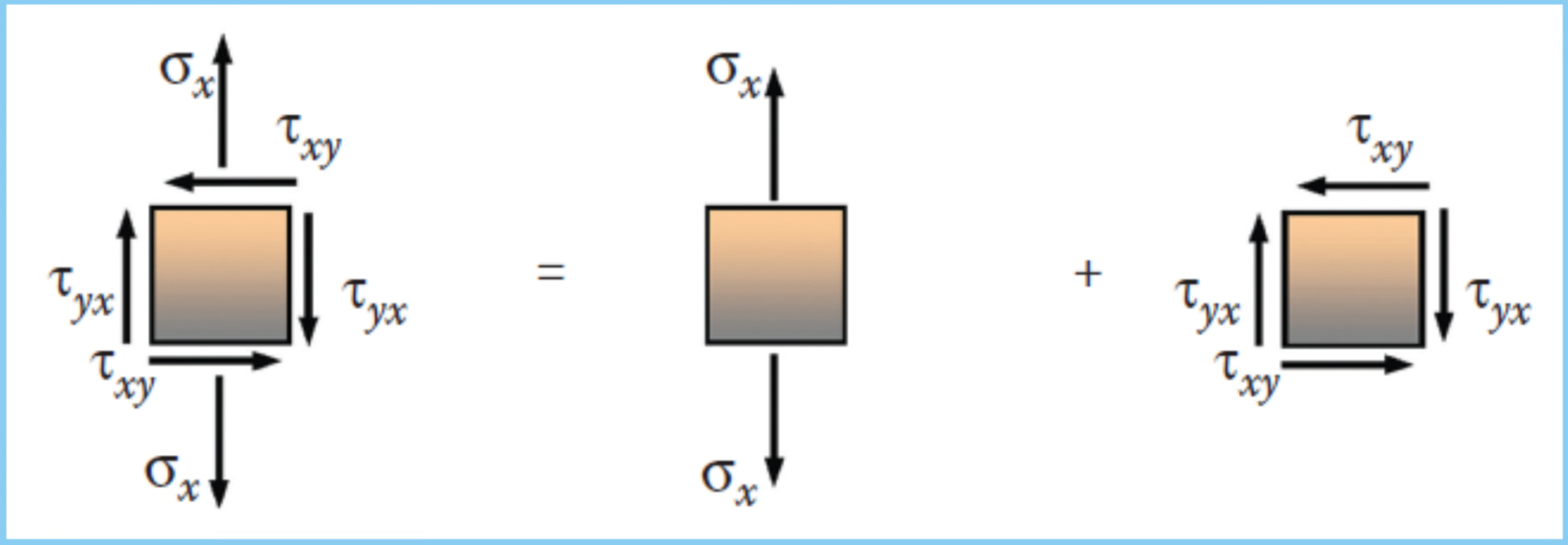


Applied Loads

Internal Loads

Combined Axial Force and Torque - Srtesses

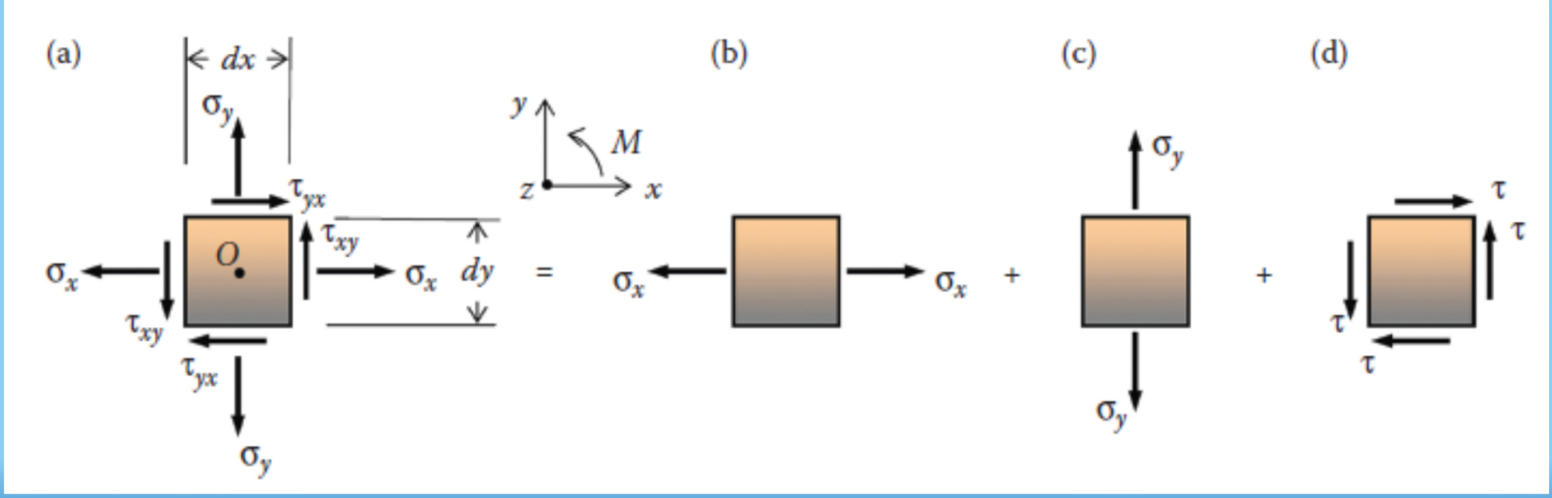
From Both Loads From Axial Load From Torque

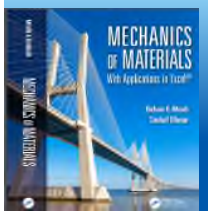


Normal Stress Shear Stress

Hooke's Law in Two Dimensions

- Condition is referred to as a state of plane stress
- Although stresses exist on one plane only (two-dimensions), strain components will be in three-dimensions because of Poisson's ratio





Hooke's Law in Two Dimensions

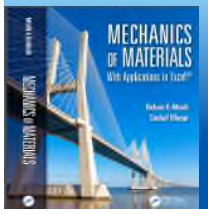
- Applying Hooke's Law and the definition of Poisson's ratio:

$$\left.\begin{aligned}
\varepsilon_x &= \frac{\sigma_x}{E} - \mu\left(\frac{\sigma_y}{E}\right) = \frac{1}{E}(\sigma_x - \mu\sigma_y) \\
\varepsilon_y &= \frac{\sigma_y}{E} - \mu\left(\frac{\sigma_x}{E}\right) = \frac{1}{E}(\sigma_y - \mu\sigma_x) \\
\varepsilon_z &= -\frac{\mu}{E}(\sigma_x + \sigma_y); \quad \gamma_{xy} = \frac{\tau_{xy}}{G}
\end{aligned}\right\} \qquad (2.22)$$

Hooke's Law in Two Dimensions

- Expressing stresses in terms of strains:

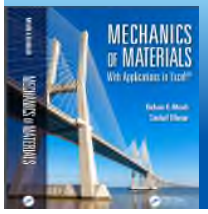
$$\left.\begin{aligned}\sigma_x &= \frac{E}{1-\mu^2}(\varepsilon_x + \mu\varepsilon_y)\\ \sigma_y &= \frac{E}{1-\mu^2}(\varepsilon_y + \mu\varepsilon_x)\\ \sigma_z &= 0\end{aligned}\right\} \qquad (2.23)$$



Hooke's Law in Two Dimensions

- Relationship between the Modulus of Elasticity and the Shear Modulus:

$$G = \frac{E}{2(1+\mu)} \qquad (2.24)$$



Examples