

Fundamental Equations of Mechanics of Materials

Axial Load

Normal Stress

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

Displacement

$$\delta = \int_0^L \frac{N(x)dx}{A(x)E}$$

$$\delta = \sum \frac{NL}{AE}$$

$$\delta_T = \alpha \Delta T L$$

Torsion

Shear stress in circular shaft

$$\tau = \frac{T\rho}{J}$$

where

$$J = \frac{\pi}{2} r^4 \quad \text{solid cross section}$$

$$J = \frac{\pi}{2} (r_o^4 - r_i^4) \quad \text{tubular cross section}$$

Power

$$P = T\omega = 2\pi nT$$

Angle of twist

$$\phi = \int_0^L \frac{T(x)dx}{J(x)G}$$

$$\phi = \sum \frac{TL}{JG}$$

Average shear stress in a thin-walled tube

$$\tau_{avg} = \frac{T}{2\pi A_m}$$

Shear Flow

$$q = \tau_{avg}t = \frac{T}{2A_m}$$

Bending

Normal stress

$$\sigma = \frac{My}{I}$$

Unsymmetric bending

$$\sigma = -\frac{M_x y}{I_x} + \frac{M_y x}{I_y} \quad \tan \alpha = \frac{I_x}{I_y} \tan \theta$$

Shear

Average direct shear stress

$$\tau_{avg} = \frac{V}{A}$$

Transverse shear stress

$$\tau = \frac{VQ}{It}$$

Shear flow

$$q = \tau t = \frac{VQ}{I}$$

Stress in Thin-Walled Pressure Vessel

Cylinder

$$\sigma_1 = \frac{Pr}{t} \quad \sigma_2 = \frac{Pr}{2t}$$

Sphere

$$\sigma_1 = \sigma_2 = \frac{Pr}{2t}$$

Stress Transformation Equations

$$\sigma_{x'} = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2} \cos 2\theta + \tau_{xy} \sin 2\theta$$

$$\tau_{x'y'} = -\frac{\sigma_x - \sigma_y}{2} \sin 2\theta + \tau_{xy} \cos 2\theta$$

Principal Stress

$$\tan 2\theta_p = \frac{\tau_{xy}}{(\sigma_x - \sigma_y)/2}$$

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

Maximum in-plane shear stress

$$\tan 2\theta_s = -\frac{(\sigma_x - \sigma_y)/2}{\tau_{xy}}$$

$$\tau_{max} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\sigma_{avg} = \frac{\sigma_x + \sigma_y}{2}$$

Absolute maximum shear stress

$$\tau_{abs} = \frac{\sigma_{max}}{2} \quad \text{for } \sigma_{max}, \sigma_{min} \text{ same sign}$$

$$\tau_{abs} = \frac{\sigma_{max} - \sigma_{min}}{2} \quad \text{for } \sigma_{max}, \sigma_{min} \text{ opposite signs}$$

Mechanical Engineering Formulas Cheat Sheet

Zhe Xu



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