

## Formula Sheet

Stresses:  $\sigma = \frac{P}{A}$   $\sigma = \frac{M \cdot c}{I}$   $\tau = \frac{T \cdot c}{J}$

Unsymmetric bending:  $\sigma = \frac{P}{A} + \frac{-M_z y}{I_z} + \frac{-M_y z}{I_y}$   $\tan \phi = \frac{I_z}{I_y} \tan \theta$

Shear stress:  $\tau = \frac{VQ}{It}$   $q = \tau \cdot t = \frac{VQ}{I}$

Thin-walled pressure vessel:  $\sigma_1 = \frac{Pr}{t}$   $\sigma_2 = \frac{Pr}{2t}$

Stress Transformation:

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

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

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

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

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

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

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

Beam Design:  $S_{\text{req}} = \frac{|M|_{\max}}{\sigma_{\text{all}}}$   $\tau_{\text{av}} = \frac{V_{\max}}{A_{\text{web}}}$ , where  $A_{\text{web}} = d \cdot t_{\text{web}}$

Yield Criteria:

Von Mises (Distortion Energy):  $\sigma_x^2 - \sigma_x \sigma_y + \sigma_y^2 < \sigma_Y^2$

Tresca (Maximal Shear Stress):  $| \sigma_x | < \sigma_Y$  and  $| \sigma_y | < \sigma_Y$   
or  $| \sigma_x - \sigma_y | < \sigma_Y$

Strain Gauge Transformation:  $\epsilon(\theta) = \epsilon_x \cos^2 \theta + \epsilon_y \sin^2 \theta + \gamma_{xy} \sin \theta \cos \theta$

Generalized Hook's Law:

$$\epsilon_x = \frac{1}{E} [\sigma_x - \nu(\sigma_y + \sigma_z)]$$

$$\gamma_{xy} = \frac{1}{G} \tau_{xy}, \quad \gamma_{yz} = \frac{1}{G} \tau_{yz}, \quad \gamma_{zx} = \frac{1}{G} \tau_{zx}$$

$$\epsilon_y = \frac{1}{E} [\sigma_y - \nu(\sigma_x + \sigma_z)]$$

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

$$\epsilon_z = \frac{1}{E} [\sigma_z - \nu(\sigma_x + \sigma_y)]$$

Plane Stress:  $\sigma_x = \frac{E}{(1-\nu^2)} [\epsilon_x + \nu \epsilon_y]$

# Mechanical Engineering Formulas Cheat Sheet

**KJ Lindholm-Leary**



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