GATE PATHSHALA

Strength of Materials - Formula Sheet

Author Name: Krishna Teja

April 9, 2025

1 Stress and Strain

Normal Stress

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

Shear Stress

$$\tau = \frac{V}{A}$$

Normal Strain

$$\varepsilon = \frac{\delta}{L}$$

Shear Strain

$$\gamma = \frac{\Delta x}{L} = \tan\theta$$

2 Hooke's Law

Axial Loading

$$\sigma = E\varepsilon$$

Shear Loading

$$\tau = G\gamma$$

Where:

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

3 Thermal Stress

$$\delta = \alpha \Delta T L, \quad \sigma = E\alpha\Delta T$$

4 Axial Deformation

$$\delta = \frac{PL}{AE} \quad \text{(for constant load and area)}$$

5 Torsion

$$\tau = \frac{T\rho}{J}, \quad \theta = \frac{TL}{GJ}$$

Polar Moment of Inertia

$$J_{\text{solid}} = \frac{\pi d^4}{32}, \quad J_{\text{hollow}} = \frac{\pi(d_o^4 - d_i^4)}{32}$$

6 Bending of Beams

Flexure Formula

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

Beam Deflection (Euler-Bernoulli)

$$EI\frac{d^2y}{dx^2} = M(x)$$

Common Deflections

Simply supported beam with center load:

$$\delta_{\text{max}} = \frac{PL^3}{48EI}$$

Cantilever with end load:

$$\delta_{\text{max}} = \frac{PL^3}{3EI}$$

7 Shear in Beams

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

Where:

$$Q = \int_A y\, dA$$

8 Moment of Inertia

[noitemsep]Rectangle: $I = \frac{bh^3}{12}$ Circle: $I = \frac{\pi d^4}{64}$ Parallel Axis Theorem: $I = I_{\text{centroid}} + Ad^2$

9 Combined Loading

$$\sigma = \frac{P}{A} \pm \frac{My}{I}, \quad \tau = \frac{T\rho}{J} + \frac{V}{A}$$

10 Principal Stresses

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

11 Mohr's Circle (2D Stress)

Center

$$C = \left(\frac{\sigma_x + \sigma_y}{2}, 0\right)$$

Radius

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

Maximum Shear Stress

$$\tau_{\max} = R$$

12 Strain Energy

[noitemsep]Axial loading: $U = \frac{1}{2}\frac{P^2 L}{AE}$ Torsion: $U = \frac{1}{2}\frac{T^2 L}{GJ}$

13 Columns (Buckling)

Euler's Buckling Load

$$P_{cr} = \frac{\pi^2 EI}{(KL)^2}$$

Effective Length Factor K:

[noitemsep]Both ends pinned: $K = 1$ One end fixed, one free: $K = 2$ Both ends fixed: $K = 0.5$

14 Factor of Safety (FoS)

$$\text{FoS} = \frac{\text{Material Strength}}{\text{Actual Stress}}$$