Statics I Equations

Average Normal Stress in Axial Loading: $\sigma = \frac{P}{A}$

Average Shear Stress: $\tau = \frac{V}{A}$

Stresses on Oblique Plane: $\sigma = \frac{N}{A_1}, \quad \tau = \frac{V}{A_1}, \quad A_1 = \frac{A}{\cos(\theta)}$

Factor of Safey: $\text{FoS} = \frac{\text{Failure Load}}{\text{Allowable Load}} = \frac{\text{Failure Stress}}{\text{Design Stress}}$

Normal Strain in Axial Loading: $\varepsilon = \frac{\delta}{L}$

Hooke's Law for Axial Loading: $\sigma = E\varepsilon$

Mechanical Deflection for Axial Loading: $\delta = \frac{PL}{EA}$

Thermal Deflection: $\delta_{\text{th}} = \alpha(\Delta T)L$

Total Deflection in Axial Loading: $\delta = \frac{PL}{EA} + \alpha(\Delta T)L$

Poisson's Ratio: $v = -\frac{\varepsilon_y}{\varepsilon_x}$

Relating elastic properties: $\frac{E}{2G} = 1 + v$

Shear of Block: $\gamma = \frac{\delta}{h}$ $\tau = G\gamma$

Stress Concentration: $\sigma_{\max} = K\sigma_{\text{nom}}$

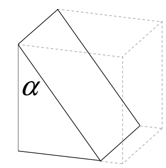
Statics II - Chapter 7

Torsion: $\tau = \dfrac{T\rho}{J}$ $\theta = \dfrac{TL}{GJ}$ $\gamma = \dfrac{\rho\theta}{L}$ $\gamma = \dfrac{\tau}{G}$

2nd Moments of Area of a Circle: $J = \dfrac{\pi}{2}c^4$

2nd Moments of Area of a Annulus: $J = \dfrac{\pi}{2}\left(c_{\text{outer}}^4 - c_{\text{inner}}^4\right)$

Gears A and B mesh: $r_A\theta_A = r_B\theta_B$ $\dfrac{T_A}{r_A} = \dfrac{T_B}{r_B}$



Stress on Oblique Plane: $\sigma_n = \tau_{xy}\sin(2\alpha)$ $\tau_{nt} = \tau_{xy}\cos(2\alpha)$

Power: $P = T\omega$

1hp = 550 ft-lb/s = 6600 in-lb/s

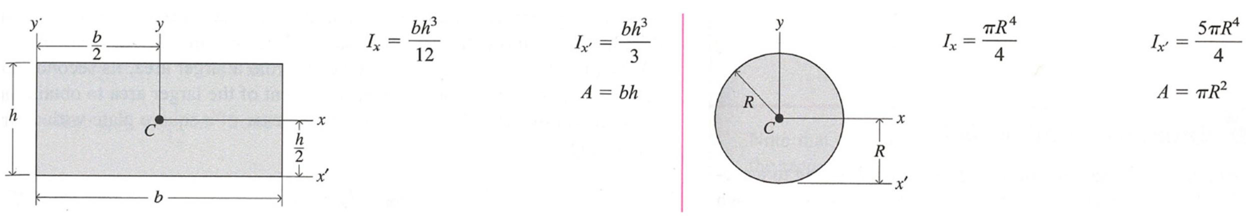
Statics II – Chapter 8

Bending stress in a beam: $\sigma = -\dfrac{My}{I}$ $\left|\sigma_{\max}\right| = \left|\dfrac{Mc}{I}\right| = \left|\dfrac{M}{S}\right|$

Shear stress in a beam: $\tau = -\dfrac{VQ}{It}$ where: $Q = A\,d$

Parallel axis: $I_{x'} = I_x + Ad^2$

Second moment of area:



Shear force and bending moment diagram relations: $\dfrac{dV}{dx} = w$ $\dfrac{dM}{dx} = V$

a clockwise point moment causes a positive jump in bending moment diagram

Statics II – Chapter 10

Stress on a plane defined by rotation angle θ

$$\sigma_n = \left(\frac{\sigma_x + \sigma_y}{2}\right) + \left(\frac{\sigma_x - \sigma_y}{2}\right)\cos(2\theta) + \tau_{xy}\sin(2\theta)$$

$$\sigma_t = \left(\frac{\sigma_x + \sigma_y}{2}\right) - \left(\frac{\sigma_x - \sigma_y}{2}\right)\cos(2\theta) - \tau_{xy}\sin(2\theta)$$

$$\tau_{nt} = -\left(\frac{\sigma_x - \sigma_y}{2}\right)\sin(2\theta) + \tau_{xy}\cos(2\theta)$$

The state of principal stresses:

$$\sigma_{\max,\min} = \left(\frac{\sigma_x + \sigma_y}{2}\right) \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \left(\tau_{xy}\right)^2} \qquad \text{where:} \quad \tan(2\theta_p) = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$

The state of maximum shear stress:

$$\tau_{nt_{\max}} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \left(\tau_{xy}\right)^2} = \frac{\sigma_{\max} - \sigma_{\min}}{2} \qquad \text{where:} \quad \tan(2\theta_\tau) = -\frac{(\sigma_x - \sigma_y)}{2\tau_{xy}}$$

Mohr's Circle: points: $(\sigma_x, -\tau_{xy})$ and (σ_y, τ_{xy})

center: $\dfrac{\sigma_x + \sigma_y}{2}$

diameter: $\phi = \sqrt{(\sigma_x - \sigma_y)^2 + (2\tau_{xy})^2}$

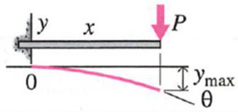
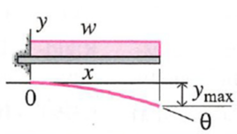
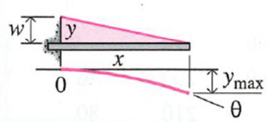
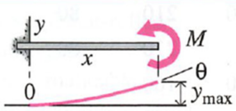
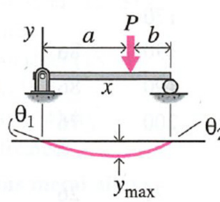
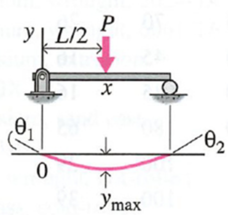
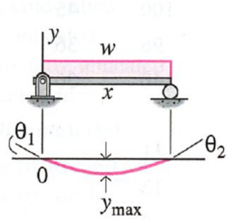
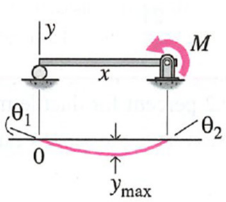
Thin-walled cylindrical pressure vessel: $\sigma_h = \dfrac{P\,r}{t}$ and $\sigma_a = \dfrac{P\,r}{2t}$

Beam deflection: $\dfrac{d^2 y}{dx^2} = \dfrac{M}{EI}$ and $\dfrac{dy}{dx} = \theta$

Column buckling: $P_{cr} = \dfrac{\pi^2 EI}{(L_{\text{eff}})^2}$

Radius of gyration: $r = \sqrt{\dfrac{I}{A}}$

TABLE A-19 Beam Deflections and Slopes

Case	Load and Support (Length L)	Slope at End ($+\triangle$)	Maximum Deflection (+ upward)	Equation of Elastic Curve (+ upward)
1		$\theta = -\frac{PL^2}{2EI}$ at $x = L$	$y_{max} = -\frac{PL^3}{3EI}$ at $x = L$	$y = -\frac{Px^2}{6EI}(3L - x)$
2		$\theta = -\frac{wL^3}{6EI}$ at $x = L$	$y_{max} = -\frac{wL^4}{8EI}$ at $x = L$	$y = -\frac{wx^2}{24EI}(x^2 - 4Lx + 6L^2)$
3		$\theta = -\frac{wL^3}{24EI}$ at $x = L$	$y_{max} = -\frac{wL^4}{30EI}$ at $x = L$	$y = -\frac{wx^2}{120EIL}(10L^3 - 10L^2x + 5Lx^2 - x^3)$
4		$\theta = +\frac{ML}{EI}$ at $x = L$	$y_{max} = +\frac{ML^2}{2EI}$ at $x = L$	$y = \frac{Mx^2}{2EI}$
5	 $b < a$	$\theta_1 = -\frac{Pb(L^2 - b^2)}{6LEI}$ at $x = 0$ $\theta_2 = +\frac{Pa(L^2 - a^2)}{6LEI}$ at $x = L$	$y_{max} = -\frac{Pb(L^2 - b^2)^{3/2}}{9\sqrt{3}\,LEI}$ at $x = \sqrt{(L^2 - b^2)/3}$ $y_{\substack{center\\not\ max}} = -\frac{Pb(3L^2 - 4b^2)}{48EI}$	$y = -\frac{Pbx}{6EIL}(L^2 - b^2 - x^2)$ $0 \le x \le a$
6		$\theta_1 = -\frac{PL^2}{16EI}$ at $x = 0$ $\theta_2 = +\frac{PL^2}{16EI}$ at $x = L$	$y_{max} = -\frac{PL^3}{48EI}$ at $x = L/2$	$y = -\frac{Px}{48EI}(3L^2 - 4x^2)$ $0 \le x \le \frac{L}{2}$
7		$\theta_1 = -\frac{wL^3}{24EI}$ at $x = 0$ $\theta_2 = +\frac{wL^3}{24EI}$ at $x = L$	$y_{max} = -\frac{5wL^4}{384EI}$ at $x = L/2$	$y = -\frac{wx}{24EI}(x^3 - 2Lx^2 + L^3)$
8		$\theta_1 = -\frac{ML}{6EI}$ at $x = 0$ $\theta_2 = +\frac{ML}{3EI}$ at $x = L$	$y_{max} = -\frac{ML^2}{9\sqrt{3}\,EI}$ at $x = L/\sqrt{3}$ $y_{\substack{center\\not\ max}} = -\frac{ML^2}{16EI}$	$y = -\frac{Mx}{6EIL}(L^2 - x^2)$