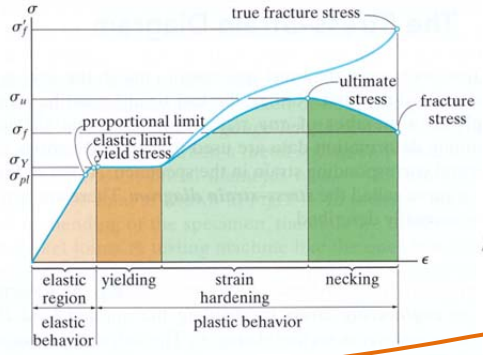
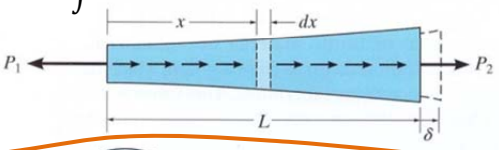
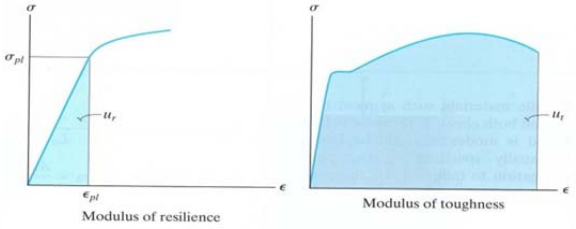


$$\sigma = E \cdot \varepsilon \quad \tau = G \cdot \gamma$$

$$G = E/[2(1+v)] \quad v = -\frac{\varepsilon_{lat}}{\varepsilon_{long}}$$

$$F = \int \sigma \, dA$$





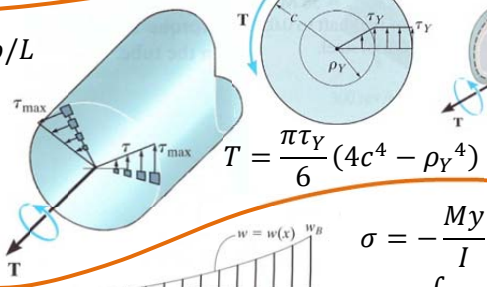
$$\delta = \int_0^l \frac{P(x)dx}{A(x)E(x)} \qquad \delta = \alpha \Delta T L$$

$$\tau = T\rho/J \quad \gamma = \phi\rho/L$$

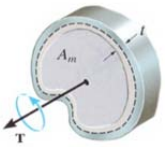
$$P = T\omega$$

$$T = 2\pi \int_0^c \tau \rho^2 d\rho$$

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

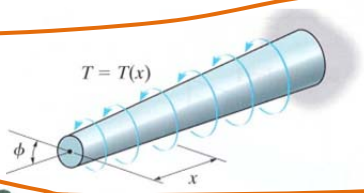


$$T = \frac{\pi \tau_Y}{6}(4c^4 - {\rho_Y}^4)$$



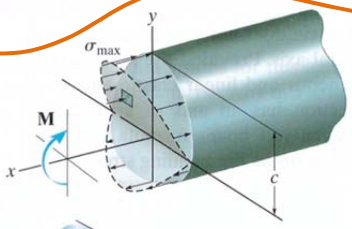
$$\tau_{avg} = T/(2tA_m)$$

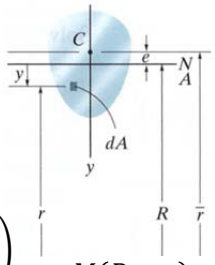
$$T_P = \frac{4}{3}T_Y$$



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

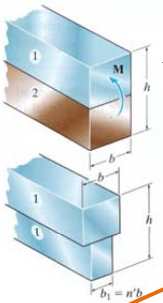
$$M = \int y\sigma \, dA$$



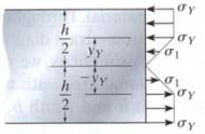


$$n = \frac{E_2}{E_1} \qquad {\sigma_2} = {\sigma'}_1 n$$

$$\sigma = -\frac{M_z y}{I_z} + \frac{M_y z}{I_y}$$

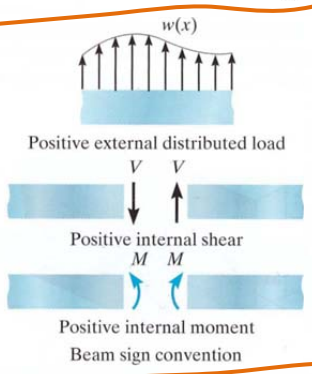


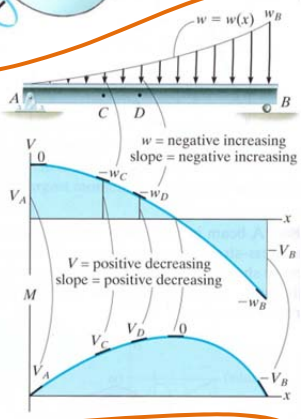
$$M = \frac{bh^2\sigma_Y}{4}\left(1 - \frac{{y_Y}^2}{h^2}\right)$$

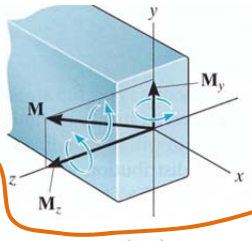


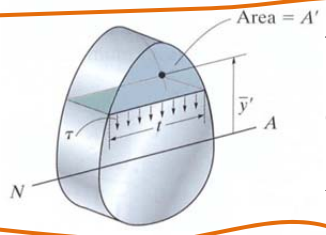
$$\sigma = \frac{M(R-r)}{Ar(\bar{r}-R)}$$

$$R = A \Big/ \int \frac{1}{r} dA$$





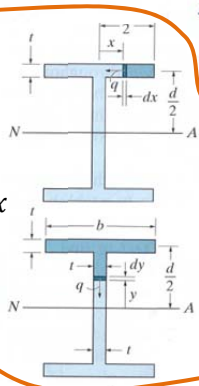


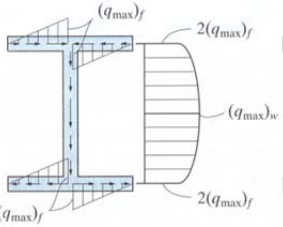


$$\tau = \frac{V\bar{y}'A'}{It}$$

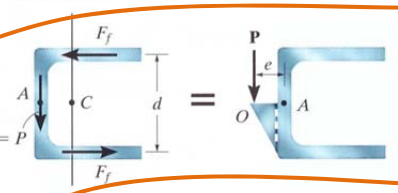
$$q = \frac{V\bar{y}'A'}{I}$$

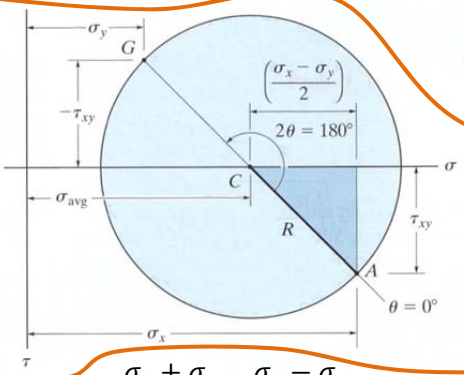
$$F = \int q \, dx$$

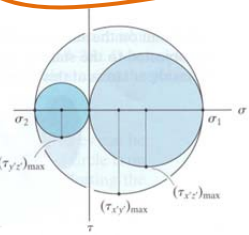




$$e = \frac{F_f d}{P}$$







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

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

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

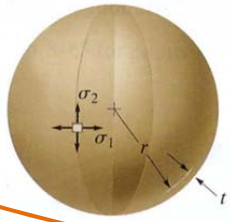
$$\theta_{p_2} = \theta_{p_1} \pm 90°$$

$$\theta_{s_{1,2}} = \theta_p \pm 45°$$

$$\sigma_1 = \frac{pr}{t}$$

$$\sigma_2 = \frac{pr}{2t}$$

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

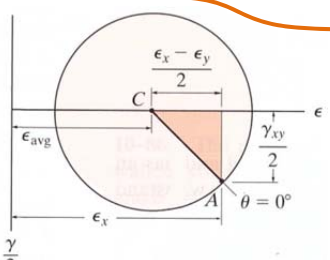


$$\sigma_{x',y'} = \frac{\sigma_x + \sigma_y}{2} \pm \frac{\sigma_x - \sigma_y}{2}\cos 2\theta \pm \tau_{xy}\sin 2\theta$$

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

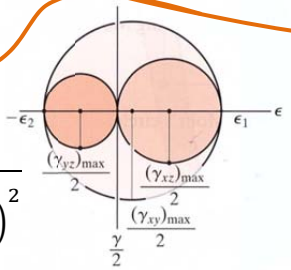
$$\epsilon_{x',y'} = \frac{\epsilon_x + \epsilon_y}{2} \pm \frac{\epsilon_x - \epsilon_y}{2}\cos 2\theta \pm \frac{\gamma_{xy}}{2}\sin 2\theta$$

$$\frac{\gamma_{x'y'}}{2} = -\frac{\epsilon_x - \epsilon_y}{2}\sin 2\theta + \frac{\gamma_{xy}}{2}\cos 2\theta$$



$$\epsilon_{avg} = \frac{\epsilon_x + \epsilon_y}{2}$$

$$R = \sqrt{\left(\frac{\epsilon_x - \epsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$$



$$\epsilon_x = 1/E \cdot \left(\sigma_x - v(\sigma_y + \sigma_z)\right)$$

$$\epsilon_y = 1/E \cdot \left(\sigma_y - v(\sigma_x + \sigma_z)\right)$$

$$\epsilon_z = 1/E \cdot \left(\sigma_z - v(\sigma_x + \sigma_y)\right)$$

$$\gamma_{xy} = \frac{\tau_{xy}}{G} \quad \gamma_{yz} = \frac{\tau_{yz}}{G} \quad \gamma_{xz} = \frac{\tau_{xz}}{G}$$

$$|\sigma_1| = \sigma_Y$$

$$|\sigma_2| = \sigma_Y \quad \text{same sign}$$

$$|\sigma_1 - \sigma_2| = \sigma_Y$$

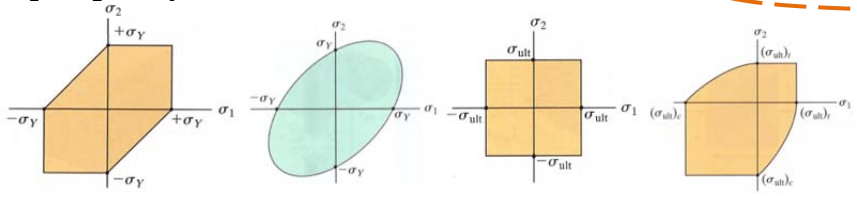
$${\sigma_1}^2 - \sigma_1\sigma_2 + {\sigma_2}^2 = {\sigma_Y}^2$$

$$|\sigma_1| = \sigma_{ult}$$

$$|\sigma_2| = \sigma_{ult}$$

$$e = \frac{1-2v}{E}(\sigma_x + \sigma_y + \sigma_z)$$

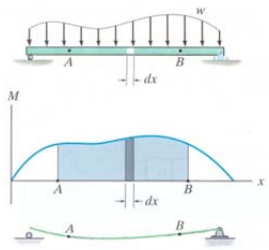
$$k = \frac{E}{3(1-2v)}$$



$$w(x) = EI \cdot \frac{d^4v}{dx^4}$$

$$V(x) = EI \cdot \frac{d^3v}{dx^3}$$

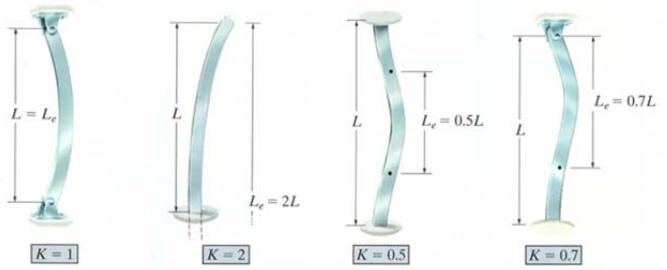
$$M(x) = EI \cdot \frac{d^2v}{dx^2}$$

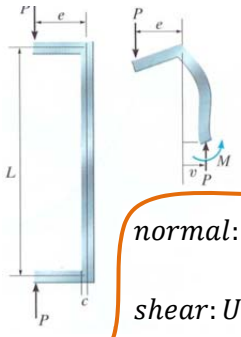


$$P_{cr} = \frac{\pi^2 EI}{(KL)^2}$$

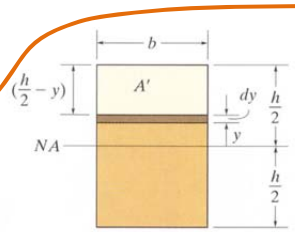
$$\sigma_{cr} = \frac{\pi^2 E}{(KL/r)^2}$$

$$r = \sqrt{I/A}$$



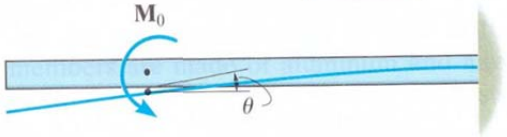


$$v_{max} = e\left[\sec\left(\sqrt{\frac{P}{EI}}\frac{KL}{2}\right) - 1\right] \qquad \sigma_{max} = \frac{P}{A}\left[1 + \frac{ec}{r^2}\sec\left(\frac{KL}{2r}\sqrt{\frac{P}{EA}}\right)\right]$$



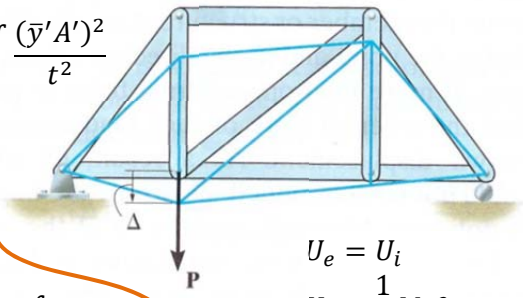
$$normal: U_i = \int \frac{\sigma^2}{2E}\, dV \qquad U_i = \int \left[\frac{1}{2E}\left(\sigma_x{}^2 + \sigma_y{}^2 + \sigma_z{}^2\right) - \frac{v}{E}\left(\sigma_x\sigma_y + \sigma_y\sigma_z + \sigma_x\sigma_z\right)\right.$$

$$shear: U_i = \int \frac{\tau^2}{2G}\, dV \qquad \left. + \frac{1}{2G}\left(\tau_{xy}{}^2 + \tau_{yz}{}^2 + \tau_{xz}{}^2\right)\right] dV$$



$$axial: U_i = \int_0^L \frac{F^2}{2AE}\, dx \qquad torsion: U_i = \int_0^L \frac{T^2}{2GJ}\, dx$$

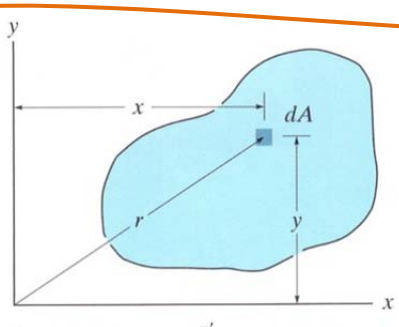
$$bending: U_i = \int_0^L \frac{M^2}{2EI}\, dx \qquad t.shear.: U_i = \int_0^L \frac{f_S V^2}{2GA}\, dx \qquad f_S = \frac{A}{I^2}\int \frac{(\bar{y}'A')^2}{t^2}$$

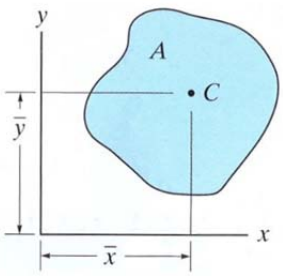


$$U_e = U_i$$

$$U_e = \frac{1}{2}M_0\theta$$

$$U_e = \frac{1}{2}P\Delta$$



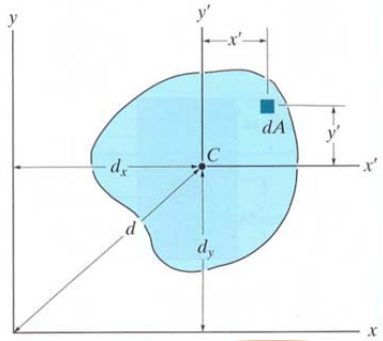


$$\bar{x} = \int x\, dA \Big/ \int dA$$

$$\bar{y} = \int y\, dA \Big/ \int dA$$

$$I_x = \int y^2\, dA \qquad I_y = \int x^2\, dA$$

$$J = \int r^2\, dA = I_x + I_y$$



$$I_x = \bar{I}_{x'} + A \cdot dy^2$$

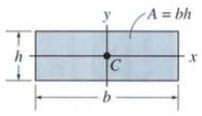
$$I_y = \bar{I}_{y'} + A \cdot dx^2$$

$$J = \bar{J} + A \cdot d^2$$

$$I_{xy} = \int xy\, dA$$

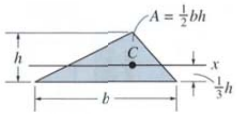
$$I_{xy} = \bar{I}_{x'y'} + Ad_xd_y$$

$$I_{min}^{max} = \frac{I_x + I_y}{2} \pm \sqrt{\left(\frac{I_x - I_y}{2}\right)^2 + I_{xy}{}^2} \qquad \tan 2\theta = \frac{-I_{xy}}{(I_x - I_y)/2}$$

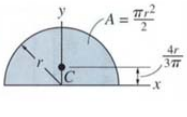


$$I_x = \frac{1}{12}bh^3$$

$$I_y = \frac{1}{12}hb^3$$

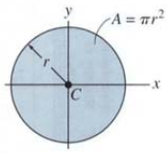


$$I_x = \frac{1}{36}bh^3$$



$$I_x = \frac{1}{8}\pi r^4$$

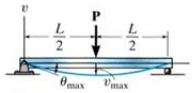
$$I_y = \frac{1}{8}\pi r^4$$



$$I_{x,y} = \frac{1}{4}\pi r^4$$

$$\Delta_{max} = \Delta_{st} \cdot \left(1 + \sqrt{1 + 2(h/\Delta_{st})}\right)$$

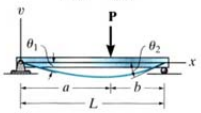
$$\Delta_{max} = \sqrt{\Delta_{st} v^2/g}$$



$$\theta_{max} = \frac{-PL^2}{16EI} \qquad v_{max} = \frac{-PL^3}{48EI}$$

$$v = \frac{-Px}{48EI}(3L^2 - 4x^2)$$

$$0 \le x \le L/2$$

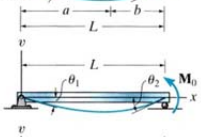


$$\theta_1 = \frac{-Pab(L+b)}{6EIL} \qquad \theta_2 = \frac{Pab(L+a)}{6EIL}$$

$$v\Big|_{x=a} = \frac{-Pba}{6EIL}(L^2 - b^2 - a^2)$$

$$v = \frac{-Pbx}{6EIL}(L^2 - b^2 - x^2)$$

$$0 \le x \le a$$

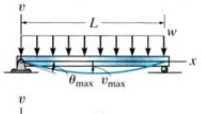


$$\theta_1 = \frac{-M_0L}{6EI} \qquad \theta_2 = \frac{M_0L}{3EI}$$

$$v_{max} = \frac{-M_0L^2}{9\sqrt{3}EI}$$

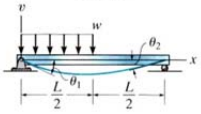
at $x = 0.5774L$

$$v = \frac{-M_0x}{6EIL}(L^2 - x^2)$$



$$\theta_{max} = \frac{-wL^3}{24EI} \qquad v_{max} = \frac{-5wL^4}{384EI}$$

$$v = \frac{-wx}{24EI}(x^3 - 2Lx^2 + L^3)$$



$$\theta_1 = \frac{-3wL^3}{128EI} \qquad \theta_2 = \frac{7wL^3}{384EI}$$

$$v\Big|_{x=L/2} = \frac{-5wL^4}{768EI}$$

$$v_{max} = -0.006563\frac{wL^4}{EI}$$

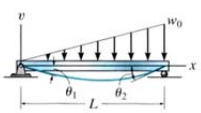
at $x = 0.4598L$

$$v = \frac{-wx}{384EI}(16x^3 - 24Lx^2 + 9L^3)$$

$$0 \le x \le L/2$$

$$v = \frac{-wL}{384EI}(8x^3 - 24Lx^2 + 17L^2x - L^3)$$

$$L/2 \le x \le L$$

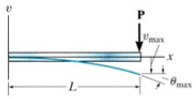


$$\theta_1 = \frac{-7w_0L^3}{360EI} \qquad \theta_2 = \frac{w_0L^3}{45EI}$$

$$v_{max} = -0.00652\frac{w_0L^4}{EI}$$

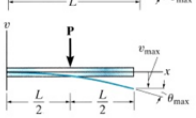
at $x = 0.5193L$

$$v = \frac{-w_0x}{360EIL}(3x^4 - 10L^2x^2 + 7L^4)$$



$$\theta_{max} = \frac{-PL^2}{2EI} \qquad v_{max} = \frac{-PL^3}{3EI}$$

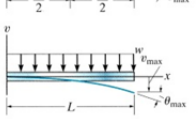
$$v = \frac{-Px^2}{6EI}(3L - x)$$



$$\theta_{max} = \frac{-PL^2}{8EI} \qquad v_{max} = \frac{-5PL^3}{48EI}$$

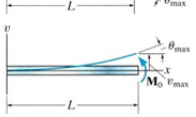
$$v = \frac{-Px^2}{12EI}(3L - 2x) \quad 0 \le x \le L/2$$

$$v = \frac{-PL^2}{48EI}(6x - L) \quad L/2 \le x \le L$$



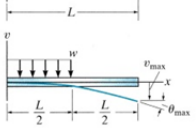
$$\theta_{max} = \frac{-wL^3}{6EI} \qquad v_{max} = \frac{-wL^4}{8EI}$$

$$v = \frac{-wx^2}{24EI}(x^2 - 4Lx + 6L^2)$$



$$\theta_{max} = \frac{M_0L}{EI} \qquad v_{max} = \frac{M_0L^2}{2EI}$$

$$v = \frac{M_0x^2}{2EI}$$



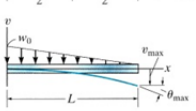
$$\theta_{max} = \frac{-wL^3}{48EI} \qquad v_{max} = \frac{-7wL^4}{384EI}$$

$$v = \frac{-wx^2}{24EI}\left(x^2 - 2Lx + \tfrac{3}{4}L^2\right)$$

$$0 \le x \le L/2$$

$$v = \frac{-wL^3}{384EI}(8x - L)$$

$$L/2 \le x \le L$$



$$\theta_{max} = \frac{-w_0L^3}{24EI} \qquad v_{max} = \frac{-w_0L^4}{30EI}$$

$$v = \frac{-w_0x^2}{120EIL}(10L^3 - 10L^2x + 5Lx^2 - x^3)$$