ME323 Mechanics of Materials

Exam 1 - Equation sheet

$$\sigma_{\text{avg}} = \frac{F_N}{A}\ , \quad \tau_{\text{avg}} = \frac{V}{A}$$

Generalized Hooke's law:

$$\varepsilon_x = \frac{1}{E}\left[\sigma_x - \nu\left(\sigma_y + \sigma_z\right)\right] + \alpha\Delta T$$
$$\varepsilon_y = \frac{1}{E}\left[\sigma_y - \nu\left(\sigma_x + \sigma_z\right)\right] + \alpha\Delta T$$
$$\varepsilon_z = \frac{1}{E}\left[\sigma_z - \nu\left(\sigma_x + \sigma_y\right)\right] + \alpha\Delta T$$

$$\gamma_{xy} = \frac{1}{G}\tau_{xy}\ , \qquad \gamma_{xz} = \frac{1}{G}\tau_{xz}\ , \qquad \gamma_{yz} = \frac{1}{G}\tau_{yz}$$

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

$$\sigma_x = \frac{E}{(1+\nu)(1-2\nu)}\left[(1-\nu)\varepsilon_x + \nu\left(\varepsilon_y + \varepsilon_z\right) - (1+\nu)\alpha\Delta T\right]$$
$$\sigma_y = \frac{E}{(1+\nu)(1-2\nu)}\left[(1-\nu)\varepsilon_y + \nu\left(\varepsilon_x + \varepsilon_z\right) - (1+\nu)\alpha\Delta T\right]$$
$$\sigma_z = \frac{E}{(1+\nu)(1-2\nu)}\left[(1-\nu)\varepsilon_z + \nu\left(\varepsilon_x + \varepsilon_y\right) - (1+\nu)\alpha\Delta T\right]$$

Axial deformations:

$$e_{AB} = u_B - u_A$$

Varying properties: $e = \int_0^L \frac{F}{AE}dx + \int_0^L \alpha\Delta T dx$

Constant properties: $e = \frac{FL}{AE} + \alpha\Delta T L$

$$e = u\cos(\theta) + v\sin(\theta)$$

Torsional deformations:

$$\phi_{AB} = \phi_B - \phi_A$$

Varying properties: $\phi = \int_0^L \frac{T(x)}{G(x)I_p(x)}dx$

Constant properties: $\phi = \frac{TL}{GI_p}$

$$\gamma = \rho\frac{d\phi}{dx}\ , \quad \tau = G\rho\frac{d\phi}{dx}\ , \quad \gamma = \frac{\rho T}{GI_p}\ , \quad \tau = \frac{\rho T}{I_p}$$

where $I_p = \int_A \rho^2 dA$, $I_p = \frac{\pi r^4}{2}$ (solid), $I_p = \frac{\pi}{2}\left(r_o^4 - r_i^4\right)$ (hollow)

Beam Flexural and Shear Stresses:

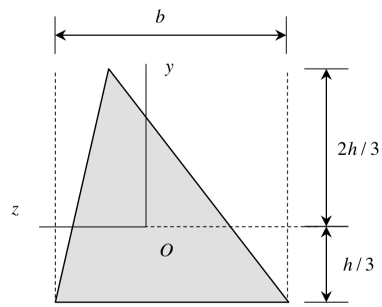
$$\frac{dV}{dx} = p(x) \qquad \frac{dM}{dx} = V(x) \qquad M = EIv'' \qquad \Delta V = P \qquad \Delta M = -M_0$$

$$\sigma(x, y) = \frac{-Ey}{\rho} = \frac{-M_{zz}y}{I_{zz}} \qquad I_{zz} = \frac{bh^3}{12} \text{ (rectangle)}, \quad I_{zz} = \frac{\pi r^4}{4} \text{ (circle)}$$

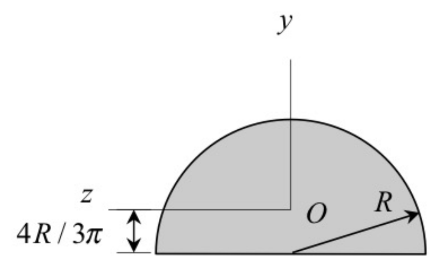
$$\tau(x, y) = \frac{VQ}{I_{zz}t} = \frac{VA^* y^*}{I_{zz}t},$$

$\tau_{\max} = \frac{3V}{2A}$ (rectangle),

$\tau_{\max} = \frac{4V}{3A}$ (circle)



$I_{zz} = \frac{1}{36}bh^3$



Parallel Axis Theorem

$\mathbf{I_B = I_O + Ad^2_{OB}}$