

Mechanical Principles Formula Sheet 1

Two-dimensional stress and strain equations:

$$\begin{aligned}\varepsilon_1 &= \frac{1}{E}(\sigma_1 - \nu\sigma_2) & \sigma_1 &= \frac{E}{1-\nu^2}(\varepsilon_1 + \nu\varepsilon_2) \\ \varepsilon_2 &= \frac{1}{E}(\sigma_2 - \nu\sigma_1) & \sigma_2 &= \frac{E}{1-\nu^2}(\varepsilon_2 + \nu\varepsilon_1)\end{aligned}$$

Three-dimensional strain equations:

$$\begin{aligned}\varepsilon_x &= \frac{1}{E}[\sigma_x - \nu(\sigma_y + \sigma_z)] \\ \varepsilon_y &= \frac{1}{E}[\sigma_y - \nu(\sigma_x + \sigma_z)] \\ \varepsilon_z &= \frac{1}{E}[\sigma_z - \nu(\sigma_x + \sigma_y)]\end{aligned}$$

Volumetric Strain:

$$\begin{aligned}\varepsilon_v &= \frac{\delta V}{V} = \varepsilon_x + \varepsilon_y + \varepsilon_z \\ \varepsilon_v &= \frac{\sigma_x + \sigma_y + \sigma_z}{E}(1 - 2\nu)\end{aligned}$$

Relationships between elastic constants:

$$E = \frac{\sigma}{\varepsilon} \quad K = \frac{\sigma}{\varepsilon_v} = \frac{E}{3(1-2\nu)} \quad G = \frac{E}{2(1+\nu)} \quad K = \frac{2G(1+\nu)}{3(1-2\nu)}$$

Stress and strains in thin walled pressure vessels:

Cylinders		Spheres
$\sigma_c = \frac{pD}{2t\eta_L}$	$\sigma_L = \frac{pD}{4t\eta_c}$	$\sigma = \frac{pD}{4t\eta}$
$\varepsilon_c = \varepsilon_D = \frac{pD}{4tE}(2 - \nu)$	$\varepsilon_L = \frac{pD}{4tE}(1 - 2\nu)$	
$\varepsilon_v = \frac{pD}{4tE}(5 - 4\nu)$		$\varepsilon_v = \frac{3pD}{4tE}(1 - \nu)$

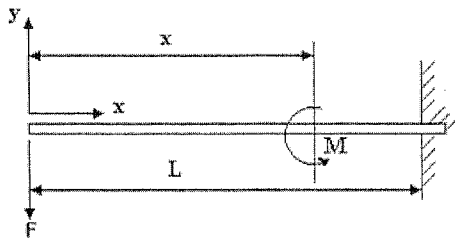
Stresses in thick walled cylinders: (Lame's Equations)

$$\sigma_R = a - \frac{b}{r^2} \quad \sigma_C = a + \frac{b}{r^2}$$

Where a and b are found by applying boundary conditions

Fixed beams : Standard Cases

Cantilever Beams:

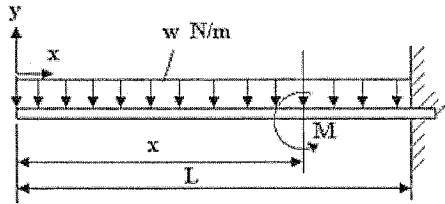


Max Slope

$$\frac{FL^2}{2EI}$$

Max Deflection

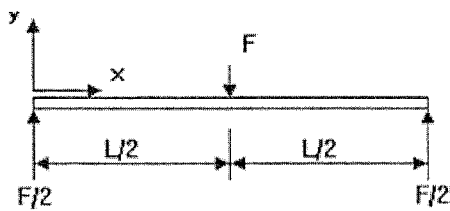
$$\frac{FL^3}{3EI}$$



$$\frac{wL^3}{6EI}$$

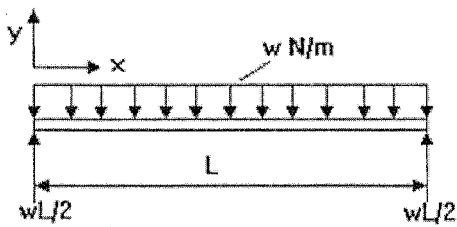
$$\frac{wL^4}{8EI}$$

Simply Supported Beams:



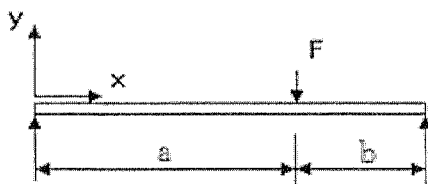
$$\frac{FL^2}{16EI}$$

$$\frac{FL^3}{48EI}$$



$$\frac{wL^3}{24EI}$$

$$\frac{5wL^4}{384EI}$$



$$\frac{Fb}{6EIL}(2L^2 - 3Lb + b^2)$$

$$\frac{Fa^2b^2}{3EIL}$$