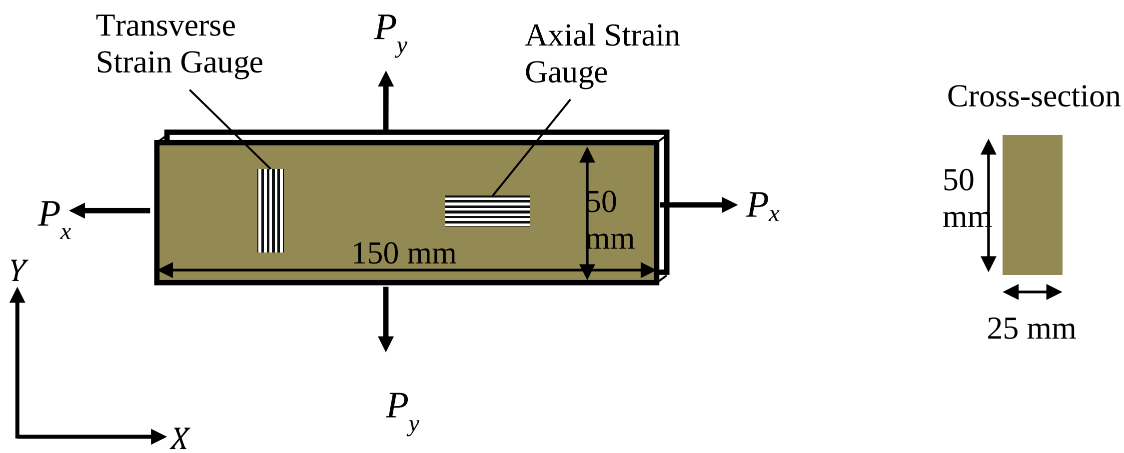
Q1 (10 Points): A $150mm \times 50mm \times 25mm$ specimen is subject to the forces $P_x = 100\ kN$, $P_y = 150\ kN$, as shown below. The strain gauges are used to measure strains in the speficied directions. The axial strain gauge appears to be uncalibrated, leaving only the transverse strain measurement $\varepsilon_y = 0.0002$. The Young's modulus of the material is $E = 100\ GPa$.

(a) What is the Poisson's ratio of this material?

(b) What strain measurement should be expected from the axial strain gauge?

(c) If a decrease in temperature of $50K$ brings the transverse strain ε_y to zero. What is the coefficient of thermal expansion of this material?



Solution:

a) Assuming uniform normal stresses are induced in the test specimen,

$$\sigma_x = \frac{P_x}{A_x} = \frac{100000}{(50)(25)} MPa = 80\ MPa$$

$$\sigma_y = \frac{P_y}{A_y} = \frac{150000}{(150)(25)} MPa = 40\ MPa$$

From Hooke's law,

$$\epsilon_y = \frac{1}{E}\left[\sigma_y - \nu\sigma_x\right] \Rightarrow 0.0002 = \frac{1}{100 \times 10^3}[40 - \nu \times 80]$$

$$\Rightarrow 20 = 40 - \nu \times 80 \Rightarrow 80\nu = 20 \Rightarrow \nu = 0.25$$

b) From Hooke's law,

$$\epsilon_x = \frac{1}{E}\left[\sigma_x - \nu\sigma_y\right] \Rightarrow \epsilon_x = \frac{1}{100 \times 10^3}[80 - 0.25 \times 40] = 0.7 \times 10^{-3} = 0.0007$$

c) When the adjustment for thermal expansion is built into Hooke's law,

$$\epsilon_y = \frac{1}{E}\left[\sigma_y - \nu\sigma_x\right] + \alpha\Delta T$$

$$\Rightarrow 0 = \epsilon_{y_0} + \alpha(-50)$$

$$\Rightarrow 0 = 0.0002 + \alpha(-50) \Rightarrow \alpha = 4 \times 10^{-6}/K$$