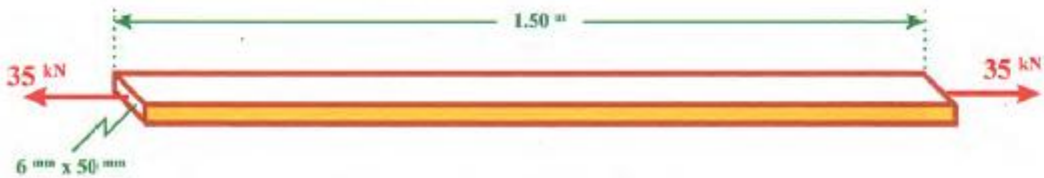
Worksheet 4A
Poisson's Effect



A 6x50 mm flat alloy bar elongates 1.22 mm in a length of 1.50 m under a total axial load of 35.0 kN. The proportional limit of this alloy is 300 MPa. Determine:

A. The axial stress in the bar.

$$\sigma = \frac{N}{A_t}$$

$$\sigma = \frac{35000\ N}{(.006 \times .05)\ m^2}$$

$$\sigma = 116666667\ N/m^2$$

$$= 116.7\ MPa$$

B. The modulus of elasticity of the material.

$$E = \frac{\sigma}{\epsilon}$$

$$\epsilon = \frac{\delta}{L_o}$$

$$\epsilon = \frac{.00122\ m}{1.5\ m} = 8.13 \cdot 10^{-4}\ \frac{m}{m}$$

$$E = \frac{116.7\ MPa}{8.13 \cdot 10^{-4}} = 143,542\ MPa$$

$$E = 143.5\ GPa$$

C. The change in the two lateral dimensions if Poisson's ratio for the material is 0.32.

$$\nu = -\frac{\epsilon_{lat}}{\epsilon_{long}}$$

$$0.32 = -\frac{\epsilon_{lat}}{8.13 \cdot 10^{-4}}$$

$$\epsilon_{lat} = -2.60 \cdot 10^{-4}$$

$$\delta_w = \epsilon_{lat}\ w_o$$

$$= (-2.6 \cdot 10^{-4})(50\ mm)$$

$$= -0.01301\ mm$$

$$\delta_h = \epsilon_{lat}\ h_o$$

$$= (-2.6 \cdot 10^{-4})(6\ mm)$$

$$= -0.001562\ mm$$

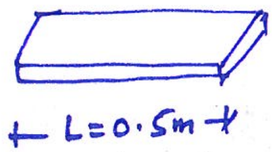
Worksheet #4B
Poisson Effect – Material Constants

A company gives you a 50mmx6mm (wxh) test coupon that is 0.5 meters in length. They tell you that from their testing, the modulus of rigidity for this material is 80 GPa, and that the yield strength is 300 MPa. They ask you to predict the lateral deformation (width and height) of a 2cmx4cm (wxh) bar they will be using in a design that will be subjected to a 40kN axial tensile load.

You test your coupon using a simple tension test, and note that during the test, when the material is within the proportional elastic limit, the coupon deforms 0.012mm when subjected to a load of 1512 N. How much will the bar deform?

Test Coupon:

Given:



$G = 80\,GPa$

$\sigma_y = 300\,MPa$

$P = 1512\,N \Rightarrow \delta = 0.012\,mm$

$$E = \frac{\sigma}{\epsilon} = \frac{\frac{P}{A}}{\frac{\delta}{L}} = \frac{\frac{1512\,N}{50\times 6\,mm^2}}{\frac{0.012\,\cancel{mm}}{0.5\times 10^3\,\cancel{mm}}} = 210000\,\frac{N}{mm^2}$$

$$= 210000\,MPa$$

$$E = \underline{210\,GPa}$$

The 2cm x 4cm bar $\Rightarrow P = 40KN$

$$\varepsilon_{long} = \frac{\sigma}{E} = \frac{P}{AE} = \frac{40\times 10^3\,N}{(20\times 40)mm^2 \times 210000\frac{N}{mm^2}} = 2.38095\times 10^{-4}$$

$$\varepsilon_{LAT} = -\nu\,\varepsilon_{long.} = -0.3125\times 2.38095\times 10^{-4} = -7.440476\times 10^{-5}$$

$$G = \frac{E}{2(1+\nu)} \Rightarrow 80\,GPa = \frac{210\,GPa}{2(1+\nu)}$$

$$\therefore \nu = 0.3125$$

$$\delta_w = \varepsilon_{LAT}\,w_0 = -7.440476\times 10^{-5}\times 2cm = -1.488\times 10^{-4}cm = \underline{-0.001488\,mm}$$

Lateral deformation of the width

$$\delta_h = \varepsilon_{LAT}\,h_0 = -7.440476\times 10^{-5}\times 4cm = -2.9762\times 10^{-4}cm = \underline{-0.00297\,mm}$$

Lateral deformation of the height