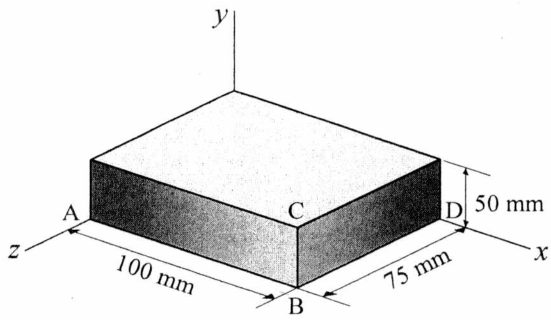
Problem 5: (20 points)

The steel block shown is subjected to a uniform pressure p on all the faces. Knowing that the change in length of edge AB is -30×10^{-3} mm and using E = 200 GPa, and G = 75 GPa, determine the followings:

8 a) The magnitude of the applied pressure, p.
3 b) The strains in the x, y, and z directions.
6 c) The new length of AB, CB, and BD after the application of the uniform pressure p.
3 d) The change in volume, using any approach.



Initial Dimensions

Solution

(a) $$\varepsilon_x = \frac{(\Delta L)_{AB}}{L_{AB}} = \frac{-30\times10^{-3}}{100} = -3\times10^{-4} \text{ mm/mm}$$ (2)

$$\varepsilon_x = -3\times10^{-4} = \frac{1}{200\times10^{9}}\left[-p - 0.333(-p-p)\right]$$

$$\boxed{p = 179.64 \text{ MPa}}$$ (4) Compression

(b) $\boxed{\varepsilon_x = -3\times10^{-4}}$ (1) $G = \frac{E}{2(1+\nu)}$, $75\times10^{9} = \frac{200\times10^{9}}{2(1+\nu)} \Rightarrow \nu = 0.333$ 2

$$\varepsilon_y = \frac{1}{200\times10^{9}}\left[-179.64\times10^{6} - 0.333(-2 * 179.64\times10^{6})\right]$$

$$\boxed{\varepsilon_y = -3\times10^{-4} \text{ mm/mm}}$$ (1)

similarly is $\boxed{\varepsilon_z = -3\times10^{-4} \text{ mm/mm}}$ 1

(c) $(L_{AB})_{new} = (-30\times10^{-3}) + 100 = \boxed{99.97 \text{ mm}}$ 2

$(L_{CB})_{new} = (50 * -3\times10^{-4}) + 50 = \boxed{49.985 \text{ mm}}$ 2

$(L_{BD})_{new} = (75 * -3\times10^{-4}) + 75 = \boxed{74.9775 \text{ mm}}$ 2

(d) change in Volume = ΔV =

$(99.97)(49.985)(74.9775) - (100)(50)(75) =$

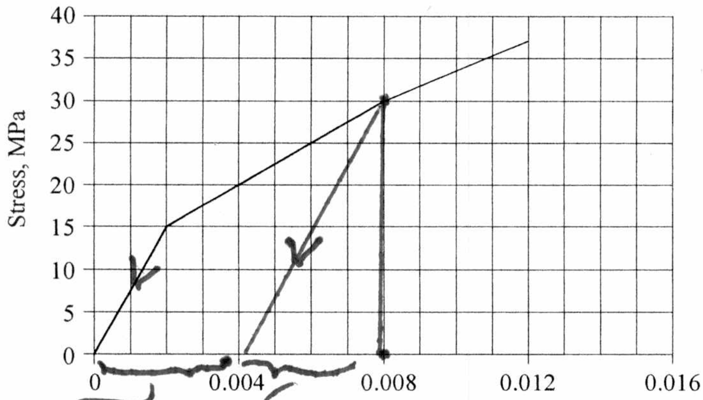
$$\boxed{\Delta V = -337.40 \text{ mm}^3}$$

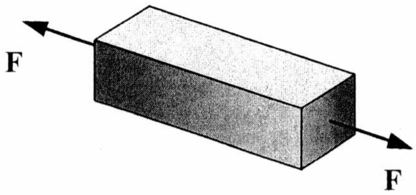
Problem 2: (20 points)

A bar with the stress-strain diagram shown was originally 1 m long with a square cross-sectional area of 100 mm x 100 mm.
When an axial tension load F is applied, the square cross-section became 99.95 mm x 99.95 mm.
Determine the following:

6 a) The magnitude of the applied force F.
3 b) The final length of the bar when the load F is applied.
2 c) The final length of the bar when the load F is released.
5 d) The final length of the bar when the applied load is 300 kN.
4 e) The final length of the bar when the 300 kN load is released.

Poisson's ratio, v = 0.25





Permentant Strain

recovered strain

Solution

(a) $\nu = -\dfrac{\varepsilon_{lat}}{\varepsilon_{long}} \Rightarrow \varepsilon_{long} = \dfrac{-\varepsilon_{lat}}{\nu}$

$\varepsilon_{lat} = \dfrac{99.95 - 100}{100} = -0.0005 \ \frac{mm}{mm}$ (2)

$\varepsilon_{long} = \dfrac{-(-0.0005)}{0.25} = 0.002 \ \frac{mm}{mm}$

From $\sigma - \varepsilon$ diagram when $\varepsilon_{long} = 0.002 \Rightarrow \boxed{\sigma = 15 \ MPa}$ (1)

$\sigma = \dfrac{P}{A_0} \Rightarrow P = \sigma A_0 = 15 \times 10000 = \boxed{150000 \ N = 150 kN}$ (2)

(b) $\varepsilon_{log} = \dfrac{L_f - L_o}{L_o} \Rightarrow L_f = (\varepsilon_{log} \times l_o) + l_o = \boxed{1.002 \ m = l_f}$ (3)

(c) when the load F is released will go back ov original Length $\sigma = \sigma_y$,
$\therefore L_f = 1 \ m$. (2)

(d) $\sigma = \dfrac{300000}{10000} = 30 \ MPa$, in The plastic range. (2)

at $\sigma = 30 \ MPa$, $\varepsilon_{long} = 0.008$ mm/mm (2)

$l_f = (0.008)(1) + 1 = \boxed{1.008 \ m}$. (1)