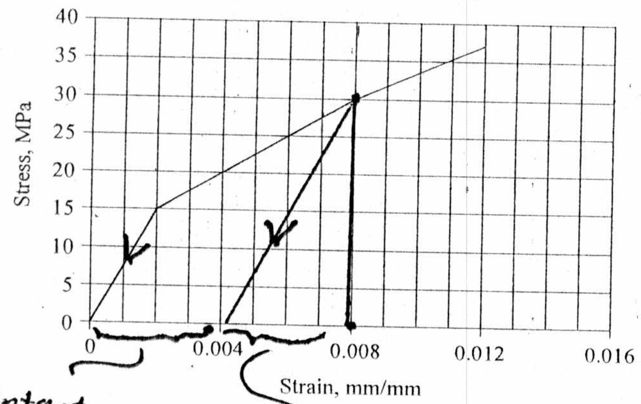
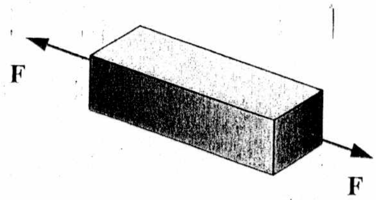
Problem 2: (20 points)

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





Solation

(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)

$\varepsilon_{long} = \dfrac{-(-0.0005)}{0.25} = 0.002 \frac{mm}{mm}$ (1)

(1)

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

(2)

$\sigma = \dfrac{P}{A_o} \Rightarrow P = \sigma A_o = 15 \times 10000 = \boxed{150000 \text{ N} = 150 \text{ kN}}$

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

(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)

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

(e) $E = \dfrac{\sigma}{\varepsilon_{long}} = \dfrac{15}{0.002} = 7500$ MPa

(3)

recovered strain $= \dfrac{30}{7500} = 0.004 \frac{mm}{mm}$, or directly form the graph

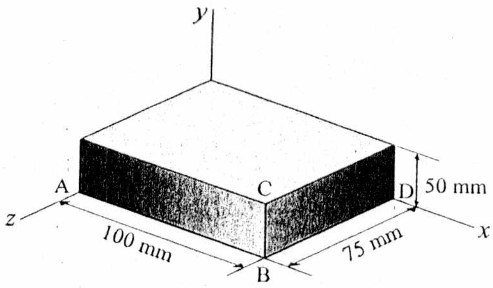
permentant strain $= 0.008 - 0.004 = .004$ mm/mm

$L_f = (1 \times .004) + 1 = \boxed{1.004 \text{ m}}$ (1)

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)

$$\varepsilon_x = \frac{(\Delta L)_{AB}}{L_{AB}} = \frac{-30 \times 10^{-3}}{100} = -3 \times 10^{-4} \text{ mm/mm}$$ (2)

$$\varepsilon_x = -3 \times 10^{-4} = \frac{1}{200 \times 10^9}\left[-p - 0.333(-p-p)\right]$$

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

(b)

$$\boxed{\varepsilon_x = -3 \times 10^{-4}}$$ (1)

$$G = \frac{E}{2(1+\nu)}, \quad 75 \times 10^9 = \frac{200 \times 10^9}{2(1+\nu)} \Rightarrow \nu = 0.333$$ (2)

$$\varepsilon_y = \frac{1}{200 \times 10^9}\left[-179.64 \times 10^6 - 0.333(-2 * 179.64 \times 10^6)\right]$$

$$\boxed{\varepsilon_y = -3 \times 10^{-4} \text{ mm/mm}}$$ (1)

similarly $\rightarrow$ $\boxed{\varepsilon_z = -3 \times 10^{-4} \text{ mm/mm}}$ (1)

(c)

$$(L_{AB})_{new} = (-30 \times 10^{-3}) + 100 = \boxed{99.97 \text{ mm}}$$ (2)

$$(L_{CB})_{new} = (50 * -3 \times 10^{-4}) + 50 = \boxed{49.985 \text{ mm}}$$ (2)

$$(L_{BD})_{new} = (75 * -3 \times 10^{-4}) + 75 = \boxed{74.9775 \text{ mm}}$$ (2)

(d) change in Volume = ΔV =

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

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

-337.4 mm^3

or $e = \frac{\Delta V}{V} = \varepsilon_x + \varepsilon_y + \varepsilon_z$

$$\frac{\Delta V}{375000} = 3(-3 \times 10^{-4})$$

$$\Delta V = -337.5 \text{ mm}^3$$