

Question one

1a

$$L = 1.5 \text{ m}$$

$$F = 3.5 \text{ kN}$$

$$W = 1500 \text{ N/m}$$

$$EI = 2.2 \times 10^6 \text{ N/m}^2$$

$$\text{Deflection} = \frac{FL^3}{3EI} + \frac{WL^4}{8EI}$$

$$= ~~1.7898 \times 10^{-3}~~ - \frac{3500 \times 1.5^3}{3 \times 2.2 \times 10^6} + - \frac{1500 \times 1.5^4}{8 \times 2.2 \times 10^6}$$

$$= ~~1.7898 \times 10^{-3}~~ - 1.7898 \times 10^{-3} - 0.4315 \times 10^{-3}$$

$$= -2.2213 \times 10^{-3} \text{ m}$$

1b

$$y_{PL} = y - y_{defl}$$

$$y_{PL} = -5 \times 10^{-3} - (-0.4315 \times 10^{-3}) = -4.5685 \times 10^{-3}$$

$$F = \frac{y_{PL} \times 3EI}{L^3}$$

$$F = \frac{-4.5685 \times 10^{-3} \times 3 \times 2.2 \times 10^6}{1.5^3}$$

$$F = -8933.95 \text{ N}$$

$$DF = 8933.95 - ~~3500~~$$

$$DF = 5433.95 \text{ N}$$

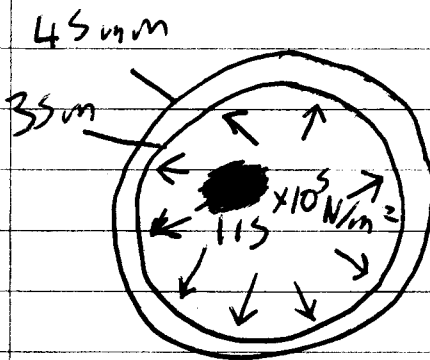
Question two

$$D_o = 45 \text{ mm} \rightarrow R_o = 22.5 \text{ mm}$$

$$D_i = 35 \text{ mm} \rightarrow R_i = 17.5 \text{ mm}$$

$$P = 115 \times 10^5 \text{ N/m}^2$$

2a



2b

$$R_o = 22.5 \times 10^{-3} \quad \sigma_R = 0$$

$$\textcircled{1} \quad \sigma_R = a - \frac{b}{r^2} \rightarrow 0 = a - \frac{b}{(22.5 \times 10^{-3})^2} \rightarrow 0 = b - \frac{(22.5 \times 10^{-3})^2}{b} a$$

$$b = 0.0225^2 a$$

$$R_i = 17.5 \times 10^{-3} \quad \sigma_R = 115 \times 10^5$$

$$\sigma_R = a - \frac{b}{R^2} \rightarrow -115 \times 10^5 = a - \frac{b}{(17.5 \times 10^{-3})^2} \rightarrow 115 \times 10^5 = \frac{b}{(17.5 \times 10^{-3})^2} a$$

$$\sigma_R = -115 \times 10^5 = \frac{b}{(17.5 \times 10^{-3})^2} a - \frac{b}{(22.5 \times 10^{-3})^2} a$$

$$-115 \times 10^5 (0.0175^2) = b - 0.0175^2 a$$

$$-115 \times 10^5 (0.0175^2) = 0.0225^2 a - 0.0175^2 a$$

$$-115 \times 10^5 (0.0175^2) = a (0.0225^2 - 0.0175^2)$$

Question two

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$$a = \frac{115 \times 10^5 \times 0.0175^2}{0.0225^2 - 0.0175^2} = 17.61 \times 10^6$$

$$b = 0.0225^2 a = 8.92 \times 10^3$$

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$$\sigma_c = a + \frac{b}{r^2} \rightarrow 17.61 \times 10^6 + \frac{8.92 \times 10^3}{R^2}$$

$$\sigma_{CI} = 17.61 \times 10^6 + \frac{8.92 \times 10^3}{0.0175^2}$$

$$\sigma_{CI} = 46.74 \times 10^6 = 46.74 \text{ MPa}$$

$$\sigma_{CO} = 31.88 \times 10^6 = 31.88 \text{ MPa}$$

3a Question three

$$\epsilon_x = -10 \times 10^{-6}$$

$$\epsilon_y = +13 \times 10^{-6}$$

$$\nu = 0.20$$

$$E = 165 \times 10^9$$

$$\sigma_x = \frac{E}{(1-\nu^2)} (\epsilon_x + \nu \epsilon_y)$$

$$\downarrow$$
$$\sigma_x = \frac{165 \times 10^9}{(1-0.2^2)} (-10 \times 10^{-6} + (0.2 \times 13 \times 10^{-6}))$$

$$\downarrow$$
$$\sigma_x \approx -1.272 \text{ MPa}$$

$$\sigma_y = \frac{E}{(1-\nu^2)} (\epsilon_y + \nu \epsilon_x)$$

$$\downarrow$$
$$\sigma_y = \frac{165 \times 10^9}{(1-0.2^2)} (13 \times 10^{-6} + (0.2 \times -10 \times 10^{-6}))$$

$$\downarrow$$
$$\sigma_y \approx 1.891 \text{ MPa}$$

Question Three

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$$\sigma_x = 20 \times 10^6$$

$$\sigma_y = -15 \times 10^6$$

$$\nu = 0.2$$

$$E = 165 \times 10^9$$

$$\epsilon_x = \frac{1}{E} (\sigma_x - \nu \sigma_y) \rightarrow \epsilon_x = \frac{1}{165 \times 10^9} (20 \times 10^6 - (0.2 \times -15 \times 10^6))$$

$$\epsilon_x = ~~139.39 \times 10^{-6}~~ 139.39 \times 10^{-6}$$

$$\epsilon_y = \frac{1}{E} (\sigma_y - \nu \sigma_x) \rightarrow \epsilon_y = \frac{1}{165 \times 10^9} (-15 \times 10^6 - (0.2 \times 20 \times 10^6))$$

$$\epsilon_y = -115.15 \times 10^{-6}$$

Question Five

5a

$$L = 350 \text{ mm}$$

$$\text{Volume} = 42875000 \text{ mm}^3$$

$$P = 50 \times 10^6$$

$$V = 0.3$$

$$E = 165.0 \times 10^9 \text{ Pa}$$

To get bulk modulus k

$$K = \frac{E}{3(1-2V)} = \frac{165 \times 10^9}{3(1-(2 \times 0.3))} = 137.5 \times 10^9 \text{ Pa}$$

To get volumetric strain

$$\epsilon_v = \frac{3}{E} (-P + V2P) \rightarrow \frac{3}{165 \times 10^9} (-50 \times 10^6 + 0.3 (2 \times 50 \times 10^6))$$

$$\epsilon_v = -363.64 \times 10^{-6}$$

To get change in volume

$$V \epsilon_v = \Delta V \rightarrow \Delta V = 350^3 \times -363.64 \times 10^{-6}$$

$$\Delta V = -15591.07 \text{ mm}^3$$