

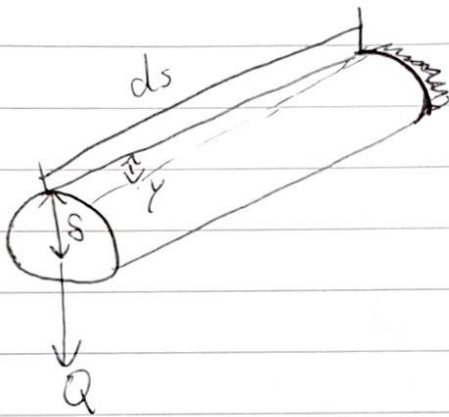
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Question 2. a) i) ii)



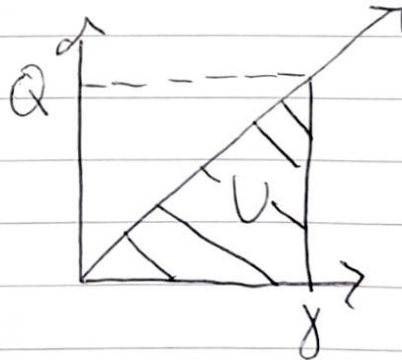
$$G = \frac{\tau}{\gamma}$$

$$\tau = \frac{Q}{A}$$

$$G = \frac{Q}{A\gamma}$$

$$\gamma = \frac{Q}{AG}$$

$$U = \frac{Q^2 L}{2AG} \text{ Prod}$$



Small section

$$U = \frac{1}{2} \cdot \gamma \cdot Q$$

$$\gamma = \frac{Q}{AG}$$

$$U = \frac{1}{2} \left(\frac{Q}{AG} \right) \cdot Q$$

$$U = \frac{Q^2}{2AG}$$

Total strain energy

$$U = \frac{Q^2}{2AG} ds$$

$$U = \int_0^L \frac{Q^2 ds}{2AG} = \frac{Q^2 L}{2AG}$$

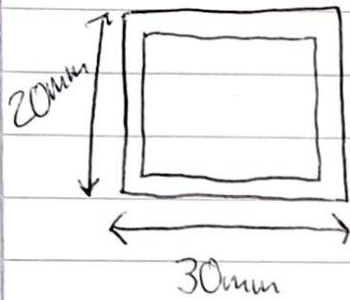
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Question 2 b)i



$$wt = 2.5 \times 10^{-3} \text{ m}$$

$$x = 30 \times 10^{-3} \text{ m}$$

$$y = 20 \times 10^{-3} \text{ m}$$

$$L = 2.4 \text{ m}$$

$$\sigma = 480 \text{ MPa} \times 10^6 \text{ Pa}$$

$$E = 190 \times 10^9 \text{ Pa}$$

$$U = \frac{P^2 L}{2AE}$$

$$P = \sigma A$$

$$A = \text{external} - \text{internal}$$

$$A = (30 \times 10^{-3} \times 20 \times 10^{-3}) - (25 \times 10^{-3} \times 15 \times 10^{-3})$$
$$6 \times 10^{-4} - 3.75 \times 10^{-4}$$

$$A = 2.25 \times 10^{-4} \text{ m}$$

$$P = (480 \times 10^6) \times (2.25 \times 10^{-4})$$
$$= 108000 \text{ N}$$

$$U = 327.41 \text{ J}$$

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Question 2) b) ii) iii)

P.E = mgh - extension is not significant

$$P.E = mgh = U \quad P = \sigma A$$

$$mgh = \frac{P^2 L}{2AE} = \frac{\sigma^2 A^2 L}{2AE} = \frac{\sigma^2 AL}{2E}$$

$$AL = V \quad mg = W$$

$$mgh = \frac{\sigma^2 V}{2E}$$

$$h = \frac{\sigma^2 V}{2EW}$$

$$m = 20 \text{ kg} \quad g = 9.81 \text{ m/s}^2 \quad h = 0.45 \text{ m}$$

$$A = 2.25 \times 10^{-4} \text{ m}^2$$

$$\sqrt{\frac{2EWh}{V}} = \sigma$$

$$= 249.2589 \times 10^6 \text{ Pa}$$

$$= 249.26 \text{ MPa}$$

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Question 2 B) iv)

$\downarrow F_z$
~~external~~ $\phi = 0.02 \text{ m}$ $L = 2.4 \text{ m}$

$$\sigma_{\max} = 249.26 \text{ MPa}$$

$$h = \frac{\sigma^2 V}{2EW}$$

$$\frac{2EWh}{\sigma^2} = AL$$

$$\frac{2EWh}{\sigma^2 L} = A$$

$$= 2.25 \times 10^{-4}$$

$$A = \pi(r_2^2 - r_1^2)$$

$$\frac{2.25 \times 10^{-4}}{\pi} = r_2^2 - r_1^2$$

$$r_1 = \sqrt{r_2^2 - \left(\frac{2.25 \times 10^{-4}}{\pi}\right)}$$

~~$$\frac{2.25 \times 10^{-4}}{\pi} - r_2^2 = r_1^2$$~~

$$r_1 = 0.0181 \text{ m}$$

$$r_1 = 18.12 \text{ mm}$$

~~$$\sqrt{\frac{2.25 \times 10^{-4}}{\pi} - r_2^2} = r_1$$~~

$$t = 20 - 18.12$$

$$t = 1.88 \text{ mm}$$

~~$$= 1.6126 \times 10^{-4} \text{ m}$$~~

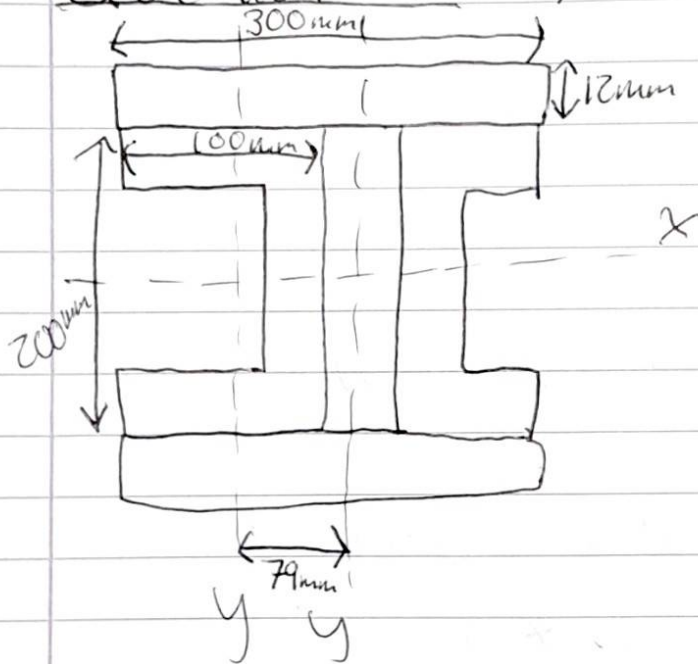
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Question 4 a)



one 'C'

$$I_{xx} = 26.2 \times 10^6 \text{ mm}^4 \quad (\times 10^{-12} \text{ m}^4)$$

$$I_{yy} = 1.57 \times 10^6 \text{ mm}^4 \quad (\times 10^{-12} \text{ m}^4)$$

$$A = 4400 \text{ mm}^2 \quad (\times 10^{-6} \text{ m}^2)$$

$$L = 8 \text{ m}$$

$$E = 200 \text{ GPa}$$

$$a = 1/500 \quad \text{pin-pin}$$

$$\sigma_y = 320 \text{ MPa}$$

$$I = \frac{bd^3}{12} \quad k = \sqrt{\frac{E}{A}}$$

$$\text{parallel} = I_{\text{net}} = I + Ah^2$$

$$I_{xx} = 2 \times \text{plate} + 2 \times \text{'C' section}$$

$$\text{'C' section } I_{xx} = 26.2 \times 10^{-6} \text{ m}^4 \times 2$$

$$\text{plate} = I + Ah^2$$

$$I = \frac{0.3 \times 0.012^3}{12} = 4.32 \times 10^{-8} \text{ m}^4$$

$$A = 0.3 \times 0.012 = 3.6 \times 10^{-3} \text{ m}^2$$

$$h = (200/2) + (12/2) = 106 \text{ mm} = 0.106 \text{ m}$$

$$\text{Plate} = 4.32 \times 10^{-8} + ((3.6 \times 10^{-3}) \times 0.106^2)$$

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Question 4 a) b) c)

$$I_{xx} \text{ Plate} = 4.0493 \times 10^{-5} \text{ m}^4 \times 2$$

$$I_{xx} = 2(26.2 \times 10^{-6}) + 2(4.0493 \times 10^{-5})$$

$$I_{xx} = \underline{1.3339 \times 10^{-4} \text{ m}^4}$$

$$I_{yy} = 2((1.57 \times 10^{-6}) + ((4.4 \times 10^{-3}) \times 0.079^2)) + 2\left(\frac{bd^3}{12}\right)$$

$$I_{yy} = 5.8061 \times 10^{-5} \text{ m}^4 + 2(2.7 \times 10^{-5})$$

$$I_{yy} = \cancel{1.206} \underline{1.1206 \times 10^{-4} \text{ m}^4}$$

$$I_{xx} (1.3339 \times 10^{-4}) > I_{yy} (1.1206 \times 10^{-4})$$

Tend to buckle around the Y axis.

$$\text{Total Area} = 0.016 \text{ m}^2$$

$$r = \sqrt{\frac{I}{A}} \quad r = \frac{1.1206 \times 10^{-4}}{0.016} = \underline{0.0837 \text{ m}} = \underline{83.7 \text{ mm}}$$

$$SR = \frac{L}{r} = \underline{95.58} = \text{Slenderness ratio}$$

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Question 4 d) f)

$$P_e = \frac{\pi^2 EI}{4L^2}$$

$$E = 200 \text{ GPa}$$

$$I = 1.1206 \times 10^{-4} \text{ m}^4$$

$$L = 8 \text{ m}$$

$$A = 0.016$$

$$P_e = 3.4562 \times 10^6 \text{ N}$$
$$\underline{\underline{3.4562 \text{ MN}}}$$

$$P_r = \frac{\sigma_y A}{1 + \alpha \left(\frac{L}{H}\right)^2}$$

$$P_r = 2.3083 \times 10^6 \text{ N}$$
$$\underline{\underline{2.3083 \text{ MN}}}$$

g)

$$I_{xx} = 1.3339 \times 10^{-4} \text{ m}^4 + 2 \left(\frac{0.006 \times 0.224^3}{12} \right) + 1.1239 \times 10^{-5}$$

$$I_{xx} = 1.4463 \times 10^{-4} \text{ m}^4$$

$$I_{yy} = 1.1206 \times 10^{-4} + 2 \left(\left(\frac{0.224 \times 0.006^3}{12} \right) + \left((1.344 \times 10^{-3}) \times 0.153^2 \right) \right) + 4.032 \times 10^{-9}$$

$$+ 6.2932 \times 10^{-5} \text{ m}^4$$

$$I_{yy} = 1.7499 \times 10^{-4} \text{ m}^4$$

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Question 4 f

If the axis of buckling was to not change and remain around yy.

$$Euler's = \frac{\pi^2 EI}{L^2}$$

$$E = 200 \text{ GPa} \quad I = 1.7499 \times 10^{-4}$$

$$P_e = 5.3971 \times 10^6 \text{ N} \text{ Around yy}$$

P_e around the now lower I_{xx}

$$I_{xx} = 1.4463 \times 10^{-4} \text{ m}^4$$

$$P_e = 4.4608 \text{ MN}$$
$$4.4608 \times 10^6 \text{ N}$$

If nothing else were to change, the increase in Euler's load is

$$5.3971 \times 10^6 - 4.4608 \times 10^6 = 0.9363 \times 10^6 \text{ N}$$

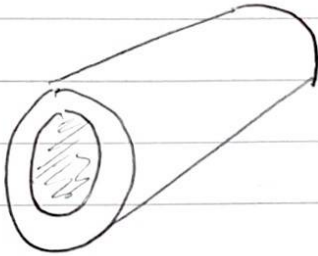
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Question 3 a)



$$o/\phi = 75 \text{ mm}$$

$$t = 5$$

$$i/\phi = \cancel{65} \text{ mm}$$

$$\sigma^* = 325 \times 10^6 \text{ Pa}$$

$$\nu = 0.3 - \text{steel}$$

$$S_f = 6 = n$$

$$\text{Hoop stress} = \frac{Pd}{2t} = \sigma_1$$

$$\text{Longitudinal} = \frac{Pd}{4t} = \sigma_2$$

$$\text{radial assumed} = 0 \quad \sigma_3 = \sigma_3$$

$$\sigma_1 - \sigma_3 = \sigma_y$$

$$\sigma_1 = \frac{Pd}{2t}$$

$$\sigma_1 - 0 = \sigma_y$$

$$\frac{Pd}{2t} = \frac{\sigma_y}{n}$$

$$P = \frac{(325 \times 10^6) 2t}{6d}$$

$$P = \cancel{4.3 \times 10^6 \text{ Pa}} \\ 7.22 \times 10^6 \text{ Pa} \\ 7.22 \text{ MPa}$$

$$\frac{T}{J} = \frac{\tau}{R}$$

$$PA = F \quad 7.22 \text{ MPa} \times 1.0996 \times 10^{-3} = 7939.112 \text{ N}$$

$$T = F \cdot r = 7939.112 \times \frac{0.075}{2} = \underline{\underline{297.7167 \text{ Nm}}}$$

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Question 3) b)

~~$$[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2] = \frac{2\sigma_y^2}{6}$$~~

~~$$\sigma_2 = 0 \quad \sigma_3 = 0$$~~

~~$$[(\sigma_1 - 0)^2 + (0 - 0)^2 + (0 - \sigma_1)^2] = \frac{2\sigma_y^2}{6}$$~~

~~$$\sigma_1^2 - \sigma_1^2$$~~

$$\sigma_3 = 0$$

$$[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - 0)^2 + (0 - \sigma_1)^2] = \frac{2\sigma_y^2}{6^2}$$

$$\left[\left(\frac{Pd}{2t}\right)^2 - \left(\frac{Pd}{4t}\right)^2\right] + \left(\frac{Pd}{4t}\right)^2 + \left(\frac{Pd}{2t}\right)^2 = \frac{2\sigma_y^2}{6^2}$$

$$\left[\frac{3Pd^2}{8t^2}\right] = \frac{2\sigma_y^2}{6^2} \quad P = \sqrt{\frac{2\sigma_y^2 \times 8t^2}{3d^2 \times 6^2}}$$

$$P = 8.3395 \times 10^6 \text{ Pa}$$

$$P \cdot A = F = 9170.1142 \text{ N}$$

$$T = F \cdot R = \underline{\underline{343.8793 \text{ Nm}}}$$