Name :- Vanshika Garg.
Branch :- CSE.
Roll No. :- 20010407 4.

EM - Assignment - 4.

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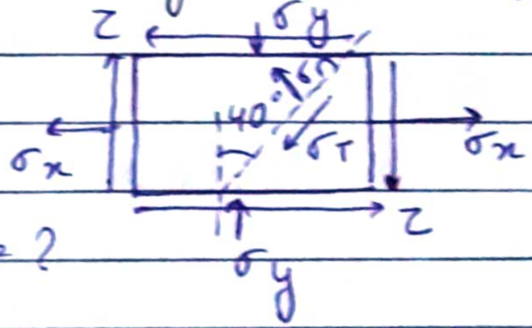
Unit - 4.

Q1. In a strained material two direct stresses of 860 N/mm² (T) and 440 N/mm² (C) are acting on two mutually perpendicular planes respectively with a shear stress of 330 N/mm². Locate principle planes and find principal stress. Find normal, tangential and resultant stress on an inclined plane making 40° with the plane of tensile stress. Also find max. tangential stress?

$\sigma_x = 860\ N/mm^2\ (T)$

$\sigma_y = -440\ N/mm^2\ (C)$.

$\tau = 330\ N/mm^2$



$\theta_p = ?$, $\theta_s = ?$, $\sigma_n = ?$, $\sigma_T = ?$

$\sigma_R = ?$. $\tau_{max} = ?$

$$\tan 2\theta_p = \frac{2\tau}{\sigma_x - \sigma_y} = \frac{2(330)}{860 - (-440)} = \frac{\cancel{2}(33\cancel{0})}{\cancel{130}\cancel{0}_{65}}$$

$$\tan 2\theta_p = 0.50.$$

$$2\theta_p = \tan^{-1}(0.50).$$

$$2\theta_p = 26.56° \Rightarrow 2\theta_s = 2\theta_p + 90°$$

$$\boxed{2\theta_s = 116.56°}$$

$$\sigma_n = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta.$$

$$\sigma_n = \frac{860 - 440}{2} + \frac{860 + 440}{2}\cos 80° + 330 \sin 80$$

$$\sigma_n = 210 + 750 \times 0.17 + 300 \times 0.98.$$

$$\boxed{\sigma_n = 631.5\ N/mm^2}$$

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$$\sigma_T = -\left(\frac{\sigma_x - \sigma_y}{2}\right)\sin 2\theta + \tau_{xy}\cos 2\theta$$

$$\sigma_T = -750 \sin 80 + 300 \cos 80$$

$$\sigma_T = -750\,(0.98) + 300\,(0.17)$$

$$\boxed{\sigma_T = -684\ N/mm^2}$$

$$\sigma_R = \sqrt{\sigma_n^2 + \sigma_T^2}$$

$$\sigma_R = \sqrt{(631.5)^2 + (-684)^2} = \sqrt{866648.25}$$

$$\boxed{\sigma_R = 930.93\ N/mm^2}$$

$$\sigma_{n1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau^2_{xy}}$$

$$= \frac{860 - 440}{2} \pm \sqrt{\left(\frac{1500}{2}\right)^2 + 9000}$$

$$= \frac{420}{2} \pm \sqrt{(750)^2 + 90000}$$

$$= 210 \pm \sqrt{562500 + 90000}$$

$$\sigma_{n1,2} = 210 \pm \sqrt{652500}$$

$$\sigma_{n1} = 1017.77\ N/mm^2, \quad \sigma_{n2} = -597.77\ N/mm^2$$

$$\tau_{max.} = \frac{\sigma_{n1} - \sigma_{n2}}{2}$$

$$= \frac{1615.54}{2}$$

$$\boxed{\tau_{max.} = 807.77\ N/mm^2}$$

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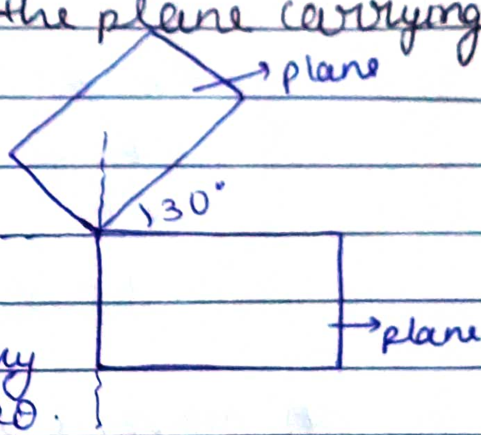
Q2 At a certain point in a strained material two stresses of 100 N/mm² and 60 N/mm² both tensile are acting on a plane mutually perp. to each other. Find out normal, tensile and resultant stress on a plane inclined at 30° with the plane carrying the stress of 100 N/mm².



$\sigma_1 = 100\ N/mm^2\ (T)$

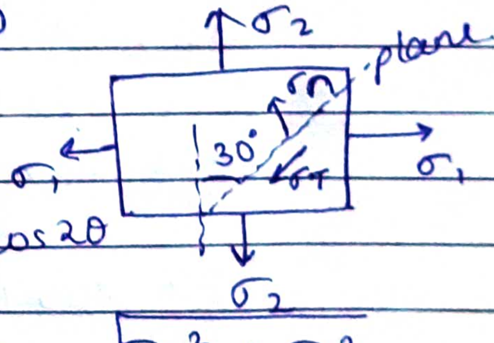
$\sigma_2 = 60\ N/mm^2\ (T)$

$\theta = 30°.$

$$\sigma_n = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta.$$

$$\sigma_n = \frac{160}{2} + \frac{40}{2}\cos 60° + 0.$$

$$\sigma_n = 80 + 20 \times \frac{1}{2} + 0 \Rightarrow 90$$



$$\boxed{\sigma_n = 90\ N/mm^2\ (T)}$$

$$\sigma_t = -\frac{(\sigma_x - \sigma_y)}{2}.\sin 2\theta + \tau_{xy}\cos 2\theta$$

$$= -20\sin 60° + 0.$$

$$= -10\,(1.73)$$

$$\boxed{\sigma_t = -17.3\ N/mm^2}$$

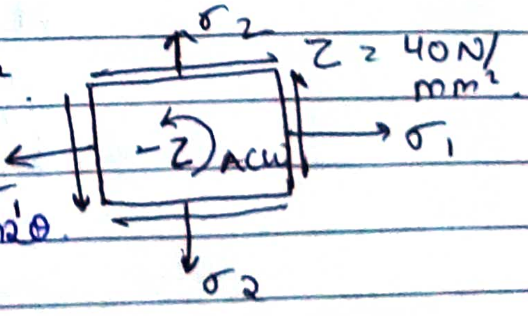
$$\sigma_R = \sqrt{\sigma_n^2 + \sigma_t^2}$$

$$\sigma_R = \sqrt{8100 + 299.29}$$

$$\boxed{\sigma_R = 91.64\ N/mm^2}$$

Q3. $\sigma_1 = 100\ N/mm^2$; $\sigma_2 = 60\ N/mm^2$.

$\tau = -40\ N/mm^2$; $\theta = 30°$; $\sigma_n = ?$ $\sigma_t = ?$



$$\sigma_n = \frac{\sigma_1 + \sigma_2}{2} + \frac{\sigma_1 - \sigma_2}{2}\cos 2\theta + \tau\sin 2\theta.$$

$$= 80 + 20 \times \frac{1}{2} - 40 \times \sqrt{3}/2$$

$\sigma_n = 80 + 10 - 20\sqrt{3}$.

$\boxed{\sigma_n = 55.35\ N/mm^2}$

$\sigma_t = -\frac{(\sigma_1 - \sigma_2)}{2}\sin 2\theta + \tau\cos 2\theta$

$\sigma_t = -20\times\sin 60^\circ - 40.\cos 60^\circ$

$\sigma_t = -20\times\sqrt{3}/2 - 40\times 1/2$

$\sigma_t = -20 - 10\sqrt{3}$.

$\boxed{\sigma_t = -37.32\ N/mm^2}$

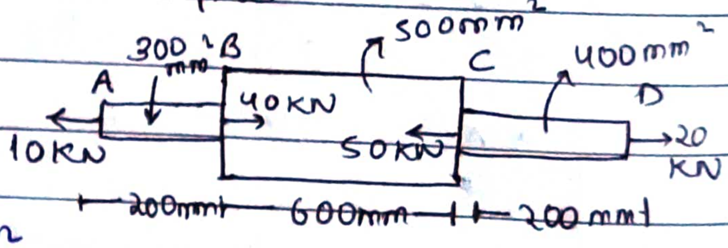
Q4. ABCD is an materialistich that total change in length of member. E = 200 GPa.

$E = 200\,GPa$

$\Delta L = ?$

$E = 200\times 10^9\ N/m^2$.

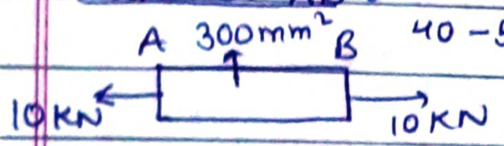
$E = 200 \times \frac{10^9}{10^6}\ N/mm^2$



$\boxed{E = 200\ kN/mm^2}$

Member AB :-

40 − 50 + 20

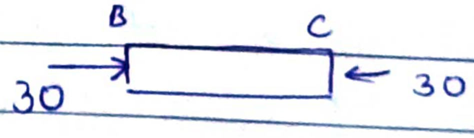


$\Delta L_1 = \frac{P_1 l_1}{A_1 E}$

$= \frac{10(200)}{300(200)}$

$\boxed{\Delta L_1 = 0.033mm.}$

member BC :-



$\Delta L_2 = \frac{P_2 l_2}{A_1 E}$

$= \frac{-30(600)}{500(200)}$

$= -9/50$

$\boxed{\Delta L_2 = -0.18\ mm}$

Member CD :-

~~50 - 40 + 20~~

$$\Delta L_3 = \frac{P_3 l_3}{A_3 E}$$

$$\Delta L_3 = \frac{\cancel{20}(\cancel{200})}{\cancel{400}_{20}(\cancel{200})} \Rightarrow \boxed{\Delta L_3 = 0.05 \text{ mm.}}$$

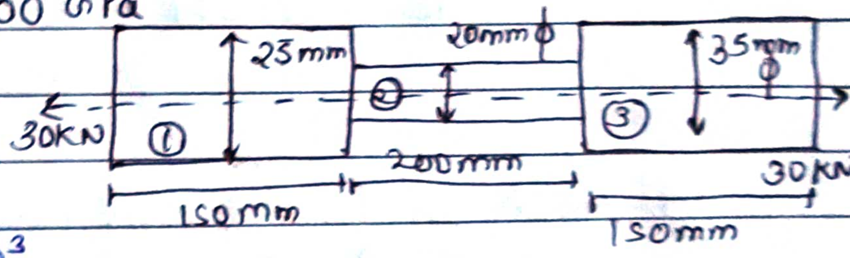
so, $\Delta L = \Delta L_1 + \Delta L_2 + \Delta L_3$

$$\Delta L = 0.033 - 0.18 + 0.05.$$

$$\boxed{\Delta L = -0.097 \text{mm (C)}} \text{ Ans}$$

Q5. Copper bar under tensile load :-

Find $\Delta L = ?$, $E = 100$ GPa



$E = 100$ GPa

$= 100 \times 10^9$ N/m^2.

$= \frac{10^{11} \text{ N} \times 10^3}{10^6 \text{ mm}^2 \times 10^3}$

$$\boxed{E = 100 \text{ KN/mm}^2.}$$

$A_1 = \frac{\pi d^2}{4} = \frac{\pi}{4}(625)^2$

$$\boxed{A_1 = 490.87 \text{mm}^2}$$

$A_2 = \frac{\pi}{4} \times (400)$

$$\boxed{A_2 = 314 \text{ mm}^2}$$

$\Delta L = \frac{Pl}{AE}.$

ϕ = sign of diameter

$\frac{\pi d^2}{4}.$

$A_3 = \frac{\pi}{4}(35)^2$

$$\boxed{A_3 = 962.11 \text{ mm}^2}$$

$$\Delta L_1 = \frac{P_1 l_1}{A_1 E} \qquad \Delta l_2 = \frac{P_2 l_2}{A_2 E}$$

$$\Delta L_1 = \frac{30(150)}{490.87(100)} \qquad \Delta L_2 = \frac{30(200)}{314(100)}$$

$$\boxed{\Delta L_1 = 0.091\,mm} \qquad \boxed{\Delta L_2 = 0.191\,mm}$$

$$\Delta L_3 = \frac{l_3 P_3}{A_3 E}$$

$$\Delta L_3 = \frac{30(150)}{962.11 \times 100} = \frac{45}{962.11}$$

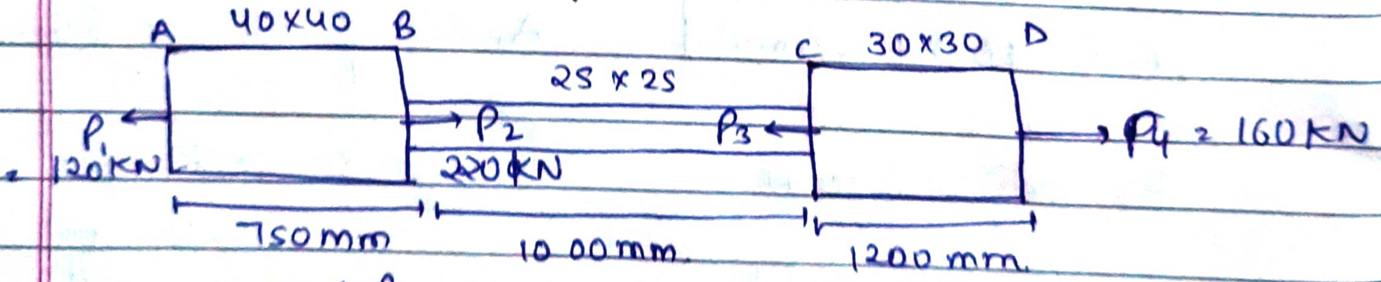
$$\boxed{\Delta L_3 = 0.046\,mm}$$

$$\Delta L = \Delta L_1 + \Delta L_2 + \Delta L_3$$

$$\Delta L = 0.091 + 0.191 + 0.046$$

$$\boxed{\Delta L = 0.328\,mm\ (T)}$$ Ans

Q6. ABCD is a steel bar have & E = 200 GPa. so, find $P_1 + P_3$ and ΔL ?



$$E = 200\,GPa = \frac{200 \times 10^9}{10^6}\,N/mm^2$$

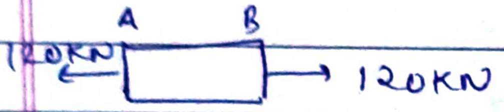
$$\boxed{E = 200\,KN/mm^2}$$

$$P_1 + P_3 = P_2 + P_4$$

$$120 + P_3 = 220 + 160 \qquad \text{or} \qquad \boxed{P_1 + P_3 = 380\,KN}$$

$$\boxed{P_3 = 260\,KN}$$

For member AB :-



$$\Delta L_1 = \frac{P_1 L_1}{A_1 E}$$

$$\Delta L_1 = \frac{120(750)}{1600(200)}$$

$$\boxed{\Delta L_1 = 0.281\,mm}$$

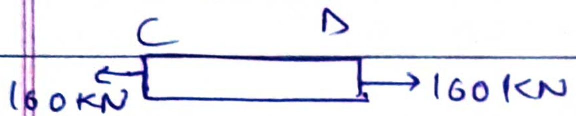
For member BC :-

$$\Delta L_2 = \frac{P_2 L_2}{A_2 E}$$

$$\Delta L_2 = \frac{-100(1000)}{25 \times 25(200)}$$

$$\boxed{\Delta L_2 = -0.8\,mm}$$

For member CD :-



$$\Delta L_3 = \frac{P_3 L_3}{A_3 E}$$

$$\Delta L_3 = \frac{160(1200)}{900(200)}$$

$$\boxed{\Delta L_3 = 1.06\,mm}$$

Hence,

$$\Delta L = \Delta L_1 + \Delta L_2 + \Delta L_3$$

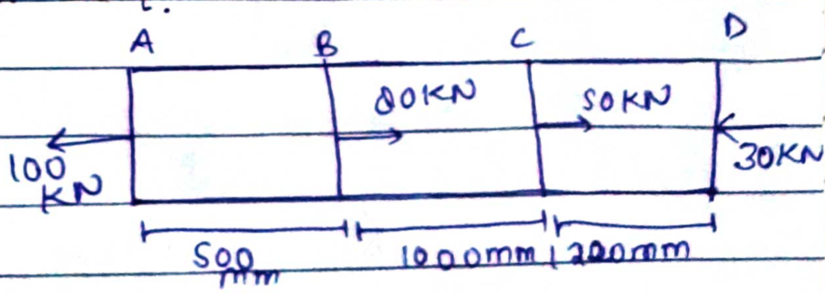
$$\Delta L = 0.281 - 0.8 + 1.06$$

$$\boxed{\Delta L = 0.44\,mm\ (T)}$$ Ans

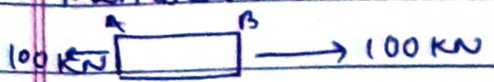
Q7. Brass bar is given having area $A = 500\,mm^2$ and $E = 80\,GPa$ then find ΔL?

$$E = \frac{80 \times 10^9}{10^6}\ N/mm^2$$

$$E = 80\ KN/mm^2.$$



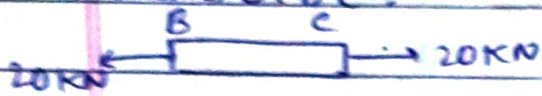
Member AB :-



$$\Delta L_1 = \frac{P_1 L_1}{A_1 E} = \frac{100(500)}{500(80)}$$

$$\boxed{\Delta L_1 = 1.25\,mm}$$

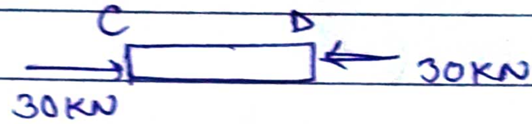
Member BC :-



$$\Delta L_2 = \frac{P_2 L_2}{A_2 E}$$

$$\Delta L_2 = \frac{20(1000)}{500(80)} = \frac{1}{2} \Rightarrow \boxed{\Delta L_2 = 0.5mm}$$

Member CD :-



$$\Delta L_3 = \frac{P_3 L_3}{A_3 E} = \frac{-30(1200)}{500 \times 80} \Rightarrow \boxed{\Delta L_3 = -0.9mm}$$

$$\Delta L = \Delta L_1 + \Delta L_2 + \Delta L_3$$

$$\Delta L = 1.25 + 0.5 - 0.9$$

$$\boxed{\Delta L = 0.85\, mm\, (T)}$$ Ans

Q8. 10N Load is to be ~~fitted~~ lifted with the help of a steel wire. If the permissible stress is 90MPa. Find the minimum diameter of wire?

$F = 10N$; $\sigma = 90 \times 10^6 Pa$. , $d = ?$

$$\sigma = \frac{F}{A}$$

$$90 \times 10^6 = \frac{10 \times 4}{\pi d^2}$$

$$d^2 = \frac{4 \times 1\cancel{0}}{3.14 \times 9\cancel{0} \times 10^6}$$

$$d^2 = \frac{4}{3.14 \times 10^6 \times 9.} = 3.74 \times 10^{-4} m$$

$$\boxed{d = 3.74 \times 10^{-1}\, mm}$$ Ans

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Q9. A steel rod having area 'A' = 20 mm × 20 mm ; L = 1m or 1000 mm , F = 40KN or 40×10^3 N then find ΔL Given - E = 200 GPa ?

$$E = \frac{200 \times 10^9}{10^6} \ N/mm^2 \Rightarrow 200KN/mm^2$$

$$\sigma = \frac{F}{A} \ ; \text{ where, } A = 400 \ mm^2 \text{ or } 400 \times 10^{-6} \ m^2.$$

$$\sigma = \frac{4 \times 10^4 \times 4}{\pi \times d^2}$$

$$\sigma = \frac{4 \times 1 \times 10^4}{4 \times 10^{-4}} = 10^8 \ N/m^2$$

$$\sigma = Ee.$$

$$\frac{\sigma}{e} = E. \text{ or } e = \frac{\sigma}{E}$$

$$e = \frac{10^8}{200 \times 10^9} = 0.5 \times 10^{-3}.$$

so,
$$\Delta L = Le.$$
$$\Delta L = (0.5 \times 10^{-3} \times 1) \ m.$$
or. $\boxed{\Delta L = 0.5 \ mm}$ Ans

Q10 Given :- d = 25mm , L = 250mm , F = 50KN or 50×10^3 N. ΔL = 0.3 mm.

To find :- E = ?

$$\Delta L = \frac{FL}{AE}$$

$$E = \frac{FL}{A \Delta L} = \frac{50 \times 10^3 \times 250 \times \cancel{10^{-3}} \times 4}{\pi \times 625 \times 10^{-6} \times 0.3 \times \cancel{10^{-3}}}$$

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$$E = \frac{50 \times 4 \times 10^9 \times 250}{\pi \times 625 \times 0.3}$$

~~$E = 84882.63\ N/mm$~~

$$E = 84.92 \times 10^9\ N/m^2$$

or $\boxed{E = 84.92\ GPa}$ Ans

Q11 A steel rod 500 mm long and 20mm x 10mm in section is subjected to an axial pull of 300 KN. If the modulus of elasticity is 2×10^5 MPa. Calculate stress, strain and elongation of rod.

$L = 500mm$, $A = 200mm^2$, $F = 300KN$.

$E = 2 \times 10^5 \times 10^6\ Pa$. or $E = 2 \times 10^5\ N/mm^2$.

$E = 2 \times 10^{11}\ Pa$

Stress $\Rightarrow \sigma = \frac{F}{A}$.

$$\sigma = \frac{300 \times 10^3}{200}.$$

$$\boxed{\sigma = 1.5\ KN/mm^2}$$

$\sigma = Ee$.

$e = \frac{\sigma}{E}$.

$$e = \frac{1.5 \times 10^3}{2 \times 10^5}$$

$\boxed{(strain)\ e = 0.75 \times 10^{-2}}$

, then, $\Delta L = Le$.

$= 500 \times 0.75 \times 10^{-2}$

$\boxed{\Delta L = 3.75\ mm}$ Ans

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Q12. A bar 500 mm long & 22mm in diameter is elongated by 1.2mm and the axial pull is of 105 KN. Calculate the intensities of stress, strain and E?

$F = 105\,KN$, $L = 500mm$, $A = \frac{\pi d^2}{4} = \frac{\pi(484)}{4}$

$\Delta L = 1.2mm.$ $A = 121\pi\ mm^2.$

$$\text{stress} = \frac{F}{A} = \frac{105 \times 10^3}{121\pi}$$

$$\boxed{\sigma = 276.21\ N/mm^2}\ \text{Ans}$$

By Hook's Law :-

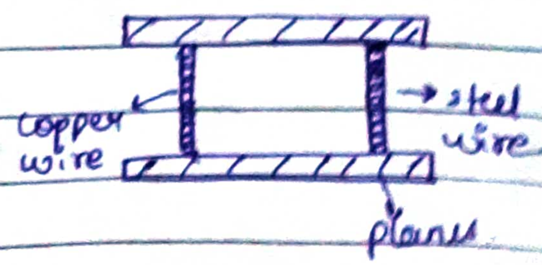
$\sigma = Ee.$; $e = \frac{\Delta L}{L}$

$\frac{\sigma}{e} = E.$; $e = \frac{1.2}{500}$

then, $\frac{276.21}{2.4 \times 10^{-3}} = E.$ $\boxed{(\text{strain})\, e = 2.4 \times 10^{-3}.}$ Ans

$$\boxed{E = 2.4 \times 10^{-3}\ mm.}\ \text{Ans}$$

Q13. A copper wire :- $A_1 = 20mm^2$, $L_1 = 1m.$
A steel wire :- $A_2 = 30mm^2$, $L_2 = 1m.$
Load $= 8KN$, $E_{steel} = 20 \times 10^5\ MPa$. $E_{copper} = 10^6\ MPa$.
Find stress of copper and steel?
Since, support is rigid
so, strain of copper = strain of steel.



$$\frac{\sigma_c}{E_c} = \frac{\sigma_s}{E_s}$$

$$\sigma_c = \frac{\sigma_s \times \cancel{10^6}\ 10}{20 \times \cancel{10^5}}$$

$$\boxed{2\sigma_c = \sigma_s}$$

Load is equally distributed to the wires :-

Total Load = Load of steel + Load of copper.

$$\cancel{8000 = \frac{\Delta L\, A_s . E_s}{L_s} + \frac{\Delta L\, A_c . E_c}{L_c}}$$

$$8000 = \sigma_s A_s + \sigma_c A_c.$$

$$8000 = 2\sigma_c (30) + \sigma_c (20)$$

$$8000 = 80\sigma_c.$$

$$\boxed{\sigma_c = 100\ KN/mm^2}\ \text{Ans}$$

so, $\sigma_c = \dfrac{\sigma_s}{2}$.

$$\sigma_s = 2\sigma_c = 2(100)$$

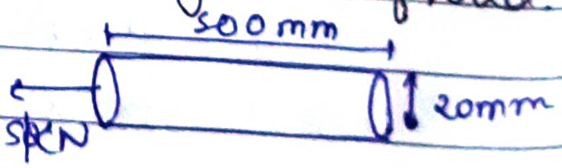
$$\boxed{\sigma_s = 200\ KN/mm^2}\ \text{Ans}$$

Q14 A circular rod of diameter 20mm and 500mm long is subjected to a tensile Load / Force 45 KN. ; E = 200 KN/mm². find stress, strain and elongation of road.

L = 500mm , d = 20mm

$\sigma = ?$; $\epsilon = ?$.

$\Delta L = ?$.



so, $\sigma = \dfrac{F}{A}$.

as, $A = \dfrac{\pi d^2}{4} = \dfrac{\pi(400)}{4}$

$= 314\ mm^2$.

$$\sigma = \frac{45000}{314}$$

$$\boxed{\sigma = 143.24\ N/mm^2}\ \text{Ans}$$

$$\sigma = eE.$$

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

$$e = \frac{143.24}{200 \times 10^3} \Rightarrow \boxed{e = 7.2 \times 10^{-4}}$$ Ans

then, $\Delta L = L \times e.$

$$\Delta L = 500 (7.2 \times 10^{-4})$$

$$\boxed{\Delta L = 0.36 mm}$$ Ans

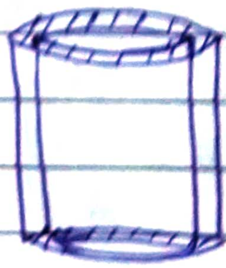
Q15. Given:- $\sigma_u = 480 N/mm^2$, $d_o = 200 mm$.

Factor of safety = 4.

then find $d_i = ?$

Axial load $\Rightarrow$ $1.9 \times 10^6 N$.

working stress = $\frac{\sigma_u}{FOS}$



Hallow steel coloumn

$$\sigma = \frac{480}{4}$$

$$\boxed{\sigma = 120 N/mm^2}$$

$$\sigma = \frac{F}{A}$$

$$120 = \frac{1.9 \times 10^6}{\frac{\pi}{4}(d_o^2 - d_i^2)}$$

$$120 = \frac{7.6 \times 10^6}{\pi((200)^2 - d_i^2)}$$

$$4\times10^4 - di^2 = \frac{7.6\times10^6}{120\times3.14}.$$

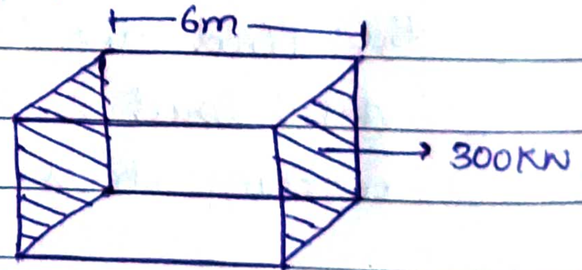
$$di^2 = 4\times10^4 - \frac{7.6\times10^6}{120\times3.14}$$

$$di^2 = 4\times10^4 - 2.01\times10^4$$

$$di = 1.41\times10^2$$

$$\boxed{di = 141.23\ mm.}$$ Ans

Q16. Given:- $t = 20mm$, wide $= 150mm$, $L = 6000\ mm$.
$E = 2\times10^7\ N/cm^2$, $P = 0.3\times10^6\ N/\cancel{cm^2}$) then find.
ΔL, Δt, Δb ?



Mild steel flat under a axial pull

$$\Delta L = \frac{PL}{AE}.$$

$$= \frac{300\times10^3 \times 6\times10^3}{3000\times2\times10^5}$$

$$\boxed{\Delta L = 3mm.}$$ Ans

$$A = b\times t$$
$$= \cancel{20\times10^3}\times150.$$
$$= 3000\ mm^2.$$
$$E = 2\times10^7\ N/cm^2$$
or $E = 2\times10^5\ N/mm^2$.

$$e_{long.} = \frac{\Delta L}{L}.$$

$$e_{long.} = \frac{3}{6\times10^3}$$

$$e_{long} = 0.5\times10^{-3}.$$

$$\frac{e_{lateral}}{e_{long}} = \alpha.$$

$$e_{lateral} = 0.3\,(0.5\times10^{-3})$$

$$e_{lateral} = 1.5\times10^{-3}.$$

then, $e_{lateral} = \frac{\Delta b}{b}$ or $\frac{\Delta t}{t}$.

$$\Delta b = b(1.5 \times 10^{-3})$$
$$= 150(1.5 \times 10^{-3})$$
$$= 2250 \times 10^{-3}.$$

or,

$$\boxed{\Delta b = 2.25 \times 10^{-1} \text{ mm}}$$ Ans

$$1.5 \times 10^{-3} = \frac{\Delta t}{20}.$$

$$\Delta t = 20(1.5) \times 10^{-3}$$

$$\Delta t = 30.0 \times 10^{-3} \text{ mm}.$$

or.

$$\boxed{\Delta t = 30 \times 10^{-3} \text{ mm}.}$$ Ans