Problem 1.8. *An axial pull of 35000 N is acting on a bar consisting of three lengths as shown in Fig. 1.6 (b). If the Young's modulus = 2.1×10^5 N/mm², determine :*

(i) stresses in each section and

(ii) total extension of the bar.

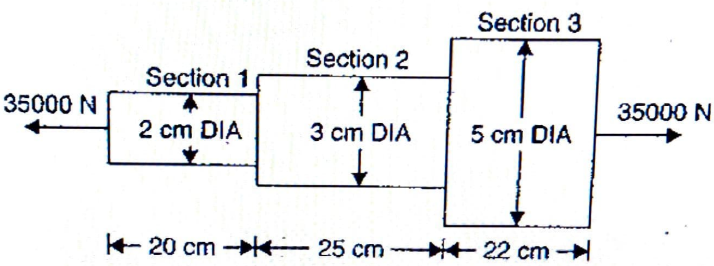
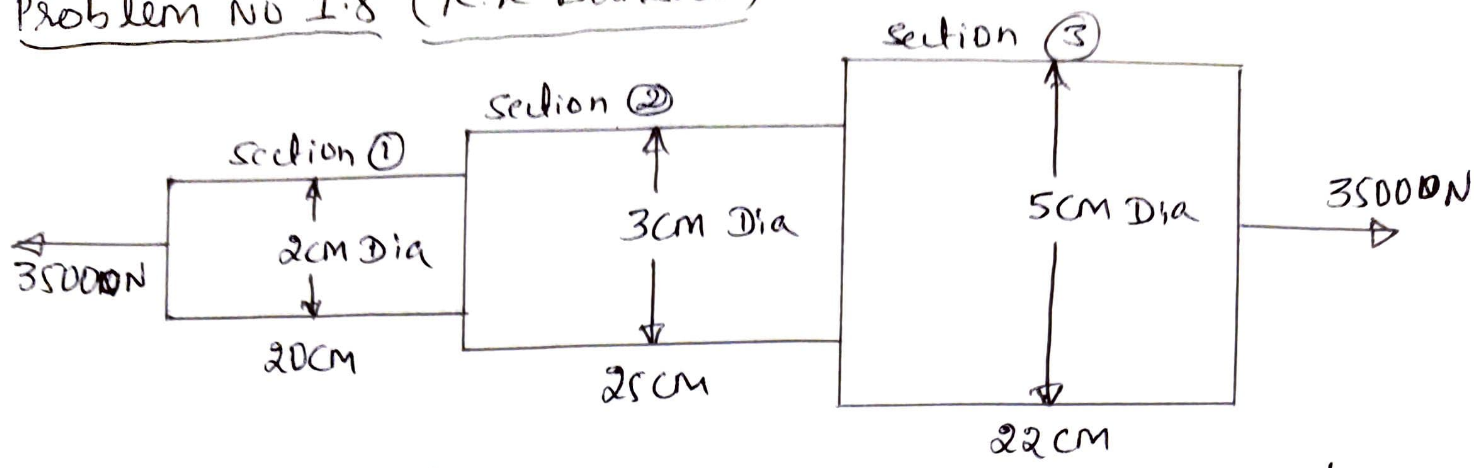


Fig. 1.6 (b)

Problem No 1.8 (R.K Bansal)



In this problem, the stepped bar is subjected to tensile load of 35000N at it's ends only,
∴ the internal resistance developed in each section is equal to 35000N

ie $P_1 = P_2 = P_3 = 35000N$ $E = 2.1 \times 10^5 \, N/mm^2$

$d_1 = 2CM = 20mm$, $d_2 = 3CM = 30mm$, $d_3 = 5CM = 50mm$

$A_1 = \frac{\pi}{4} \times 20^2 = 100\pi$, $A_2 = \frac{\pi}{4} \times 30^2 = 225\pi \, mm^2$

$A_3 = \frac{\pi}{4} \times 50^2 = 625\pi \, mm^2$

Ans (i) To find stress in section

stress in section ① $= \sigma_1 = \frac{P_1}{A_1} = \frac{35000}{100\pi} = 111.4 \, N/mm^2$

— " — ② $= \sigma_2 = \frac{P_2}{A_2} = \frac{35000}{225\pi} = 49.5 \, N/mm^2$ 49.5

— " — ③ $= \sigma_3 = \frac{P_3}{A_3} = \frac{35000}{625\pi} = 17.82 \, N/mm^2$ 17.82

Ans ii) To find total extension of bar

$L_1 = 20 \, CM = 200mm$, $L_2 = 25CM = 250mm$

$L_3 = 22CM = 220mm$

Extension in section 1

i.e $\Delta_1 = \frac{P_1 L_1}{A_1 E} = \frac{35000 \times 200}{100\pi \times 2.1 \times 10^5} = 0.106$ mm

Extension in section 2

i.e $\Delta_2 = \frac{P_2 L_2}{A_2 E} = \frac{35000 \times 250}{225\pi \times 2.1 \times 10^5} = 0.059$ mm

IIIly $\Delta_3 = \frac{P_3 L_3}{A_3 E} = \frac{35000 \times 220}{625\pi \times 2.1 \times 10^5} = 0.0186$ mm

$\Delta = \Delta_1 + \Delta_2 + \Delta_3$

∴ Total extension of bar $= 0.106 + 0.059 + 0.0186$

$\boxed{\Delta = 0.183 \text{ mm}}$

Problem 1.11. *A brass bar, having cross-sectional area of 1000 mm², is subjected to axial forces as shown in Fig. 1.9.*

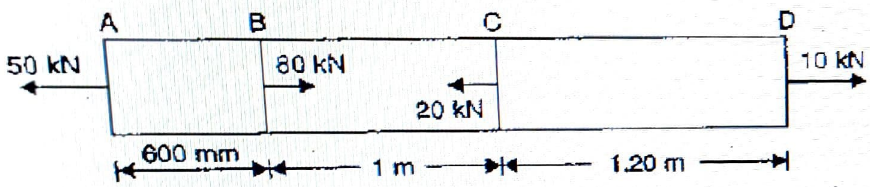


Fig. 1.9

Find the total elongation of the bar. Take $E = 1.05 \times 10^5$ *N/mm²*.

Problem 1.11

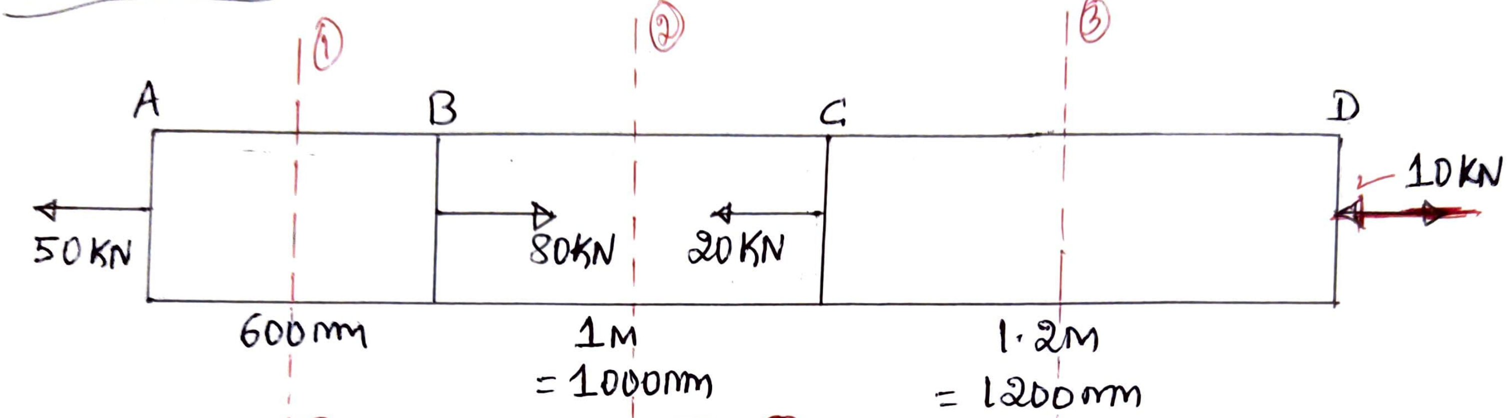


Fig. 1

In this problem, the bar is of same cross sectional area. ∴ $A_{AB} = A_{BC} = A_{CD} = 1000\,mm^2$

$L_{AB} = 600\,mm$, $L_{BC} = 1000\,mm$, $L_{CD} = 1200\,mm$.

And bar is subjected to different loads at different sections, therefore internal resistance developed in each section is different.

ie internal resistances are P_{AB}, P_{BC} & P_{CD}

To calculate internal resistance P_{AB} in AB section (2)
Consider a section (1) - (1) in AB as shown in fig. (1) below

(1)

Net force acting 50KN in left of Section (1)-(1)

Net force acting in right of (1)-(1) 50KN (80 − 20 − 10 = 50)

(1)

∴ Section (1)-(1) = AB is under tension

∴ $P_{AB} = +50 KN$

IIIly to calculate P_{BC}, considering section 2-2 in BC

(2)

Net force in left of (2)-(2)

30KN

(80 − 50 = 30)

Net force in right of (2)-(2)

30KN (−20 −10 = −30KN = 30KN (←))

(2)

∴ section (2)-(2) is under compression

∴ $P_{BC} = -30 KN$

IIIly to calculate P_{CD}, considering section (3)-(3) in CD

(3)

Net force in left of (3)-(3)

10KN

(−50 + 80 − 20 = 10)

Net force in right of (3)-(3) section

10KN

(3)

∴ section (3)-(3) is under compression,

∴ $P_{CD} = -10 KN$

↳

∴ To calculate total elongation of the bar,

ie $\Delta = \Delta_{AB} + \Delta_{BC} + \Delta_{CD}$

$$\Delta_{AB} = \frac{P_{AB} L_{AB}}{A_{AB} \times E} = \frac{50 \times 10^3 \times 600}{1000 \times 1.05 \times 10^5} = 0.285 \text{ mm}$$

$$\Delta_{BC} = \frac{P_{BC} L_{BC}}{A_{BC} \times E} = \frac{-30 \times 10^3 \times 1000}{1000 \times 1.05 \times 10^5} = -0.285 \text{ mm}$$

$$\Delta_{CD} = \frac{P_{CD} \times L_{CD}}{A_{CD} \times E} = \frac{-10 \times 10^3 \times 1200}{1000 \times 1.05 \times 10^5} = -0.114 \text{ mm}$$

$$\therefore \Delta = 0.285 - 0.285 - 0.114 = -0.114 \text{ mm}$$