



# POSTAL BOOK PACKAGE 2026

## CIVIL ENGINEERING

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### CONVENTIONAL Practice Sets

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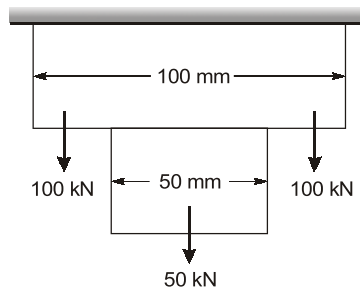
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# Simple Stress Strain and Elastic Constants

- Q1** A bar of varying square cross-section is loaded symmetrically as shown in the figure. Loads shown are placed on one of the axes of symmetry of cross-section. Ignoring self-weight, calculate the maximum tensile stress anywhere in the section

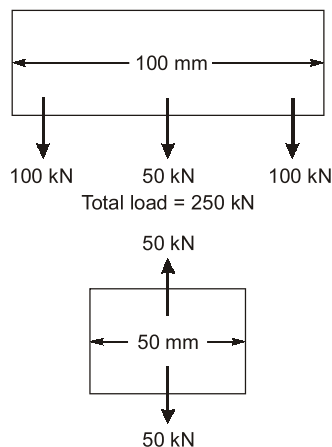


**Solution:**

$$\text{The stress in lower bar} = \frac{50 \times 1000}{50 \times 50} = 20 \text{ N/mm}^2$$

$$\text{The stress in upper bar} = \frac{250 \times 1000}{100 \times 100} = 25 \text{ N/mm}^2$$

Thus the maximum tensile stress anywhere in the bar is  $25 \text{ N/mm}^2$ .



- Q2** A metal bar of length 100 mm is inserted between two rigid supports and its temperature is increased by  $10^\circ\text{C}$ . If the coefficient of thermal expansion is  $12 \times 10^{-6}$  per  $^\circ\text{C}$  and the Young's modulus is  $2 \times 10^5 \text{ MPa}$ , then calculate the stress in the bar

**Solution:**

Method-I

$$\text{Temperature stress} = \alpha TE$$

$$= 12 \times 10^{-6} \times 10 \times 2 \times 10^5 = 24 \text{ MPa}$$

## Method-II

Due to temperature,

$$\Delta L = L\alpha\Delta T$$

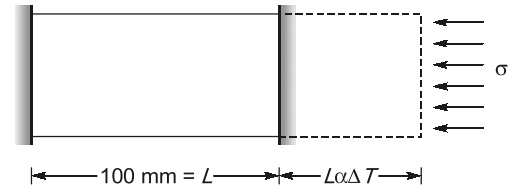
But since support is fixed so, expansion is not allowed so stress is developed in the bar which is compressive in nature.

Now,

$$\text{Expansion due to temperature} = \text{Compression due to stress}$$

$$L\alpha\Delta T = \frac{\sigma}{E} \times L$$

$$\begin{aligned}\sigma &= E\alpha\Delta T \\ &= 1 \times 10^5 \times 12 \times 10^{-6} \times 10 \\ &= 24 \text{ MPa}\end{aligned}$$



**Q3** A mild steel specimen is under uniaxial tensile stress. Young's modulus and yield stress for mild steel are  $2 \times 10^5$  MPa and 250 MPa respectively. Calculate the maximum amount of strain energy per unit volume that can be stored in this specimen without permanent set

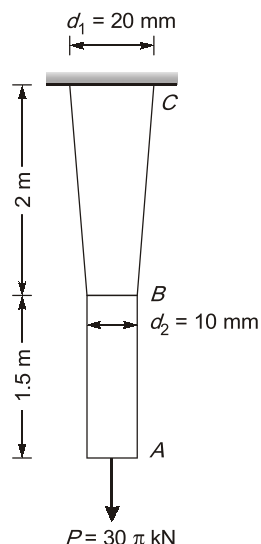
**Solution:**

The strain energy per unit volume may be given as

$$u = \frac{1}{2} \times \text{Stresses} \times \text{Strain}$$

$$\begin{aligned}u &= \frac{1}{2} \times \frac{\sigma_y^2}{E} = \frac{1}{2} \times \frac{(250)^2}{2 \times 10^5} \\ &= 0.156 \text{ N-mm/mm}^3\end{aligned}$$

**Q4** A tapered circular rod of diameter varying from 20 mm to 10 mm is connected to another uniform circular rod of diameter 10 mm as shown in the following figure. Both bars are made of same material with the modulus of elasticity,  $E = 2 \times 10^5$  MPa. If load subjected is  $30\pi$  kN, then calculate deflection at point A (in mm)



**Solution:**

Total elongation,  
AB is uniform

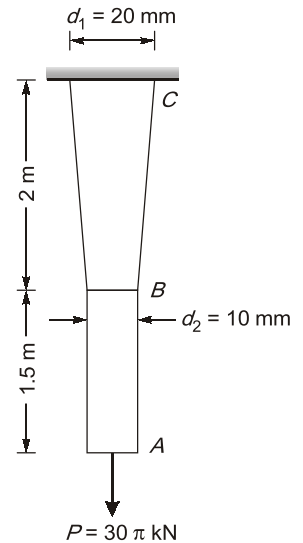
$$\text{So, } \Delta = \frac{PL}{AE}$$

BC is tapered

$$\Delta = \frac{PL}{\frac{\pi}{4} d_1 d_2 E}$$

$$\begin{aligned} \Delta &= \Delta_{AB} + \Delta_{BC} \\ &= \frac{PL}{AE} + \frac{4PL}{\pi d_1 d_2 E} \end{aligned}$$

$$\begin{aligned} &= \frac{30\pi \times 10^3 \times 1.5 \times 10^3}{\frac{\pi}{4} \times (10)^2 \times 2 \times 10^5} + \frac{30\pi \times 10^3 \times 2 \times 10^3}{\frac{\pi}{4} \times 10 \times 20 \times 2 \times 10^5} \\ &= (9 + 6) \text{ mm} = 15 \text{ mm} \end{aligned}$$



**Q5** A steel specimen of 12 mm diameter extends by  $6.31 \times 10^{-2}$  mm over a gauge length of 150 mm when subjected to an axial load of 10 kN. The same specimen undergoes a twist of  $0.5^\circ$  on a length of 150 mm over a twisting moment of 10 N-m. Using the above data, determine the elastic constants  $E$ ,  $\mu$ ,  $G$  and  $K$ .

**Solution:**

**Tensile Test:**  $P = 10 \text{ kN}$

Length of specimen,  $L = 150 \text{ mm}$

Cross-sectional area,  $A = \frac{\pi}{4} \times 12^2 = 113.09 \text{ mm}^2$

Change in length of specimen,  $\Delta = 6.31 \times 10^{-2} \text{ mm}$

Let  $E \text{ N/mm}^2$  is modulus of elasticity of material.

We know, axial deformation due to axial load is given by

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

$$\therefore E = \frac{PL}{A\Delta} = \frac{10 \times 1000 \times 150}{113.09 \times 6.31 \times 10^{-2}} = 2.10 \times 10^5 \text{ N/mm}^2$$

**Torsion test:**

We know,

$$\frac{T}{I_p} = \frac{G\theta}{L}$$

...(i)

$\therefore$  Modulus of rigidity,

$$G = \frac{TL}{I_p\theta}$$

$$I_p = \frac{\pi}{32} D^4 = \frac{\pi}{32} \times (12)^4 = 2035.75 \text{ mm}^4$$

$$\text{Angle of twist, } \theta = \frac{0.5 \times \pi}{180} \text{ radian} = 8.73 \times 10^{-3} \text{ radian}$$

From eq. (i), we get

$$G = \frac{10 \times 10^3 \times 150}{2035.75 \times 8.73 \times 10^{-3}} = 8.44 \times 10^4 \text{ N/mm}^2$$

We know,

$$E = 2G(1 + \mu)$$

$$\frac{E}{2G} = 1 + \mu$$

$\therefore$

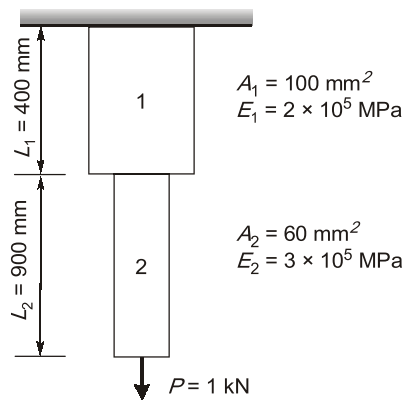
$$\mu = \frac{E}{2G} - 1 = \frac{2.10 \times 10^5}{2 \times 8.44 \times 10^4} - 1 = 1.24 - 1 = 0.24$$

Also

$$E = 3k(1 - 2\mu)$$

$$k = \frac{E}{3(1 - 2\mu)} = \frac{2.10 \times 10^5}{3(1 - 2 \times 0.24)} = 1.35 \times 10^5 \text{ N/mm}^2$$

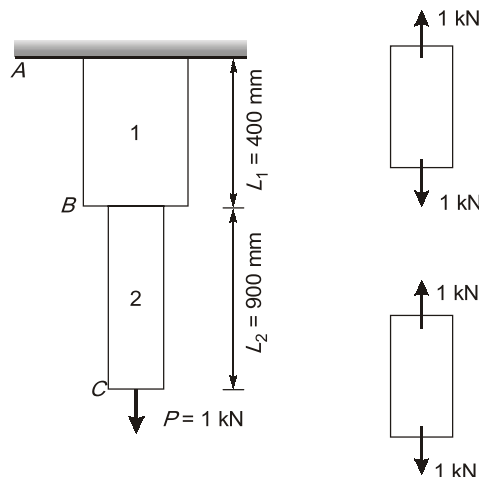
**Q.6** Consider the stepped bar made with a linear elastic material and subjected to an axial load of 1 kN, as shown in the figure.



Segments 1 and 2 have cross-sectional area of 100 mm<sup>2</sup> and 60 mm<sup>2</sup>. Young's modulus of 2 × 10<sup>5</sup> MPa and 3 × 10<sup>5</sup> MPa, and length of 400 mm and 900 mm, respectively. Calculate the strain energy stored in the bar (in N-mm) due to the axial load

**Solution:**

$$A_1 = 100 \text{ mm}^2, E_1 = 2 \times 10^5 \text{ MPa}, \quad A_2 = 60 \text{ mm}^2, E_2 = 3 \times 10^5 \text{ MPa}$$



$$\Delta_{AC} = \Delta_{AB} + \Delta_{BC}$$

$$= \frac{1 \times 10^3 \times 400}{100 \times 2 \times 10^5} + \frac{1 \times 10^3 \times 900}{60 \times 3 \times 10^5} = 0.02 + 0.05 = 0.07 \text{ mm}$$

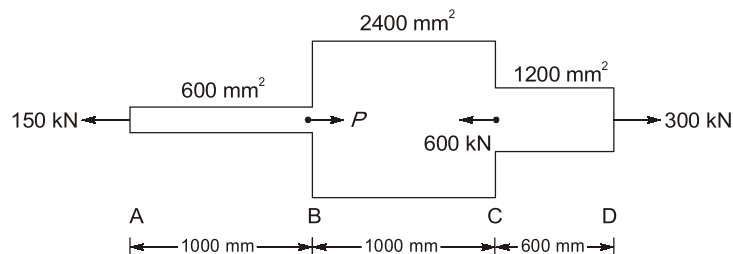
$$U = \frac{1}{2} \times P \times \Delta = \frac{1}{2} \times 1 \times 1000 \times 0.07 = 35 \text{ N-mm}$$

**Q.7** A member ABCD is subjected to concentrated loads as shown. Calculate

(i) Force  $P$  necessary for equilibrium

(ii) Total elongation of bar

$$E = 2 \times 10^5 \text{ N/mm}^2$$



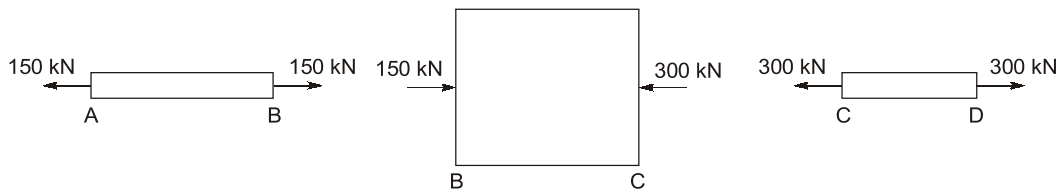
**Solution:**

(i)

$$\Sigma F = 0$$

$$(P + 300) - (150 + 600) = 0$$

$$P = 450 \text{ kN}$$



(ii)

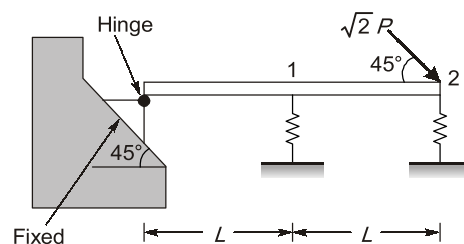
$$\Delta_{\text{Total}} = \Delta_{AB} + \Delta_{BC} + \Delta_{CD}$$

$$= \frac{150 \times 1000 \times 1000}{600 \times 2 \times 10^5} - \frac{300 \times 1000 \times 1000}{2400 \times 2 \times 10^5} + \frac{300 \times 600 \times 1000}{1200 \times 2 \times 10^5}$$

$$= 1.25 - 0.625 + 0.75$$

$$= 1.375 \text{ mm (elongation)}$$

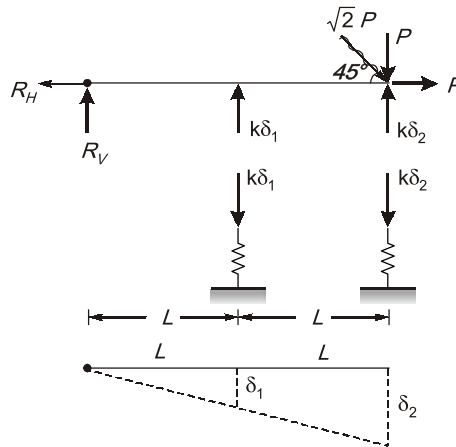
**Q.8** A rigid beam is hinged at one end and supported on linear elastic springs (both having a stiffness of ' $k$ ') at points '1' and '2', and an inclined load acts at '2', as shown in figure in term of  $P$ .



Find the deflections at point (1) and (2) as shown in figure in terms of  $P$ .

**Solution:**

The free diagram of the beam is shown below,



From similar triangles, we get,

$$\frac{L}{\delta_1} = \frac{2L}{\delta_2}$$

⇒

$$\delta_2 = 2\delta_1$$

...(i)

Taking moments about hinge, we get,

$$P \times 2L - k\delta_2 \times 2L - k\delta_1 \times L = 0$$

⇒

$$2P - k(2\delta_2 + \delta_1) = 0$$

[∴ from (i)]

⇒

$$2P - k(4\delta_1 + \delta_1) = 0$$

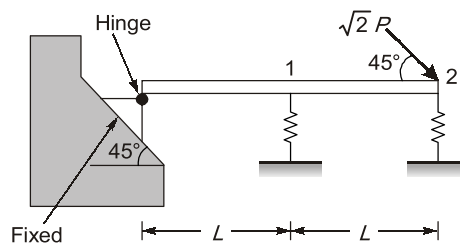
⇒

$$\delta_1 = \frac{2P}{5k}$$

From (i), we get,

$$\delta_2 = 2 \times \frac{2P}{5k} = \frac{4P}{5k}$$

**Q.9** A rigid beam is hinged at one end and supported on linear elastic springs (both having a stiffness of 'k') at points '1' and '2', and an inclined load acts at '2', as shown in figure in term of P.



If the load  $P$  equals 100 kN, then calculate reaction force at (1) and (2) respectively (in kN).

**Solution:**

From previous questions,

$$R_1 = k\delta_1 = k \times \frac{2P}{5k} = \frac{2 \times 100}{5} = 40 \text{ kN}$$

$$R_2 = k\delta_2 = k \times \frac{4P}{5k} = \frac{4 \times 100}{5} = 80 \text{ kN}$$