Chapter
Mechanical Properties of Solids

Topic-1: Hooke's Law & Young's Modulus

1 MCQs with One Correct Answer

1. One end of a horizontal thick copper wire of length $2L$ and radius $2R$ is welded to an end of another horizontal thin copper wire of length L and radius R. When the arrangement is stretched by applying forces at two ends, the ratio of the elongation in the thin wire to that in the thick wire is **[Adv. 2013]**

(a) 0.25 (b) 0.50 (c) 2.00 (d) 4.00

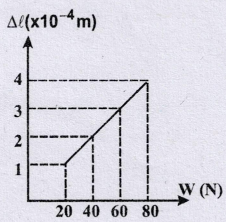
2. The adjacent graph shows the estension ($\Delta\ell$) of a wire of length 1 m suspended from the top of a roof at one end and with a load W connected to the other end. If the cross-sectional area of the wire is 10^{-6} m^2, calculate the Young's modulus of the material of the wire. **[2003S]**

(a) 2×10^{11} N/m

(b) 2×10^{-11} N/m

(c) 3×10^{-12} N/m

(d) 2×10^{-13} N/m



3. The following four wires are made of the same material. Which of these will have the largest extension when the same tension is applied ? **[1981- 2 Marks]**

(a) length = 50 cm, diameter = 0.5 mm

(b) length = 100 cm, diameter = 1 mm

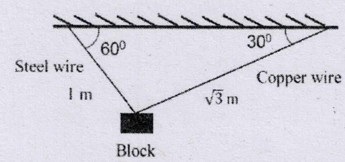
(c) length = 200 cm, diameter = 2 mm

(d) length = 300 cm, diameter = 3 mm.

2 Integer Value Correct Type

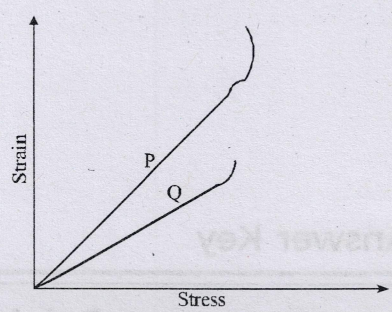
4. A block of weight 100N is suspended by copper and steel wires of same cross sectional area 0.5cm^2 and, length m and 1m, respectively. Their other ends are fixed on a ceiling as shown in figure. The angles subtended by copper and steel wires with ceiling are 30° and 60°, respectively. If elongation in copper wire is and elongation in steel wire is (Δl_s), then the ratio $\frac{\Delta l_c}{\Delta l_s}$ is_____

[Young's modulus for copper and steel are $1\times10^{11} N/m^2$ and $2\times 10^{11} N/m^2$, respectively.] **[Adv. 2019]**



6 MCQs with One or More Than One Correct

5. In plotting stress versus strain curves for two materials P and Q, a student by mistake puts strain on the y-axis and stress on the x-axis as shown in the figure. Then the correct statement(s) is (are) **[Adv. 2015]**



(a) P has more tensile strength than Q

(b) P is more ductile than Q

(c) P is more brittle than Q

(d) The Young's modulus of P is more than that of Q

Topic-2: Bulk & Rigidity Modulus and Work Done in Stretching a Wire

4 Fill in the Blanks

1. A wire of length L and cross sectional area A is made of a material of Young's modulus Y. If the wire is stretched by an amount x, the work done is .... **[1987 - 2 Marks]**

Answer Key

Topic-1 : Hooke's Law & Young's Modulus

1. (c) **2.** (a) **3.** (a) **4.** (2) **5.** (a, b)

Topic-2 : Bulk & Rigidity Modulus and Work Done in Stretching a Wire

1. $\left(\frac{1}{2}\left(\frac{YA}{L}\right)x^2\right)$

Hints & Solutions

Topic-1: Hooke's Law & Young's Modulus

1. **(c)** Using, $Y = \dfrac{F/A}{\Delta\ell/\ell_0}$

$$Y = \frac{F/\pi(2R)^2}{\Delta\ell_1/2L} = \frac{F/\pi R^2}{\Delta\ell_2/L} \qquad \therefore \frac{\Delta\ell_2}{\Delta\ell_1} = 2$$

2. **(a)** Using, $Y = \dfrac{F}{A}\Big/\dfrac{\Delta\ell}{\ell} = \dfrac{F}{A}\cdot\dfrac{\ell}{\Delta\ell} = \dfrac{20\times 1}{10^{-6}\times 10^{-4}}$

$= 2\times 10^{11}\ \mathrm{N/m^2}$.

3. **(a)** Using, $Y = \dfrac{T/A}{\Delta\ell/\ell} \Rightarrow \Delta\ell = \dfrac{T\times\ell}{A\times Y} = \dfrac{T}{Y}\times\dfrac{\ell}{A}$

$\therefore\ \Delta\ell \propto \dfrac{\ell}{A}$. $\qquad \left(\because \dfrac{T}{Y}\ \text{is constant}\right)$

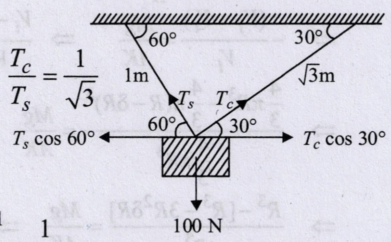
$\dfrac{\ell}{A}$ is largest in (a) hence largest extension.

4. **(2)** Given : $l_c = \sqrt{3}$ m; $l_s = 1$ m; $Y_c = 1\times 10^{11}$ N/m² and $Y_s = 2\times 10^{11}$ N/m².

At equilibrium, $T_s \cos 60° = T_c \cos 30°$

$\Rightarrow \dfrac{T_s}{2} = \dfrac{T_c\sqrt{3}}{2}$

$\Rightarrow T_s = \sqrt{3}T_c \Rightarrow \dfrac{T_c}{T_s} = \dfrac{1}{\sqrt{3}}$



$\therefore \dfrac{l_c}{l_s} = \dfrac{\sqrt{3}}{1}$

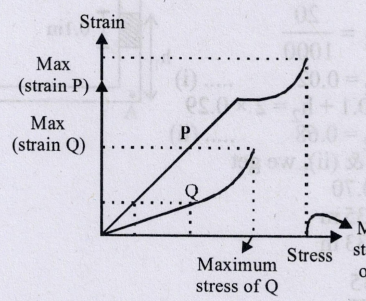
and $\dfrac{Y_c}{Y_s} = \dfrac{1\times 10^{11}}{2\times 10^{11}} = \dfrac{1}{2}$

From, $Y = \dfrac{Fl}{A\Delta l} \Rightarrow \Delta l = \dfrac{Fl}{AY}$

Here, $A_s = A_c$

$$\therefore \frac{\Delta l_c}{\Delta l_s} = \left(\frac{T_c}{T_s}\right)\times\left(\frac{l_c}{l_s}\right)\times\left(\frac{Y_s}{Y_c}\right) = \left(\frac{1}{\sqrt{3}}\right)\times\left(\frac{\sqrt{3}}{1}\right)\times\left(\frac{2}{1}\right) = 2$$

5. **(a, b)** From graph, the maximum stress that P can withstand before breaking is greater than Q.



The strain of P is more than Q therefore P is more ductile.

$\because\ Y = \dfrac{\text{stress}}{\text{strain}}$ So a given strain, stress is more for Q.

$\therefore\ Y_Q > Y_P$.

Topic-2: Bulk & Rigidity Modulus and Work Done in Stretching a Wire

1. $\left(\dfrac{1}{2}\left(\dfrac{YA}{L}\right)x^2\right)$

Work done, $W = \dfrac{1}{2}Kx^2$

where $K = \dfrac{YA}{L}$ and x = extension in wire

$\therefore\ W = \dfrac{1}{2}\left(\dfrac{YA}{L}\right)x^2$