CHAPTER 8

Mechanical Properties of Solids

1. A spring of force constant 800 N/m has an extension of 5 cm. The work done in extending it from 5 cm to 15 cm is **[2002]**

(a) 16 J (b) 8 J
(c) 32 J (d) 24 J

2. A wire fixed at the upper end stretches by length ℓ by applying a force F. The work done in stretching is **[2004]**

(a) $2F\ell$ (b) $F\ell$
(c) $\frac{F}{2\ell}$ (d) $\frac{F\ell}{2}$

3. If 'S' is stress and 'Y' is young's modulus of material of a wire, the energy stored in the wire per unit volume is **[2005]**

(a) $\frac{S^2}{2Y}$ (b) $2S^2Y$
(c) $\frac{S}{2Y}$ (d) $\frac{2Y}{S^2}$

4. A wire elongates by l mm when a load W is hanged from it. If the wire goes over a pulley and two weights W each are hung at the two ends, the elongation of the wire will be (in mm) **[2006]**

(a) l (b) $2l$
(c) zero (d) $l/2$

5. Two wires are made of the same material and have the same volume. However wire 1 has cross-sectional area A and wire 2 has cross-sectional area $3A$. If the length of wire 1 increases by Δx on applying force F, how much force is needed to stretch wire 2 by the same amount? **[2009]**

(a) $4F$ (b) $6F$
(c) $9F$ (d) F

6. The pressure that has to be applied to the ends of a steel wire of length 10 cm to keep its length constant when its temperature is raised by 100ºC is:

(For steel Young's modulus is $2\times10^{11}\,\text{Nm}^{-2}$ and coefficient of thermal expansion is $1.1\times10^{-5}\,\text{K}^{-1}$) **[2014]**

(a) 2.2×10^8 Pa (b) 2.2×10^9 Pa
(c) 2.2×10^7 Pa (d) 2.2×10^6 Pa

Answer Key

1	2	3	4	5	6									
(b)	(d)	(a)	(a)	(c)	(a)									

SOLUTIONS

1. **(b)** Small amount of work done in extending the spring by dx is

$dW = k\,x\,dx$

$$\therefore W = k\int_{0.05}^{0.15} x\,dx$$

$$= \frac{800}{2}\left[(0.15)^2 - (0.05)^2\right]$$

$$= 400\,[(0.15+0.05)(0.15-0.05)]$$

$$= 400\times0.2\times0.1 = 8\text{ J}$$

2. **(d)** Work done by constant force in displacing the object by a distance ℓ.

= change in potential energy

$= \frac{1}{2} \times \text{stress} \times \text{strain} \times \text{volume}$

$= \frac{1}{2} \times \frac{F}{A} \times \frac{\ell}{L} \times A \times L = \frac{F\ell}{2}$

3. **(a)** Energy stored per unit volume,

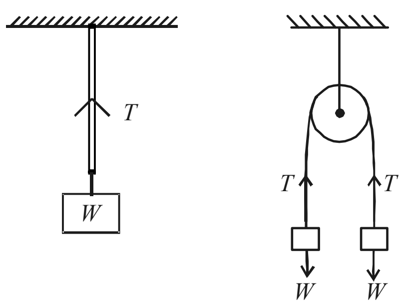
$E = \frac{1}{2} \times \text{stress} \times \text{strain}$

We know that,

$Y = \frac{\text{stress}}{\text{strain}}$ or $\text{strain} = \frac{\text{stress}}{Y}$

$E = \frac{1}{2} \times \text{stress} \times \frac{\text{stress}}{Y} = \frac{1}{2} \cdot \frac{S^2}{Y}$

4. **(a)** Case (i)



At equilibrium, $T = W$

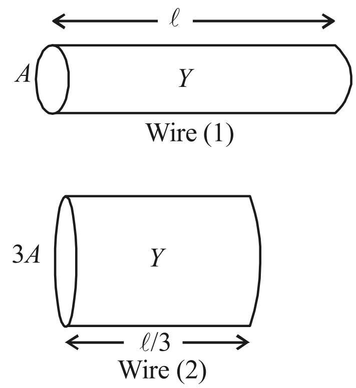
$Y = \frac{W/A}{\ell/L}$ .....(1)

Case (ii) At equilibrium $T = W$

$\therefore Y = \frac{W/A}{\frac{\ell/2}{L/2}} \Rightarrow Y = \frac{W/A}{\ell/L}$

$\Rightarrow$ Elongation is the same.

5. **(c)**



As shown in the figure, the wires will have the same Young's modulus (same material) and the length of the wire of area of cross-section $3A$ will be $\ell/3$ (same volume as wire 1).

For wire 1,

$Y = \frac{F/A}{\Delta x/\ell}$ ...(i)

For wire 2,

$Y = \frac{F'/3A}{\Delta x/(\ell/3)}$ ...(ii)

From (i) and (ii), $\frac{F}{A} \times \frac{\ell}{\Delta x} = \frac{F'}{3A} \times \frac{\ell}{3\Delta x}$

$\Rightarrow F' = 9F$

6. **(a)** Young's modulus $Y = \frac{\text{stress}}{\text{strain}}$

stress = Y × strain

Stress in steel wire = Applied pressure

Pressure = stress = Y × strain

Strain $= \frac{\Delta L}{L} = \alpha \Delta T$ (As length is constant)

$= 2 \times 10^{11} \times 1.1 \times 10^{-5} \times 100 = 2.2 \times 10^8$ Pa