AVIRAL CLASSES
IIT-JEE | NEET | FOUNDATIONS

PHYSICS
CRASH COURSE

LECTURE - 03

TOPICS : Mechanics of Solids

1. Force constant of a spring (k) is analogous to

(a) $\frac{YA}{L}$ (b) $\frac{YL}{A}$ (c) $\frac{AL}{Y}$ (d) ALY

2. The Young's modulus of brass and steel are respectively 1.0×10^{11} N m^{-2} and 2.0×11^{11} Nm^{-2}. A brass wire and a steel wire of the same length are extended by 1 mm each under the same force. If radii of brass and steel wires are R_B and R_S respectively, then

(a) $R_S = \sqrt{2}\,R_B$ (b) $R_S = \frac{R_B}{\sqrt{2}}$

(c) $R_S\ 4R_B$ (d) $R_S = \frac{R_B}{2}$

3. Modulus of rigidity of ideal liquids is
(a) infinity (b) zero
(c) unity
(d) some finite small non-zero constant value

4. Which of the statement is incorrect ?
(a) Steel is more elastic than rubber.
(b) The stretching of a coil is determined by its shear modulus
(c) Stress is a vector quantity
(d) Metal have larger values of Young's modulus than alloys and elastomers

5. The ratio of tensile stress to the longitudinal strain is defined as
(a) bulk modulus (b) Young's modulus
(c) shear modulus (d) compressiblity

6. The average depth of Indian ocean is about 3000 m. The fractional compression, $\frac{\Delta V}{V}$ of water at the bottom of the ocean is
(Given : Bulk modulus of the water $= 2.2 \times 10^9$ N m^{-2} and g = 10 ms^{-2})
(a) 0.82% (b) 0.91%
(c) 1.36% (d) 1.24%

7. A structural steel rod has a radius of 10 mm and a length of 1 m. A 100 kN force s tretches it along its length. The strain on the rod is
($Y_{steel} = 200 \times 10^9$ N m^{-2})
(a) 1.6 mm (b) 2.6 mm
(c) 3.6 mm (d) 4.6 mm

8. A wire of length L and radius r is clamped at one end. On stretching the other end of the wire with a force F, the increase in its length is l. If another wire of same material but of length 2L and radius 2r is stretched with a force 2F, the increase in its length will be

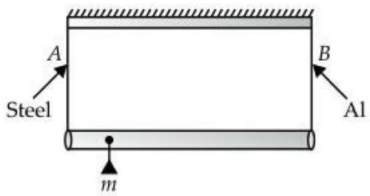
(a) $\frac{l}{4}$ (b) $\frac{l}{2}$

(c) l (d) $2l$

9. Which of the following substances has highest value of Young's modulus ?
(a) Aluminium (b) Iron
(c) Copper (d) Steel

10. Which one of the following statements are wrong ?
(a) Young's modulus for a perfectly rigid body is zero
(b) Bulk modulus is relevant for solids, liquids and gases
(c) The young's modulus and shear modulus are relevant for solids
(d) The stretching of a coil spring is determined by its shear modulus

11. A rod of length L and negligible mass is suspended at its two ends by two wires of steel (wire A) and aluminium (wire B) of equal lengths as shown in the figure. The cross-sectional areas of wires A and B are 1 mm^2 and 2 mm^2 respectively.
($Y_{Al} = 70 \times 10^9$ N m^{-2} and $Y_{steel} = 200 \times 10^9$ N m^{-2})



To have equal stress in both the wires, mass m should be suspended at a distance of

(a) $\frac{1}{3}$L from the wire A (b) $\frac{1}{2}$L from the wire B

(c) $\frac{2}{3}$L from the wire B (d) $\frac{2}{3}$L from the wire A

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TOPICS : Mechanics of Solids (SOLUTION)

1. **(a) :** $Y = \dfrac{FL}{A\Delta L}$ or $F = \left(\dfrac{YA}{L}\right)\Delta L$

Comparing this with $F = k\Delta x$, we get $k = \dfrac{YA}{L}$

2. **(b) :** Increase in length

$$\Delta L = \frac{FL}{YA} = \frac{FL}{Y\pi R^2}$$

As F, L and ΔL are same hence,

YR^2 = a constant

$$\therefore \quad 2.0\times10^{11}R_S^2 = 1.0\times10^{11}R_B^2 \Rightarrow R_S = \frac{R_B}{\sqrt{2}}$$

3. **(b) :** Modulus of rigidity of ideal liquids is zero.

4. **(c) :** Stress is not a vector quantity as it cannot be assigned a specific direction. It is a tensor quantity.

5. **(b) :** Young's modulus is defined as the ratio of tensile (or compressive) stress to the longitudinal strain.

6. **(c) :** The pressure exerted by a 3000 m column of water on the bottom layer is

$P = h\rho g$

$= 3000\text{ m} \times 1000\text{ kg m}^{-3} \times 10\text{ m s}^{-2}$

$= 3 \times 10^7\text{ N m}^{-2}$

Fractional compression $\dfrac{\Delta V}{V}$ is

$$\frac{\Delta V}{V} = \frac{P}{B} = \frac{3\times10^7\text{ N m}^{-2}}{2.2\times10^9\text{ N m}^{-2}} = 1.36\times10^{-2} = 1.36\%.$$

7. **(a) :** Here, $r = 10\text{ mm} = 10 \times 10^{-3}\text{ m}$

$L = 1\text{ m}$

$F = 100\text{ kN} = 100 \times 10^3\text{ N} = 10^5\text{ N}$

Stress on the rod is given by

$$\text{Stress} = \frac{F}{A} = \frac{F}{\pi r^2}$$

$$= \frac{100\times10^3\text{ N}}{3.14\times(10^{-2}\text{ m})^2} = 3.18\times10^8\text{ N m}^{-2}$$

Elongation,

$$\Delta L = \frac{(F/A)L}{Y} = \frac{(3.18\times10^8\text{ N m}^{-2})(1\text{ m})}{2\times10^{11}\text{ N m}^{-2}}$$

$= 1.59 \times 10^{-3}\text{ m} = 1.59\text{ mm}$

The strain on the rod is given by

$$\text{Strain} = \frac{\Delta L}{L}$$

$$= \frac{1.59\times10^{-3}\text{m}}{1\text{ m}} = 1.59\times10^{-3}\text{ m} = 1.59\text{ mm}$$

$= 1.6\text{ mm}$

8. **(c) :** Let Y be the Young's modulus of the material of the wire. Then

For the first wire

$$Y = \frac{F/\pi r^2}{l/L} = \frac{FL}{\pi r^2 l} \quad ...(i)$$

As both the wires are made of the same material, so their Young modulus is same.

Let the extension produced in second wire be l'. Then

$$Y = \frac{2F/\pi(2r)^2}{l'/2L} = \frac{FL}{\pi r^2 l'} \quad ...(ii)$$

Equating (i) and (ii), we get

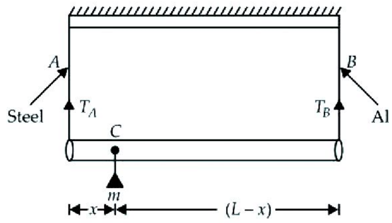
$$\frac{FL}{\pi r^2 l} = \frac{FL}{\pi r^2 l'} \text{ or } l' = l$$

9. **(d) :**

Substance	Young's modulus 10^9 N m^{-2}
Aluminium	70
Copper	120
Iron	190
Steel	200

From the table, it is clear that among the given substances steel has the highest value of Young's modulus.

10. **(d) :** All other statements are correct.



Let mass m be suspended at a distance x from the wire A. Let T_A and T_B be tensions in the wire A (steel) and wire B (aluminium) respectively.

$\therefore$ Stress in wire $A = \dfrac{T_A}{A_A}$

Stress in wire $B = \dfrac{T_B}{A_B}$

For equal stress in both the wires,

$$\frac{T_A}{A_A} = \frac{T_B}{A_B}$$

$$\frac{T_A}{T_B} = \frac{A_A}{A_B} = \frac{1\text{ mm}^2}{2\text{ mm}^2} = \frac{1}{2} \qquad \text{...(i)}$$

As the system is in equilibrium, taking moments about C, we get

$$T_A x = T_B(L - x)$$

$$\frac{L-x}{x} = \frac{T_A}{T_B}$$

$$\frac{L-x}{x} = \frac{1}{2} \qquad \text{(Using (i))}$$

$$2L - 2x = x \quad \text{or} \quad x = \frac{2}{3}L$$