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Section A · Multiple Choice

Choose the correct option. Questions 1–21

- 1 The possible value of Poisson's ratio (σ) for any material can be:
- (a) Between 0 and 0.5 (b) Between 0.5 and 1.5
(c) Between -1 and -2 (d) Between 0.5 and -1
- 2 Shearing strain is equivalent to:
- (a) An extension strain (b) A compressive strain
(c) The sum of mutually parallel expansion and contraction strains (d) The sum of mutually perpendicular expansion and contraction strains
- 3 When a wire is twisted, the strain produced in it is:
- (a) Normal strain (b) Longitudinal strain (c) Lateral strain (d) Shearing strain
- 4 If two identical balls, one made of ivory and the other made of clay, are dropped from the same height onto the floor, then:
- (a) The ivory ball will bounce to a higher height (b) The clay ball will bounce to a higher height
(c) Both balls will bounce to the same height (d) The ivory ball will not bounce at all
- 5 Which of the following is the most elastic material?
- (a) Glass (b) Quartz (c) Steel (d) Rubber
- 6 The following four wires are made of the same material. On applying the same tension, which one will have the maximum increase in length?
- (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
- 7 A wire of length L and cross-sectional area A is made of a material whose Young's modulus is Y . If an extension x is produced in its length, the work done is:
- (a) $\frac{Yx^2}{2}$ (b) $\frac{YAx^2}{2L}$ (c) YAx^2 (d) $\frac{Yx^2}{L^2}$
- 8 Copper wires are more easily drawn out than iron wires because:
- (a) Copper is a good conductor of heat (b) The resistance of copper is less
(c) The modulus of rigidity of copper is high (d) The Young's modulus of copper is high
- 9 In a metallic wire, if the stress is T and the Young's modulus is Y , then the energy stored per unit volume is:
- (a) $\frac{TY^2}{2}$ (b) $\frac{TY}{2}$ (c) TY (d) $\frac{T^2}{2Y}$

- 10 Elasticity is a property of matter that is:
- (a) Molecular in nature (b) Electromagnetic in nature
(c) Nuclear in nature (d) Gravitational in nature
-
- 11 The relation between Y , η and K is:
- (a) $\frac{1}{9Y} = \frac{1}{3\eta} + \frac{1}{K}$ (b) $\frac{1}{K} = \frac{1}{3Y} + \frac{1}{9\eta}$
(c) $\frac{1}{\eta} = \frac{1}{3Y} + \frac{1}{9K}$ (d) $\frac{1}{Y} = \frac{1}{3\eta} + \frac{1}{9K}$
-
- 12 The relation between Y , η and σ is:
- (a) $\frac{1}{\eta} = 2(1 + 2\sigma)$ (b) $Y = 2\eta(1 + \sigma)$
(c) $\eta = 2Y(1 + 2\sigma)$ (d) $Y = 3\eta(1 - 2\sigma)$
-
- 13 If the radius of a wire and the force applied to it are both doubled, then the increase in its length will become:
- (a) Four times (b) Two times (c) Unchanged (d) Half
-
- 14 The Young's modulus of elasticity of a wire material is $2 \times 10^{11} \text{ N/m}^2$. If the strain produced in it is 0.15, then the applied stress (in N/m^2) will be:
- (a) 3×10^{10} (b) 3×10^{11} (c) 2×10^{11} (d) 2×10^{10}
-
- 15 The dimensions of strain are the same as those of which of the following quantities?
- (a) Stress (b) Modulus of elasticity (c) Angle (d) Pressure
-
- 16 When a weight is suspended from one end of a wire, the wire gets stretched. The potential energy per unit volume of the wire in terms of longitudinal strain σ and Young's modulus Y will be:
- (a) $\frac{Y\sigma^2}{2}$ (b) $\frac{Y\sigma}{2}$ (c) $\frac{2Y\sigma^2}{2}$ (d) $\frac{Y^2\sigma}{2}$
-
- 17 The upper end of a wire of radius 4 mm and length 100 cm is clamped, and the other end is twisted by 30° . The shearing angle will be:
- (a) 12° (b) 0.12° (c) 1.2° (d) 0.012°
-
- 18 The Young's modulus of a given substance is 2.4 times its modulus of rigidity. Its Poisson's ratio will be:
- (a) 2.4 (b) 1.2 (c) 0.4 (d) 0.2
-
- 19 On applying a load to a wire, its length increases by 3 mm. The extension in another wire of the same material and same length, but whose radius is half, under the same load will be:
- (a) 12 mm (b) 0.75 mm (c) 6 mm (d) 15 mm
-
- 20 How much force is required to stretch a steel wire of cross-sectional area 1 cm^2 to 1.1 times its length?
- (a) $2 \times 10^6 \text{ N}$ (b) $2 \times 10^3 \text{ N}$ (c) $2 \times 10^{-6} \text{ N}$ (d) $2 \times 10^{-7} \text{ N}$
-
- 21 A wire of length L and cross-sectional area A has a Young's modulus of elasticity Y . If the length of the wire is doubled and the cross-sectional area is halved, then the Young's modulus of elasticity of the wire will become:
- (a) $4Y$ (b) Y (c) $2Y$ (d) $Y/2$

Section B • Short Answer & Numericals

Show all steps. Questions 22–25

- 22 The edge of a solid copper cube is 10 cm. When a hydraulic pressure of 7.20×10^6 Pa is applied to it, its volume contracts by 0.06 cm^3 . Find the bulk modulus of copper.

- 23 Two wires A and B of different metals, having the same radius and equal length, are joined together to make a long wire. By fixing one end of it and applying a force on the other end, the elongation in the length of this composite wire is 4 cm. If $Y_B = 3Y_A$, find the change in length of wire B. (Y = Young's modulus of elasticity)

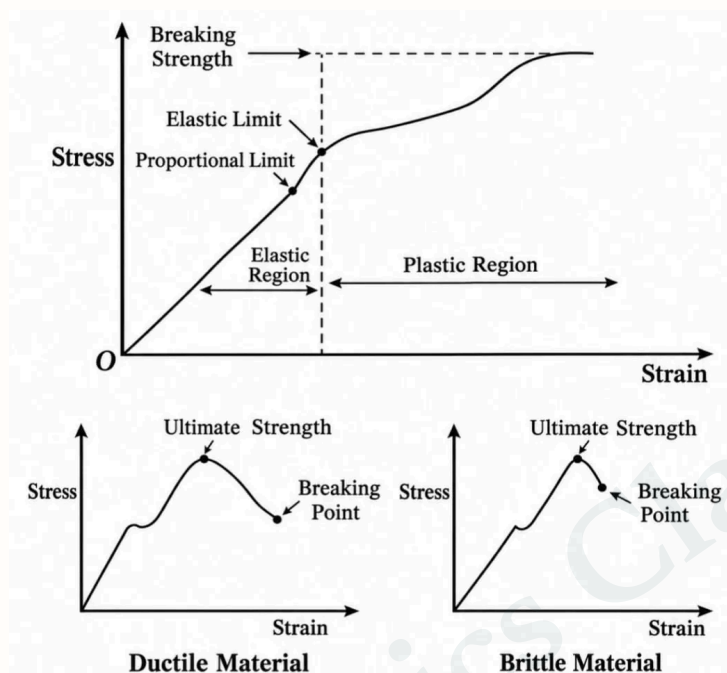
- 24 Find the work done per unit volume to increase the length of a wire by 1%, having Young's modulus Y and a cross-sectional area of 1 mm^2 . ($Y = 9 \times 10^{11} \text{ N/m}^2$)

- 25 What is the density of water at a depth where the pressure is 80.0 atm, given that its density at the surface is $1.03 \times 10^3 \text{ kg m}^{-3}$?

■ Hooke's law & stress-strain curve

Hooke's law (within elastic limit)

Stress $\propto$ Strain



■ Young's modulus (Y)

Definition

$$Y = \frac{\text{Longitudinal stress}}{\text{Longitudinal strain}} = \frac{F/A}{\Delta l/l}$$

Wire of length L , radius r , load Mg

$$Y = \frac{Mg/\pi r^2}{\Delta l/L}$$

Elongation due to the wire's own weight

$$\Delta l = \frac{mgL}{2AY}$$

Force constant of the wire

$$k = \frac{YA}{L}$$

Actual length of the wire (L found from these) $L_1 = L + \frac{T_1}{k}, \quad L_2 = L + \frac{T_2}{k}$

Work done in stretching the wire

$$W = \frac{1}{2} k l^2 = \frac{1}{2} \frac{YA}{L} l^2$$

Stored energy in a wire

$$U = \frac{1}{2} \times \text{Stress} \times \text{Strain} \times \text{Volume}$$

■ Bulk modulus (K)

Definition	$K = \frac{\text{Bulk stress}}{\text{Volume strain}} = \frac{F/A}{-\Delta V/V} = \frac{-P}{\Delta V/V}$
Isothermal elasticity modulus	$E_\theta = P$
Adiabatic elasticity modulus	$E_\phi = \gamma P$
Density of compressed liquid	$\rho' = \rho \left[1 + \frac{\Delta P}{K} \right]$
Compressibility	$C = \frac{1}{K}$

■ Modulus of rigidity (η), Poisson's ratio (σ) & relations

Modulus of rigidity	$\eta = \frac{\text{Shearing stress}}{\text{Shearing strain}} = \frac{F_{\text{tangential}}/A}{\phi}$
Poisson's ratio	$\sigma = \frac{\text{Lateral strain}}{\text{Longitudinal strain}} = \frac{-dr/r}{dL/L}$
Change in volume	$\frac{dV}{V} = (1 - 2\sigma) \frac{dL}{L}$
Theoretical value	$-1 < \sigma < 0.5$
Practical value	$0 < \sigma < 0.5$
Relation between Y , K and σ	$Y = 3K(1 - 2\sigma)$
Relation between Y , η and σ	$Y = 2\eta(1 + \sigma)$

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