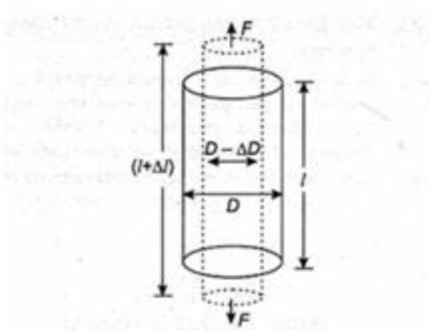
Class: XI
Subject: Physics
Topic: Mechanical properties of solids
No. of Questions: 20

Q1. There is no change in the volume of a wire due to change in its length on stretching. The Poisson's ratio of the material of the wire is

a. + 0.50
b. − 0.50
c. 0.25
d. − 0.25

Sol: a

When two equal and opposite forces are applied to a body along a certain direction, the body extends along that direction. At the same time, the body contracts along the perpendicular directions. The fractional change in the direction along which the forces have been applied is called the 'longitudinal strain' while the fractional change in a perpendicular direction is called the 'lateral strain'. The ratio of lateral strain to the longitudinal strain is called the 'Poisson's ratio'. It is a constant for the material of the body.



In figure, a wire of original length l and diameter D is subjected to equal and opposite forces F, along its length. If the length increases to $l + \Delta l$ and the diameter decreases to $D - \Delta D$, then longitudinal strain $= \frac{\Delta l}{l}$

and lateral strain $= \frac{\Delta D}{D}$

The Poisson's ratio of the material of the wire is

$$\sigma = \frac{\Delta D/D}{\Delta l/l}$$

The relation for volume of wire is

$$V = \pi r^2 l \qquad \left(\text{But, } r = \frac{D}{2}\right)$$

$$V = \pi\left(\frac{D}{2}\right)^2 l = \frac{\pi D^2 l}{4} \qquad \ldots\text{(i)}$$

Differentiating both sides of Eq. (i)

$$dV = \frac{\pi l}{4}\cdot 2D\cdot dD + \pi D^2 \times \frac{1}{4} dl$$

As volume remains constant, hence we get

$$0 = \pi\frac{l}{2}D\,dD + \pi\frac{D^2}{4}dl$$

or

$$-\pi\frac{l}{2}D\,dD = \frac{\pi D^2}{4}dl$$

or

$$-\frac{dD}{D}\frac{l}{dl} = \frac{2}{4} = 0.5$$

Q2. The increase in length of a wire on stretching is 0.025%. If its Poisson ratio is 0.4, what is the percentage decrease in diameter?

a. 0.01
b. 0.02
c. 0.03
d. 0.04

Sol: a

σ = lateral strain / longitudnal strain
Lateral strain = 0.4 x 0.025 = 0.01

Q3. An elastic ball is dropped from a height h and it rebounds many times from the floor. If the coefficient of restitution is e, the time interval between the second and the third impact, is

a. ev/g
b. e^2 v/g
c. $e^2\sqrt{\left(\frac{8h}{g}\right)}$
d. $e^2\sqrt{\left(\frac{h}{g}\right)}$

Sol: c

$$t = \sqrt{\left(\frac{2h}{g}\right)} \qquad \ldots(1)$$

The second impact occurs after an additional time

$$= 2\sqrt{2h_1 g} = 2e\sqrt{\frac{2h}{g}}$$

∴ The third impact occurs after an additional time

$$= 2\sqrt{2h_2 g}$$
$$= 2e^2\sqrt{\frac{2h}{g}}$$
$$= e^2\sqrt{\frac{8h}{g}}$$

Q4. Two wires of the same length and same material but radii in the ratio 1 : 2 are stretched by unequal forces to produce equal elongation. What is the ratio of the two forces?

a. 1 : 4
b. 1 : 2
c. 2 : 1
d. 4 : 5

Sol: a

$$Y = \frac{FL}{\pi r^2 l} F = \frac{Y\pi r^2 l}{L} \frac{F_1}{F_2} = \frac{\pi r_1^2}{\pi r_2^2} = \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$$

Q5. If the length of a rod of aluminium is 1.0 m and its area of cross-section is 5 cm^2. Its one end is kept at 250^{o}C and the other end at 50^{o}C. How much heat will flow in the rod in 5 minutes? (K for Al = 2 x 10^{-1} kJ/msec ^{o}C)

a. 1435.4 cal
b. 630.2 cal
c. 1050.1 cal
d. 1470.6 cal

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Sol: a

$$Q = \frac{KA(T_1 - T_2)t}{d}$$

K = 2 x 10^{-1} kJ/msec ^oC = 200 J(m-sec ^oC)
A = 5 x 10^{-4} m^2
T1 - T2 = 250 - 50 = 200 ^oC
t = 5 x 60 = 300 sec
d = 1 mQ = $\frac{200 * 5 * 10^{-4} * 200 * 300}{1} = 6000J$
$= \frac{6000}{4.18} = 1435.4$ Cal

Q6. Out of the following which is the most elastic?

a. Rubber
b. Glass
c. Steel
d. Plastic

Sol: c

Steel is the most elastic.

Q7. A wire can be broken by applying a load of 200 N. The force required to break another wire of the same length and the same material, but double in diameter, is

a. 200 N
b. 400 N
c. 600 N
d. 800 N

Sol: d

$$Y = \frac{FL}{Al}$$

or $$F = \frac{YAl}{L}$$

or $F \propto A$ or $F \propto r^2$ or $F \propto d^2$

$$\therefore \quad \frac{F_1}{F_2} = \frac{d_1^2}{d_2^2}$$

Given, $d_1 = d$, $d_2 = 2d$, $F_1 = 200\ \text{N}$

$$\therefore \quad \frac{200}{F_2} = \frac{(d)^2}{(2d)^2} = \frac{1}{4}$$

or $$F_2 = 4 \times 200 = 800\ \text{N}$$

Q8. A wire of length 2 m is made from 10 cc of copper. A force F is applied so that its length increases by 2 mm. Another wire of length 8 m is made from the same volume of copper. If the force F is applied to it, its length will increase by

a. 0.8 mm
b. 1.6 cm
c. 2.4 cm
d. 3.2 cm

Sol: d

$$Y = \frac{FL}{\pi r^2 l}$$

$$\pi r^2 L = V$$

$$\therefore Y = \frac{FL^2}{Vl}$$

In both the positions F, Y, V are the same.

$$\therefore \frac{L_1^2}{l_1} = \frac{L_2^2}{l_2}$$

$$\frac{2^2}{2} = \frac{8^2}{l_2}$$

l_2 = 32 mm= 3.2 cm

Q9. When a long spring is stretched by 2 cm, its potential energy is U. If the spring is stretched by 10 cm, the potential energy in it will be

a. 10 U
b. 25 U
c. U/5
d. 5 U

Sol: b

U = $\frac{1}{2}kx^2$

U = $\frac{1}{2}k(2)^2$

$U = \frac{1}{2}k(10)^2$

After solving these equations we get, PE = 25 U

Q10. A wire of length L and area of cross-section A is stretched through a distance x metres by applying a force F along the length. The work done in this process is (Y is Young's modulus of the material)

a. $\frac{1}{2}(A.L)\left(\frac{Yx}{L}\right)\left(\frac{x}{L}\right)$
b. $(A.L)(YL)\left(\frac{x}{L}\right)$
c. $2(A.L)(YL)\left(\frac{x}{L}\right)$
d. $3(A.L)(YL)\left(\frac{x}{L}\right)$

Sol: a

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

or $$W = \frac{1}{2} Y \frac{x}{L} \times \frac{x}{L} \times AL$$

$$= \frac{1}{2}(AL)\left(Y\frac{x}{L}\right)\left(\frac{x}{L}\right)$$

Q11. Which one of the following is not a unit of Young's modulus?

a. Nm^{-1}
b. Nm^{-2}
c. dyne cm^{-2}
d. MPa

Sol: a

Nm^{-1} is not a unit of Young's modulus

Q12. Out of the following which is the most elastic?

a. Rubber
b. Glass
c. Steel
d. Plastic

Sol: c

Steel is the most elastic

Q13. A body of mass 10 Kg is attached to a wire 0.3 m long. Its breaking stress is 4.8×10^7 N / m^2. The area of cross section of wire is 10^{-6} m^2. What is the maximum angular velocity with which it can be rotated in the horizontal circle?

a. 1 rad / sec
b. 2 rad / sec
c. 3 rad / sec
d. 4 rad / sec

Sol: d

$F = \frac{mv^2}{r} = mr\omega^2 stress = \frac{force}{areaofcrosssection} 4.8 * 10^7 = \frac{force}{10^{-6}}$ force = 48 N $force = mr\omega^2 48 = 10 * 0.3\omega^2 \omega = 4rad/sec$

Q14. A wire of length 'l' meters, made of a material of specific gravity 8 is floating horizontally on the surface of water. It is not wet by water, the maximum diameter of the wire (in millimeters) upto which it can continue to float is : (surface tension of water is $T = 70 \times 10^{-3}\ Nm^{-1}$)

a. 1.5
b. 1.1
c. 0.75
d. 0.55

Sol: b

$T \cdot l = v\rho g$

or $T \cdot l = \pi r^2 l \rho g$

or $T = \pi r^2 \rho g$

$\therefore\ 70 \times 10^{-3} = 3.14 \times r^2 \times 8 \times 10^{-3} \times 9.8$

or $r^2 = \frac{70 \times 10^{-3}}{3.14 \times 8 \times 10^{-3} \times 9.8} = 0.28$

$\therefore\ r = 0.53$

$\therefore$ Minimum diameter of the wire

$= 2r$

$= 2 \times 0.53$

≈ 1.1 m

Q15. A wire can be broken by applying a load of 200 N. The force required to break another wire of the same length and the same material, but double in diameter, is

a. 200 N
b. 400 N
c. 600 N
d. 800 N

Sol: d

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$$Y = \frac{FL}{Al}$$

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$\therefore$ $$\frac{200}{F_2} = \frac{(d)^2}{(2d)^2} = \frac{1}{4}$$

or $$F_2 = 4 \times 200 = 800\text{ N}$$

Q16. If the length of a rod of aluminium is 1.0 m and its area of cross-section is 5 cm^2. Its one end is kept at 250°C and the other end at 50°C. How much heat will flow in the rod in 5 minutes? (K for Al = 2 x 10^{-1} kJ/msec °C)

a. 1435.4 cal
b. 630.2 cal
c. 1050.1 cal
d. 1470.6 cal

Sol: a

$$Q = \frac{KA(T_1 - T_2)t}{d}$$

K = 2 x 10^{-1} kJ/msec °C = 200 J(m-sec °C)
A = 5 x 10^{-4} m^2
T1 - T2 = 250 - 50 = 200 °C
t = 5 x 60 = 300 sec
d = 1 mQ = $\dfrac{200 * 5 * 10^{-4} * 200 * 300}{1} = 6000J$

$= \dfrac{6000}{4.18} = 1435.4$ Cal

Q17. Directions: In these statements of assertion and reason mark the correct answer as:

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If reason is true but reason is false.
(d) If both assertion and reason are false

Assertion: If earth did not have atmosphere, its average surface temperature would be lower than what is now.
Reason: Green house effect of the atmosphere would be absent if earth did not have atmosphere.

a. (a)
b. (b)
c. (c)
d. (d)

Sol: a

If earth did not have atmosphere, its average surface temperature would be lower than what is now.
Green house effect of the atmosphere would be absent if earth did not have atmosphere.

Q18. Which one of the following physical quantities does NOT have the dimensions of force per unit area?

a. Stress
b. Strain
c. Young's modulus
d. Pressure

Sol: b

Q19. A metal bar of length L and area of cross-section A is rigidly clamped between two walls. The Young's modulus of its material is Y and the coefficient of linear expansion is α. The bar is heated so that its temperature increases by θ °C. Then, the force exerted at the ends of the bar is given by

a. YL $\alpha\theta$
b. YL $\alpha\theta/A$
c. YA $\alpha\theta$
d. Y $\theta\alpha/LA$

Sol: c

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The coefficient of linear expansion is defined as

$$\alpha = \frac{\text{increase in length}}{\text{original length} \times \text{temp.rise}} = \frac{l}{L\theta}$$

∴ Increase in length $l = \alpha L\theta$. Now

$$Y = \frac{FL}{Al}$$

or $$F = \frac{YAl}{L} = \frac{YA\alpha L\theta}{L} = YA\alpha\theta$$

Hence the correct choice is (3).

Q20. A wire of length L is stretched by a length / when a force F is applied at one end. If the elastic limit is not exceeded, the amount of energy stored in the wire is given by

a. F × I
b. 1/2(F × I)
c. FI^2/L
d. $1/2Ft^2/L$

Sol: b

The force F can be assumed to act at the mid-point of the wire. Therefore, the average force responsible for extension is $F/2$. Thus, the work done by the force $\frac{F}{2}$ to produce an extension l in the wire $=$ force $\times$ extension $= \frac{1}{2}(F \times l)$. Hence the correct choice is (2).