DPP – Elasticity

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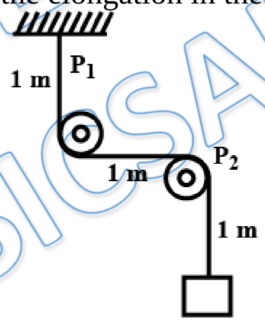
Q 1. For a constant force, a rope breaks due to stress. Which of the following is useful to reduce the stress?
(a) Increase the length of the rope
(b) Reduce the length of the rope
(c) Increase the cross sectional area of the rope
(d) Reduce the cross sectional area of the rope

Q 2. The elongation produced in a copper wire of length 2m and diameter 3mm, when a force of 30N is applied is [young's modulus Y = $1 \times 10^{11}\ N/m^2$]
(a) 8.5 mm (b) 0.85 mm
(c) 0.085 mm (d) 85 mm

Q 3. Copper wire of length 3m and area of cross-section 1 mm^2, passes through an arrangement of two frictionless pulleys, P_1 and P_2. One end of the wire is rigidly clamped and a mass of 1 kg is hanged from the other end. If Young's modulus for copper is $10 \times 10^{10}\ N/m^2$, the elongation in the wire is :



(a) 0.05 mm (b) 0.1 mm
(c) 0.2 mm (d) 0.3 mm

Q 4. The force that must be applied to a steel wire 6m long and diameter 1.6mm to produce an extension of 1mm [Y = $2 \times 10^{11}\ N/m^2$] is approximate.
(a) 100 N (b) 50 N
(c) 67 N (d) 33.5 N

Q 5. The Young's modulus of a material is $2 \times 10^{11}\ N/m^2$ and its elastic limit is $1.8 \times 10^8\ N/m^2$. For a wire of 1m length of this material, the maximum elastic elongation achievable is
(a) 0.2 mm (b) 0.5 mm
(c) 0.4 mm (d) 0.9 mm

Q 6. A compressive force, F is applied at the two ends of a long thin steel rod. It is heated, simultaneously, such that its temperature increases by ΔT. The net change in its length is zero. Let L be the length of the rod, A is its area of cross-section. Y is Young's modulus, and α is its coefficient of linear expansion. Then, F is equal to (thermal expansion due to temperature change is given by $\Delta l = l\alpha\Delta T$)

(a) $L^2 Y\alpha\Delta T$ (b) $\frac{AY}{\alpha\Delta T}$
(c) $AY\alpha\Delta T$ (d) $LAY\alpha\Delta T$

Q 7. A wire suspended vertically from one of its ends is stretched by attaching a weight of 200 N to the lower end. The weight stretches the wire by 1mm. Then the elastic energy stored in the wire is

(a) 20 J (b) 1 J
(c) 2 J (d) 0.1 J

Q 8. The following four wires are made of the same material. Which of these will have the largest extension when the same tension is applied?

(a) length = 200 cm, diameter = 2 mm
(b) length = 300 cm, diameter = 3 mm
(c) length = 50 cm, diameter = 0.5 mm
(d) length = 100 cm, diameter = 1 mm

Q 9. If P is the stress and Y is Young's Modulus of the material of the wire, the energy stored in the wire per unit volume is

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

Q 10. Two wires of the same material and length but diameter in the ratio 1 : 2 are stretched by the same force. The ratio of potential energy per unit volume for the two wires when stretched will be :

(a) 1 : 1 (b) 2 : 1
(c) 4 : 1 (d) 16 : 1

Q 11. A wire fixed at the upper end stretches by length l by applying a force F. The work done in stretching is:

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

Q 12. A metal wire of mass 10 kg, 3 m long and having a cross-sectional are 4 mm^2 is suspended on roof. Find the elongation produced in wire due to its self weight (Young modulus of the metal is $2 \times 10^{11} N/m^2$ & g = 10 m/s^2)

(a) 0.375 mm (b) 0.187 mm
(c) 0.276 mm (d) 0.421 mm

Q 13. A wire is made of a material of density 10 g/cm^3 and breaking stress $5 \times 10^9\ N/m^2$. If g = 10ms^{-2} the length of the wire that will break under its own weight when suspended vertically is
(a) 5×10^2 m (b) 5×10^3 m
(c) 5×10^4 m (d) 5×10^5 m

Q 14. Young's modulus of a rod is $\frac{AgL^2}{2\lambda}$ for which elongation is λ due to its own weight when suspended from the ceiling. L is the length of the rod and A is constant, which is:
(a) Area
(b) Mass per unit length
(c) Mass per unit length per unit area
(d) Area per unit mass

Q 15. The compressibility of water is 4×10^{-5} per unit atmospheric pressure. The decrease in volume of 100 cubic centimeter of water under a pressure of 100 atmosphere will be
(a) 0.4 cc (b) 4×10^{-5} cc
(c) 0.025 cc (d) 0.004 cc

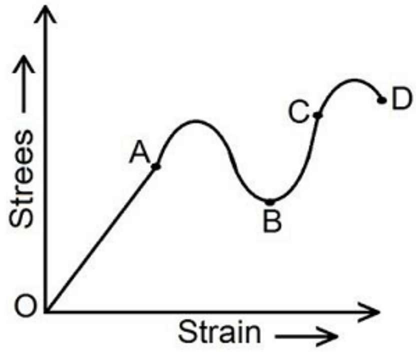
Q 16. When a pressure of 100 atmosphere is applied on a spherical ball, then its volume reduces to 0.01%. The bulk modulus of the material of the rubber in dyne/cm^2 is
(a) 10×10^{12} (b) 100×10^{12}
(c) 1×10^{12} (d) 1000×10^{12}

Q 17. The Young's modulus, bulk modulus and the modulus of rigidity have
(a) no dimensions (b) same dimensions
(c) different dimensions (d) none of the above

Q 18. The volume of a solid at 1 atm pressure is $10^4\ cm^3$. If the pressure is increased to 51 atm then find percentage change in its volume ($\beta = 10^{12}\ dyne/cm^2$)
(a) 0.5 % (b) 0.05 %
(c) 0.005 % (d) 0.0005 %

Q 19. The longitudinal stain in a metal bar is 0.05. If the Poison's ratio for this metal is 0.25, then the lateral strain will be
(a) 0.2 (b) 0.02
(c) 0.15 (d) 0.0125

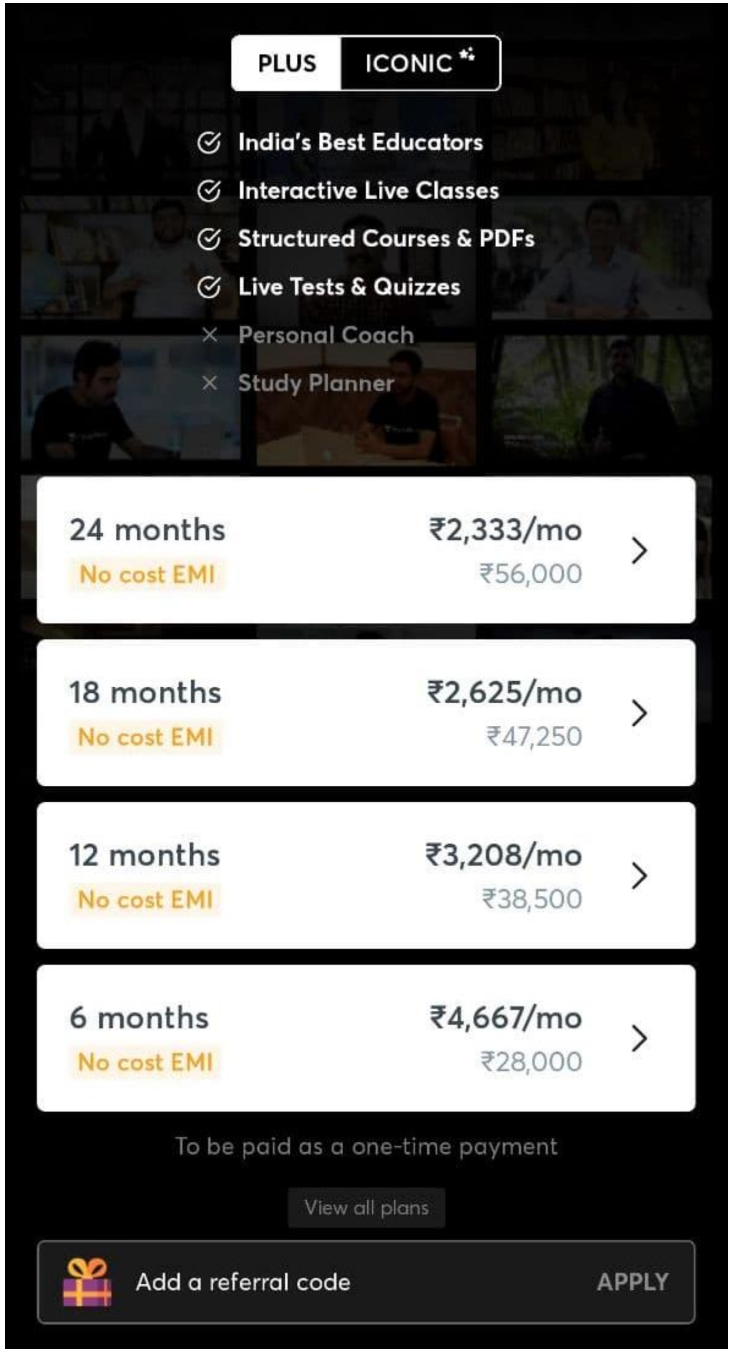
Q 20. A graph is shown between stress and strain for a metal. The part in which Hooke's law holds good is



(a) OA (b) AB
(c) BC (d) CD

Answer Key

Q.1 c	**Q.2 c**	**Q.3 d**	**Q.4 c**	**Q.5 d**
Q.6 c	**Q.7 d**	**Q.8 c**	**Q.9 c**	**Q.10 d**
Q.11 c	**Q.12 b**	**Q.13 c**	**Q.14 c**	**Q.15 a**
Q.16 c	**Q.17 b**	**Q.18 c**	**Q.19 d**	**Q.20 a**



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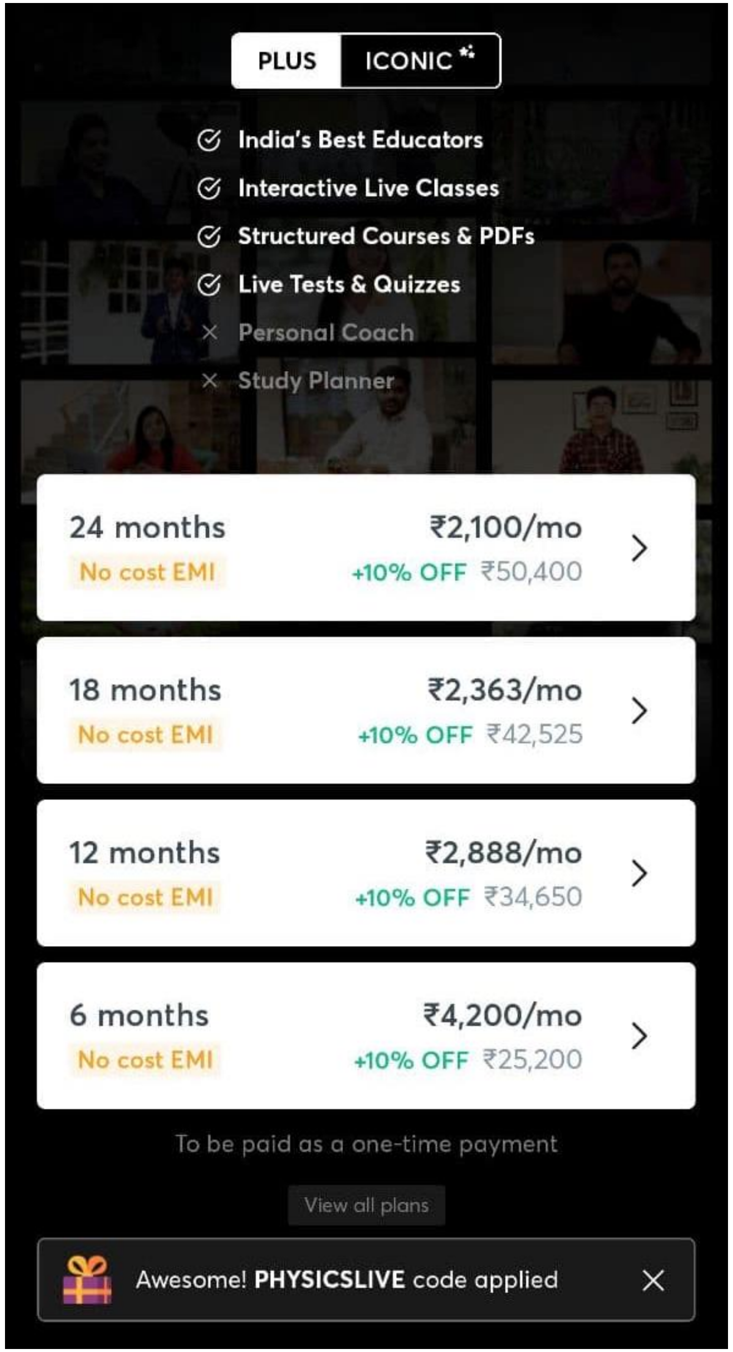

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NEET & JEE Main Solution

DPP- Elasticity

By Physicsaholics Team

Solution: 1

Stress; $\sigma = \frac{F}{A}$

if $F =$ constant

then to reduce σ

$A \uparrow$ $[\because \sigma \propto \frac{1}{A}]$

Ans. c

Solution: 2

$$Y = \frac{F/A}{\Delta L/L}$$

$$\Delta L = \frac{FL}{AY}$$

$$= \frac{30 \times 2}{\left[\pi \times \left(\frac{3}{2} \times 10^{-3}\right)^2\right] \times 10^{11}}$$

$$= \frac{60 \times 4}{\pi \times 9 \times 10^{-6} \times 10^{11}}$$

$$= \frac{240}{9\pi} \times 10^{-5}$$

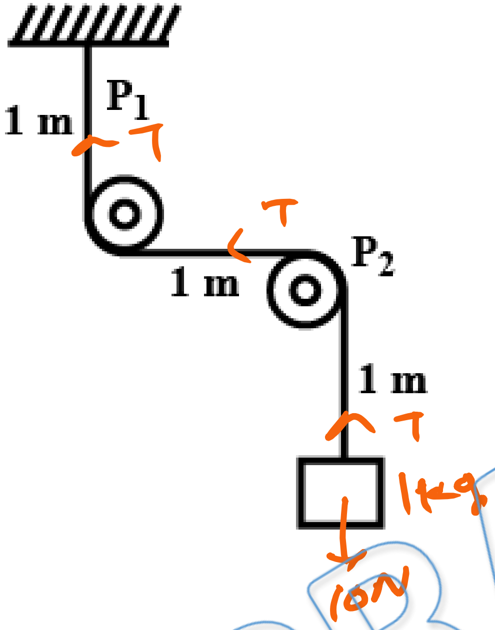
$$= 8.49 \times 10^{-5} \text{ m}$$

$$= 8.5 \times 10^{-5} \text{ mm}$$

$$\boxed{\Delta L = 0.085 \text{ mm}}$$ As.

Ans. c

Solution: 3



Tension in string; $T = mg$

$$T = 10\,N$$

$$\Delta L = \frac{FL}{AY}$$

$$= \frac{10 \times 3}{10^{-6} \times 10 \times 10^{10}}$$

$$= 3 \times 10^{-4}\ m$$

$$= 0.3 \times 10^{-3}\ m$$

$$\Delta L = 0.3\ mm \quad \text{Ans.}$$

$A = 1\ mm^2$

$= 1 \times (10^{-3}\ m)^2$

$A = 10^{-6}\ m^2$

Ans. d

Solution: 4

$$\Delta L = \frac{FL}{AY}$$

$$10^{-3} = \frac{F \times 6}{\left[\pi \times \left(\frac{1.6 \times 10^{-3}}{2}\right)^2\right] \times 2 \times 10^{11}}$$

$$10^{-3} = \frac{F \times 6 \times 4}{\pi \times 2.56 \times 10^{-6} \times 2 \times 10^{11}}$$

$$10^{-3} = \frac{F \times 24}{\pi \times 2.56 \times 10^{5} \times 2}$$

$$F = \frac{\pi \times 2.56 \times 10^{2} \times 2}{24}$$

$$F = 0.67 \times 10^{2}$$

$$\boxed{F = 67\ N}\ \text{Ans}$$

Ans. c

Solution: 5

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

elastic limit $= 1.8 \times 10^{8}\ N/m^2$

so; max. stress $\sigma_{max} = 1.8 \times 10^{8}\ N/m^2$

$$Y = \frac{\sigma}{(\Delta L/L)}$$

$$\Delta L = \frac{\sigma L}{Y}$$

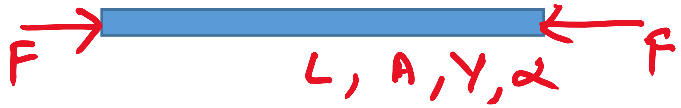
$$\Delta L_{max} = \frac{\sigma_{max} L}{Y} = \frac{1.8 \times 10^{8} \times 1}{2 \times 10^{11}}$$

$$\Delta L_{max} = 0.9 \times 10^{-3}$$

$$\boxed{\Delta L_{max} = 0.9\ mm}$$ Ans

Ans. d

Solution: 6



Expansion due to heating.

$\Delta l = l\alpha\Delta T$

Now compression due to force F is also Δl

so, $Y = \frac{F l}{A \Delta l}$ $\Rightarrow$ $F = AY\alpha\Delta T$ Ans.

$F = \frac{AY\Delta l}{(l+\Delta l)}$ → at $T = T + \Delta T$

$F = \frac{AY(l\alpha\Delta T)}{(l+\Delta l)}$ Since $l + \Delta l \simeq l$

Ans. c

Solution: 7

Energy density; $\frac{U}{Vol.} = \frac{1}{2}(stress)(strain)$

$U = \frac{1}{2}(stress)(strain) \times (Vol.)$

$U = \frac{1}{2}\left(\frac{200}{A}\right)\left(\frac{10^{-3}}{\ell}\right) \times (A \times \ell)$

$U = \frac{1}{2} \times 200 \times 10^{-3}$

$\boxed{U = 0.1\ J}$ Ans.

OR

$U = \frac{1}{2} K x^2$ where $K = \frac{YA}{\ell}$

$= \frac{1}{2}(Kx)x$

$= \frac{1}{2} F.x = \frac{200 \times 10^{-3}}{2}$

$= .1\ J$

Ans. d

Solution: 8

$$\Delta l = \frac{FL}{AY}$$

$\because$ Y = same for all
[$\because$ all wires are made of same material]

& F = same [given]

So; $\Delta l \propto \frac{L}{A} = \frac{L}{\pi d^2} \times 4$

$\Delta l \propto \frac{L}{d^2}$

(a) $\frac{L}{d^2} = \frac{(2)}{(2\times10^{-3})^2} = \frac{1}{2}\times10^6$

(b) $\frac{L}{d^2} = \frac{3}{(3\times10^{-3})^2} = \frac{1}{3}\times10^6$

(c) $\frac{L}{d^2} = \frac{(0.5)}{(5\times10^{-4})^2} = \frac{5\times10^{-1}}{25\times10^{-8}} = \frac{1}{5}\times10^7$

(d) $\frac{L}{d^2} = \frac{(0.1)}{(10^{-3})^2} = 10^5$

$\because$ $\frac{L}{d^2}$ is heighest for (c); so it will have largest extension.

so; option (c) is correct

Ans. c

Solution: 9

Energy density; $\frac{U}{Vol.} = \frac{1}{2}(\text{stress}) \times (\text{strain})$

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

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

so; $\frac{U}{Vol.} = \frac{1}{2}\frac{(\text{stress})^2}{Y}$

$= \frac{1}{2} \times \frac{P^2}{Y}$

$$\boxed{\frac{U}{Vol.} = \frac{P^2}{2Y}}$$ Ans.

Ans. c

Solution: 10

$\because$ Y = same for both wires.

$\frac{d_1}{d_2} = \frac{1}{2}$

F = same for both.

so; Energy density $= \frac{U}{Vol.} = K = \frac{1}{2}\frac{(stress)^2}{Y}$

$K \propto (stress)^2 = \left(\frac{F}{A}\right)^2 = \left(\frac{F}{\pi d^2}\right)^2$

$K \propto \frac{1}{d^4}$

$\frac{K_1}{K_2} = \left(\frac{d_2}{d_1}\right)^4 = \left(\frac{2}{1}\right)^4$

$$\boxed{\frac{K_1}{K_2} = \frac{16}{1}}$$ Ans.

Ans. d

Solution: 11

$$Y = \frac{FL}{Al} \quad \text{--- (1)} \quad [\because l = \text{streched length}]$$

$$F = \frac{AYl}{L}$$

$$dW = F \cdot dl = \frac{AYl}{L} dl$$

$$\int dW = \frac{AY}{L}\int_0^l l\, dl$$

$$W = \frac{AY}{L}\left[\frac{l^2}{2}\right]_0^l$$

$$W = \frac{AYl^2}{2L}$$

Put value of Y from eqn (1)

$$W = \frac{Al^2}{2L} \times \frac{FL}{Al}$$

$$\boxed{W = \frac{Fl}{2}} \quad \text{Ans.}$$

Ans. c

Solution: 12

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

$$= \frac{10 \times 10 \times 3}{2 \times 4 \times 10^{-6} \times 2 \times 10^{11}}$$

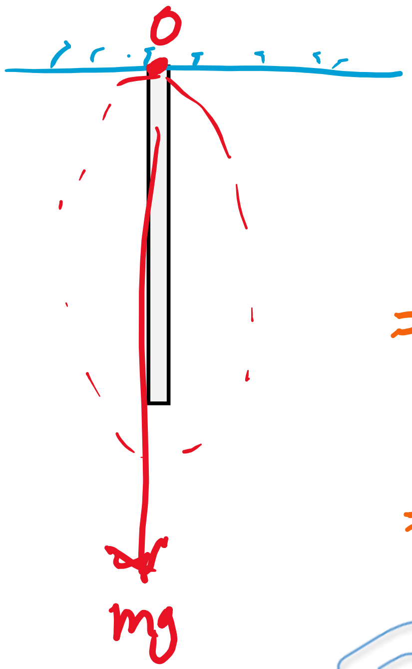
$$= \frac{3 \times 10^{2}}{16 \times 10^{5}}$$

$$= \frac{3}{16} \times 10^{-3}$$

$$\boxed{\Delta l = 0.187 \text{ mm}}$$ Ans.

Ans. b

Solution: 13



when stress at point 'o' is

$\sigma_0 \geq 5\times10^9\ N/m^2$

wire will break

$\rho = 10\ g/cm^3$

$= 10\times10^{-3}\ \frac{kg}{(10^{-2}\,m)^3}$

$= 10^4\ kg/m^2$

$\sigma_0 \geq 5\times10^9\ N/m^2$

$\sigma_{min} = 5\times10^9\ N/m^2$ [for breaking]

$\frac{mg}{A} = 5\times10^9$

$\frac{\rho(A\times l)g}{A} = 5\times10^9$

$l = \frac{5\times10^6}{g\times\rho} = \frac{5\times10^9}{10\times10^4}$

$\boxed{l = 5\times10^4\ m}$ Ans

Ans. c

Solution: 14

elongation due to self weight

$$\Delta l = \frac{mgL}{2aY} \; ; \; a = \text{area of cross-section}$$

given; $Y = \frac{AgL^2}{2d}$

$\Rightarrow$ given; $d = \Delta l$

$$\frac{AgL^2}{2Y} = \frac{mgL}{2aY}$$

$$A = \frac{m}{LA} = \text{density} \quad [\because A \times L = \text{Volume}]$$

or; A = mass per unit length per unit area. Ans. c

Ans.

Solution: 15

Bulk modulus = β

Compressibility = K

$V = 100\ cc = 100 \times (10^{-2} m)^3 = 10^{-4} m^3$

$$K = \frac{1}{\beta} = \frac{1}{\left[\frac{\Delta P}{\left(\frac{\Delta V}{V}\right)}\right]} = \frac{\Delta V/V}{\Delta P}$$

$$4 \times 10^{-5} = \frac{\Delta V}{100 \times 100}$$

$\Delta V = 4 \times 10^{-1}\ cc$

$\boxed{\Delta V = 0.4\ cc}$ Ans.

Ans. a

Solution: 16

$$\beta = \frac{\Delta P}{\left[\frac{\Delta V}{V}\right]} = \frac{\Delta P}{\Delta V} \times V$$

$$\beta = \frac{100}{\frac{0.01}{100} \times V} \times V$$

$$\beta = \frac{10^4}{0.01}$$

$$\boxed{\beta = 10^6 \text{ atm}} = 10^6 \times 10^5 \text{ N/m}^2$$

$$\boxed{\beta = 10^{11} \text{ N/m}^2}$$

$$\beta = 10^{11} \times \frac{10^5 \text{ dyne}}{(10^2 \text{ cm})^2} \Rightarrow \boxed{\beta = 10^{12} \text{ dyne/cm}^2} \text{ Ans.}$$

Ans. c

Solution: 17

Young's modulus

$$Y = \frac{\text{long. stress}}{\text{long. strain}} = \frac{F/A}{\Delta l/l} \quad [N/m^2]$$

Bulk modulus

$$\beta = \frac{\Delta P}{-\left[\frac{\Delta V}{V}\right]} \quad ; \quad [\beta] = [\Delta P] = N/m^2$$

Modulus of rigidity

$$\eta = \frac{\text{shear stress}}{\text{shear strain}} \quad [N/m^2]$$

So; all have same units & Dimensions.

Ans. b

Solution: 18

$V = 10^4\ cm^3$

$P_1 = 1\ atm$, $P_2 = 50\ atm$; $\Delta P = 50\ atm = 50 \times 10^5\ N/m^2$

$= 5 \times 10^6 \times \frac{10^5\ dyne}{(10^2 cm)^2}$

$= 5 \times 10^7\ dyne/cm^2$

$\beta = \frac{\Delta P}{\Delta V / V}$

$\frac{\Delta V}{V} = \frac{\Delta P}{\beta}$

$\frac{\Delta V}{V} \times 100 = \frac{\Delta P}{\beta} \times 100 = \frac{5 \times 10^5}{10^{12}} \times 100$

$\frac{\Delta V}{V} \% = 5 \times 10^7 \times 10^{-12} \times 100$

$\frac{\Delta V}{V} \% = 5 \times 10^{-3} \%$

$\boxed{\frac{\Delta V}{V} \% = 0.005 \%}$ Ans.

Ans. c

Solution: 19

Poison's ratio; $\sigma = 0.25$

$$\sigma = \frac{\text{lat. strain}}{\text{long. strain}}$$

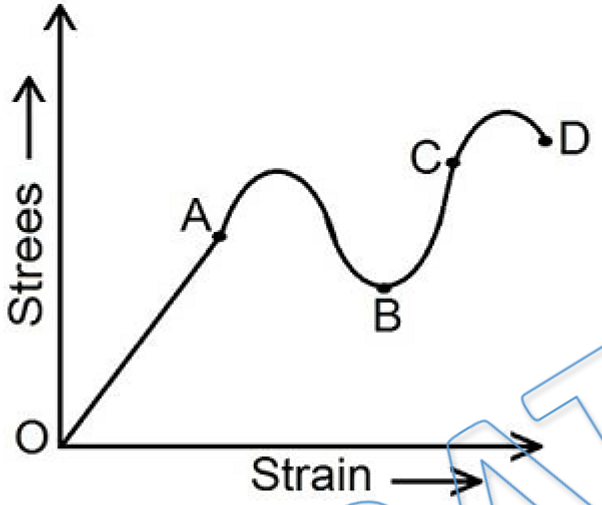
$$0.25 = \frac{\text{lat. strain}}{0.05}$$

$$\text{lat. strain} = 0.25 \times 0.05$$

$$\boxed{\text{lat. strain} = 0.0125}$$ Ans.

Ans. d

Solution: 20



so, hook's law is valid or holds good till proportionality limit point (A)

so, in this graph Hook's law holds good for 'OA'
Ans.

Hook's law

stress ∝ strain

Ans. a

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