

Level - 2	JEE Advanced Pattern/Solutions
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131.(D) One can take an elastic rod as a spring under elastic limits.

If the temperature is increased by $\Delta\theta$, then $L_1' = L_1(1 + \alpha_1\Delta\theta)$, $L_2' = L_2(1 + \alpha_2\Delta\theta)$ where L_1' and L_2' are Natural Length of rod at final temperature. By force balance

$$K_1x_1 = K_2x_2 \text{ or, } \frac{Y_1A_1}{L_1} \cdot L_1\alpha_1\Delta\theta = \frac{Y_2A_2}{L_2} \cdot L_2\alpha_2\Delta\theta \quad \text{or,} \quad Y_1A_1\alpha_1 = Y_2A_2\alpha_2, \quad \frac{A_1}{A_2} = \frac{Y_2\alpha_2}{Y_1\alpha_1}$$

132.(C) If V is initial volume then,

The natural volume at $T = 100^\circ\text{C}$ will be

$$V(1 + Y\Delta T)$$

So, $\Delta V = -VY\Delta T$

$$\text{Also } \beta = -V \frac{\Delta P}{\Delta V} = -V \frac{\Delta P}{-VY\Delta T} = \frac{\Delta P}{Y\Delta T} \quad \text{or,} \quad \Delta P = 250 \times 10^6 \times 1.82 \times 10^{-4} \times 80, \quad P_2 = 3.6 \text{ MPa}$$

133. A-P, Q; B-P; C-R, S; D-R

$$\Delta \ell = \frac{F\ell}{AY} \text{ and stress} = \frac{F}{A}$$

134.(BC) Deformation force will be same as tension in the rod, which will be there at all points. Hence, (C) is incorrect

$$\text{Now, } m_1 = \frac{M}{L}(L - x)$$

$$m_2 = \frac{M}{L}x \Rightarrow a = \frac{F}{M}$$

and $F' = T = m_1a$ where F' is the deforming force

$$= \frac{M}{L}(L - x) \frac{F}{M} = F \frac{(L - x)}{L} \Rightarrow \text{stress} = \frac{F'}{A} = \frac{F(L - x)}{AL}$$

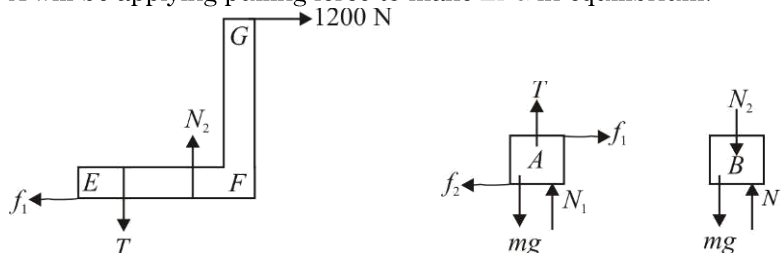
$\Rightarrow$ Stress varies linearly with ' x '. It is maximum at $x = 0$ and zero at $x = L$

Hence, (A) is correct

135.(AC) The slope of the linear portion of the curve gives the Young's modulus of the material. The slope of the linear portion OP for material A is greater than that of the linear portion OR for material B. Hence, statement (A) is correct. The plastic region for material A (from P to Q) is greater than that (from R to S) for material B, which indicates that material A is more ductile. Hence, statement (B) is in correct. The breaking stress for material B (i.e., stress corresponding to point S) is less than that for material A (i.e., stress corresponding to point Q), hence material A is stronger than material B.

136.(B) 137.(A) 138.(C)

A will be applying pulling force to make EFG in equilibrium.



For vertical equilibrium of EFG , $T = N_2$

As A is in equilibrium $f_1 = f_2 = f$ (suppose)

For horizontal equilibrium of EFG, $f_1 = 1200N$

For rotational equilibrium, $\tau_A = 0 \Rightarrow N_2 \times 4 - 1200 \times 3 = 0 \Rightarrow N_2 = 900N$

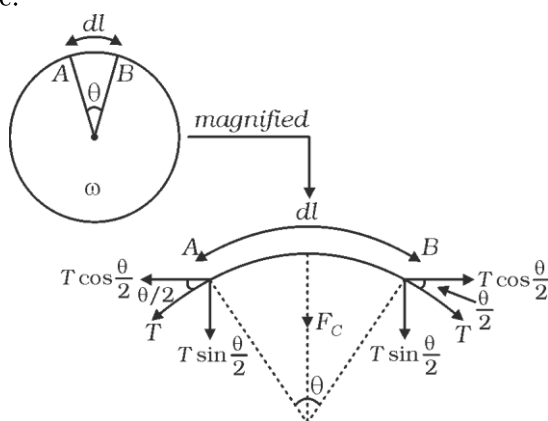
Shearing stress in A = $\frac{F}{A} = \frac{1200}{5} = 240N/cm^2$

Shearing stress in B = 0

Longitudinal stress in A = $\frac{T}{A} = 180N/cm^2$

Longitudinal stress in B = $\frac{N_2}{A} = 180N/cm^2$ & it will be compressive in nature

- 139.(2)** Consider an element AB of length dl . Let T be the tension and a be the area of cross-section of the wire.



Mass of the element is $dm = (\text{Volume})(\text{Density}) = (a dl)\rho$

The component of T , i.e., $\left(T \sin \frac{\theta}{2} + T \sin \frac{\theta}{2}\right)$ provides required centripetal forces to the element considered.

$$\therefore F_C = 2T \sin \frac{\theta}{2}$$

$$(dm)R\omega^2 = 2T \left(\frac{\theta}{2}\right) \quad \left(\because \theta \text{ is small, } \sin \frac{\theta}{2} = \frac{\theta}{2}\right)$$

$$T = \frac{(a dl)\rho R \omega^2}{\theta}, \quad \theta = \frac{dl}{R}$$

$$\therefore T = aR^2 \rho \omega^2 \quad \dots (i)$$

Let ΔR be the increase in radius of the ring

$$\text{Longitudinal strain } \frac{\Delta l}{l} = \frac{\Delta(2\pi R)}{2\pi R} = \frac{\Delta R}{R}$$

$$Y = \frac{T/a}{\Delta R/R} \Rightarrow \Delta R = \frac{TR}{aY}$$

$$\text{From Eq. (i), } \Delta R = \frac{R}{aY}(aR^2 \rho \omega^2) \quad \therefore \Delta R = \frac{\rho R^3 \omega^2}{Y} \Rightarrow n = 2$$

140.(6) Consider an element as shown in the figure.

$$\text{Stress in the element} = \frac{\text{Force}}{\text{Area}} = \frac{xAp g}{A} = x\rho g$$

Now, elastic potential energy stored in the wire is

$$dU = \frac{1}{2} (\text{Stress}) (\text{Strain}) (\text{Volume})$$

$$= \frac{1}{2} \cdot \frac{(\text{Stress})^2}{Y} (\text{Volume})$$

$$dU = \frac{1}{2} \cdot \frac{(x\rho g)^2}{Y} A dx = \frac{1}{2} \cdot \frac{\rho^2 g^2 A}{Y} x^2 dx$$

$$\text{Total elastic potential energy} = \frac{1}{2} \cdot \frac{\rho^2 g^2 A}{Y} \int_0^L x^2 dx = \frac{\rho^2 g^2 A}{6Y}$$

