PROPERTIES OF MATERIALS

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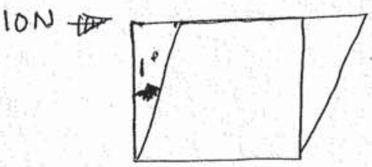
1-a

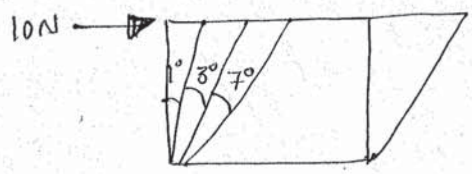
Engg. Science
- Solid Mechanics
- Fluid Mechanics
- Properties of Material



$t = 2\,sec \rightarrow 1°$

$t = 5\,sec \rightarrow 1°$

$t = 10\,sec \rightarrow 1°$



$t = 2\,sec = 1°$

$t = 5\,sec = 3°$

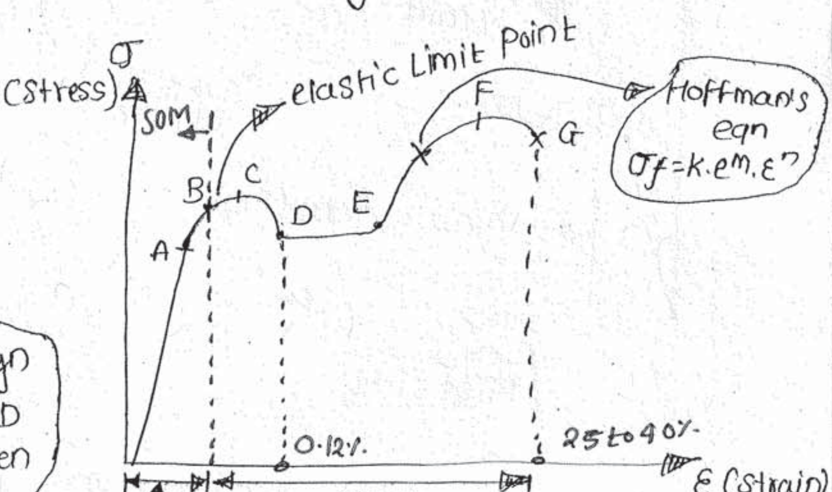
$10\,sec = 7°$

- Engg. Mechanics
- SOM / MOS / MOHDB → Mechanics of Highly Deformed Body.

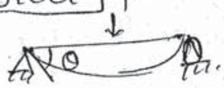
Deformation
- Elastic
- Plastic

Upto A, $\sigma \propto \epsilon$

for design A, B, C, D is taken same



Steel



$\delta = \frac{PL^3}{48EI}$

δ, θ very small

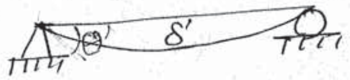
$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

$$\frac{1}{R} = \frac{d^2y/dx^2}{\left[1 + \left(\frac{dy}{dx}\right)^2\right]^{3/2}} \quad \left(\frac{dy}{dx} \rightarrow 0\right)$$

$$\Rightarrow \frac{1}{R} = \frac{d^2y}{dx^2} \Rightarrow \frac{M}{EI} = \frac{d^2y}{dx^2}$$

$$\boxed{M = EI.\frac{d^2y}{dx^2}}$$

Hard Rubber



δ', θ' is Large

$$\delta' \neq \frac{PL^3}{48EI} \qquad \frac{1}{R} \neq \frac{d^2y}{dx^2}$$

$$\frac{1}{R} = \frac{d^2y/dx^2}{\left[1 + \left(\frac{dy}{dx}\right)^2\right]^{3/2}}$$

$\left(\frac{dy}{dx}\right) \neq 0$

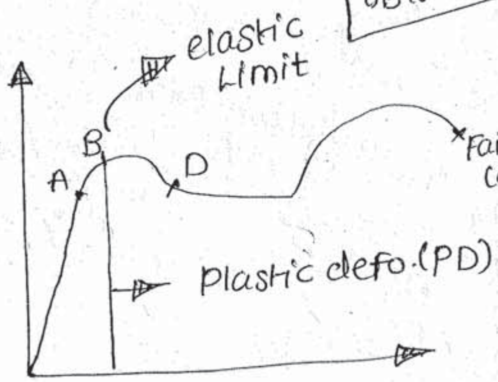
Plastic Deformation is greater than Elastic Deformation

1-(b)

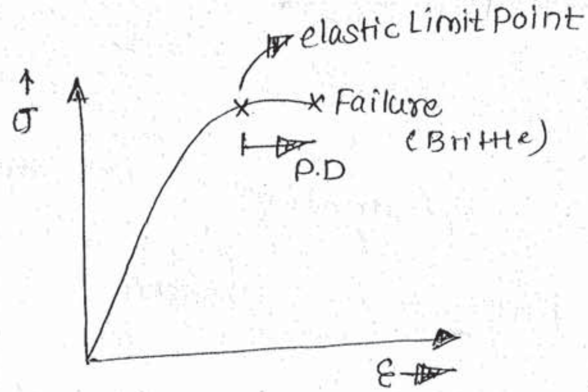
Failure Of Material :-

- Plastic Deformation (Ductile)
- Fracture (Brittle)

$\sigma_B \approx \sigma_D \approx 250 MPa$



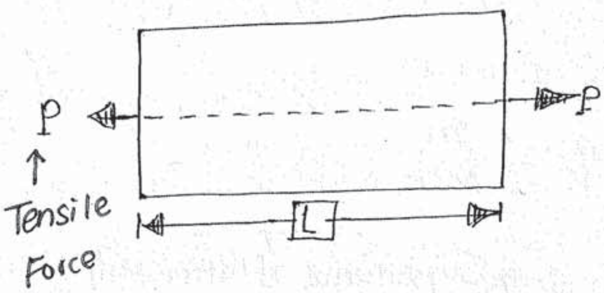
Mild steel

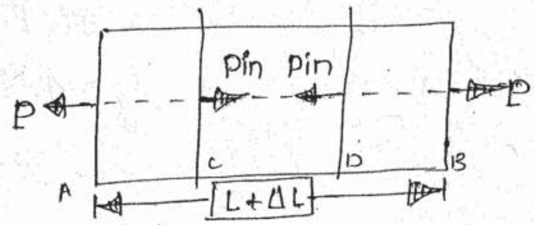


Cast Iron

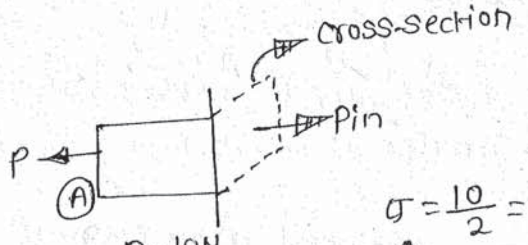
More plastic deformation More ductility

*. Difference B/w Strength and Stress :





$\varepsilon = \frac{\Delta L}{L}$ ← Tensile strain.

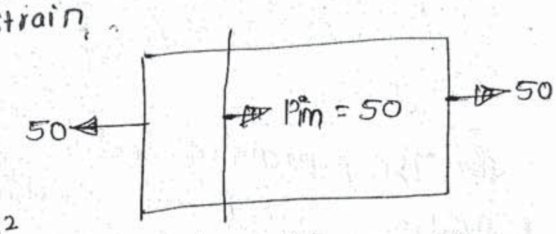


P = 10N

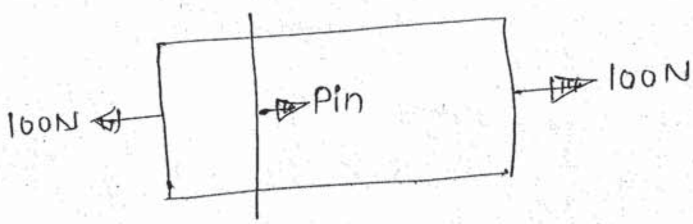
$A_c = 2\,mm^2$

$\sigma = \frac{10}{2} = 5\ N/mm^2$

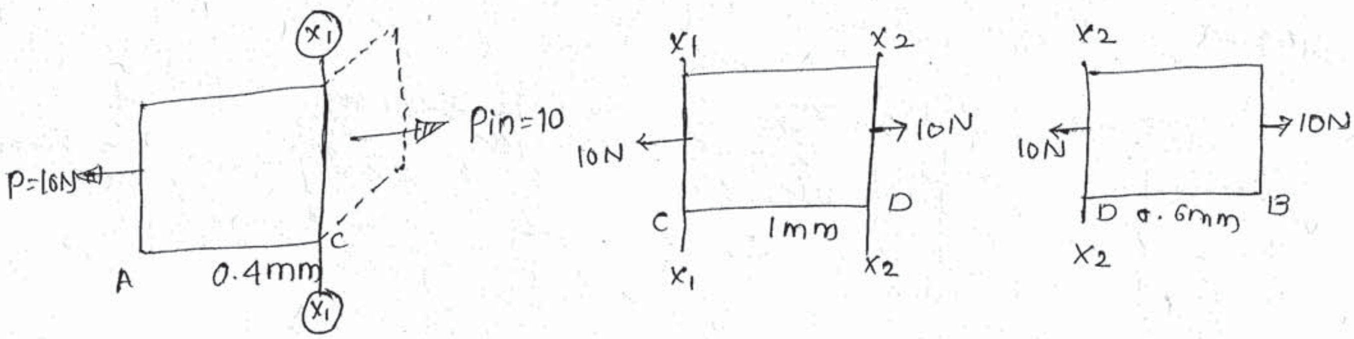
↑ Tensile Stress



$\sigma = \frac{50}{2} = 25\,MPa$



$\sigma = \frac{100}{2} = 50\,MPa \Rightarrow$ Strength



* Strain is a cause of Stress.

Stress is a internal resisting force offered by material against deformation.

* Hook's Law: (Axial Deformation)

$\varepsilon = \frac{\Delta L}{L}$

$\sigma = \frac{P_{in}}{A_c} = \frac{P}{A}$

Hook's Law

$\sigma \propto \varepsilon$

$\sigma = E\varepsilon$

$\varepsilon = \frac{\sigma}{E} = \frac{P/A}{\Delta L/L}$

$$\boxed{\Delta L = \frac{PL}{AE}} \Rightarrow \text{Constitutive relationship.}$$

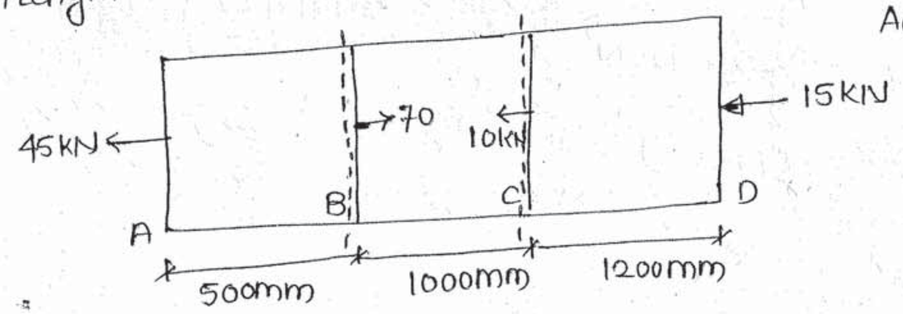
The equation relating stress and strain is called Constitutive Equation because, it depend on material behaviour.

Statically determinate problem.

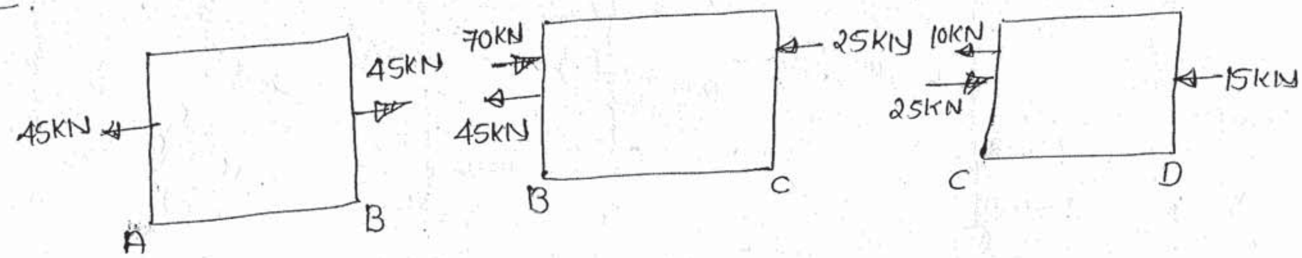
Que: A rectangular c/s Bar having cross-sectional area $800mm^2$ is subjected to axial Loading as shown. Determine the total change in Length of Bar.

$E = 100GPa$

$A_c = 800mm^2$



Solⁿ:-



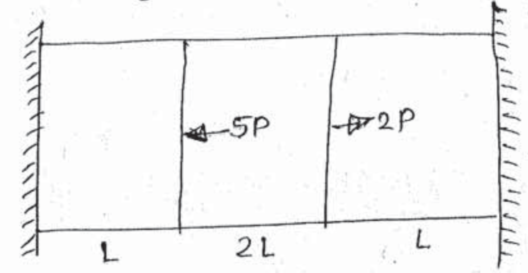
$$\Delta_{Total} = \Delta_1 + \Delta_2 + \Delta_3$$

$$= \frac{1}{(800mm^2)(100\times10^3)\frac{N}{mm^2}}\left[\{(45\times10^3)(500)\} + ((-25\times10^3)(1000)) + ((-15\times10^3)\times1200)\right]$$

$$= -0.25625\,mm$$

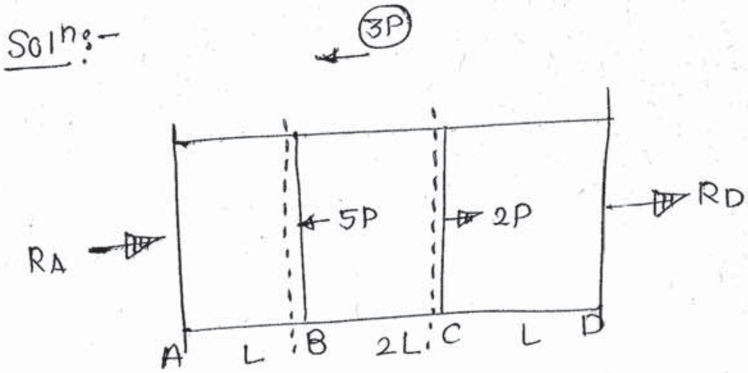
Que: $E = 100\ GPa$ — Statically Indeterminate Problem

$A_c = 800\ mm^2$

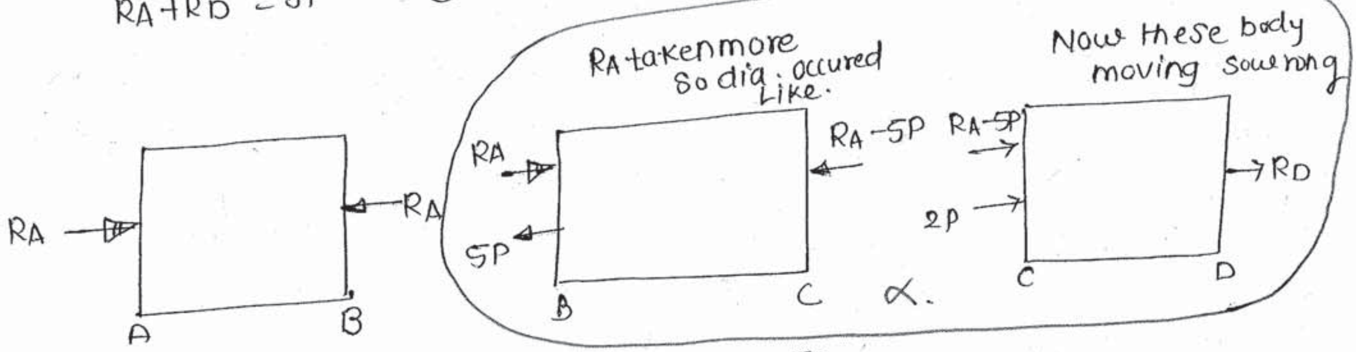


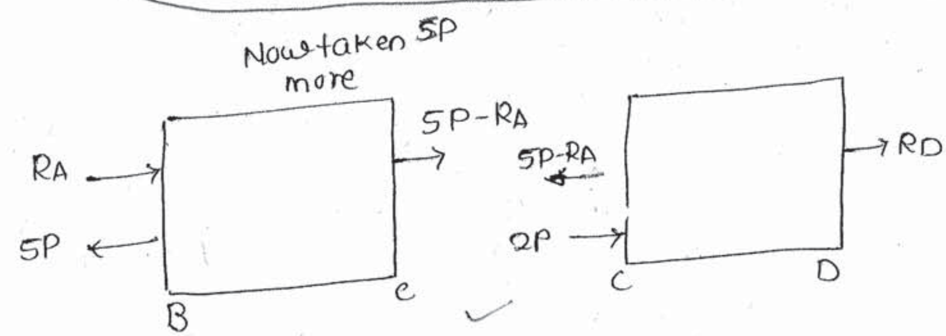
A bar arrangement as shown. Determine Support Reaction and draw axial Force diagram

Soln:-



$R_A + R_D = 3P$ — ①





$5P - R_A - R_D - 2P = 0$

$\boxed{R_A + R_D = 3P}$ checked.

$\Delta_{Total} = 0$ (bcz both ends are fixed)

$\Delta_1 + \Delta_2 + \Delta_3 = 0$ (compatibility eqn)

$$\frac{1}{AE}\left[\{(-R_A \cdot L)\} + \{(5P - R_A)2L\} + \{(+R_D \cdot L)\}\right] = 0 \quad \text{—②}$$

$-R_A \cdot L + 10PL - 2R_A L + R_D \cdot L = 0$

$-R_A + 10P - 2R_A + R_D = 0$

$-3R_A + 10P + R_D = 0$

$3R_A - R_D = 10P$ — (2)

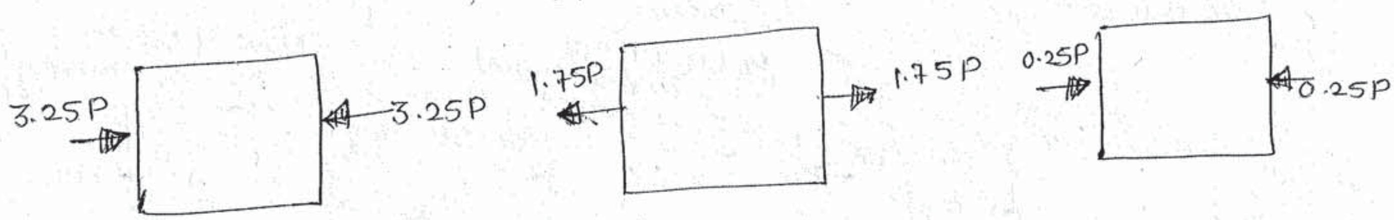
$R_A + R_D = 3P$ — (1)

$4R_A = 13P$

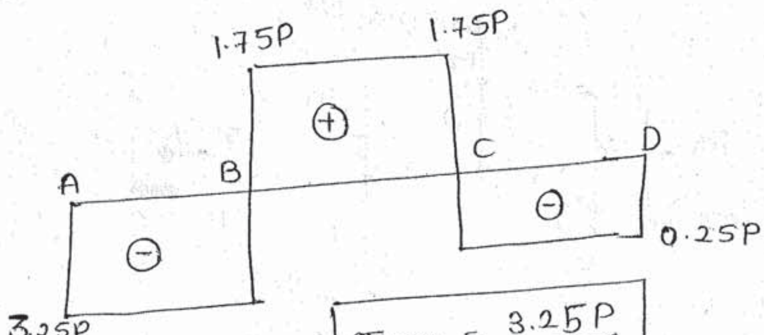
$R_A = \frac{13P}{4} = \boxed{3.25P}$

$\boxed{\therefore R_D = -0.25P}$

Final.



Axial Force Diagram : (equillibrium Diagram)



$\boxed{\sigma_{max} = \frac{3.25P}{A_c}}$

Compatibility Equation is the relationship b/w unknown forces and Known Deformation.

* Stress Tensor :

Scalar → Magnitude → Zero order Tensor

Vector → Mag + Dire^n → Ist order Tensor — F_x, F_y

Tensor → (Direction + plane) → 2nd order Tensor

↓

Stress, strain, M.I, P.M.O.I. (polar M.I.)

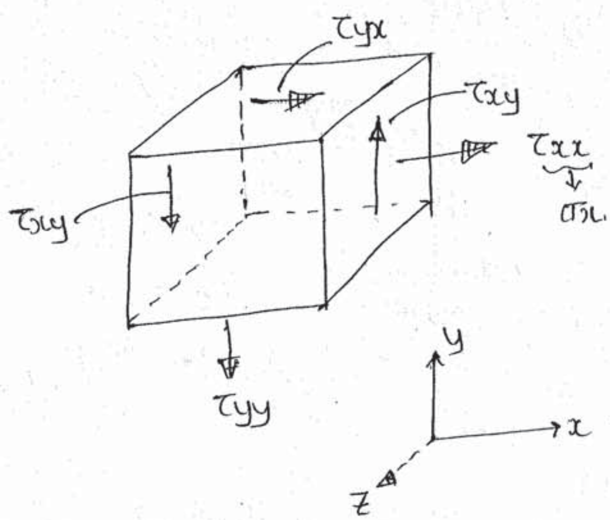
τ_{xy}, τ_{xz}, $\sigma_x \rightarrow \tau_{xx}$.

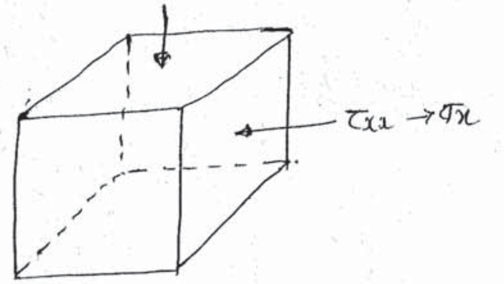
Stress Representation :

τ_{ij} → j represent the stress direction

↓ i represent the plane (outward Normal) at which stress acting.

τ_{yy} } — σ_y $\quad$ $\tau_{zz} \rightarrow \sigma_z$





τ_{xx}, τ_{yy} → Normal Stress

$\tau_{xy}, \tau_{yz}, \tau_{zy}$ → shear stress.

* Sign Convention For stress: पहले subscript में Plane को देखना then arrow को देखना