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MADE EASY CIVIL ENGINEERING Strength of Material BY-Rishi Sir

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- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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PROPERTIES OF MATERIALS

9871609412
Rishi sir

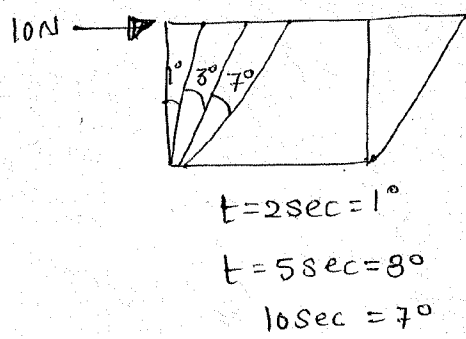
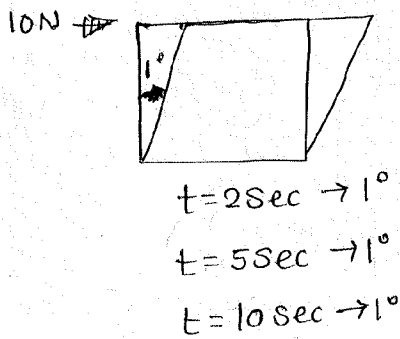
1-Q

Engg. Science

Solid Mechanics

Fluid Mechanics

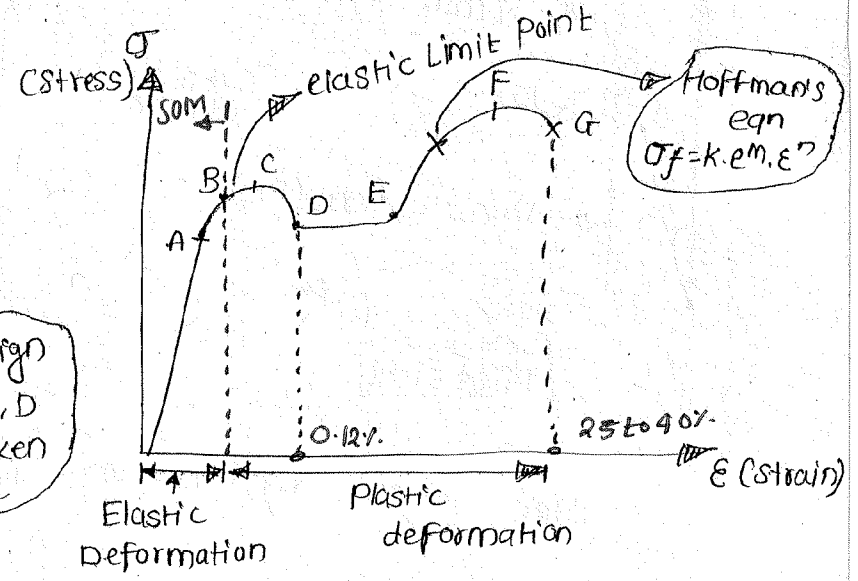
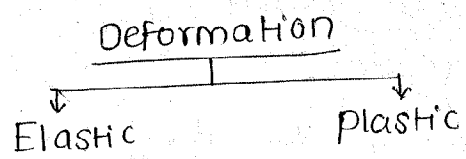
Properties of Material



Engg. Mechanics

SOM/MOS/MOHDB

Mechanics of Highly Deformed Body.



upto A, $\sigma \propto \epsilon$

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

Steel



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

δ is very small

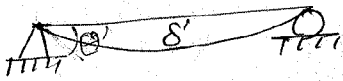
$$\frac{1}{R} = \frac{d^2y/dx^2}{\left[1 + \left(\frac{dy}{dx}\right)^2\right]^{3/2}}$$

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

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

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

Hard Rubber



$$\delta' \neq \frac{PL^3}{48EI}$$

$$\frac{1}{R} \neq \frac{d^2y}{dx^2}$$

δ', θ' is Large

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

$\neq 0$

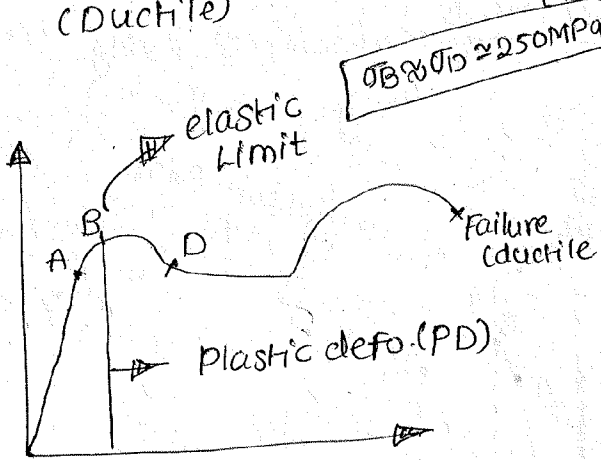
Plastic Deformation is greater than Elastic Deformation

1-B

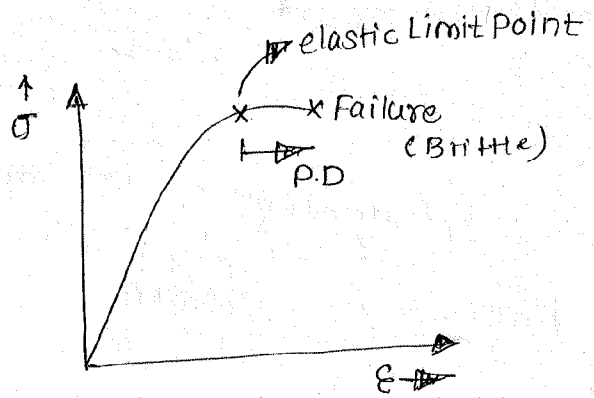
Failure of Material:-

Plastic Deformation (Ductile)

Fracture (Brittle)



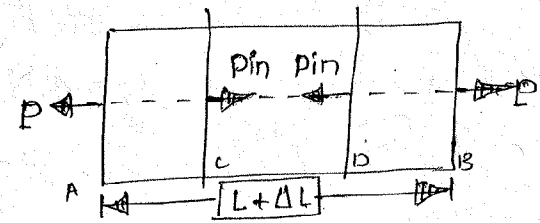
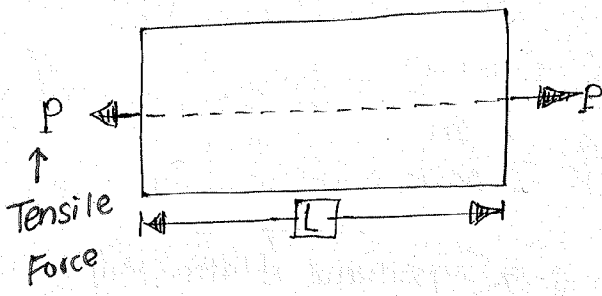
Mild steel



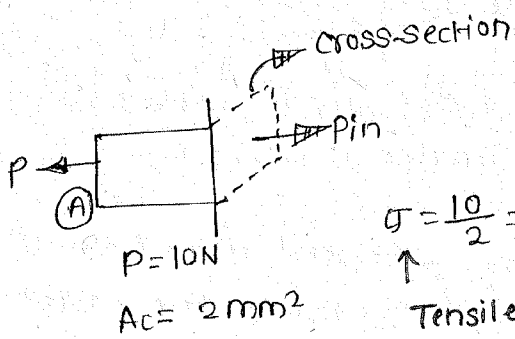
Cast Iron

More plastic deformation More ductility

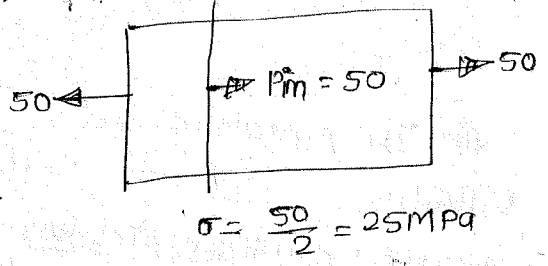
* Difference B/w Strength and Stress :



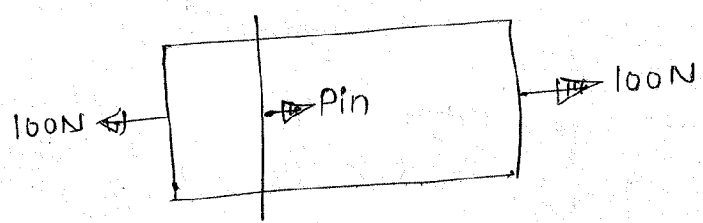
Tensile strain, $\epsilon = \frac{\Delta L}{L}$



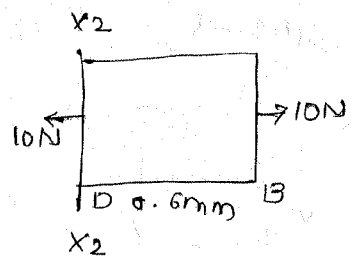
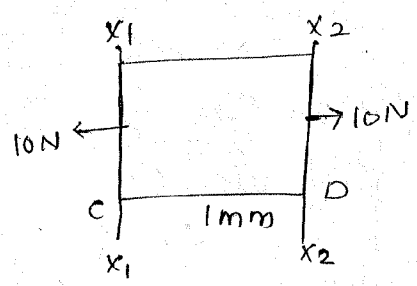
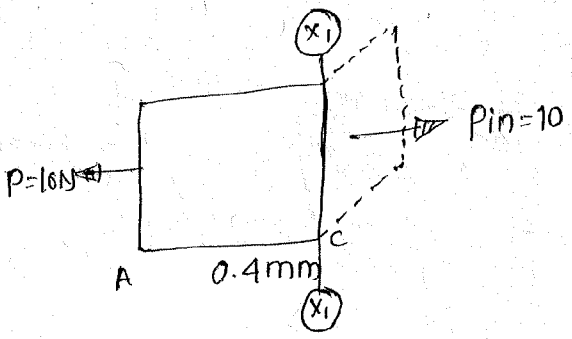
Tensile Stress $\sigma = \frac{10}{2} = 5 \text{ N/mm}^2$



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



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



→ * Strain is a cause of Stress.

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

* Hook's Law: (Axial Deformation)

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

Hook's Law

$$\sigma \propto \epsilon$$

$$\sigma = \frac{P \cdot l_0}{A_c} = \frac{P}{A}$$

$$\sigma = E \epsilon$$

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

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

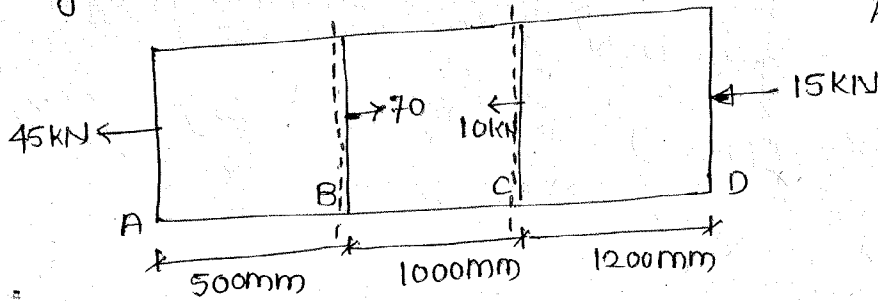
The equation relating stress and strain is called Constitutive Equation because, it depends on material behaviour.

Statically determinate problem.

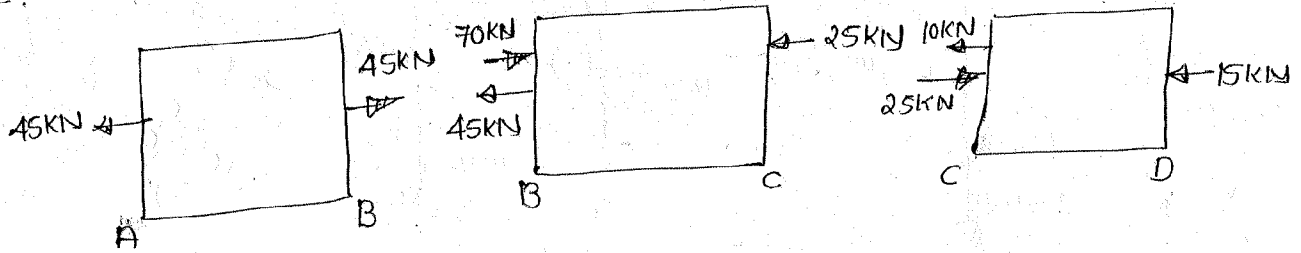
Ques: A rectangular cis Bar having cross-sectional area 800 mm^2 is subjected to axial loading as shown. Determine the total change in length of Bar.

$$E = 100 \text{ GPa}$$

$$A_c = 800 \text{ mm}^2$$



Soln:-



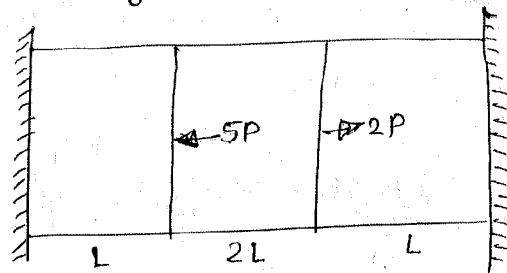
$$\Delta_{\text{Total}} = \Delta_1 + \Delta_2 + \Delta_3$$

$$= \frac{1}{(800 \text{ mm}^2) (100 \times 10^3) \frac{\text{N}}{\text{mm}^2}} \left[(45 \times 10^3)(500) + (-25 \times 10^3)(1000) + (-15 \times 10^3)(1200) \right]$$

$$= -0.25625 \text{ mm}$$

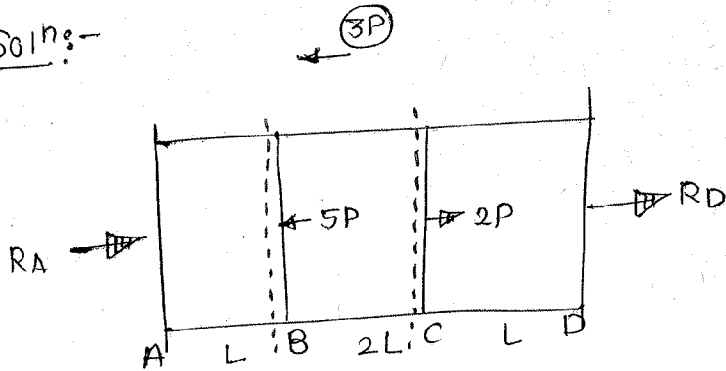
Que: $E = 100 \text{ GPa}$
 $A_c = 800 \text{ mm}^2$

Statically Indeterminate Problem

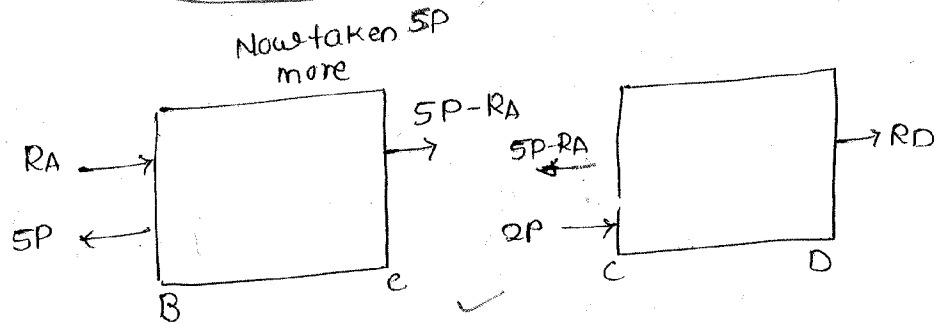
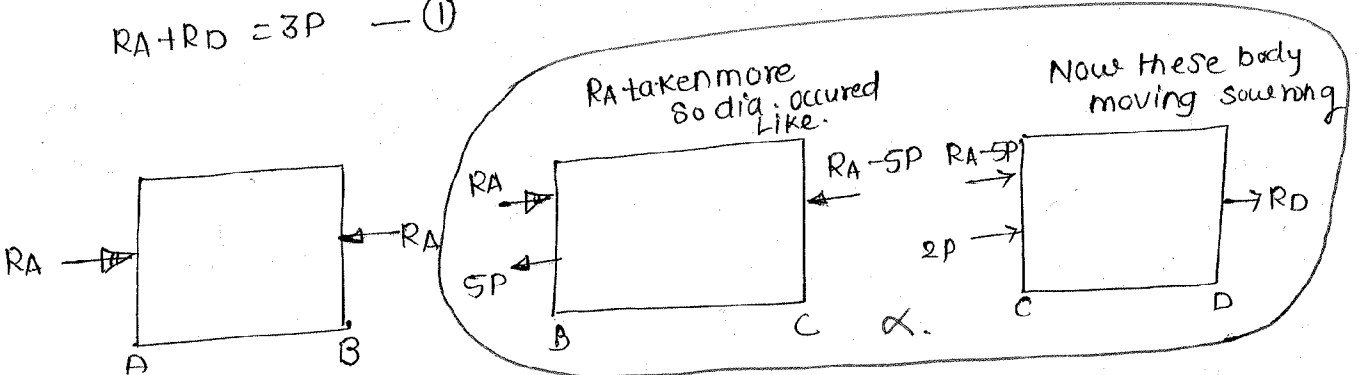


A bar arrangement as shown. Determine Support Reaction and draw axial force diagram

Soln:-



$RA + RD = 3P$ — (1)



$5P - RA - RD - 2P = 0$

$RA + RD = 3P$ checked.

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

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

$\frac{1}{AE} \left[\{(-RA \cdot L)\} + \{(5P - RA)2L\} + \{(+RD \cdot L)\} \right] = 0$ — (2)

$$-RA \cdot L + 10PL - 2RA \cdot L + RD \cdot L = 0$$

$$-RA + 10P - 2RA + RD = 0$$

$$-3RA + 10P + RD = 0$$

$$3RA - RD = 10P \quad \text{--- (2)}$$

$$RA + RD = 3P \quad \text{--- (1)}$$

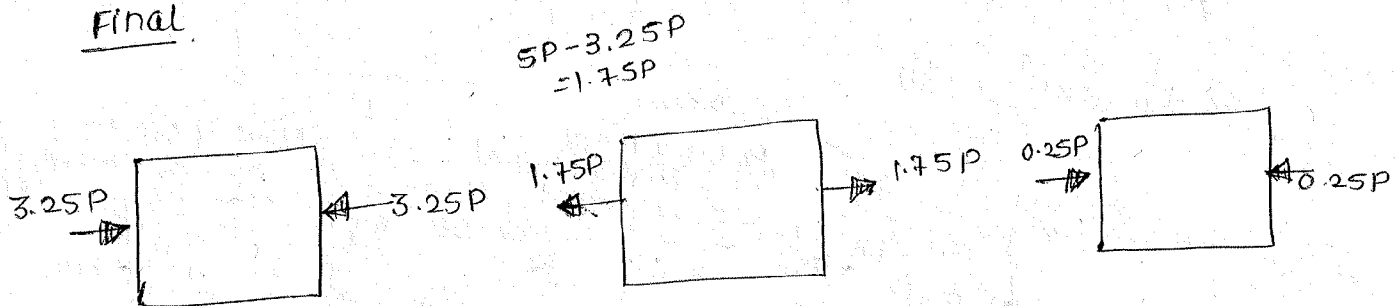
$$\underline{\hspace{10em}}$$

$$4RA = 13P$$

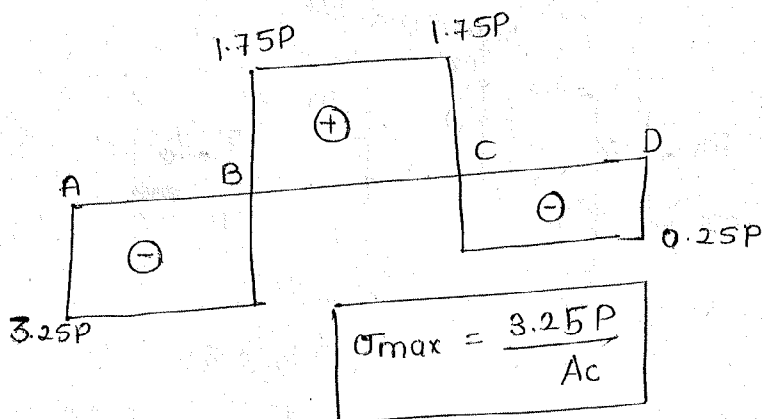
$$RA = \frac{13P}{4} = 3.25P$$

$$\therefore RD = -0.25P$$

Final



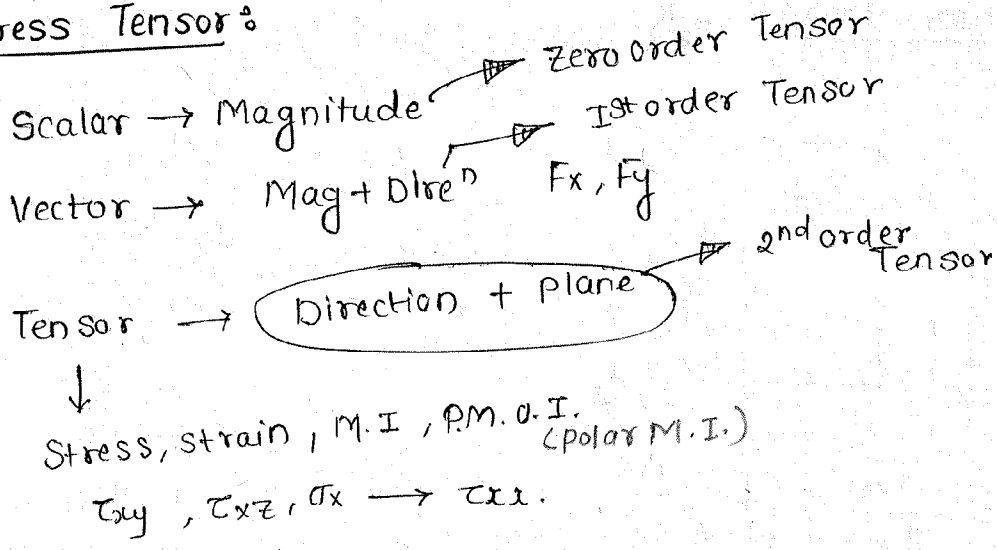
Axial Force Diagram : (equilibrium Diagram)



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

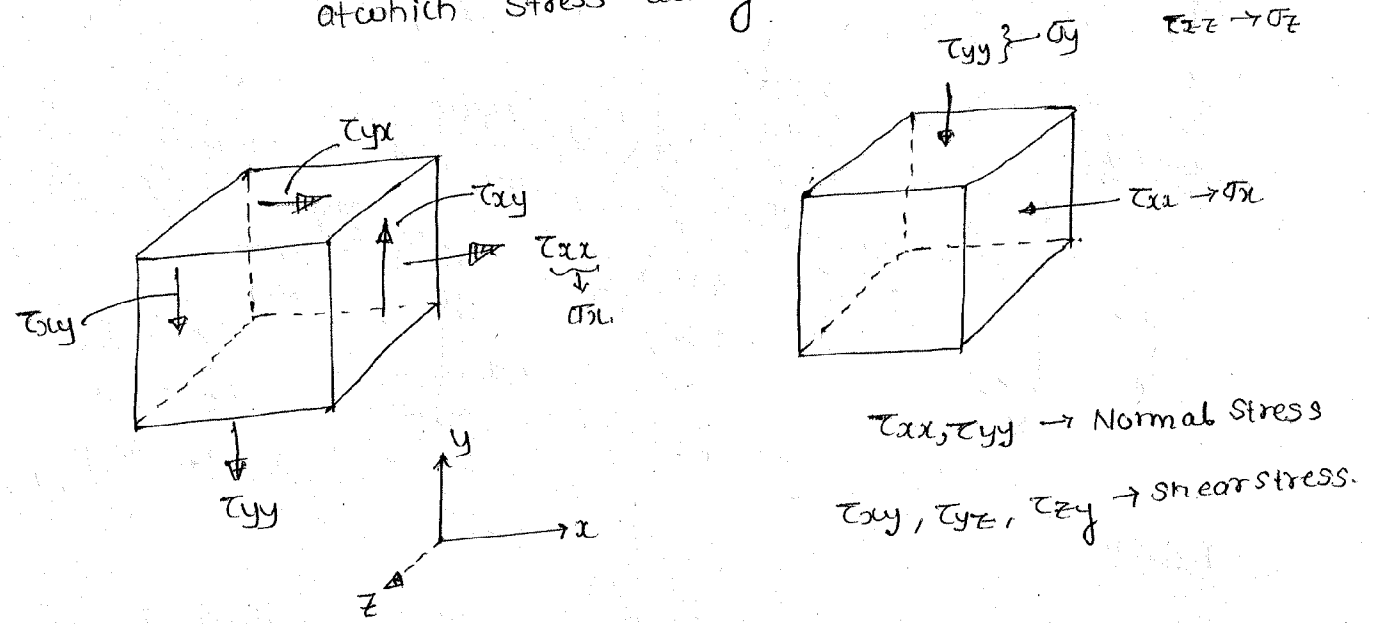
Compatibility Equation is the relationship b/w unknown forces and known deformation.

* Stress Tensor:

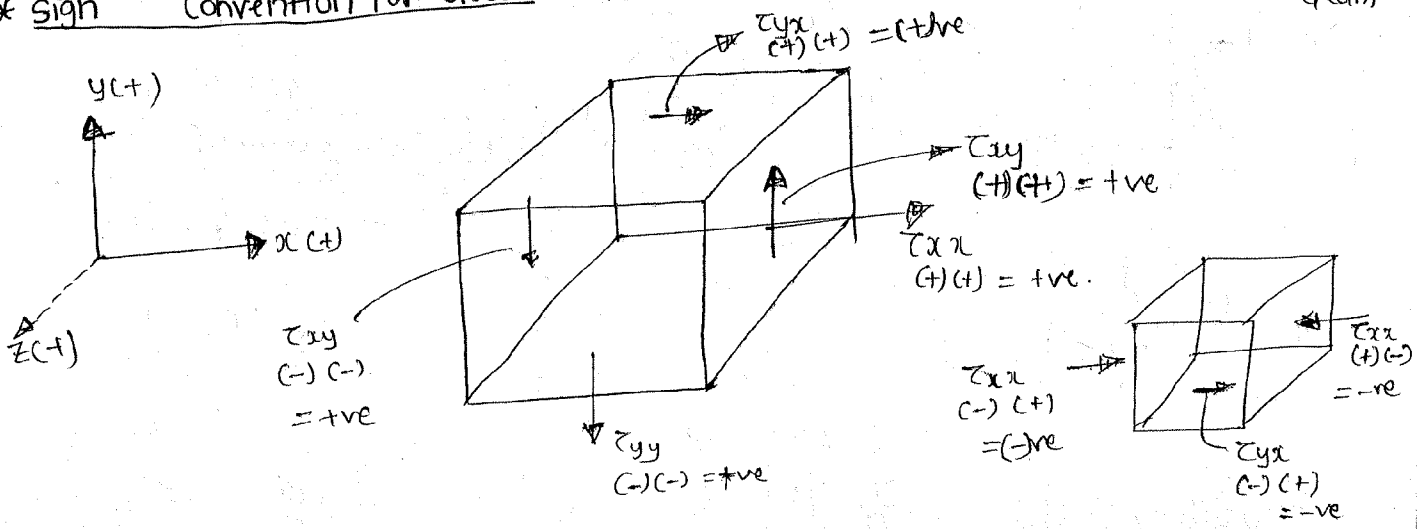


Stress Representation:

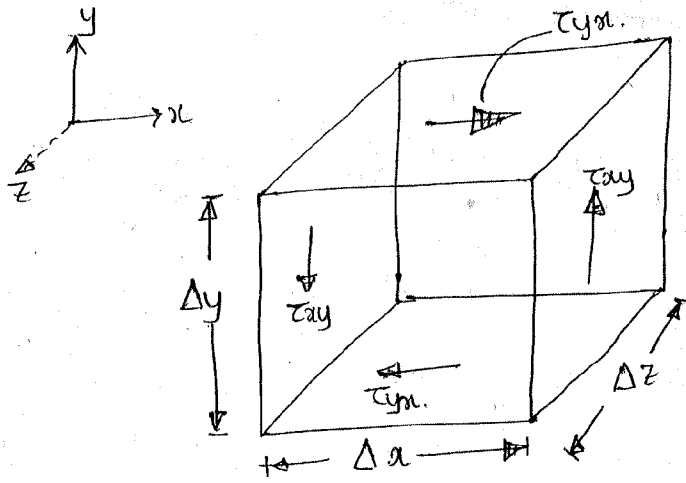
τ_{ij} \rightarrow represent the stress direction
 \downarrow
 represent the plane (outward Normal)
 at which stress acting.



* Sign Convention for stress: पहले subscript में plane को देखना then arrow को देखना.

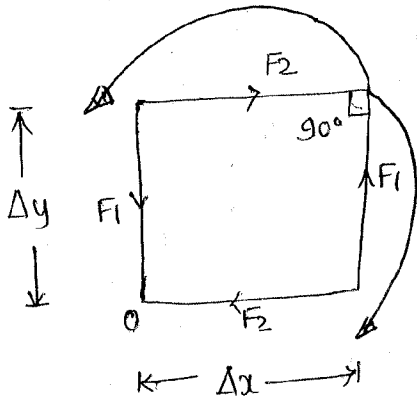


Equality Of Shear Stress: (2.10)



$$F_1 = \tau_{xy} (\Delta z \cdot \Delta y)$$

$$F_2 = \tau_{yx} (\Delta x \cdot \Delta z)$$



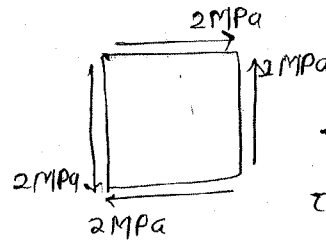
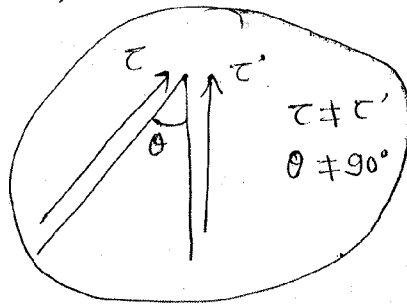
By moment Equilibrium Condition

$$\sum M_0 = 0$$

$$F_1 \cdot \Delta x = F_2 \cdot \Delta y$$

$$\tau_{xy} \cdot (\Delta z \cdot \Delta y) \Delta x = \tau_{yx} \cdot (\Delta x \cdot \Delta z) \cdot \Delta y$$

$$\tau_{xy} = \tau_{yx}$$

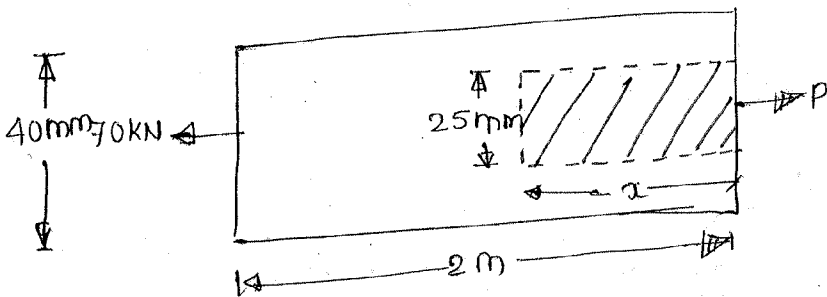


$$\tau_{xy} = \tau_{yx}$$

$$\tau_{xz} = \tau_{zx}$$

$$\tau_{yz} = \tau_{zy}$$

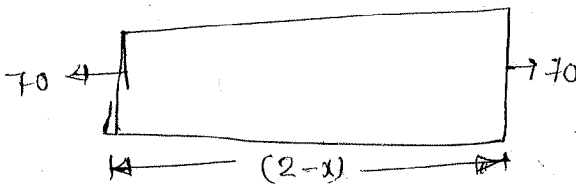
Que: 6: WB: CH-02



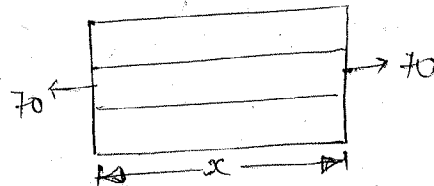
When No Boring

$$\delta_1 = \frac{(70 \times 10^3) (2 \times 10^3)}{\frac{\pi}{4} (40)^2 E}$$

When Boring Complete



$$\delta_1 = \frac{(70 \times 10^3) (2-x) \times 10^3}{\frac{\pi}{4} (40)^2 \times E}$$



$$\delta_2 = \frac{(70 \times 10^3) (x \times 10^3)}{\frac{\pi}{4} (40^2 - 25^2) E}$$