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Subject :- MOS II

Submitted to :- Engr. Saqib Khan

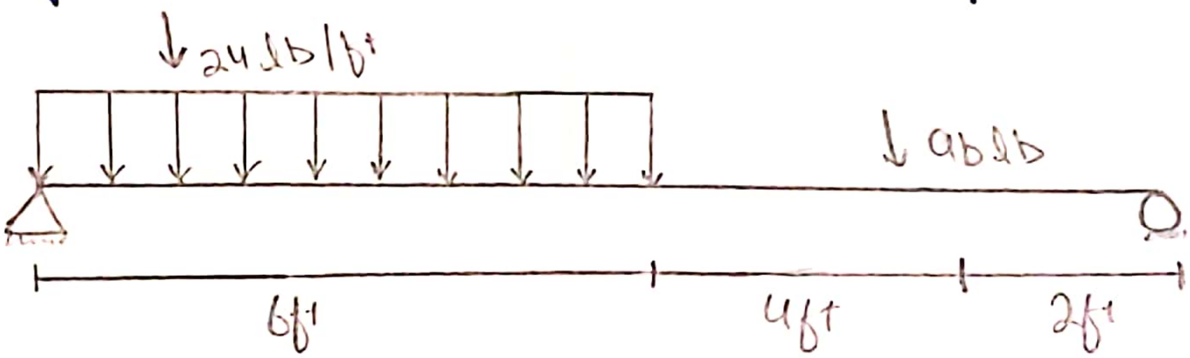
Question no 01:-

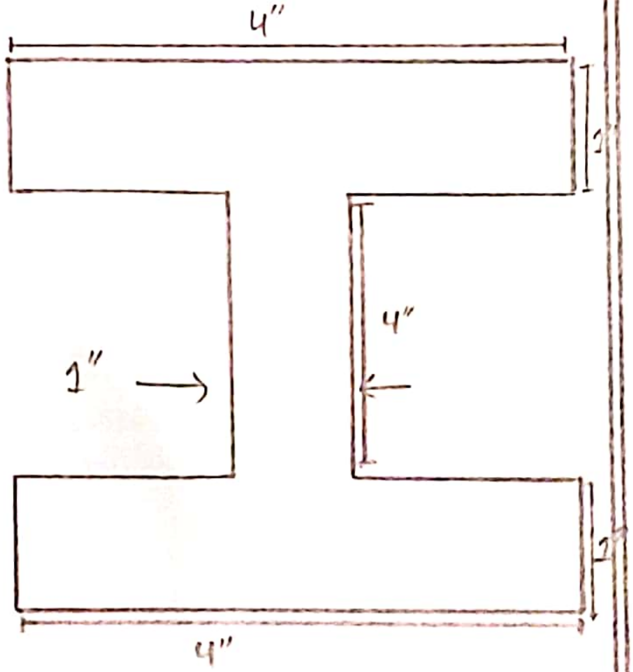
Construct the Mohr's Circle diagram and find the principle Stress and maximum in plane Shear stress for the stress State of a point C located at the center of Uniformly disturbuted load and 1 inch below the top fibre of beam Cross Section Shown in the figure. However to Construct the Mohr's circle it is necessary to draw the Shear stress and flexure Stress variation diagram for maximum Shear force and bending Moment respectively. Compare the Mohr's circle with the stress transfo-rmation equations.

Hint :-

To calculate the stress in the beam cross-section the moment of inertia must be known.

Where P is the last two digits of your class registration number in pounds.





Solution:-

$$\sum F_y = 0 \uparrow +$$

$$R_A - 24 \times 6 - 96 + R_B = 0$$

$$\underline{R_A + R_B = 240\ lb}$$

$$\sum M_A = 0 \circlearrowleft +$$

$$R_B(12) - (96)(10) - (24)(6)(3) = 0$$

$$R_B(12) = 1392$$

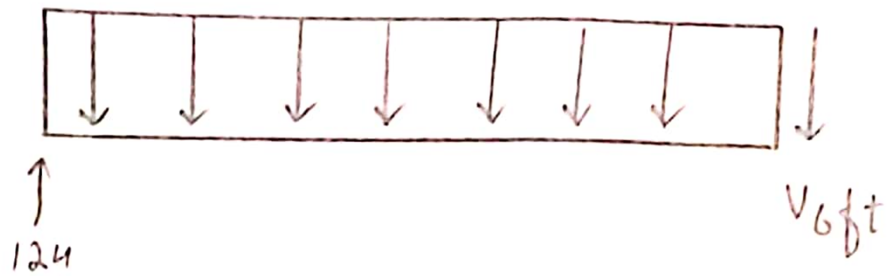
$$\underline{R_B = 116\ lb}$$

$$R_A + R_B = 240$$

$$R_A = 240 - 116$$

$$\underline{R_A = 124\ lb}$$

Shear force at 6ft

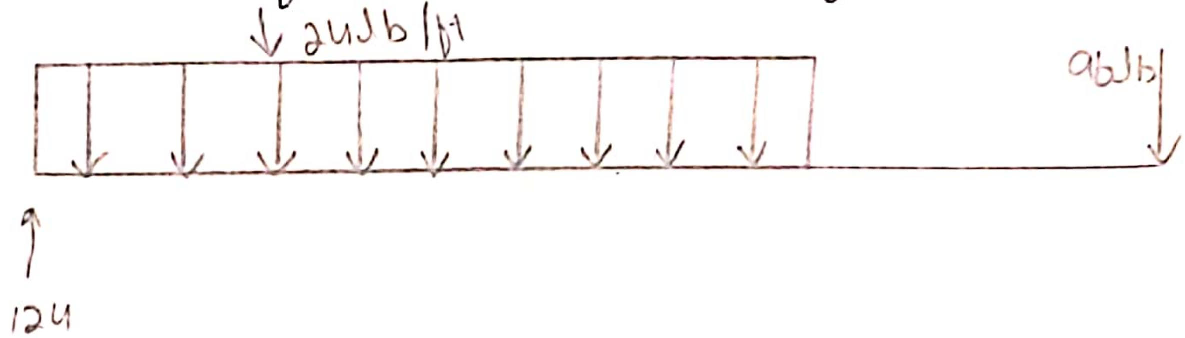


$$\sum F_y = 0 \uparrow +$$

$$124 - 24 \times 6 - V_{6ft}$$

$$\underline{V_{6ft} = -20 lb}$$

Shear force at 10ft

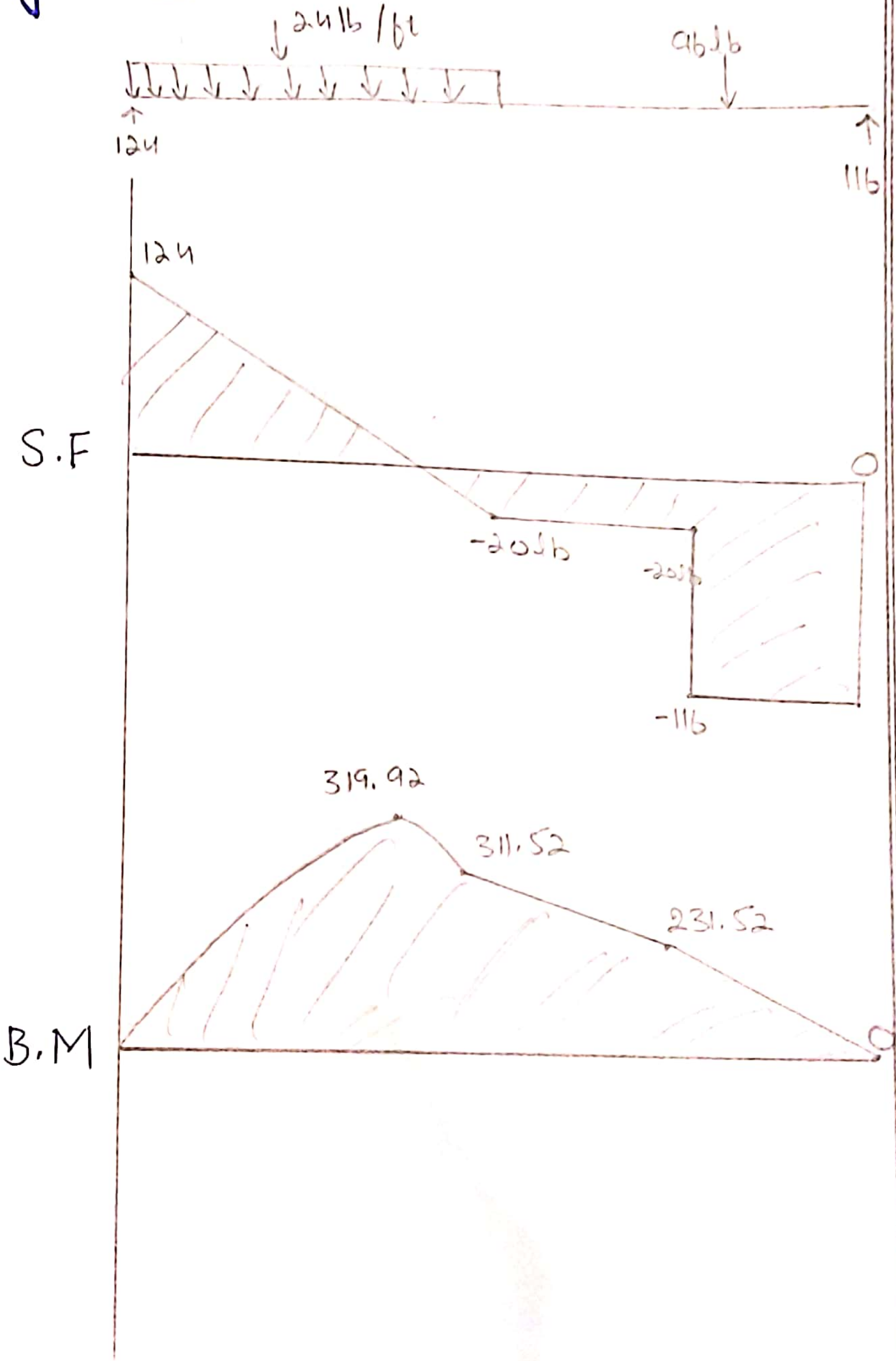


$$\sum F_y = 0 \uparrow +$$

$$124 - 24 \times 6 - 96 - V_{10ft}$$

$$\underline{V_{10ft} = -116}$$

Shear force and bending diagram:-



Moment at 3ft Which C point

$$\sum M_{3ft} = \circlearrowright +$$

$$M_{3ft} - (124 \times 3) + (24 \times 3 \times 1.5) = 0$$

$$\underline{M_{3ft} = 264 \, lb}$$

$$\sum F_y = 0 \uparrow +$$

$$124 - 24 \times 3 - V_{3ft} = 0$$

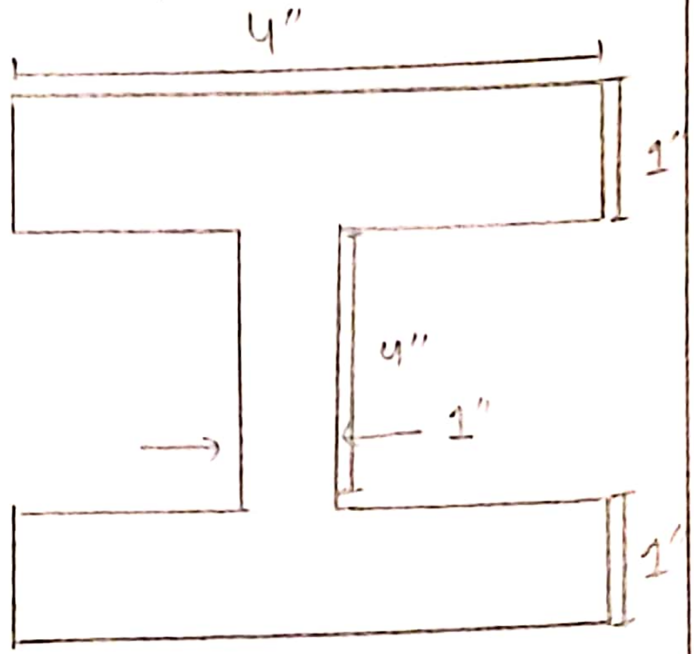
$$\underline{V_{3ft} = 52 \, lb}$$

Shear Stress:-

Shear Stress at C point is the Shear 52 lb.

Moment of Inertia:-

Find moment of Inertia of I Section



$$I_{xx1} = \frac{1}{12}(4)(1^3) + 4(2.5)^2 = 25.33 \text{ in}^4$$

$$I_{xx2} = \frac{1}{12}(4^3)(1) + (4)(0) = 5.33 \text{ in}^4$$

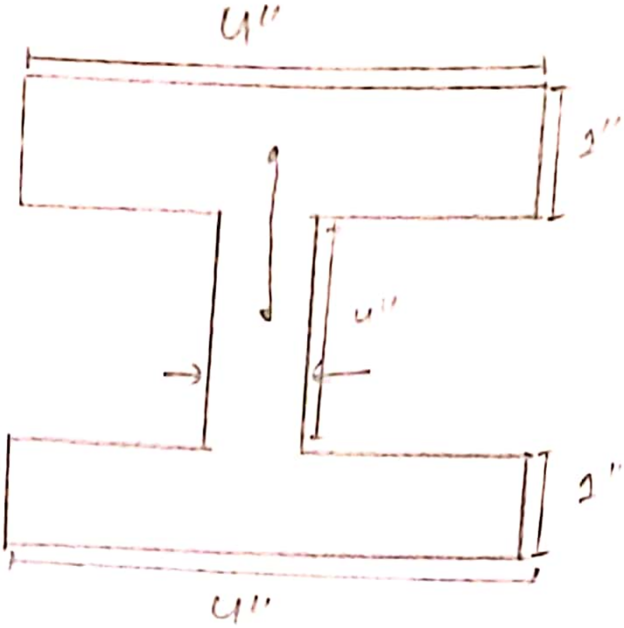
$$I_{xx3} = \frac{1}{12}(1^3)(4) + 4(-2.5)^2 = 25.33 \text{ in}^4$$

$$I_{xx} = I_{xx1} + I_{xx2} + I_{xx3}$$

$$\underline{I_{xx} = 56 \text{ in}^4}$$

Shear stress at c point

$$\tau = \frac{VQ}{Ib}$$



$I = 56\ in^4$

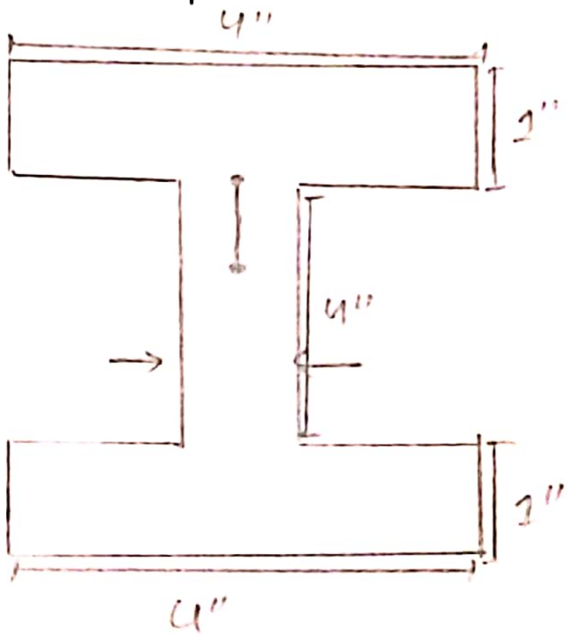
$Q = YA$

$Q = 1 \times 4 \times 2.5$

$\tau = \frac{52 \times 10}{56 \times 4}$

$\tau = 2.32 psi$

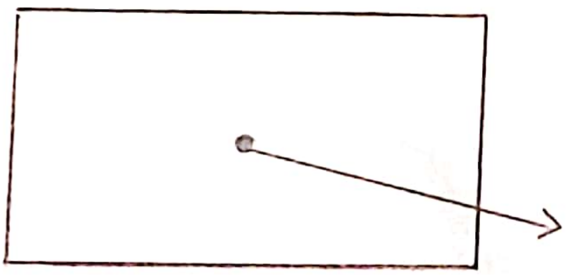
Flexure stress at point c



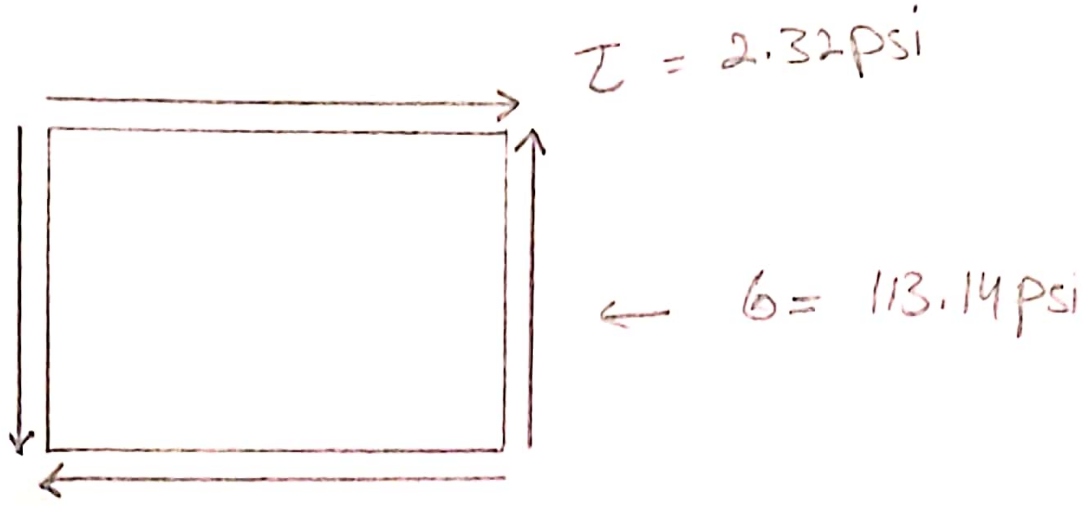
$\sigma = \frac{My}{I}$

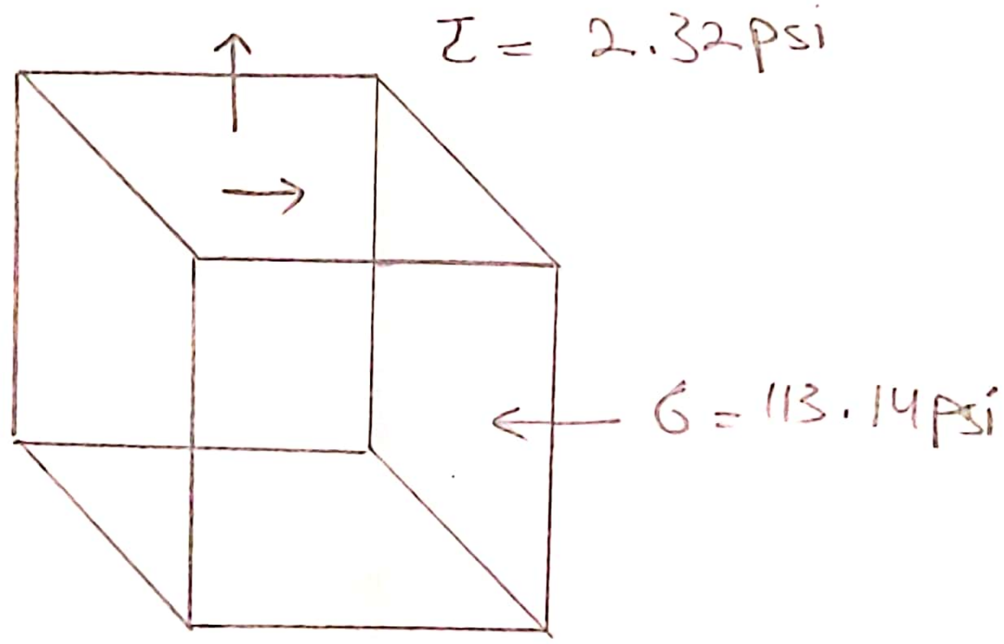
$\sigma = \frac{264 \times 12 \times 2}{56}$

$\sigma_x = 133.14\ psi$



On 2D

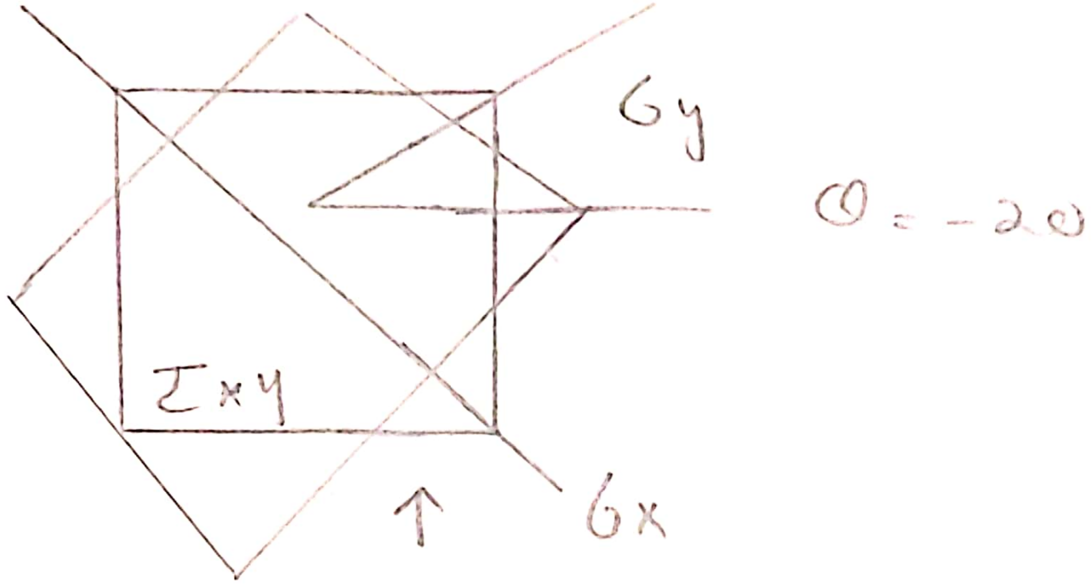




Stress State Condition:-

Assume angle is 20° clockwise

$\alpha = 20^\circ$



drive stress transformation equation

$$\sigma_{x'} = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$$

$$\sigma_{x'} = \frac{-113.14 + 0}{2} + \frac{-113.14 - 0}{2}\cos 2(-20) + 2.32\sin 2(-20)$$

$$\underline{\sigma_{x'} = -101.39 \text{ psi}}$$

$$\sigma_{y'} = \frac{\sigma_x + \sigma_y}{2} - \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$$

$$\sigma_{y'} = \frac{-113.14 + 0}{2} - \frac{-113.14 - 0}{2}\cos 2(-20) + 2.32\sin 2(-20)$$

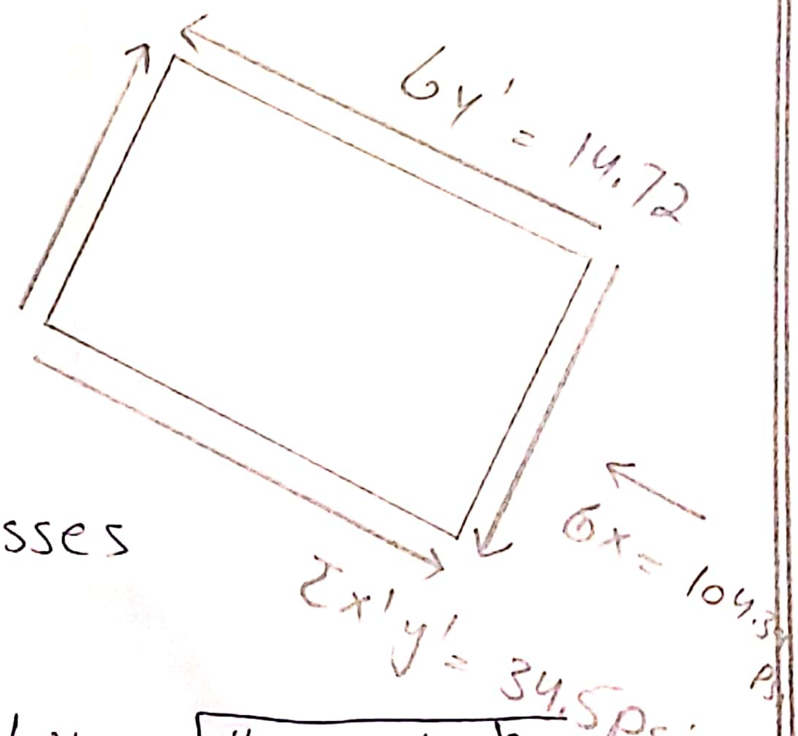
$$\underline{\sigma_{y'} = -14.72 \text{ psi}}$$

$$\tau_{x'y'} = \frac{-\sigma_y - \sigma_y}{2} \sin 2\theta + \tau_{xy} \cos 2\theta$$

$$\tau_{x'y'} = \frac{-113.14 - 0}{2} \sin 2(-20) + 2.32 \cos 2(-20)$$

$$\underline{\tau_{x'y'} = -34.58 \text{psi}}$$

Now stress state after 20° Clockwise



Principle stresses

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\sigma_{1,2} = \frac{-113.14 + 0}{2} \pm \sqrt{\left(\frac{-113.14 - 0}{2}\right)^2 + (2.32)^2}$$

(12)

$$\sigma_{1,2} = -56.57 \pm 56.61$$

$$\sigma_y = \sigma_1 = -56.57 + 56.61 = 0.04 psi$$

$$\sigma_x = \sigma_2 = -56.57 + 56.6 = 113.18 psi$$

Find θ_p :-

$$\tan 2\theta_p = \frac{\tau_{xy}}{(\sigma_x - \sigma_y)/2}$$

$$= \frac{2.32}{(-113.14 - 0)/2}$$

$$\underline{\theta_p = -2.60}$$

Put in General Equation

$$\sigma x'_{max} = \frac{-113.14 + 0}{2} + \frac{-113.14 - 0}{2} \cos 2(-2.60)$$

$$+ 2.32 \sin 2(-2.60)$$

$$\underline{\sigma x'_{max} = -113.11 psi}$$

Max in plane Shear Stress

$$\tan 2\theta_s = -\frac{(\sigma_x - \sigma_y)/2}{\tau_{xy}}$$

$$\tan 2\theta_s = -\frac{(-113.14 - 0)/2}{2.32}$$

$$\underline{\theta_s = 43.82}$$

Put this in general equation for $\tau_{x'y'}$

$$\tau_{x'y'} = -\left[\frac{\sigma_x - \sigma_y}{2}\right] \sin 2\theta + \tau_{xy} \cos 2\theta$$

$$= -\frac{(-113.14 - 0)}{2} \sin 2(43.82) + 2.32 \cos 2(43.82)$$

$$\underline{\tau_{x'y'} = 56.53 \text{ psi}}$$

Mohr's Circle:-

Draw the mohr circle we need coordinate and radius of circle

Centre Coordinate

$$(h,k) = \left(\frac{-113.14+0}{2}, 0\right)$$

$$(h,k) = (-56.57, 0)$$

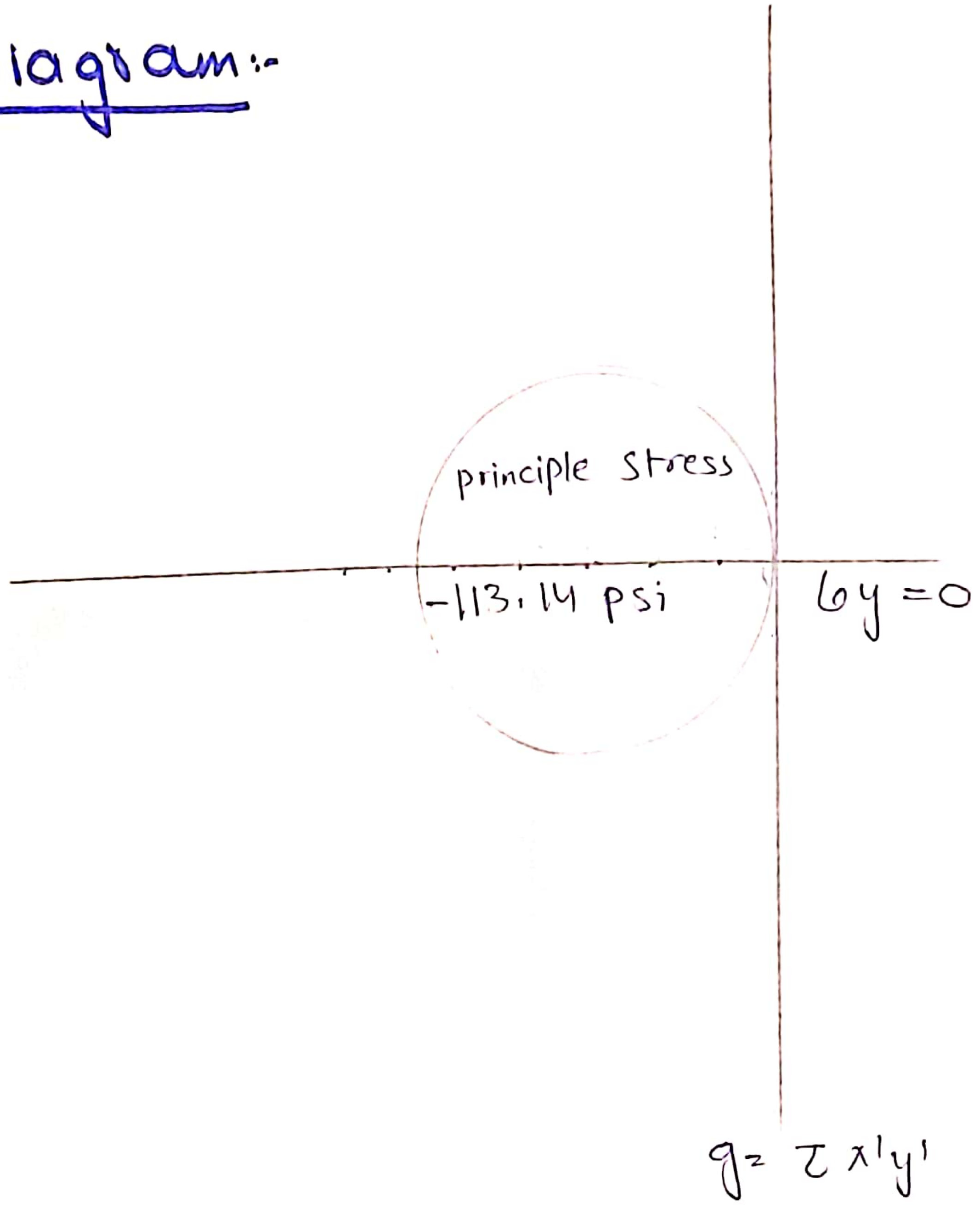
Radius of Mohr's circle is

$$r = \sqrt{\left(\frac{\sigma x - \sigma y}{2}\right)^2 + \tau_{xy}^2}$$

$$r = \sqrt{\left(\frac{-113.14-0}{2}\right)^2 + (2.32)^2}$$

$$r = 56.57 \text{psi}$$

Diagram:-



Conclusion:-

The value obtained from principle stresses is same is values obtained from transformation equation.