Paper: Mos - II

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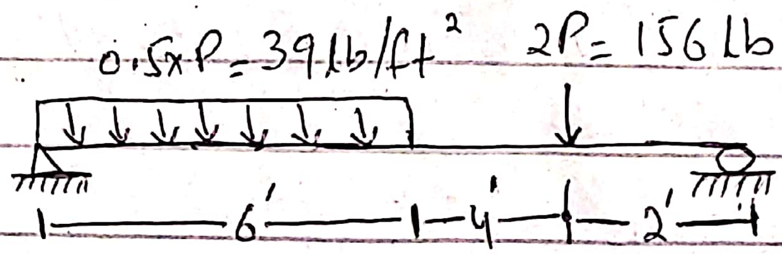
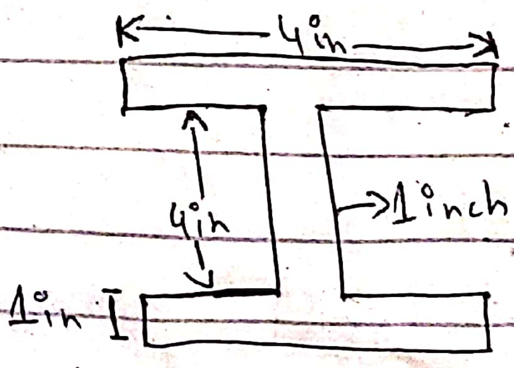
Q construct the mohr's circle diagram & find Principle stresses & maximum in plane shear stress for the stress of point C located at the center of uniformly distributed load & 1 inch below the top fiber of beam cross section shown in fig. How ever construct the mohr circle it is nessary to draw shear stress & fluxural stress variation diagram for maximum shear force & bending movement respectively. Compare result from mohr circle with stress transformation equation.

Note:- I.D is 7278 $0.5 = 0.5 \times 78 = 39\,lb/ft^2$
so load is 78 lb $2P = 2 \times 78 = 156\,lb$
$P = 78\,lb$





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Sol: → first find Reaction forces RA & RB

$RA + RB = 220\,lb$

$(+) \sum M = 0$

$-(39 \times 6 \times 3) - (156 \times 10) + 12RB = 0$

$RB \times 12 - 858 = 0$

$RB = \frac{858}{12}$

$\boxed{RB = 71.5}$

now we know that

$RA + RB = 220\,lb$

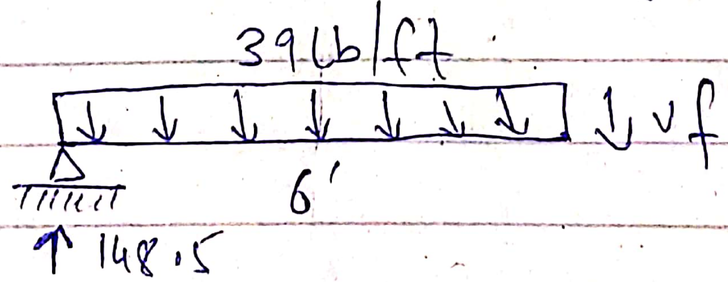
$RA = 220 - RB$

$RA = 220 - 71.5$

$\boxed{RA = 148.5}$

Now shear force at change point

beam



shear force at 6 ft from left

$\sum fy = 0 \uparrow +$

$148.5 - (39 \times 6) - vf6' = 0$

$148.5 - 234 = vf_{6th}$

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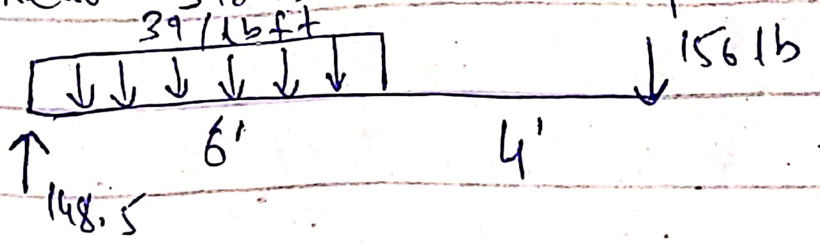
$V_{f\,6ft} = -85.5$

Now shear stress at 10 ft

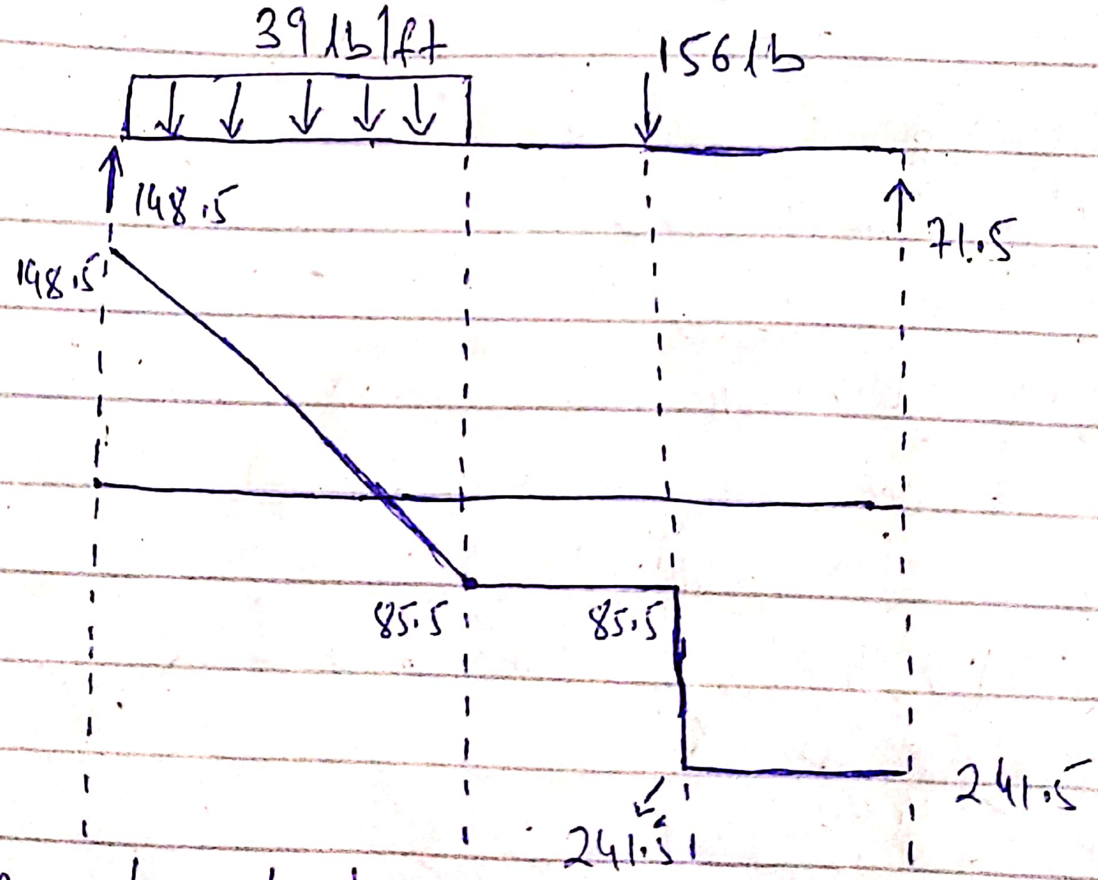


$\Sigma F_y = 0 \; +\uparrow$

$148.5 - (39 \times 6) - 156 - V_{f10'} = 0$

$V_{f10ft} = 241.5 \; (-ve)$

Shear force & moment diagram



Moment at change point

find zero shear point first

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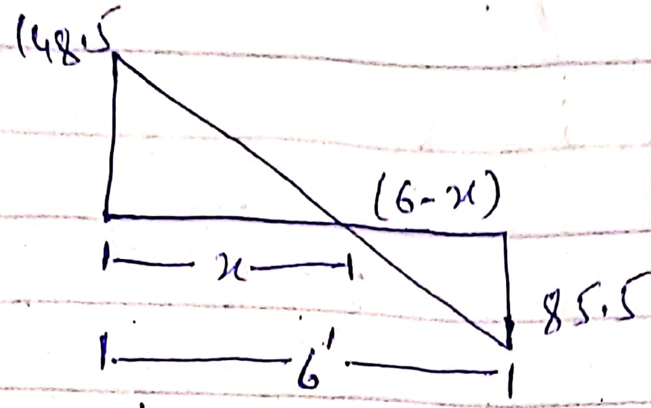


by similar triangles

$$\frac{148.5}{x} = \frac{85.5}{(6-x)}$$

$$891 = 148.5x + 85.5x$$

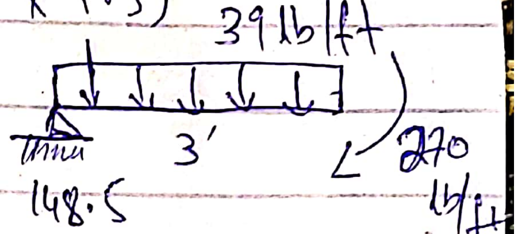
$$x = \frac{891}{234}$$

$$\boxed{x = 3.80}$$

(i) at center UDL 3ft from left

$M = -148.5 \times 3 + (39 \times 3 \times 1.5)$

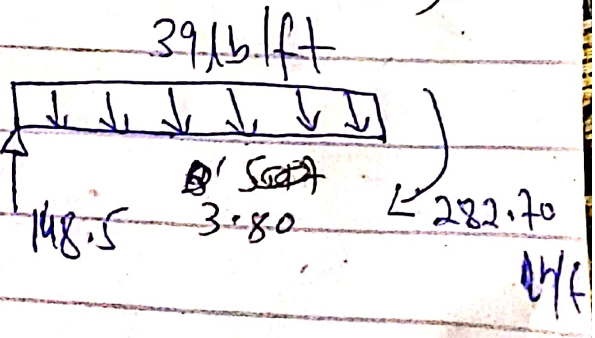
$\boxed{M = 270 \text{ lbft}}$



ii. at distance 3.80 ft from left

$M = (-148.5 \times 3.80)(39 \times 3.80 \times \frac{3.80}{2})$

$\boxed{M = 282.42 \text{ lb/ft}}$



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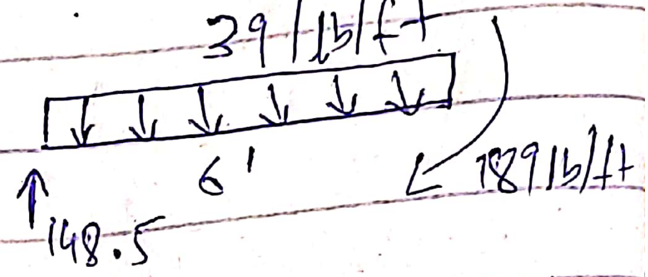
at a distance of 6' from left

(+↻) $M = (-148.5 \times 6) + (39 \times 6) \times 3)$

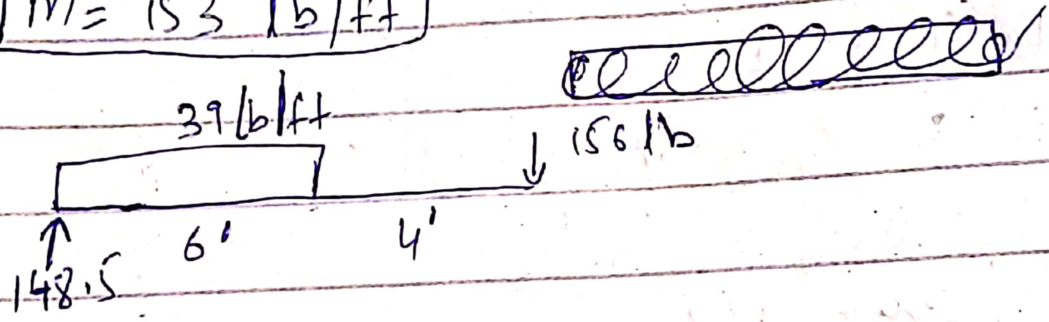
$\boxed{M = 189\ lb/ft}$

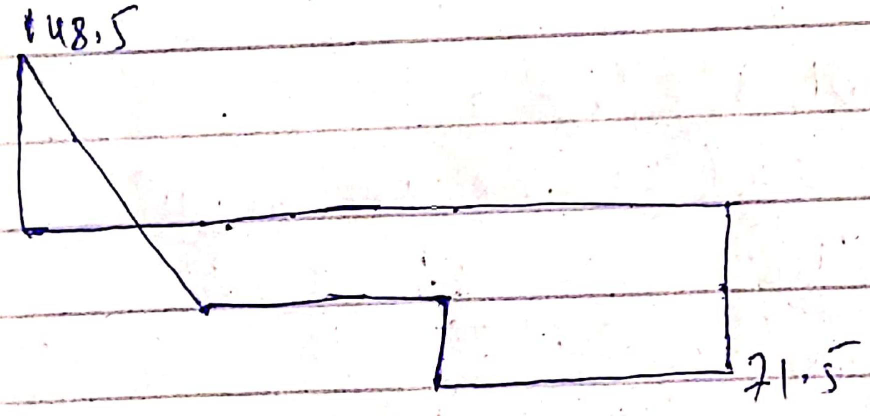


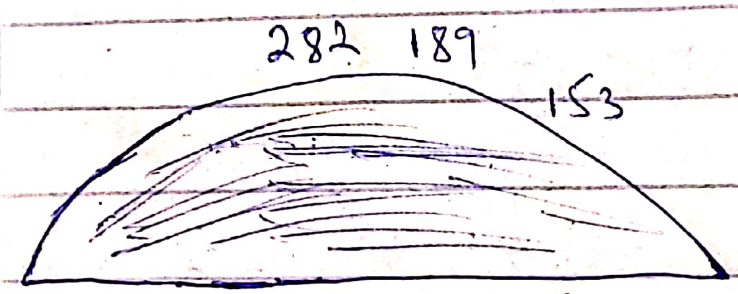
at a distance of 10' from left

(+↻) $M = (-148.5 \times 10) + (39 \times 6 \times 7)$

$\boxed{M = 153\ lb/ft}$







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Shear stress :-

As per the Question the maximum shear stress $T = \frac{VQ}{It}$ occurs where the maximum shear force lies in above diagram max-shear force is 31.5 lb.

$+\uparrow \Sigma fy = 148.5 - 39 \times 3 - V = 0$

$V = 31.5 lb$

find moment of interia :-

$I_{xx} = I_{xx_1} + I_{xx_2} + I_{xx_3}$ from given question

$I_{xx_1} = \frac{1}{12}(4)(1)^3 + 4(2.5)^2 = 25.33$

$I_{xx_2} = 1/12 (4^3)(1) + 4(0)^2 = 5.33$

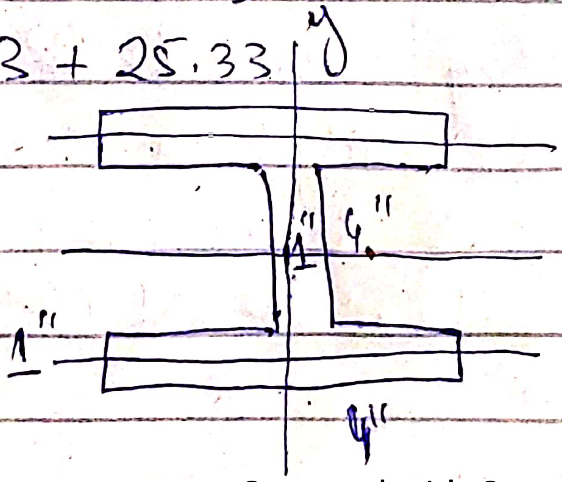
$I_{xx_3} = 1/12 (1^3)(4) + (3-5.5)^2 4 = 25.33$

$I_{xx_3} - 1/12 (1^3)(4) + (3-5.5)^2 4 = 25.33$

$I_{xx} = I_{xx_1} + I_{xx_2} + I_{xx_3}$

$I_{xx} = 25.33 + 5.33 + 25.33$

$I_{xx} = 56 in^4$



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$I_{yy} = I_{yy_1} + I_{yy_2} + I_{yy_3}$

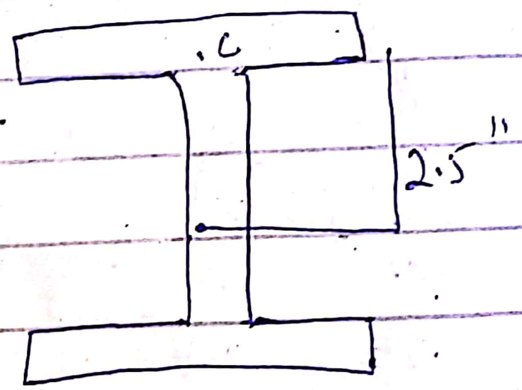
$= \frac{bh^3}{12} + \frac{bh^3}{12} + \frac{bh^3}{12}$

$= \frac{4^3 \times 1}{12} + \frac{1^3 \times 4}{12} + \frac{1 \times 4^3}{12}$

$I_{yy} = 11 \, in^4$

finding shear stress at point C (1" below from top fibre

$\tau_{xy} = \tau_{yx} = \frac{VQ}{IB}$, I



$Q = A\bar{y}$

$A = 1 \times 4$

$A = 4 in^2$

$Q = 1 \times 4 \times 2.5$

$Q = 10 in$

$\tau_{xy} = \tau_{yx} = \frac{47.66 \times 10}{56 \times 4}$

$\tau_{xy} = 2.12 \, lb/in^2$

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

$= \frac{12 \times 242.61 \times 2}{56}$

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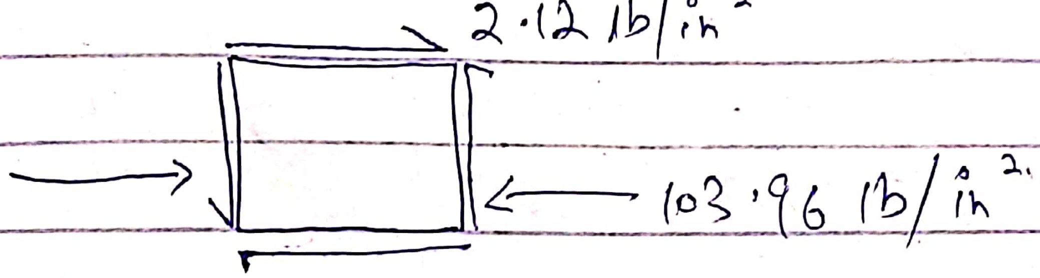
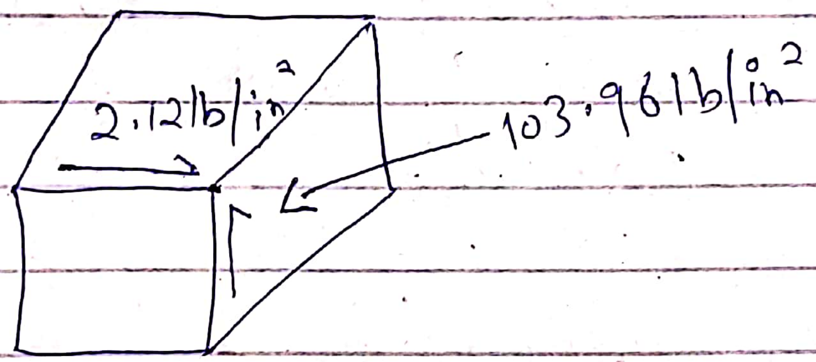
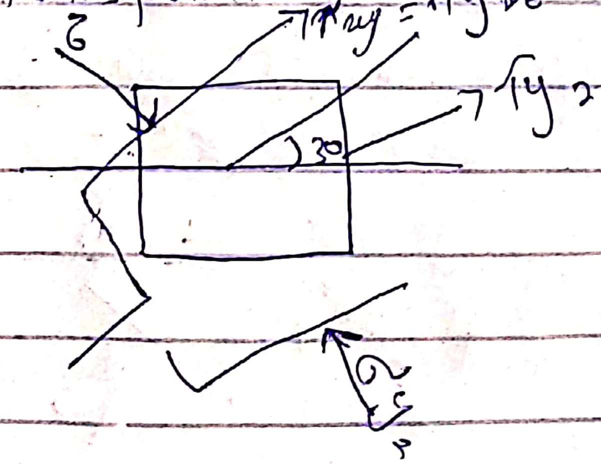
(8)

$\sigma_x = 103.97\ lb/in^2$
fluxure stress at point C
$\sigma = 103.97\ lb/in^2$
strees stress at point "C"
$\tau = 2.12\ lb/in^2$





Assume that element rotates at 30° rotation
assume derive following equaction for stress transformation



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$$\sigma x' = \frac{\sigma x + \sigma y}{2} + \left(\frac{\sigma x - \sigma y}{2}\right)(\cos 2\phi) + \tau xy \sin 2\theta$$

$$\sigma x' = -\frac{103.76 + 0}{2} + \left(\frac{-103.76 + 0}{2}\right)(\cos 2 \times 30^\circ) + 2.12 \sin 60^\circ$$

$$\sigma' x = -172.07 \ lb/in^2$$

for σy

$$\sigma y' = \frac{\sigma x + \sigma y}{2} - \left(\frac{\sigma x - \sigma y}{2}\right)(\cos 2\theta) - \tau xy \sin \theta$$

$$\sigma y' = -\frac{103.6 + 0}{2} - \left(\frac{-103.6 - 0}{2}\right)(\cos 60^\circ) - 21/2 \sin 60^\circ$$

$$\sigma y' = -121.00 \ lb/in^2$$

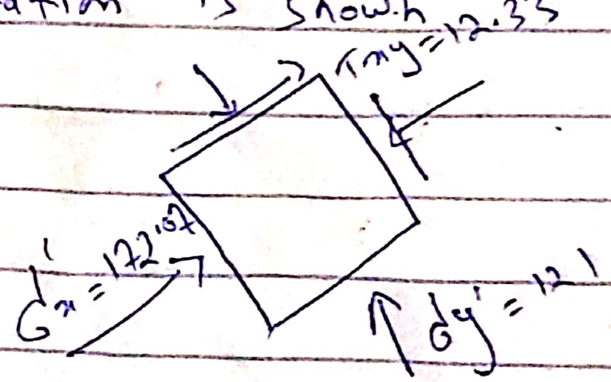
for,

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

$$\tau x'y' = -\frac{103.6 - 0}{2} \sin 60 + 2.12 \cos 60$$

$$\tau xy' = 12.33 \ lb/in^2$$

Now stress state after 30° clockwise orientation is shown



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Q2: find principles stress :—

we know that the principles stress equation as :

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

$$\sigma_{1,2} = \frac{-103.67 + 0}{2} \pm \sqrt{\frac{(-103.67 - 0)^2}{2} + (2.21)^2}$$

$$\sigma_{1,2} = -51.83 \pm 51.88$$

$\sigma_y = \sigma_1 = 0.051 \, lb/in^2$

$\sigma_x = \sigma_2 = -51.83 - 51.88 = -103.7 \, lb/in^2$

or

first find θ_p = ?

$$\tan 2\theta_p = \frac{\tau_{xy}}{(\sigma_x - \sigma_y)/2} = \frac{2.21}{(-103.60)} = -70$$ clockwise

put in general equation

$$\sigma'_{x\,max} = \frac{-103.67 + 0}{2} + \frac{(-103.67 - 0)}{2} \cos(2)(-2.70)$$

$$+ 2.21 \sin 2(-2.70)$$

$$\boxed{\sigma'_{x\,max} = 103.67}$$

Max in plane shear stress in this case

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

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$\tan 2\theta_s = 23.21$

$\theta = 175.11$ Anticlock wise.

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

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

$\tau_{x'y'} = -\frac{(-103.67 - 0)}{2} \sin 2(175.11) + 2.21 \cos 2(175)$

$\tau_{x'y'} = 6.57$ lbin [Max in Plane shear stress]

Mohr's circle

Center coordinate

$(h,k) = \left[\frac{-103.67+0}{2}, 0\right]$

$= [-51.33, 0]$

Radius of Mohr circles is

$r = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$

$r = \sqrt{\left(\frac{-103.67 - 0}{2}\right)^2 + (2.21)^2}$

$r = 51.33$ in

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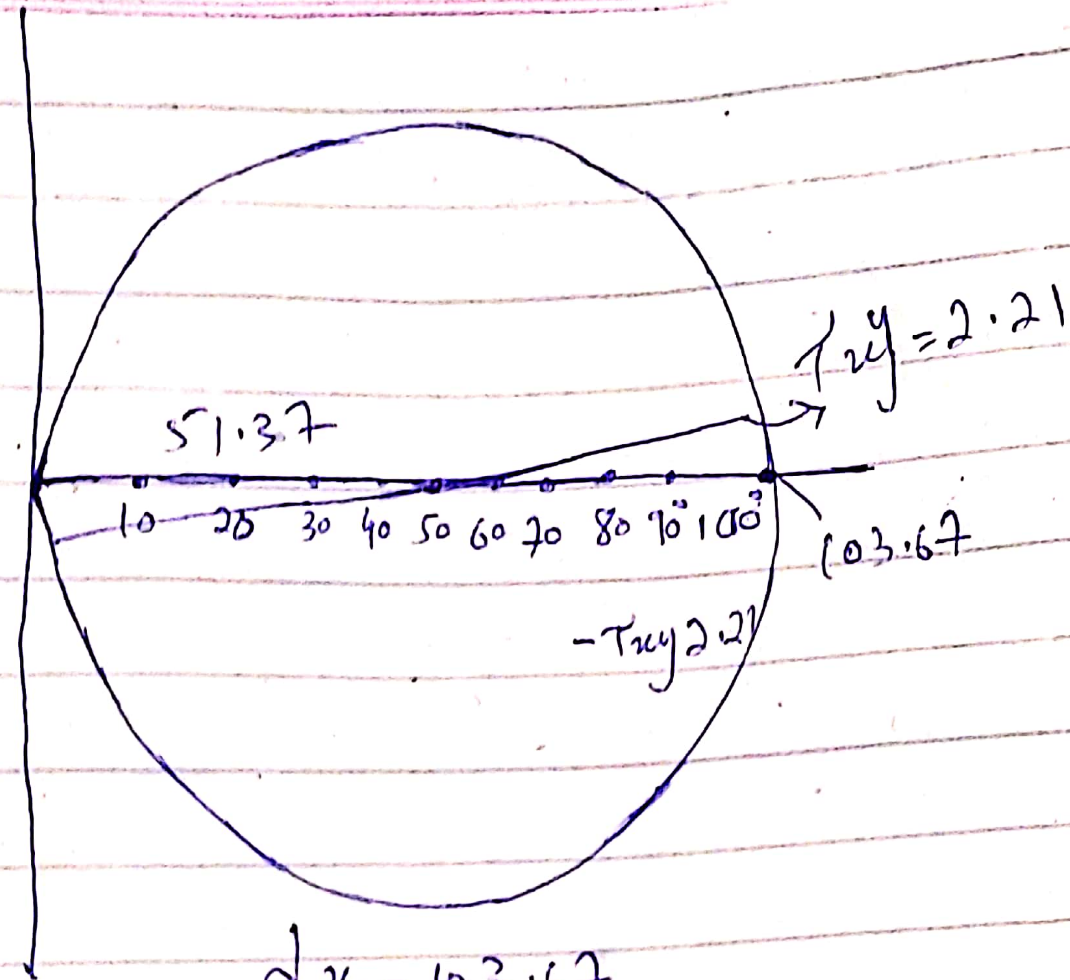

$\sigma_{x_1} = 103.67$

$\sigma_{x_2} = 0$

As shown from Mohr' circle:

The value obtain that of Principal stress & Maximum shear stress are almost same with value obtained from transformation equation.

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