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Section ⇛ Senior.

Subject Name ⇛ Mechanics of Solid 2.

Semester ⇛ Senior.

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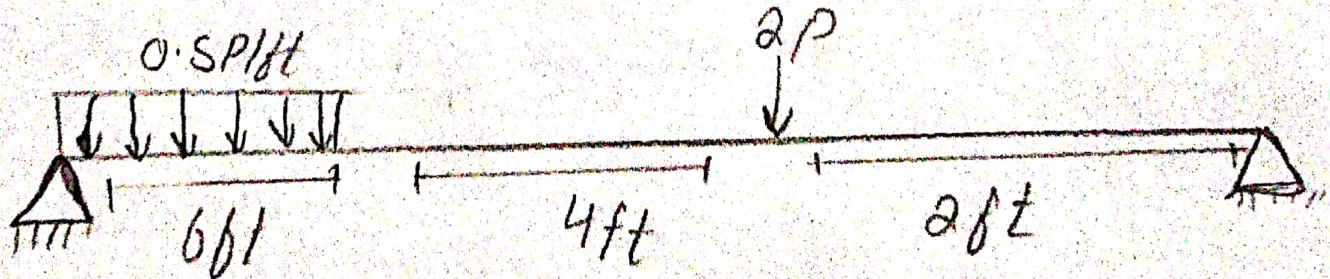
Construct the mohr's circle digram and find the princaple stress and maximum in plane shear stress for the stress state of a point "c" located at the centre of uniform distributed load and 1inches below the top of fiber of beam cross section shown in figure. However to construct the mohr's circl it is necessary to draw the shear and flexusal stress variation digram for maximum shear force fore and bending moment respectively. Compare the resuct oblaibed from the mohr's circle with the stress transformation equation.

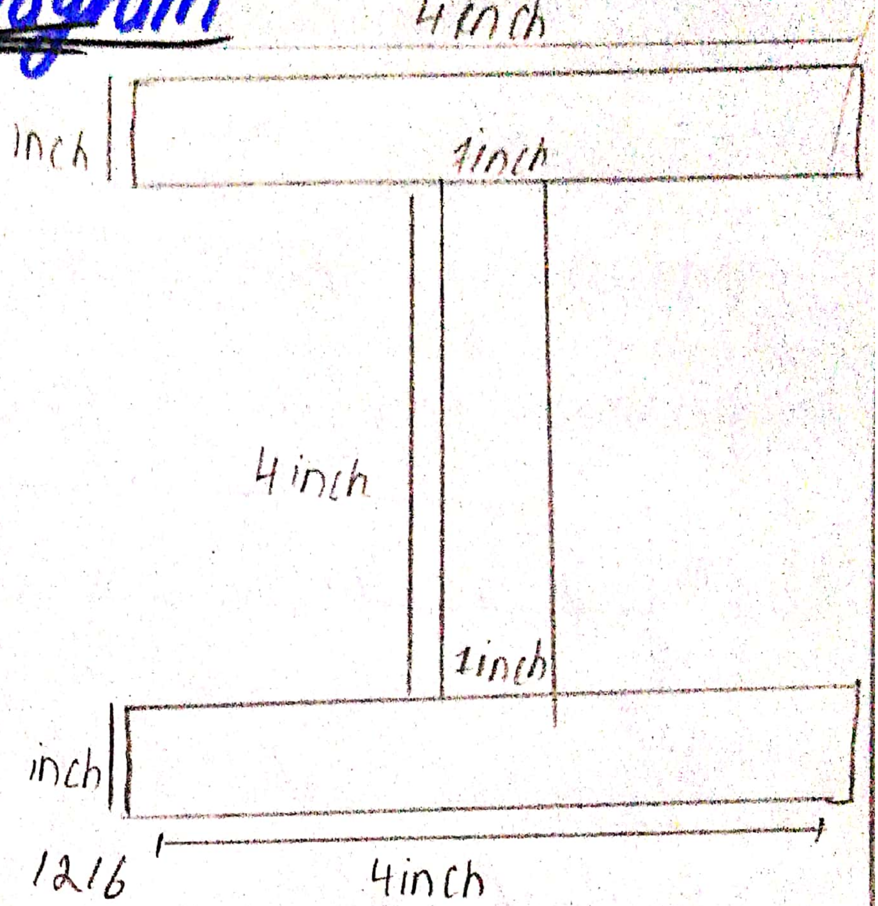
Coke P is the last two digits of class registration number in points.

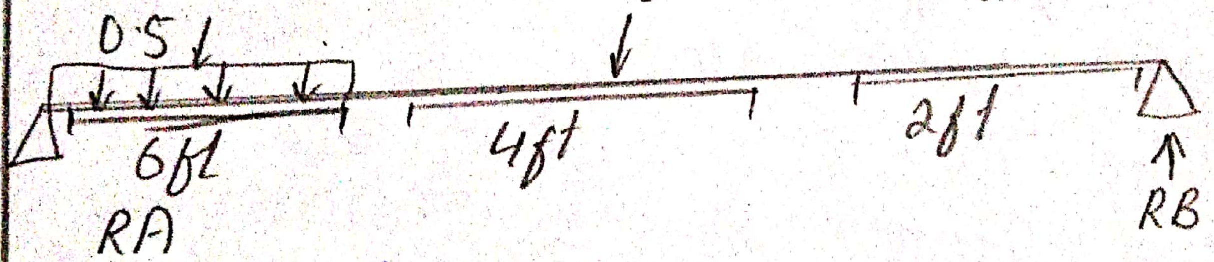


Here my class ragistration number is 7906

So $2P = 2 \times 06 = 12 lb$

Free Body Diagram





Support Reactions:

As we know that

$\sum F_y = 0 \quad \uparrow^{+} \downarrow^{-}$

$RA + RB = 12.5$

Now

$\sum M = 0 \circlearrowleft^{+} \circlearrowright^{-}$

$RB \times 12 - 12 \times 10 - 3 \times 3 = 0$

$12RB - 120 - 9 = 0$

$12RB = 120 + 9$

$\frac{12RB}{12} = \frac{129}{12}$

$\boxed{R_B = 10.75}$

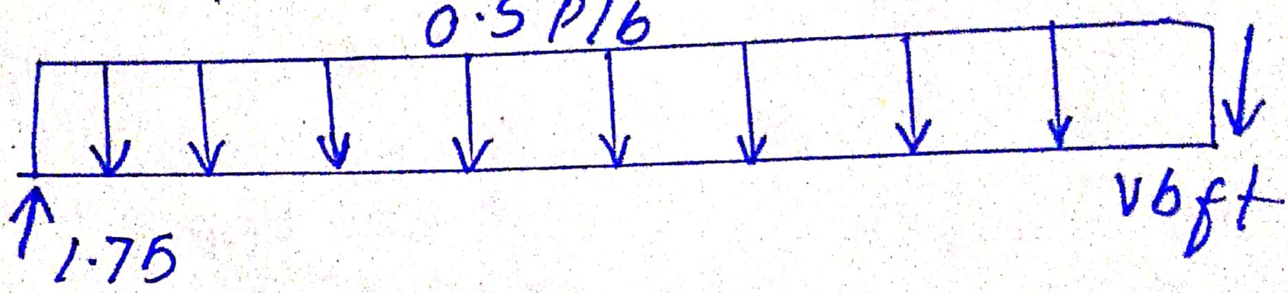
$R_A + R_B = 12.5$

$R_A + 10.75 = 12.5$

$R_A = 12.5 - 10.75$

$\boxed{R_A = 1.75}$

Now Shear four at change point of beam



So,
Shear four at 6ft from left support

$\Sigma F_y = 0 \quad \uparrow^- \downarrow^+$

$+V_{6ft} - 1.75 + 0.5 \times 6 = 0$

$+V_{6f} - 1.75 + 3 = 0$

$+V_{6f} - 1.75 + 3 = 0$

$V_{6f} = +1.75 - 3$

$V_{6f} \quad 25 - 1.25\ lb$

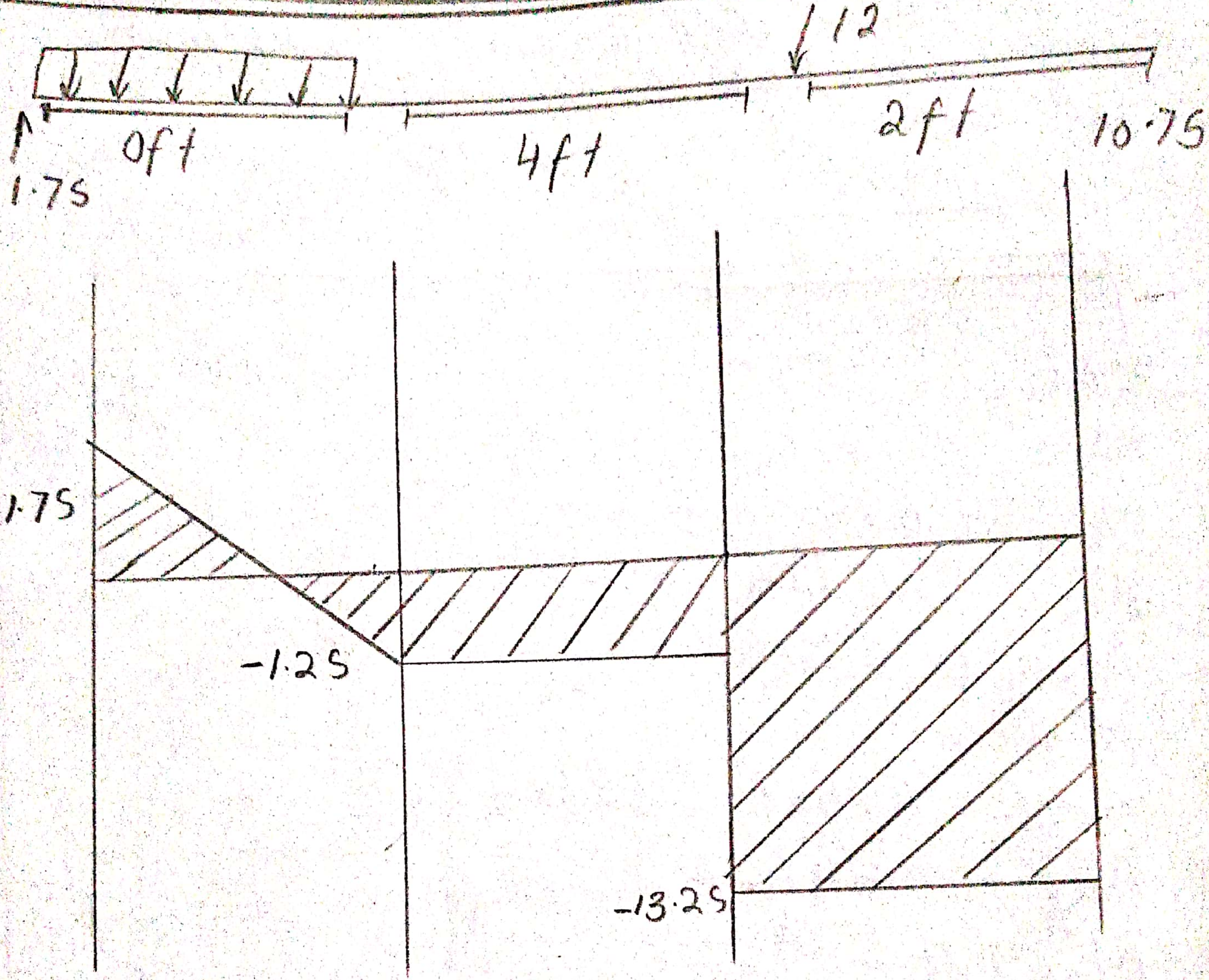
Now Shear force at V_{10ft}

$\Sigma F_y = \uparrow^- \downarrow^+$

$-1.75 + 3 + 12 + V_{10ft} = 0$

$V_{10ft} = 1.75 - 3 - 12$

$V_{10ft} = -13.25$



Now moment at change point.
Find Zero shear point

$$\frac{1.75}{x} = \frac{1.25}{(6-x)}$$

$$1.75(6-x) = 1.25(x)$$

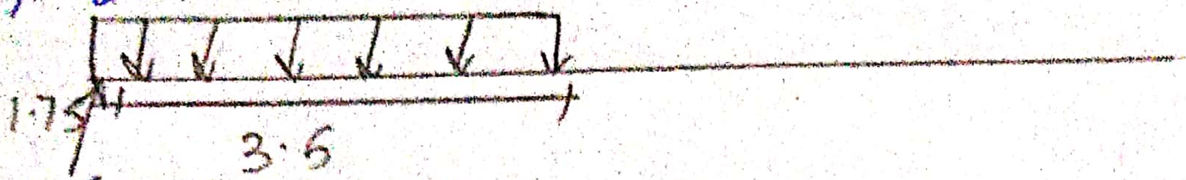
$$10.5 - 1.75x = 1.25x$$

$$10.6 = 1.25x + 1.75x$$

$$\frac{10.5}{\cancel{3}} = \frac{\cancel{3}x}{\cancel{3}}$$

$$x = 3.3$$

As we know that moment is Maximum where Shear force is Zero.
Take Sectim at 3.5 from left support end find moment



$\sum M_{3.5} = 0 \circlearrowright^{+}$

$M_{3.5} - 1.75\times3.5 + 3\left(\frac{3.5}{2}\right) = 0$

$M_{3.5} - 6.125 + 5.25 = 0$

$M_{3.5} = 6.125 - 5.25$

$M_{3.5} = 0.875$

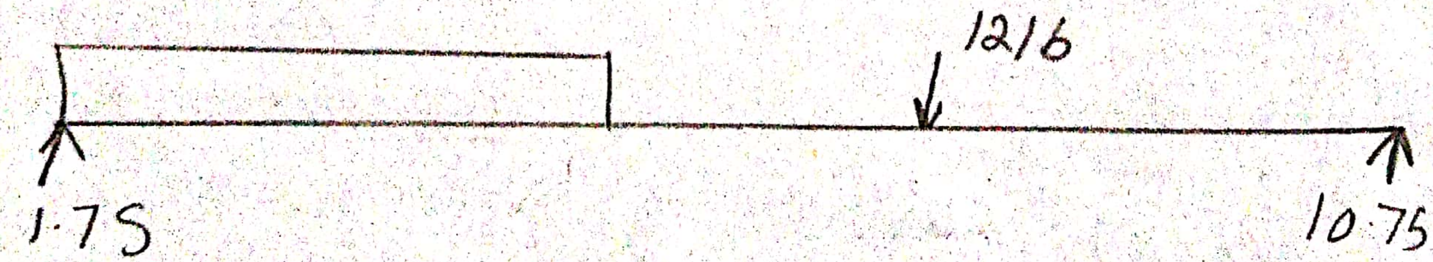
Now:

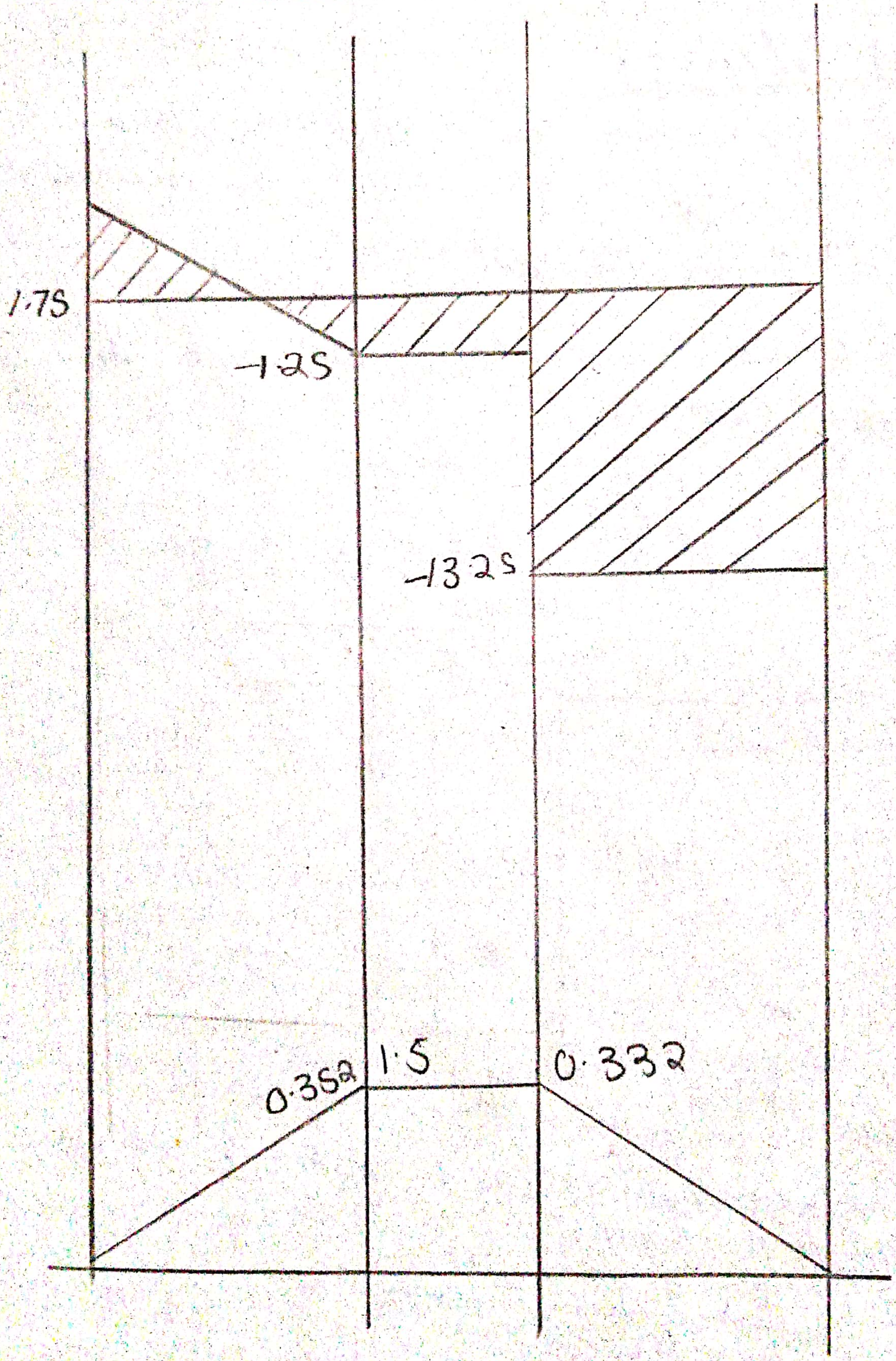
$M_{oft} = 1.75\times6 + 0.5\times6\times3 = 0$

$M_{of} = -105 + 9 = 0$

$M_{of} = 10.5 - 9$

$M_{of} = 1.5$





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NOW;

Shear Stress;

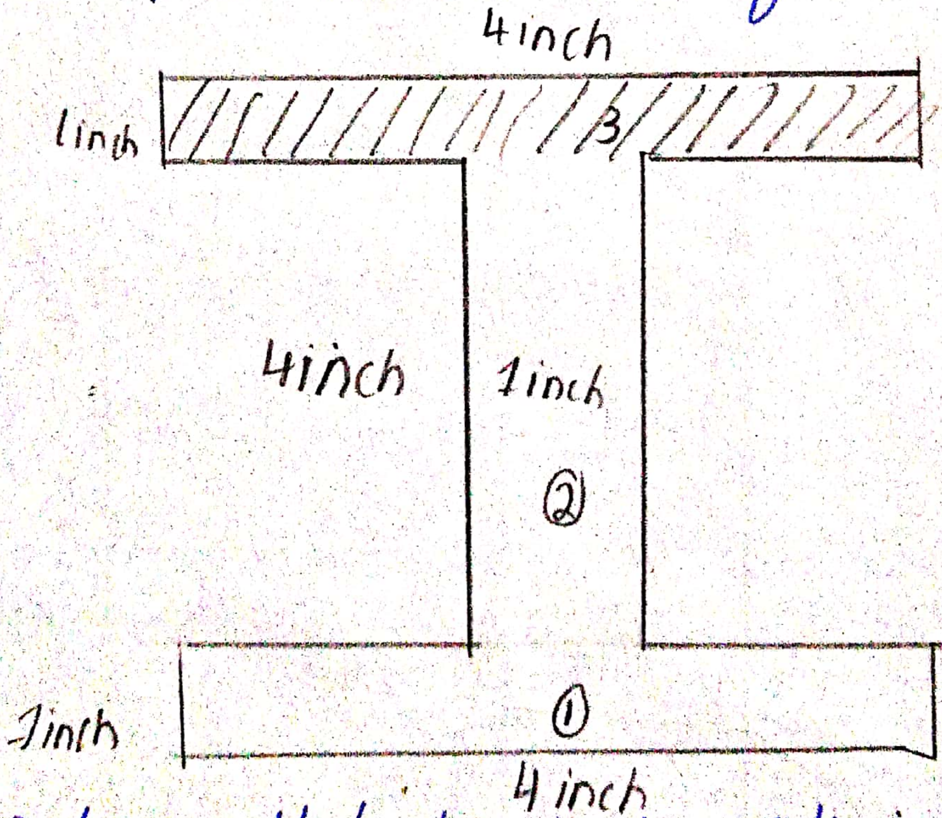
As per Question the maximum shear Stress $\tau = \frac{VQ}{It}$ ocurs where the maximum shear force is 10.75 Ib.

So,

To find the shear stress we have the following formula

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

we first find the moment of inertia



As we know that to find antroid we have the following formula:

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2 + A_2 y_2}{A_1 + A_2 + A_3}$$

$A_1 = 4 \times 1 = 4$

$A_2 = 4 \times 1 = 4$

$A_3 = 4 \times 1 = 4$

$$\bar{y} = \frac{4 \times 0.5 + 4 \times 3 + 4 \times 5.5}{4 + 4 + 4}$$

$\bar{y} = 3"$

Now moment of inertia

NO	A (in^2)	Ix (in)	$d = (\bar{y} - y_1)$ $(\bar{y} - y_2)(\bar{y} - y_2)$
①	4	$\frac{4 \times (1)^2}{12} = 0.333$	
②	4	$\frac{1 \times (4)^3}{12} = 5.333$	
③	4	$\frac{4 \times (1)^3}{12} = 0.333$	

(Now "d")

① $d = (\bar{y} - y_2) = (3 - 0.5) = 2.5$

② $d = (\bar{y} - y_2) = (3 - 3) = 0$

③ $d = (3 - 5.5) = -2.5$

(Now Ad^2)

① $4 \times (2.5)^2 = 25$

② $4 \times (0)^2 = 0$

③ $4 \times (-2.5)^2 = 25$

Now

$I_x = \bar{I}_x + Ad^2$

① $0.333 + 25 = 25.333$

② $5.333 + 25 = 5.333$

③ $\bar{0}.333 + 25 = 25.333$

Total

$I = I_{x1} + I_{x2} + I_3$

$I = 25.333 + 5.333 + 25.333$

$I = 55.999 \text{ in}^4$

Now shear stress

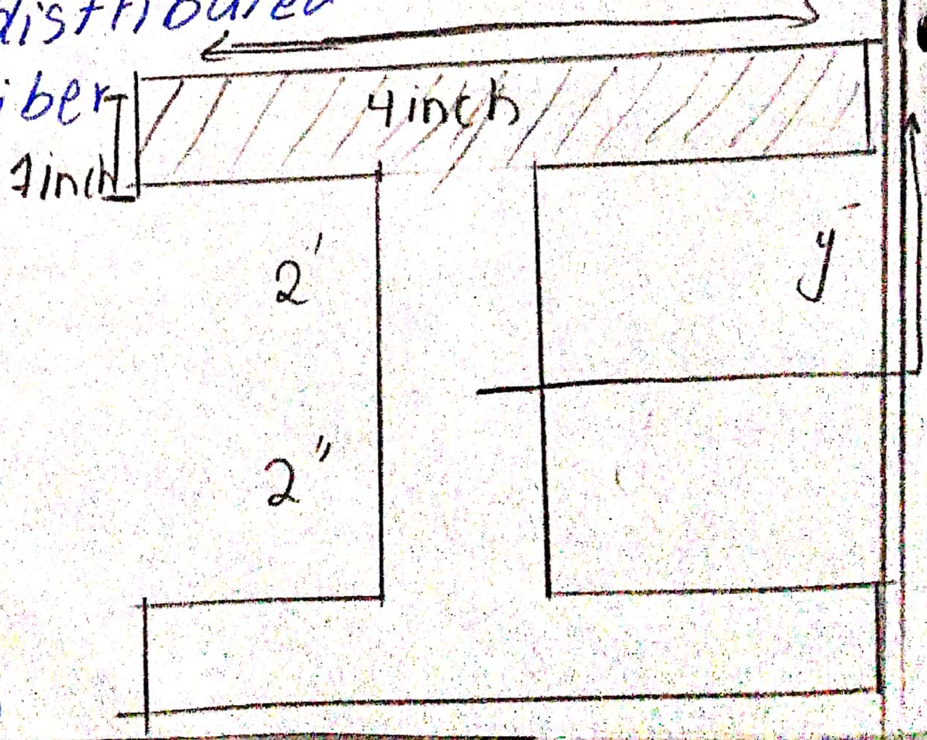
$\tau = \dfrac{VQ}{Ib}$

$V_{max} = 10.75$

$Q = \bar{y}A$

b = breath of that fiber

Shear stress at point c location at centre of uniformly distributed load and inch below the top fiber



$\bar{y} = 2 + 0.5 = 2.5$

$A = 1 \times 4 = 4$

$Q = 4 \times 2.5 = 10$

As we know that

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

$\tau = \dfrac{(10.75)(10)}{(55.996)(4)}$

$\boxed{\tau = 0.479}$ Psi

Now Flexeral Stress Analysis

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

where M is maximum moment in BMA

$M = 1.5$

$$\sigma = \frac{(1.5)(2)}{55.996}$$

$$\boxed{\sigma = 0.0555}$$

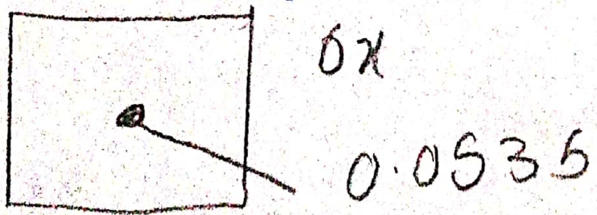
So, shear stress at point c is

$\tau = 0.475$ Psi

Flexaral stress at point c

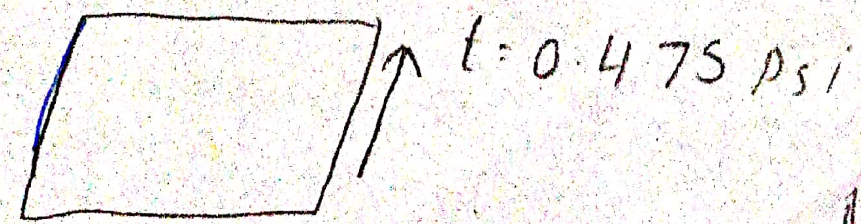
$\sigma = 0.0535$ Psi

Now consider c is a planer elements

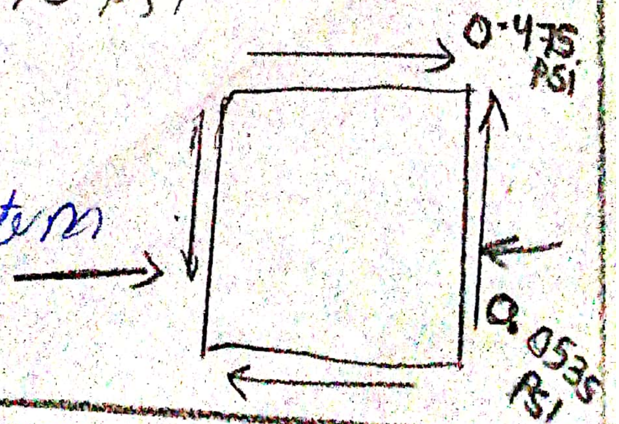


0.0535 psi is compressive Because point c lies in compression zone of Beam cross

Now



combine stress on 2D elem



Now we can find the stress state consider of point C at a digree of 20° clockwaise orientation.

Solve

Given stress state

$\sigma_x = -0.0535$

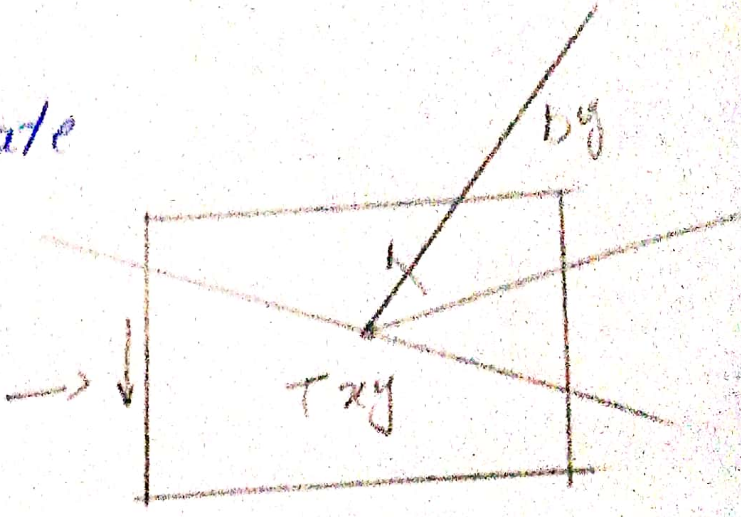
$\sigma_y = 0$

$\tau_{xy} = 0.475$

$\sigma_{x'} = ?$

$\sigma_{y'} = ?$

$\tau_{x'y'} = ?$



As we Drive the following formules equation for stress transformation

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

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

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

For $\sigma_{x'}$

$$\sigma_{x'} = \frac{-0.0535}{2} + \frac{-0.0535}{2} \cos(2(-20)) + (0.475) \sin(2(+20))$$

$$-0.02675 - 0.0204 \cdot 0.3053$$

$$\sigma_{x'} = -0.02675$$

$\boxed{\sigma_{x'} = -0.3524 \text{ Psi}}$ compression

For σ_y'

$$\sigma_y' = -\frac{0.0535}{2} - \frac{(-0.0535)}{2}\cos(2(-20))$$

$$- (0.475)\sin 2(-20)$$

$$\sigma_y' = -0.02675 - 0.0204 - 0.3053$$

$$\boxed{\sigma_y' = -0.3524}$$ comprissine

For $\tau_{x'y'}$

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

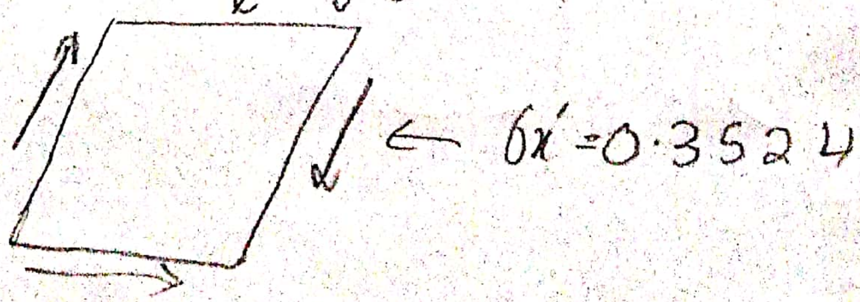
$$\tau_{x'y'} = -\frac{(-0.0535)}{2} - 0\sin(2(-20))$$

$$+ 0.475\cos(2(-20))$$

$$= -0.01719 + 0.3638$$

$$\tau_{x'y'} = 0.39661$$

So, the New Stress state after 20° clockwiss orientatio is shown



Find its Principle Stress:-

$$\sigma_{12} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\sigma_{12} = \frac{-0.0535+0}{2} \pm \sqrt{\left(\frac{-0.0535-0}{2}\right)^2 + (0.478)^2}$$

$$\sigma_{12} = -0.0267 \pm \sqrt{7.155 + 0.2256}$$

$$\sigma_{12} = -0.0267 \pm \sqrt{7.155 + 02256}$$

$$\sigma_{12} = -0.0267 \pm 2.7166$$

$$\sigma_{12} = \sigma_1 = -0.0267 + 27166 = 2.689$$

$$\sigma_x = \sigma_2 = -0.0267 - 2.7166 = -2.07383$$

Max in Plane Shear Stress

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

$$\tau_{xy} = \sqrt{0.00071 + 0.225}$$

$$\tau_{xy} = \sqrt{0.22571}$$

$$\tau_{xy} = 0.4750 \text{ Psi}$$

To Draw Mohrs Circle for the given Problem

Solve: As we know that to draw the circle we need the coordinates of circle as well as radius.

The Coordinates of circle can be find by this

$\left(\frac{\sigma x + \sigma y}{2}, 0\right)$

centre Coordinates

(h,k) $\left(\frac{-0.0535}{2}, 0\right)$

$= (-0.026, 0)$

Radius of mohrs circle is

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

$r = \sqrt{\left(\frac{-0.0535 - 0}{2}\right)^2 + (0.475)^2}$

$r = \sqrt{0.000715 + 0.2256}$

$r = \sqrt{0.226375}$

$r = 0.4757$