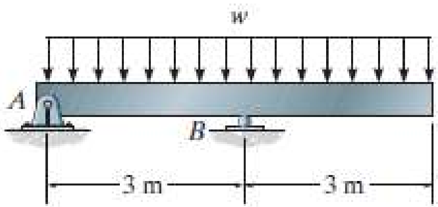
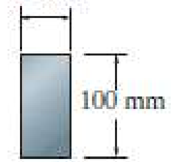
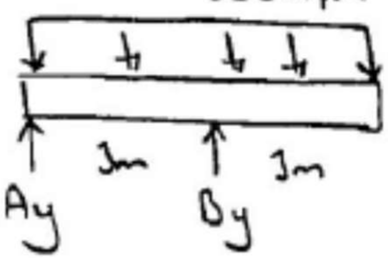
The overhang beam is subjected to the uniform distributed load having an intensity of $w = 50$ kN/m. Determine the maximum shear stress developed in the beam.





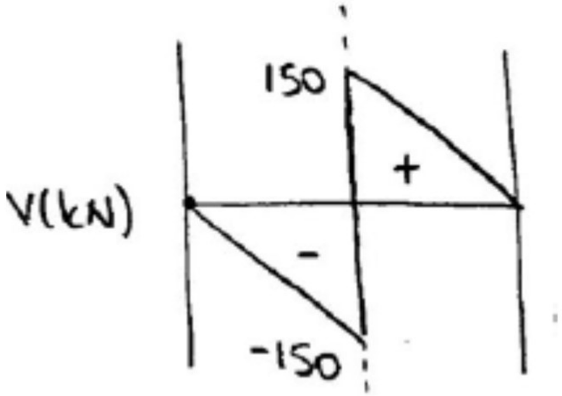


$$\circlearrowleft + \Sigma M_A = 0 ; \; B_y(3) - (50)(6)(3) = 0$$

$$B_y = 300 \text{ kN}$$

$$\uparrow + \Sigma F_y = 0 ; \; A_y + 300 - (50)(6) = 0$$

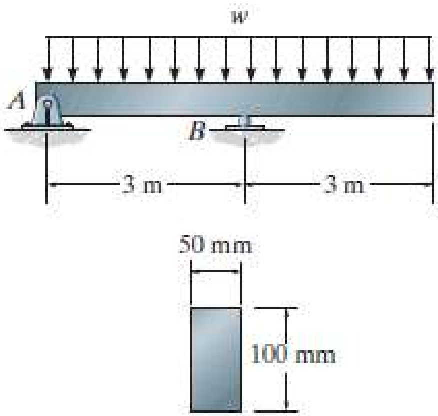
$$A_y = 0$$



$$V_{max} = 150 \text{ kN}$$

$$\tau_{max} = \frac{V_{max} \cdot Q_{max}}{It}$$

The overhang beam is subjected to the uniform distributed load having an intensity of $w = 50$ kN/m. Determine the maximum shear stress developed in the beam.



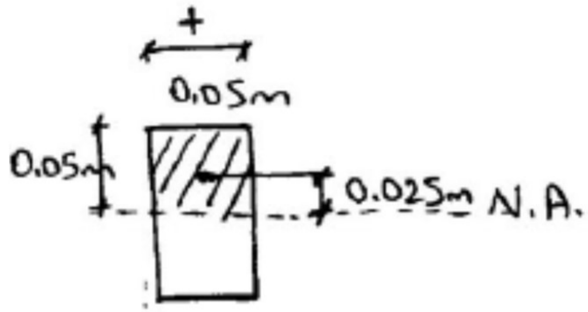
$$\tau_{max} = \frac{V_{max} \cdot Q_{max}}{I t}$$

$$V_{max} = 150 \text{ kN}$$

$$I = \frac{1}{12}(0.05)(0.1)^3$$

$$= 4.17 \times 10^{-6} \text{ m}^4$$

$$Q_{max} = A \cdot y$$



$$Q_{max} = (0.05)(0.05)(0.025)$$

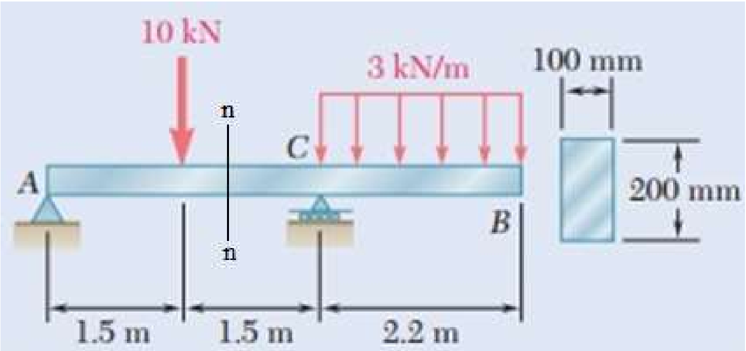
$$= 6.25 \times 10^{-5} \text{ m}^3$$

$$t = 0.05 \text{ m}$$

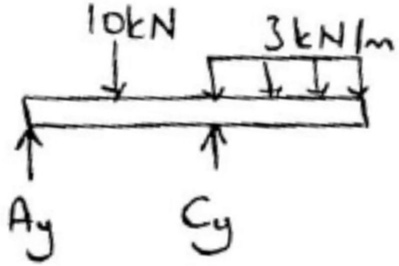
$$\tau_{max} = \frac{(150 \times 10^3)(6.25 \times 10^{-5})}{(4.17 \times 10^{-6})(0.05)} = 45 \times 10^6 \text{ Pa}$$

$$= 45 \text{ MPa}$$

For the beam and loading shown, determine the maximum normal and maximum shear stresses at section n-n 2 m from the point A.



FBD of the beam:

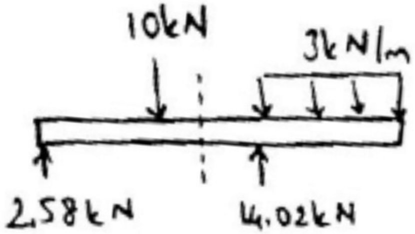


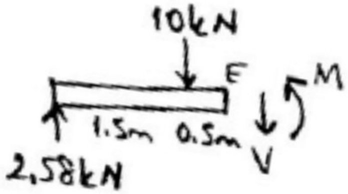
$\circlearrowleft + \Sigma M_A = 0 \qquad 3.C_y - (10)(1.5) - (3)(2.2)(4.1) = 0$

$C_y = 14.02 \text{ kN}$

$\uparrow + \Sigma F_y = 0 \qquad 14.02 - 10 - 3(2.2) + A_y = 0$

$A_y = 2.58 \text{ kN}$

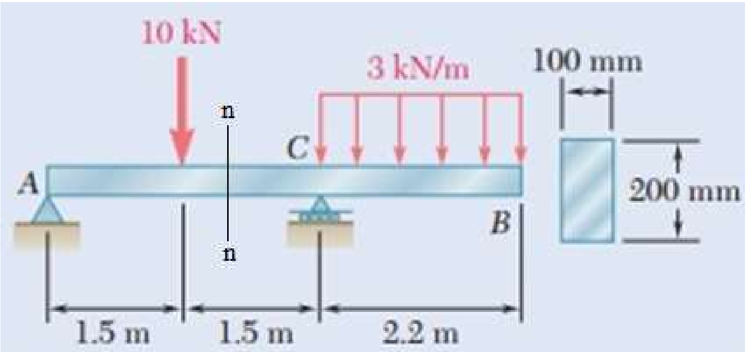




$\Sigma M_E = -(2.58)(2) + (10)(0.5) + M = 0 \qquad M = 0.16 \text{ kN.m}$

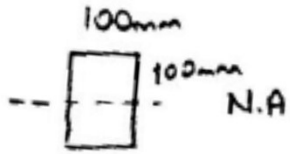
$\Sigma F_y = 0 \qquad -V - 10 + 2.58 = 0 \qquad V = -7.42 \text{ kN}$

For the beam and loading shown, determine the maximum normal and maximum shear stresses at section n-n 2 m from the point A.



$M = 0.16 \text{ kN.m}$

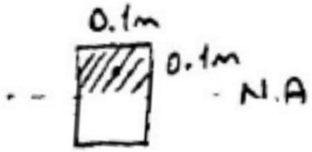
$V = -7.42 \text{ kN}$



$$\sigma_{max} = \frac{M.c}{I} = \frac{(0.16\times10^{3})(0.1)}{\frac{1}{12}(0.1)(0.2)^3}$$

$$= 0.24\times10^{6} \text{ Pa}$$

$$= 0.24 \text{ MPa}$$



$t = 0.1m.$

$$I = \frac{1}{12}(0.1)(0.2)^3 = 6.67\times10^{-5} \text{ m}^4$$

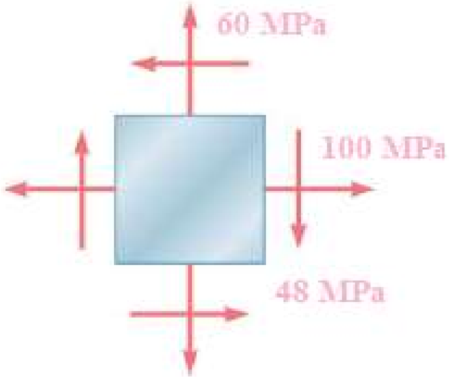
$$Q = (0.1)(0.1)\left(\frac{0.1}{2}\right) = 5\times10^{-4} \text{ m}^3$$

$$\tau_{max} = \frac{V.Q_{max}}{I.t} = \frac{(7.42\times10^{3})(5\times10^{-4})}{(6.67\times10^{-5})(0.1)}$$

$$= 0.557\times10^{6} \text{ Pa}$$

$$= 0.557 \text{ MPa}$$

Determine the principal stresses and principal planes.



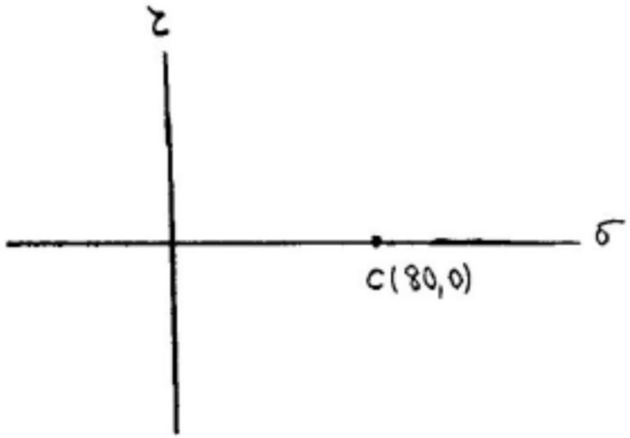
$\sigma_x = 100$ MPa

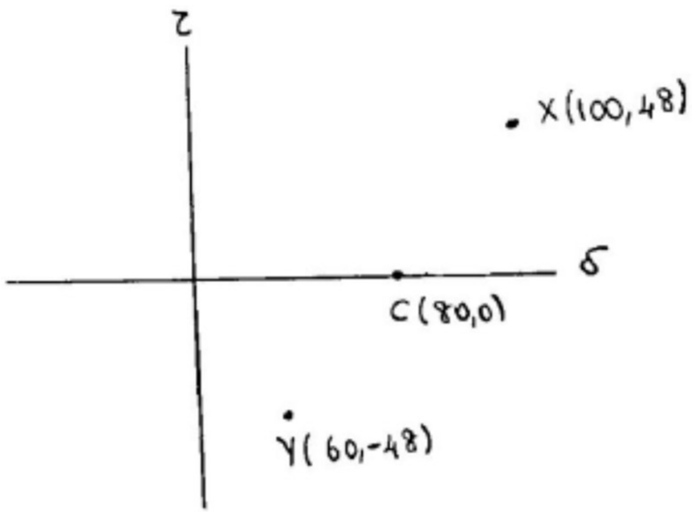
$\sigma_y = 60$ MPa

$\tau_{xy} = 48$ MPa

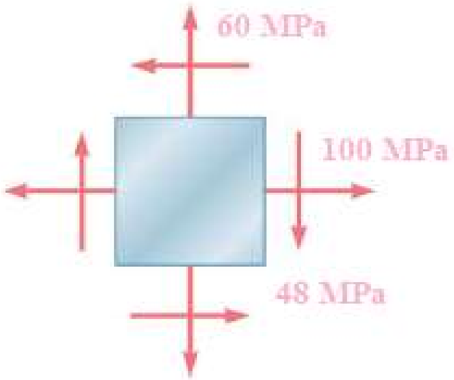
① Center $\dfrac{\sigma_x+\sigma_y}{2} = \dfrac{100+60}{2} = 80$ MPa

② $X(100, 48)$ $Y(60, -48)$





Determine the principal stresses and principal planes.

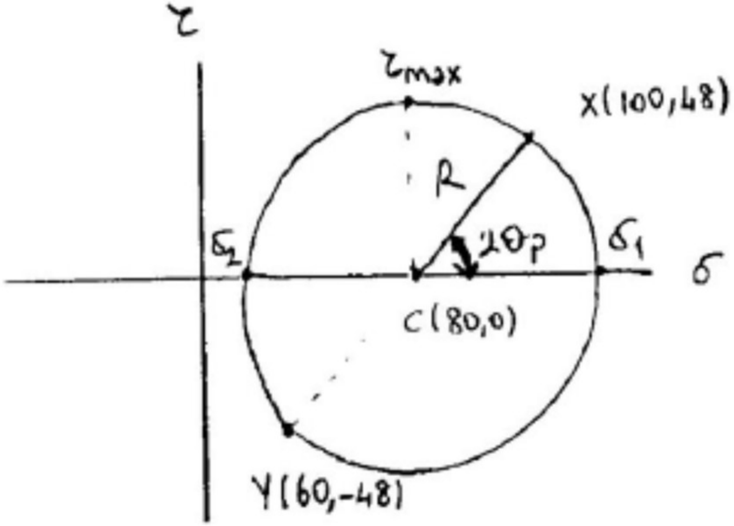


$\sigma_x = 100$ MPa

$\sigma_y = 60$ MPa

$\tau_{xy} = 48$ MPa

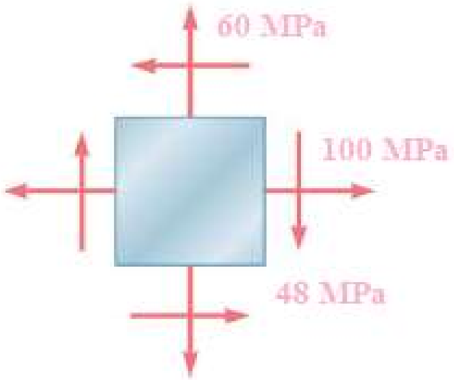
(3) $R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} = 52$ MPa

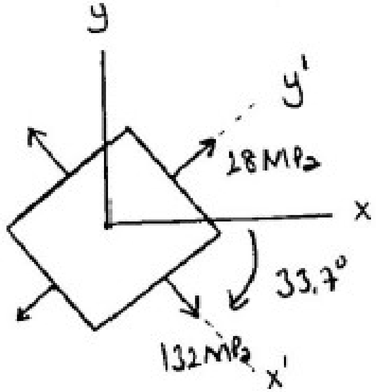


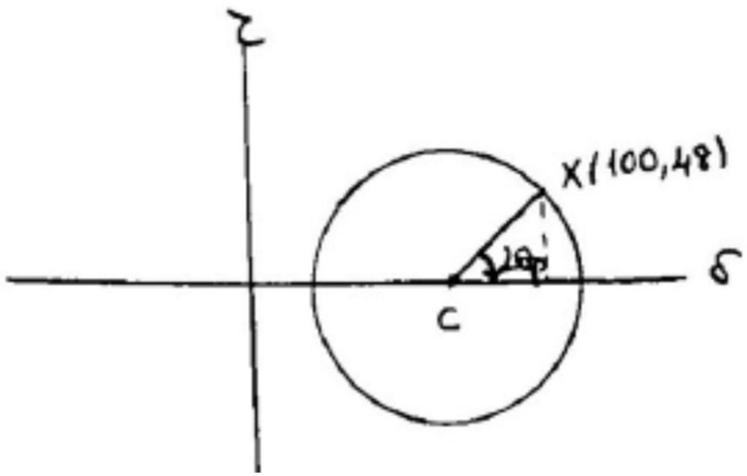
$\sigma_1 = 80 + 52 = 132$ MPa

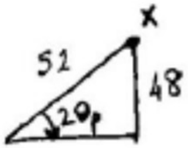
$\sigma_2 = 80 - 52 = 28$ MPa

Determine the principal stresses and principal planes.





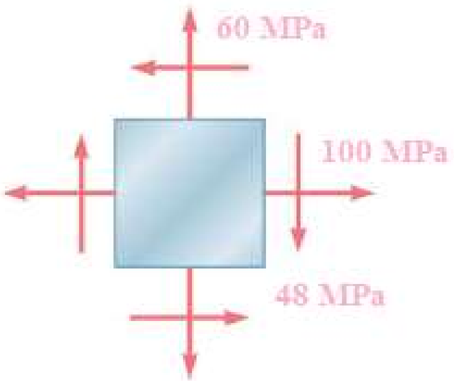




$$\sin 2\theta_p = \frac{48}{52}$$

$$\theta_p = 33.7^\circ$$

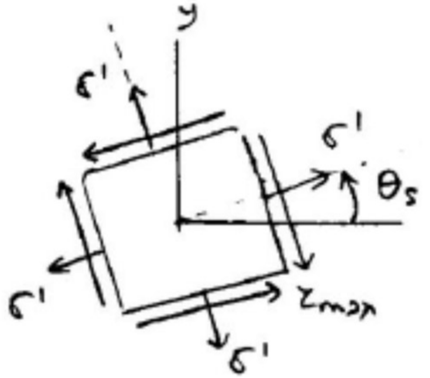
Determine the maximum in-plane shear stress.



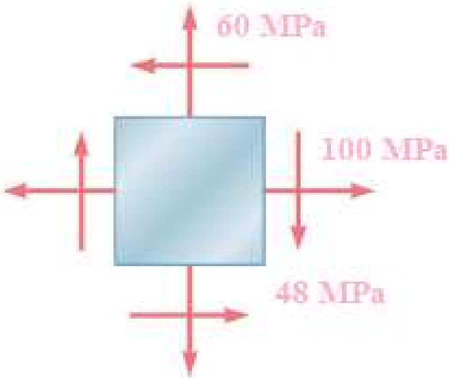
$\tau_{max} = R = 52$ MPa

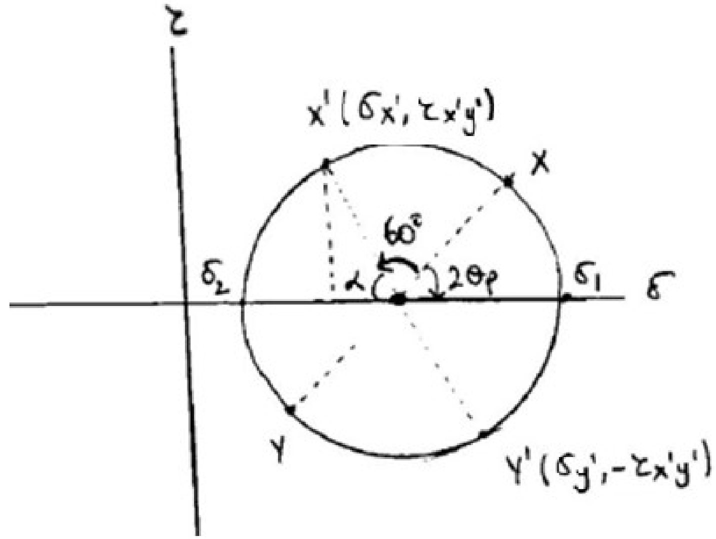
$\theta_s = 11.3°$

$\sigma' = \sigma_{ave} = 80$ MPa



Determine the equivalent state of stress if an element is oriented 30° counterclockwise from the element shown.



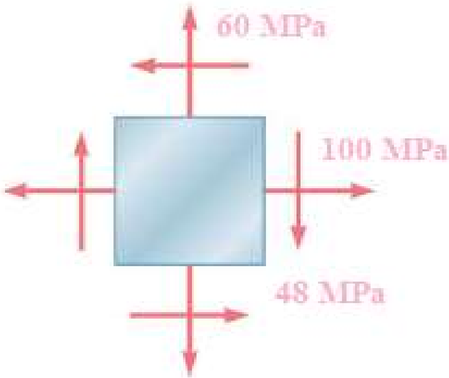


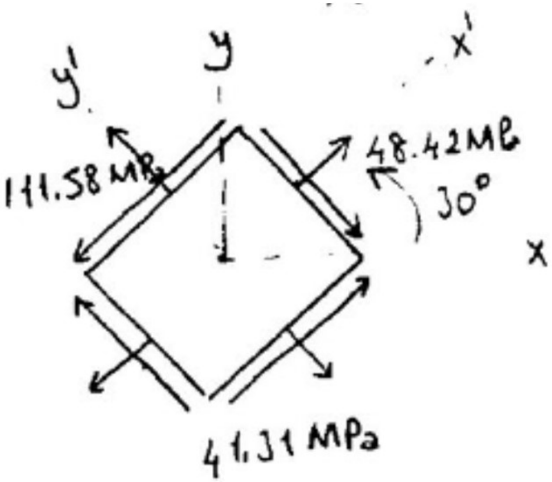
$\alpha = 180° - 60° - 2\theta_p$

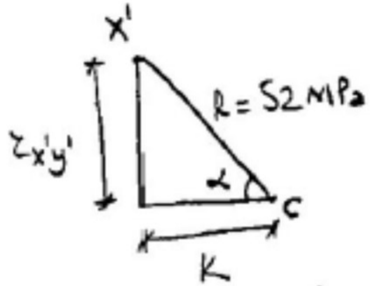
$\alpha = 180° - 60° - 2(33.7°)$

$\alpha = 52.6°$

Determine the equivalent state of stress if an element is oriented 30° counterclockwise from the element shown.







$\sin\alpha = \dfrac{\tau_{x'y'}}{R}$

$\sin 52.6^\circ = \dfrac{\tau_{x'y'}}{52}$

$\tau_{x'y'} = 41.31\ \text{MPa}$

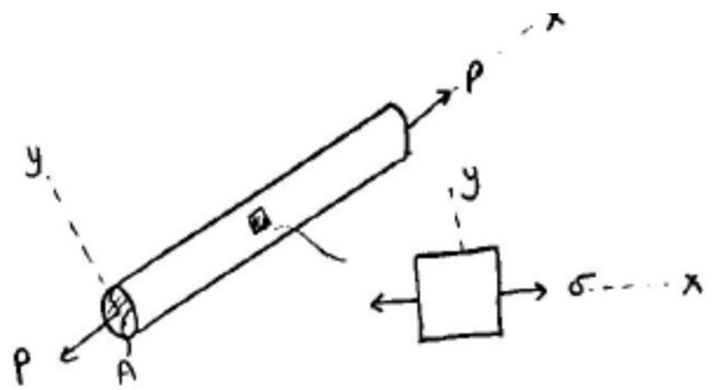
$\cos\alpha = \dfrac{K}{52}$

$K = 52\cos 52.6^\circ$

$K = 31.58\ \text{MPa}$

$\sigma_{x'} = 80 - 31.58 = 48.42\ \text{MPa}$

$\sigma_{y'} = 80 + 31.58 = 111.58\ \text{MPa}$



$\sigma_x = \sigma = \frac{P}{A}$

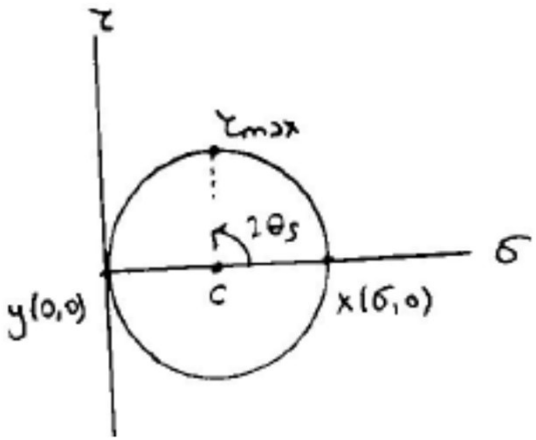
$\sigma_y = 0$

$\tau_{xy} = 0$

① Center $\frac{\sigma_x + \sigma_y}{2} = \frac{\sigma + 0}{2} = \frac{\sigma}{2}$

② $x(\sigma, 0) \quad y(0,0)$

③ $R = \sqrt{\left(\frac{\sigma - 0}{2}\right)^2 + 0^2} = \frac{\sigma}{2}$



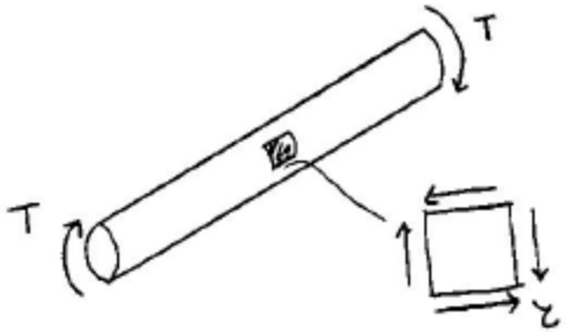
$\sigma_1 = \sigma$

$\sigma_2 = 0$

$\tau_{max} = \frac{\sigma}{2}$

$\theta_s = 45^\circ$ ↺

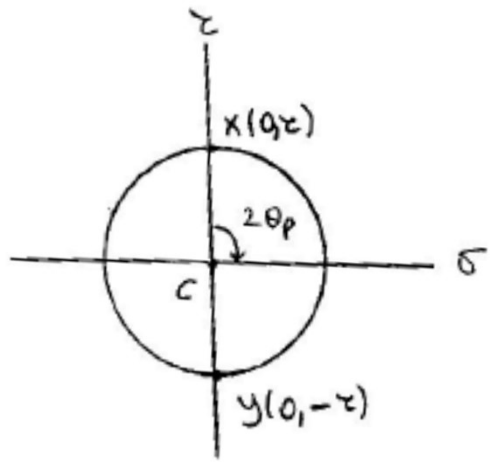
$\theta_p = 0$



$\sigma_x = 0$

$\sigma_y = 0$

$\tau_{xy} = \tau$



$\sigma_1 = \tau$

$\sigma_2 = -\tau$

$\tau_{max} = \tau$

$2\theta_p = 90^\circ$

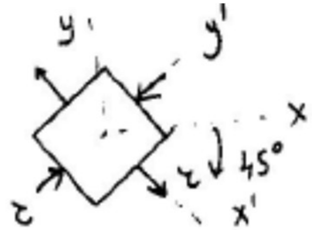
$\theta_p = 45^\circ$

$\theta_s = 0$

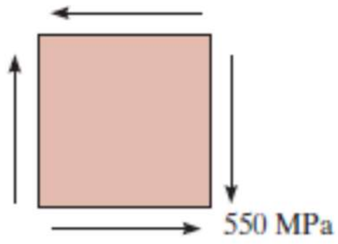
① Center $\frac{\sigma_x + \sigma_y}{2} = \frac{0+0}{2} = 0$

② $x(0, \tau)$ $\quad y(0, -\tau)$

③ $R = \tau$



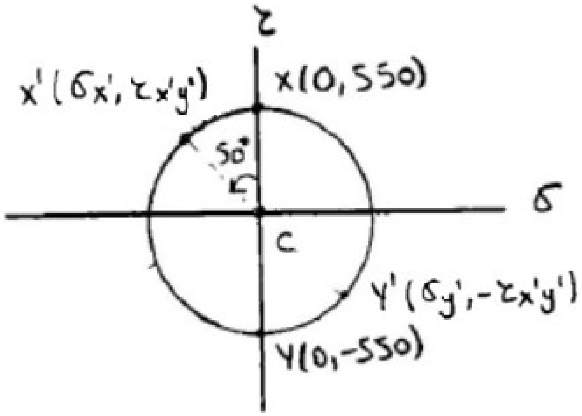
Determine the equivalent state of stress if an element is oriented 25° counterclockwise from the element shown.



$\sigma_x = 0$

$\sigma_y = 0$

$\tau_{xy} = 550$ MPa



① Center $\frac{\sigma_x + \sigma_y}{2} = \frac{0+0}{2} = 0$

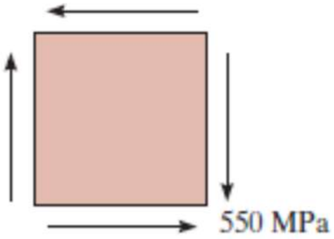
② $X(0, 550)$ $\quad Y(0, -550)$

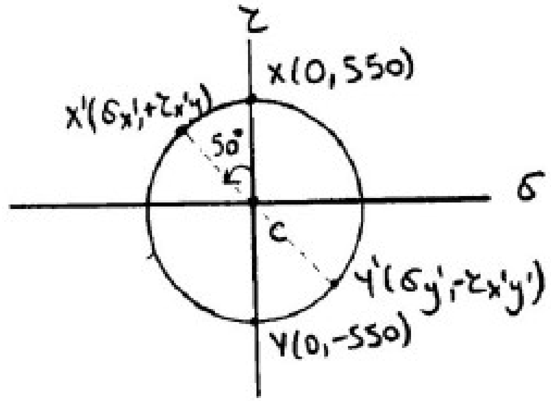
③ $R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$

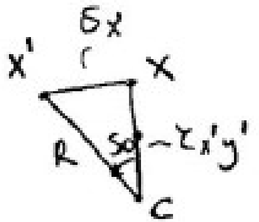
$= \sqrt{\left(\frac{0-0}{2}\right)^2 + (550)^2}$

$R = 550$ MPa

Determine the equivalent state of stress if an element is oriented 25° counterclockwise from the element shown.







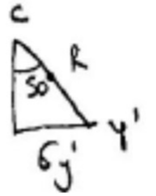
$$\sin 50^\circ = \frac{\sigma_{x'}}{R}$$

$$\sigma_{x'} = R \sin 50^\circ = 550 \sin 50^\circ$$

$$\sigma_{x'} = -421 \text{ MPa}$$

$$\cos 50^\circ = \frac{\tau_{x'y'}}{R}$$

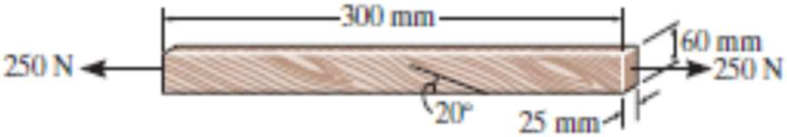
$$\tau_{x'y'} = +354 \text{ MPa}$$

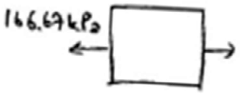


$$\sigma_{y'} = R \cdot \sin 50^\circ$$

$$\sigma_{y'} = 421 \text{ MPa}$$

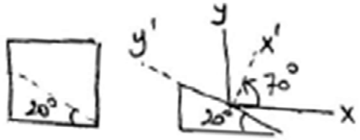
The grains of wood in the board make an angle of 20° with the horizontal as shown. Determine the normal and shear stress that act perpendicular and parallel to the grains if the board is subjected to an axial load of 250 N.



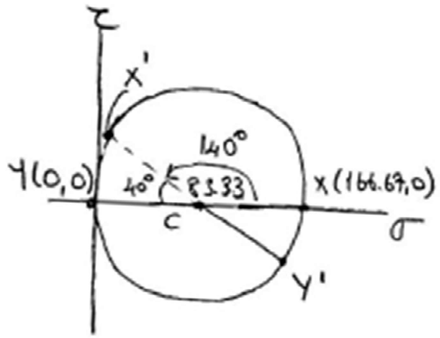


$$\sigma_x = \frac{P}{A} = \frac{250}{(0.06)(0.025)} = 166.67 \text{ kPa}$$

$$\sigma_y = 0 \quad \tau_{xy} = 0$$



$\theta = 70°$



① center $\frac{166.67+0}{2} = 83.33$ kPa

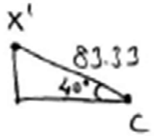
② X (166.67, 0) Y (0, 0)

③ $R = 166.67 - 83.34 = 83.33$ kPa

$\sigma_1 = 166.67$ kPa

$\sigma_2 = 0$

$\tau_{max} = R = 83.33$ kPa



$83.33 \sin 40° = 53.56$ kPa

$83.33 \cos 40° = 63.83$ kPa

$83.33 - 63.83 = 20$ kPa

X' (20, 53.56)