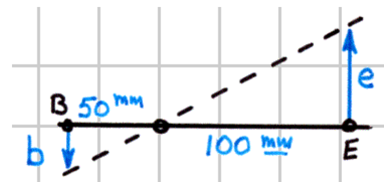
3-10*



$$\delta_D = \varepsilon_D L_D = 0.0075(150) = 1.1250 \text{ mm}$$

$$\frac{e}{100} = \frac{b}{50} \qquad e = 2b$$

(a) $b = \delta_D + 0.09 \text{ mm} \qquad e = \delta_{CE}$

$$\delta_{CE} = 2(\delta_D + 0.09) = 2(1.1250 + 0.09) = 2.4300 \text{ mm}$$

$$\varepsilon_{CE} = \frac{\delta_{CE}}{L_{CE}} = \frac{2.4300}{300} = 0.00810 \text{ m/m} = 8100 \ \mu\text{m/m}$$ .... **Ans.**

(b) $b = \delta_D + 0.09 \text{ mm} \qquad e = \delta_{CE} + 0.10 \text{ mm}$

$$(\delta_{CE} + 0.10) = 2(\delta_D + 0.09) = 2(1.12500 + 0.09) = 2.4300 \text{ mm}$$

$$\delta_{CE} = 2.3300 \text{ mm}$$

$$\varepsilon_{CE} = \frac{\delta_{CE}}{L_{CE}} = \frac{2.3300}{300} = 0.00777 \text{ m/m} = 7770 \ \mu\text{m/m}$$ .... **Ans.**

3-26

The given values are

$$\varepsilon_x = 1950\ \mu\text{m/m} \qquad \varepsilon_y = -1625\ \mu\text{m/m} \qquad \varepsilon_n = -1275\ \mu\text{m/m}$$

$$\sin\theta_n = 3/5 \qquad \cos\theta_n = 4/5$$

(a) $\varepsilon_n = (1950)\cos^2\theta_n + (-1625)\sin^2\theta_n + \gamma_{xy}\sin\theta_n\cos\theta_n = -1275$

$\gamma_{xy} = -4037.500\ \mu\text{rad} \cong -4040\ \mu\text{rad}$ .... **Ans.**

(b) $\varepsilon_{QR} = (1950)\cos^2(-\theta_n) + (-1625)\sin^2(-\theta_n) + (-4037.5)\sin(-\theta_n)\cos(-\theta_n)$

$\varepsilon_{QR} = 2600\ \mu\text{m/m}$ .... **Ans.**

3-36*

The given values are

$$\varepsilon_x = 900\ \mu\text{m/m} \qquad \varepsilon_y = 650\ \mu\text{m/m} \qquad \gamma_{xy} = 300\ \mu\text{rad}$$

$$\theta_p = \frac{1}{2}\tan^{-1}\frac{\gamma_{xy}}{\varepsilon_x - \varepsilon_y} = \frac{1}{2}\tan^{-1}\frac{(300)}{(900)-(650)} = 25.097°, \quad -64.903°$$

When $\theta_p = 25.097°$

$$\varepsilon_n = \varepsilon_x \cos^2\theta + \varepsilon_y \sin^2\theta + \gamma_{xy}\sin\theta\cos\theta$$

$$= (900)\cos^2\theta_p + (650)\sin^2\theta_p + (300)\sin\theta_p\cos\theta_p$$

$$= 970.256\ \mu\text{m/m} = \varepsilon_{p1}$$

$$\varepsilon_{p2} = \varepsilon_x + \varepsilon_y - \varepsilon_{p1} = 579.744\ \mu\text{m/m}$$

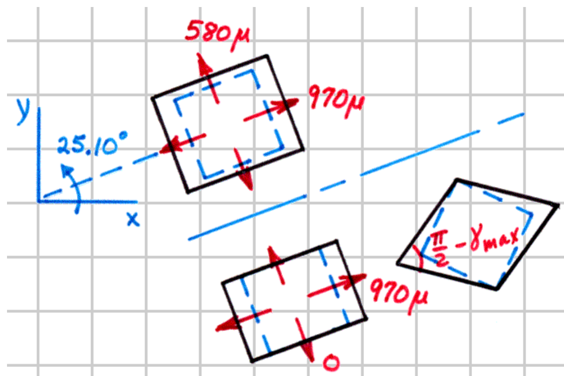
$$\gamma_p = \varepsilon_{p1} - \varepsilon_{p2} = 390.512\ \mu\text{rad}$$

$\varepsilon_{p1} = +970\ \mu\text{m/m}$ ∡ 25.10° .... **Ans.**

$\varepsilon_{p2} = +580\ \mu\text{m/m}$ ∡ 64.90° .... **Ans.**

$\varepsilon_{p3} = 0\ \mu\text{m/m}$ .... **Ans.**

$\gamma_p = 391\ \mu\text{rad}$ .... **Ans.**



$\gamma_{max} = \varepsilon_{max} - \varepsilon_{min} = 970 - 0 = 970\ \mu\text{rad}$ (out-of-plane) .... **Ans.**

3-45

The given values are

$$\varepsilon_y = -750\ \mu\text{in./in.} \qquad \gamma_{xy} = -750\ \mu\text{rad} \qquad \varepsilon_{p2} = -1500\ \mu\text{in./in.}$$

$$-1500 = \frac{\varepsilon_x + (-750)}{2} + \sqrt{\left[\frac{\varepsilon_x - (-750)}{2}\right]^2 + \left(\frac{-750}{2}\right)^2}$$

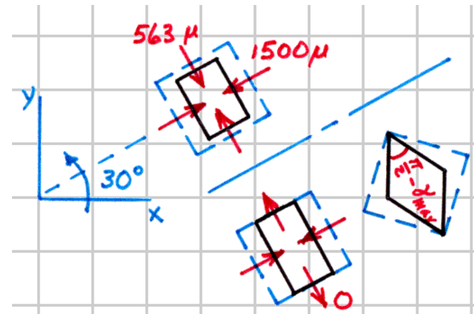
$\varepsilon_x = -1312.500\ \mu\text{in./in.} \cong -1313\ \mu\text{in./in.}$ .... **Ans.**

$$\theta_p = \frac{1}{2}\tan^{-1}\frac{\gamma_{xy}}{\varepsilon_x - \varepsilon_y} = \frac{1}{2}\tan^{-1}\frac{(-750)}{(-1312.5)-(-750)} = 26.565°, \quad -63.435°$$

$$\varepsilon_{p1} = \varepsilon_x + \varepsilon_y - \varepsilon_{p2} = -562.500\ \mu\text{in./in.}$$

$$\gamma_p = \varepsilon_{p1} - \varepsilon_{p2} = 937.500\ \mu\text{rad}$$

$$\gamma_{max} = \varepsilon_{max} - \varepsilon_{min} = (0) - (-1500) = 1500\ \mu\text{rad}$$



$\varepsilon_{p1} = -563\ \mu\text{in./in.}$ ∡ 63.43° .... **Ans.**

$\varepsilon_{p3} = 0\ \mu\text{in./in.}$ .... **Ans.**

$\gamma_p = 937\ \mu\text{rad}$ .... **Ans.**

$\gamma_{max} = 1500\ \mu\text{rad}$ (out-of-plane) .... **Ans.**

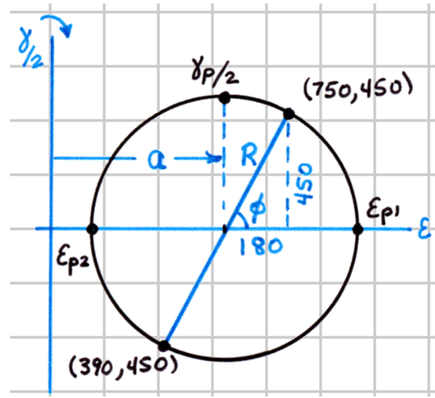
3-53

The given values for use in drawing Mohr's circle are

$$\varepsilon_x = 750\ \mu\text{in./in.}$$

$$\varepsilon_y = 390\ \mu\text{in./in.}$$

$$\gamma_{xy} = -900\ \mu\text{rad}$$

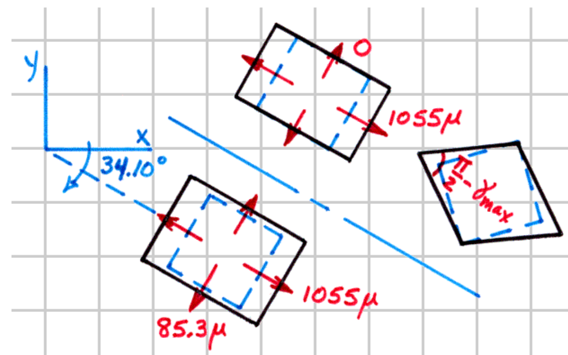


$$a = \frac{750+390}{2} = 570\ \mu\text{in./in.}$$

$$R = \sqrt{(180)^2 + (450)^2} = 484.66\ \mu\text{in./in.}$$

$$\theta_{p1} = \frac{\phi}{2} = \frac{1}{2}\tan^{-1}\frac{450}{180} = 34.100°\ \text{(CW)}$$

$$\varepsilon_{p1} = 570 + 484.66 = +1054.66\ \mu\text{in./in.}$$



$\varepsilon_{p1} \cong +1055\ \mu\text{in./in.}$ ↻ 34.10° .... **Ans.**

$$\varepsilon_{p2} = 570 - 484.66 = +85.34\ \mu\text{in./in.}$$

$\varepsilon_{p2} \cong +85.3\ \mu\text{in./in.}$ ↺ 55.90° .... **Ans.**

$\gamma_p = 2R = 969\ \mu\text{rad}$ .... **Ans.**

$\gamma_{max} = \varepsilon_{max} - \varepsilon_{min} = 1055 - 0 = 1055\ \mu\text{rad}$ (out-of-plane) .... **Ans.**

3-57

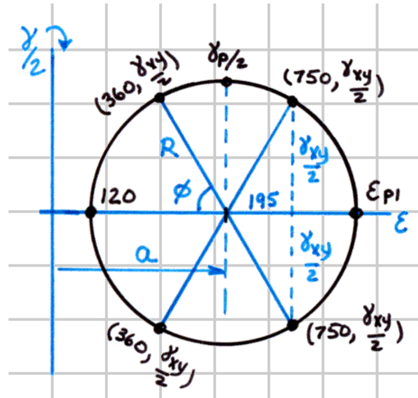
The given values for use in drawing Mohr's circle are

$$\varepsilon_x = 360\ \mu\text{in./in.}$$

$$\varepsilon_y = 750\ \mu\text{in./in.}$$

$$\varepsilon_{p2} = 120\ \mu\text{in./in.}$$

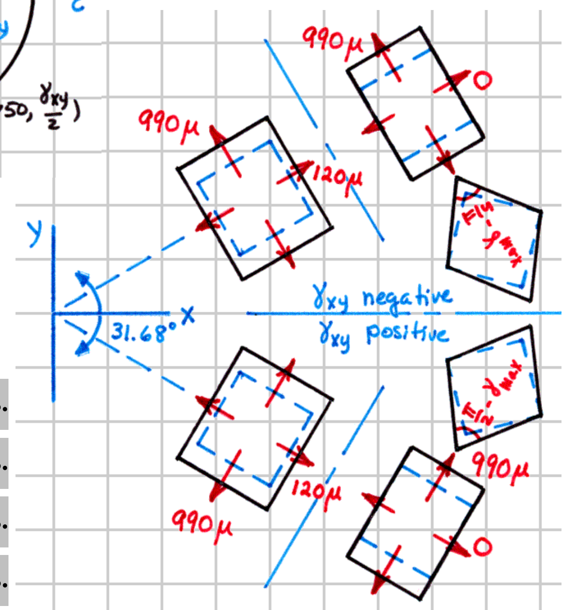
$$a = \frac{(360)+(750)}{2} = 555\ \mu\text{in./in.}$$



$$R = 555 - 120 = 435\ \mu\text{in./in.}$$

$$\theta_p = \frac{\phi}{2} = \frac{1}{2}\cos^{-1}\frac{195}{435} = 31.683°$$

$$\gamma_{xy} = 2(435)\sin 63.367°$$



$\gamma_{xy} = \pm 778\ \mu\text{rad}$ .... **Ans.**

$\varepsilon_{p1} = 555 + 435 = +990\ \mu\text{in./in.}$ .... **Ans.**

$\varepsilon_{p3} = 0\ \mu\text{in./in.}$ .... **Ans.**

$\gamma_p = 2R = 870\ \mu\text{rad}$ .... **Ans.**

$\gamma_{max} = \varepsilon_{max} - \varepsilon_{min} = 990 - 0 = 990\ \mu\text{rad}$ (out-of-plane) .... **Ans.**

3-66

(a) The given values are $\varepsilon_a = \varepsilon_x = 875\ \mu\text{m/m}$ $\quad \varepsilon_b = \varepsilon_{120°} = 700\ \mu\text{m/m}$

$\varepsilon_c = \varepsilon_{60°} = -650\ \mu\text{m/m}$ $\quad \nu = 0.33$

$$\varepsilon_n = \varepsilon_x \cos^2\theta + \varepsilon_y \sin^2\theta + \gamma_{xy}\sin\theta\cos\theta$$

$$\varepsilon_b = (875)\cos^2(120°) + \varepsilon_y \sin^2(120°) + \gamma_{xy}\sin(120°)\cos(120°) = 700$$

$$\varepsilon_c = (875)\cos^2(60°) + \varepsilon_y \sin^2(60°) + \gamma_{xy}\sin(60°)\cos(60°) = -650$$

$$0.75000\varepsilon_y - 0.43301\gamma_{xy} = 481.25$$

$$0.75000\varepsilon_y + 0.43301\gamma_{xy} = -868.75$$

$$\varepsilon_y = -258.333\ \mu\text{m/m}$$

$$\gamma_{xy} = -1558.846\ \mu\text{rad}$$

$$\theta_p = \frac{1}{2}\tan^{-1}\frac{\gamma_{xy}}{\varepsilon_x - \varepsilon_y} = \frac{1}{2}\tan^{-1}\frac{(-1558.846)}{(875)-(-258.333)}$$

$$= -26.991°,\quad 63.009°$$

When $\theta_p = -26.991°$

$$\varepsilon_n = (875)\cos^2\theta_p + (-258.333)\sin^2\theta_p + (-1558.846)\sin\theta_p\cos\theta_p$$

$$= 1271.978\ \mu\text{m/m} = \varepsilon_{p1}$$

$$\varepsilon_{p2} = \varepsilon_x + \varepsilon_y - \varepsilon_{p1} = -655.312\ \mu\text{m/m}$$

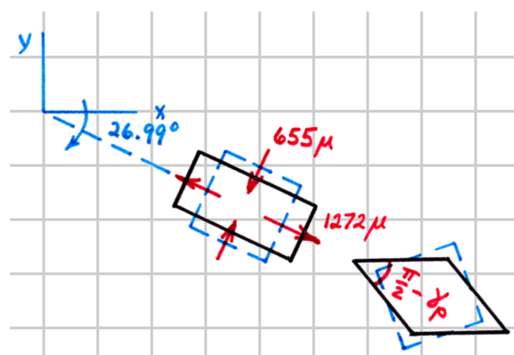
$$\varepsilon_{p3} = \varepsilon_z = \frac{-\nu}{1-\nu}(\varepsilon_x + \varepsilon_y) = \frac{-0.33}{1-0.33}\left[(875)+(-258.333)\right] = -303.732\ \mu\text{m/m}$$

$\varepsilon_{p1} = +1272\ \mu\text{m/m}$ ↘ $26.99°$ .... **Ans.**

$\varepsilon_{p2} = -655\ \mu\text{m/m}$ ↗ $63.01°$ .... **Ans.**

$\varepsilon_{p3} = -304\ \mu\text{m/m}$ .... **Ans.**

$\gamma_{max} = \gamma_p = \varepsilon_{p1} - \varepsilon_{p2} = 1927\ \mu\text{rad}$ .... **Ans.**



(b) $$\gamma_{nt} = -2(\varepsilon_x - \varepsilon_y)\sin\theta\cos\theta + \gamma_{xy}(\cos^2\theta + \sin^2\theta)$$

$$= -2\left[(875)-(258.333)\right]\sin(40°)\cos(40°)$$

$$+(-1558.846)\left[\cos^2(40°)+\sin^2(40°)\right]$$

$\gamma_{nt} = -1387\ \mu\text{rad}$ .... **Ans.**

3-75

The given values are $\varepsilon_a = \varepsilon_x = 600\ \mu\text{in./in.}$ $\varepsilon_b = \varepsilon_{45^\circ} = 500\ \mu\text{in./in.}$

$\varepsilon_c = \varepsilon_y = -200\ \mu\text{in./in.}$ $\nu = 0.30$

$$\varepsilon_n = \varepsilon_x \cos^2\theta + \varepsilon_y \sin^2\theta + \gamma_{xy}\sin\theta\cos\theta$$

$$\varepsilon_b = (600)\cos^2(45^\circ) + (-200)\sin^2(45^\circ) + \gamma_{xy}\sin(45^\circ)\cos(45^\circ) = 500$$

$$\gamma_{xy} = 600.00\ \mu\text{rad}$$

$$\theta_p = \frac{1}{2}\tan^{-1}\frac{\gamma_{xy}}{\varepsilon_x - \varepsilon_y} = \frac{1}{2}\tan^{-1}\frac{(600)}{(600)-(-200)} = 18.435^\circ, \quad -71.565^\circ$$

When $\theta_p = 18.435^\circ$

$$\varepsilon_n = (600)\cos^2\theta_p + (-200)\sin^2\theta_p + (600)\sin\theta_p\cos\theta_p$$
$$= 700.00\ \mu\text{in./in.} = \varepsilon_{p1}$$

$$\varepsilon_{p2} = \varepsilon_x + \varepsilon_y - \varepsilon_{p1} = -300.00\ \mu\text{in./in.}$$

$\varepsilon_{p1} = +700\ \mu\text{in./in.}$ ∡ 18.43° .... **Ans.**

$\varepsilon_{p2} = -300\ \mu\text{in./in.}$ ∡ 71.57° .... **Ans.**

$\varepsilon_{p3} = \varepsilon_z = \dfrac{-\nu}{1-\nu}(\varepsilon_x + \varepsilon_y) = \dfrac{-0.30}{1-0.30}\left[(600)+(-200)\right] = -171.4\ \mu\text{in./in.}$ .... **Ans.**

$\gamma_{max} = \gamma_p = \varepsilon_{p1} - \varepsilon_{p2} = 1000\ \mu\text{rad}$ .... **Ans.**