

Mechanics of Materials



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Ferdinand P.Beer, E.Russel Johnston, Jr., John T.Dewolf

Other Reference:

J.Wat Oler “Lectures notes on Mechanics od Materials”

Ibrahim A.Assakkaf “Lectures notes on Mechanics od Materials”

Homework-06

By: Kaveh Karami

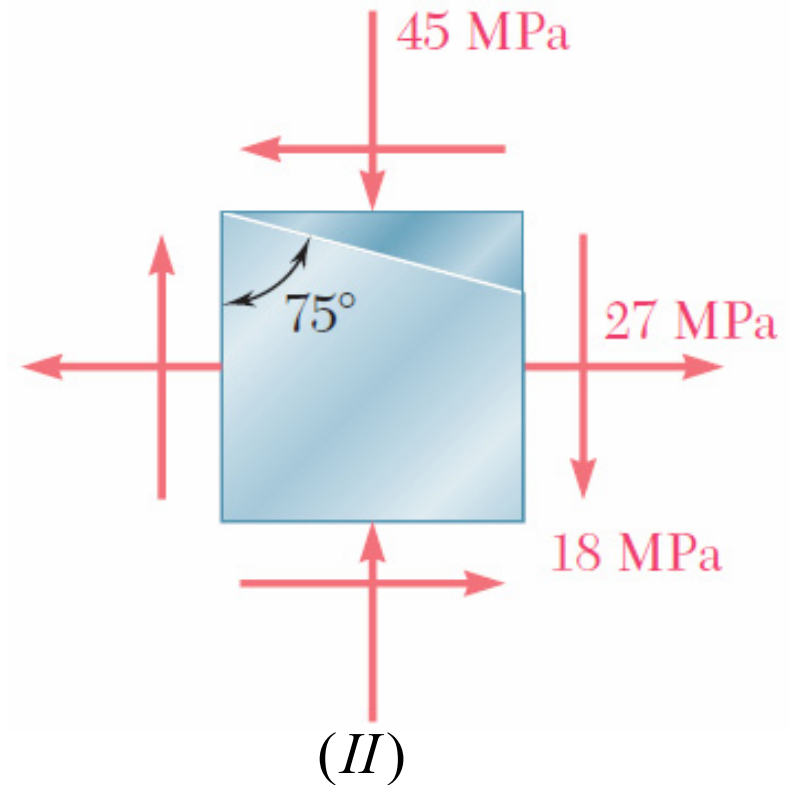
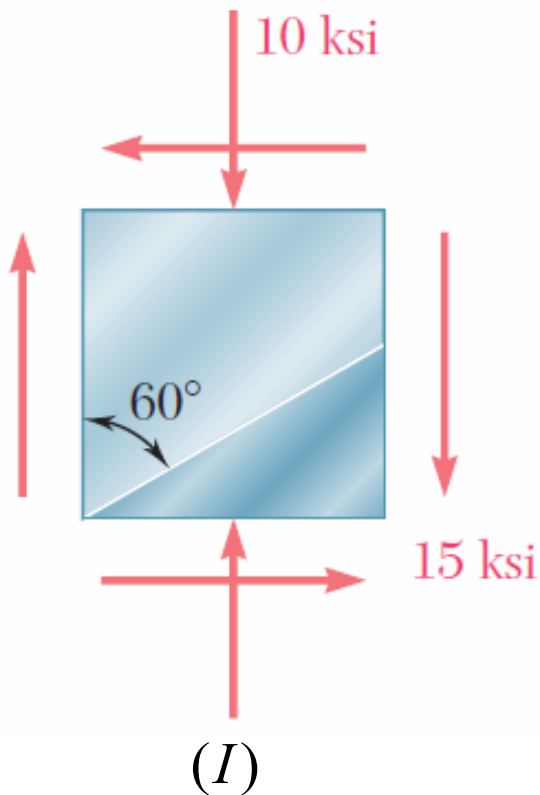
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Homework-06

□ Problem 01

For the given state of stress, determine the normal and shearing stresses exerted on the oblique face of the shaded triangular element shown.

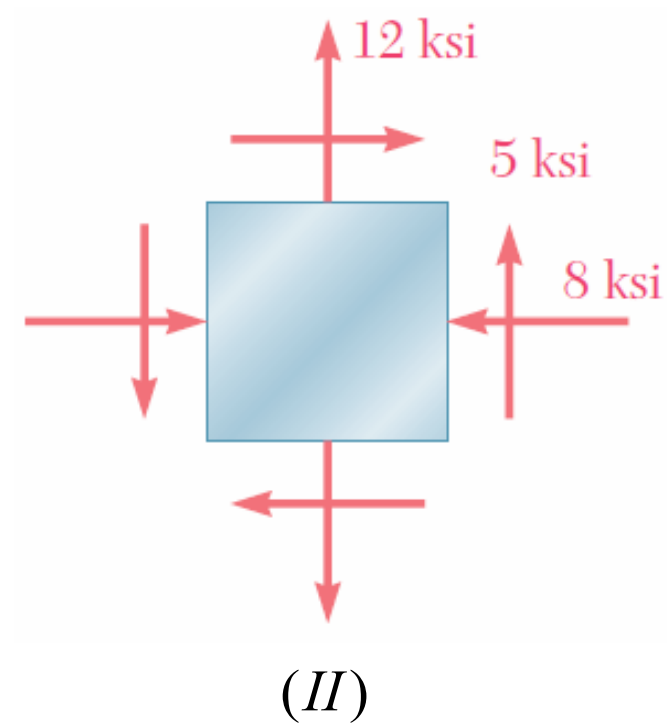
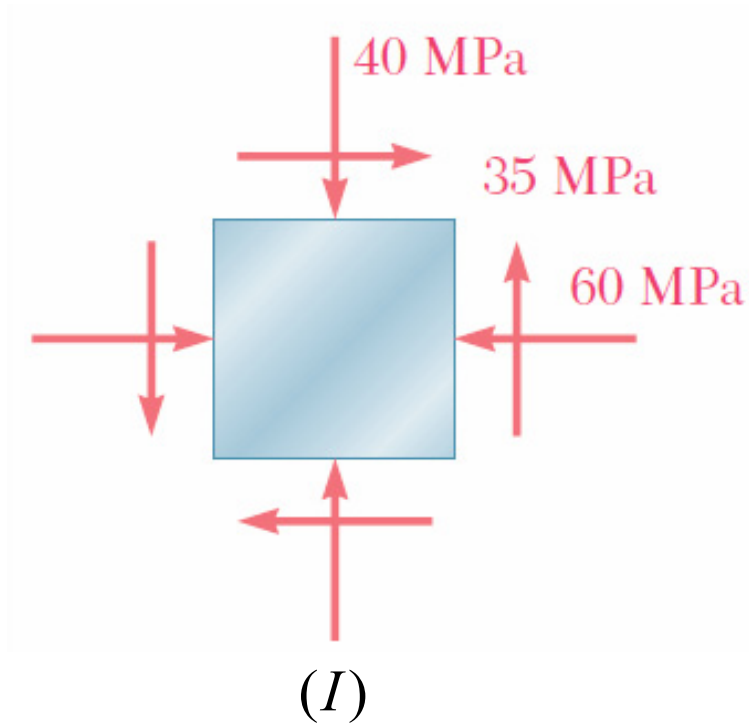


Key Answer: I. $\sigma = 5.49 \text{ ksi}$; $\tau = 11.83 \text{ ksi}$.
II. $\sigma = -49.2 \text{ Mpa}$; $\tau = 2.41 \text{ Mpa}$.

Homework-06

□ Problem 02

For the given state of stress, determine (a) the principal planes, (b) the principal stresses.

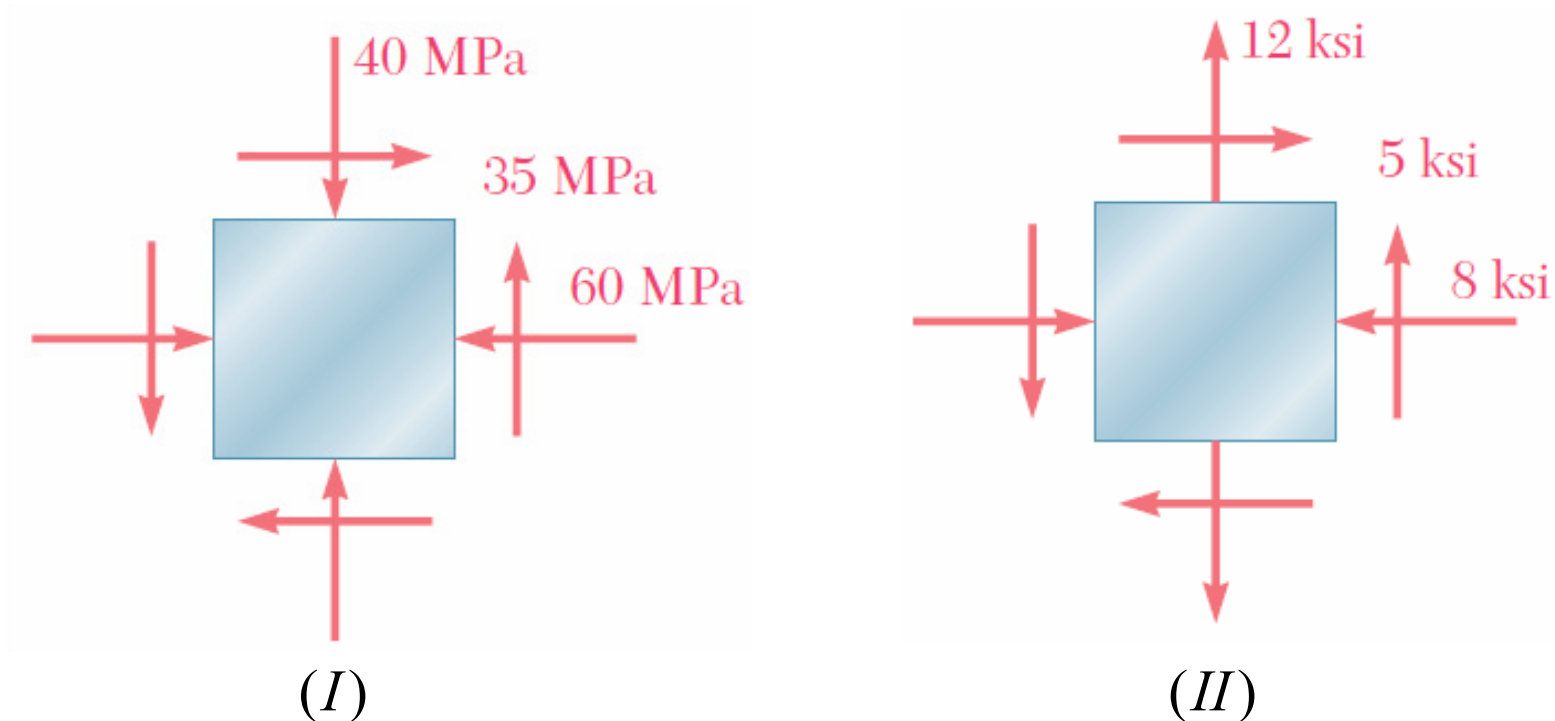


Key Answer: I. (a) -37.0° , 53.0° (b) -13.60 Mpa , -86.4 Mpa

Homework-06

□ Problem 03

For the given state of stress, determine (a) the orientation of the planes of maximum in-plane shearing stress, (b) the maximum in-plane shearing stress, (c) the corresponding normal stress.



Key Answer:

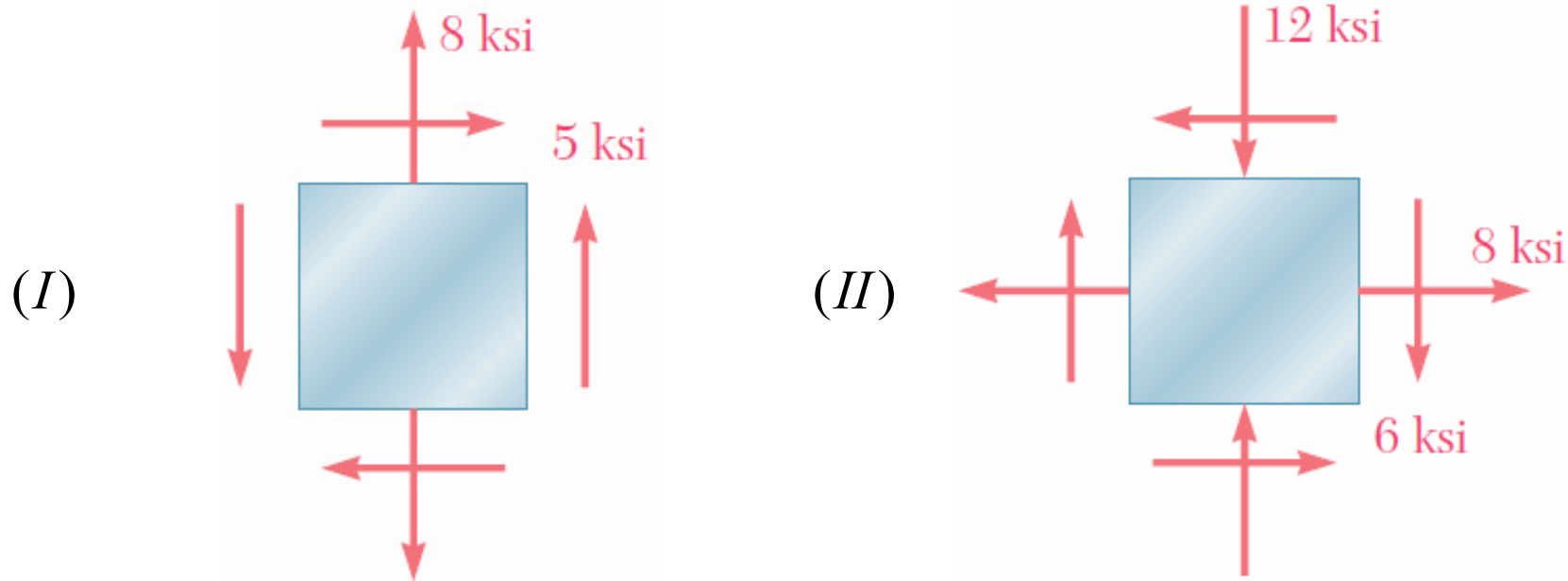
I. (a) 8.0° , 98.0° (b) 36.4Mpa , -50.0Mpa

II. (a) 31.7° , 121.7° (b) 11.18ksi , 2.00ksi

Homework-06

□ Problem 04

For the given state of stress, determine the normal and shearing stresses after the element shown has been rotated through (a) 25° clockwise, (b) 10° counterclockwise.



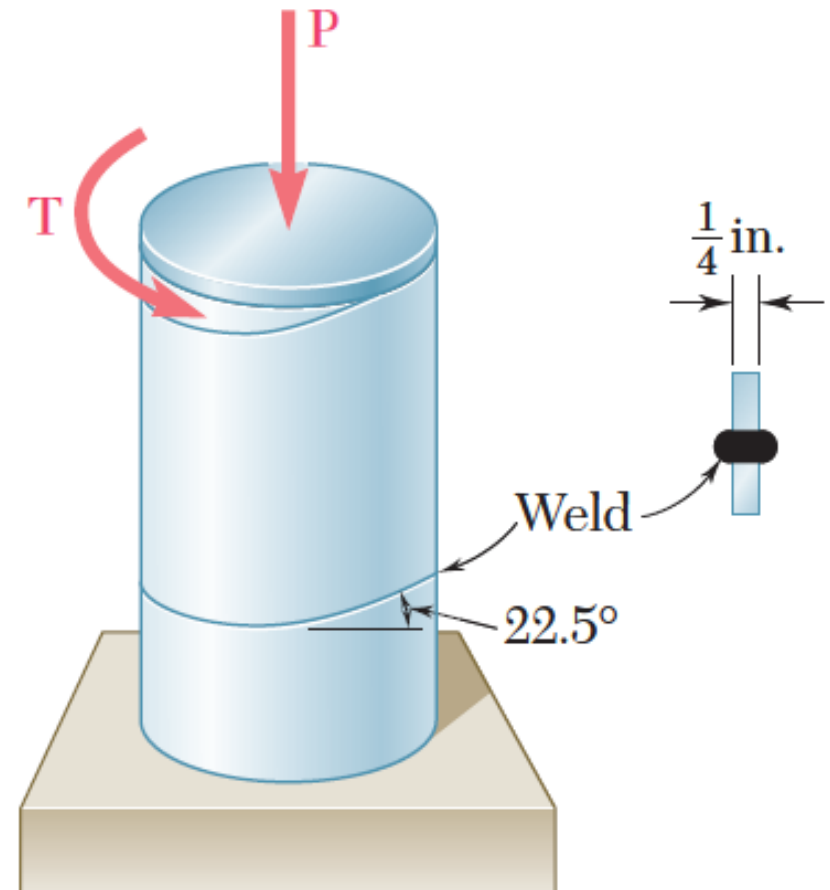
Key Answer:

$$I. \begin{cases} (a) & \sigma_{x'} = -2.40 \text{ ksi} ; \tau_{x'y'} = 0.15 \text{ ksi} ; \sigma_{y'} = 10.40 \text{ ksi} \\ (b) & \sigma_{x'} = 1.95 \text{ ksi} ; \tau_{x'y'} = 6.07 \text{ ksi} ; \sigma_{y'} = 6.05 \text{ ksi} \end{cases}$$
$$II. \begin{cases} (a) & \sigma_{x'} = 9.02 \text{ ksi} ; \tau_{x'y'} = 3.80 \text{ ksi} ; \sigma_{y'} = -13.02 \text{ ksi} \\ (b) & \sigma_{x'} = 5.34 \text{ ksi} ; \tau_{x'y'} = -9.06 \text{ ksi} ; \sigma_{y'} = -9.34 \text{ ksi} \end{cases}$$

Homework-06

□ Problem 05

A steel pipe of 12-in. outer diameter is fabricated from 14-in.-thick plate by welding along a helix that forms an angle of 22.5° with a plane perpendicular to the axis of the pipe. Knowing that a 40-kip axial force P and an 80-kip.in. torque T , each directed as shown, are applied to the pipe, determine σ and τ in directions, respectively, normal and tangential to the weld.

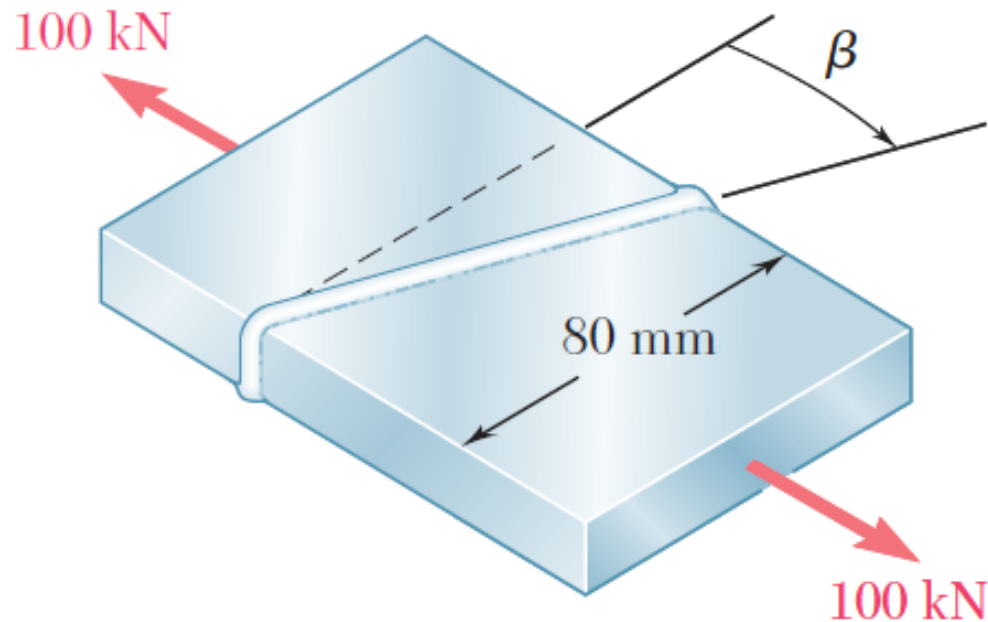


Key Answer: $\sigma = -4.76 \text{ ksi}$; $\tau = -0.467 \text{ ksi}$.

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□ Problem 06

Two steel plates of uniform cross section 10×80 mm are welded together as shown. Knowing that centric 100-kN forces are applied to the welded plates and that $\beta = 25^\circ$, determine (a) the in-plane shearing stress parallel to the weld, (b) the normal stress perpendicular to the weld.



Key Answer:

(a) 47.9 Mpa ; (b) 102.7 Mpa

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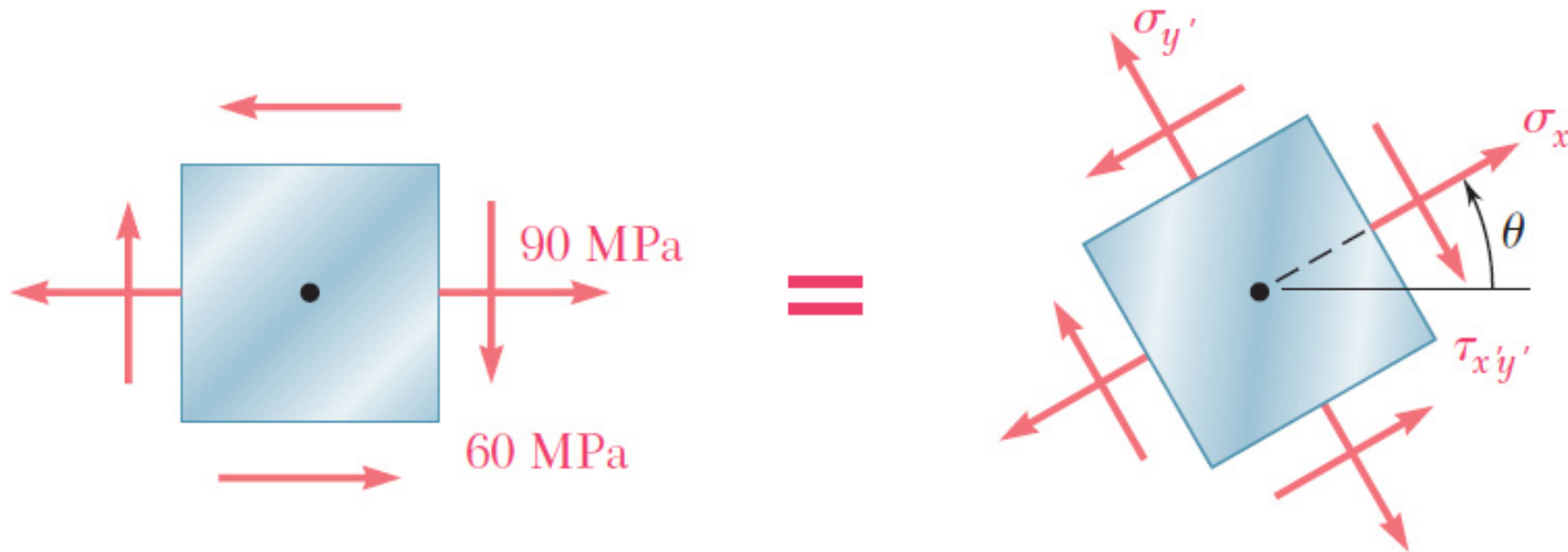
□ Problem 07

Solve Problems 1 , 2 , 3
using Mohr's circle.

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□ Problem 08

For the state of stress shown, determine the range of values of θ for which the normal stress $\sigma_{x'}$ is equal to or less than 50 MPa.

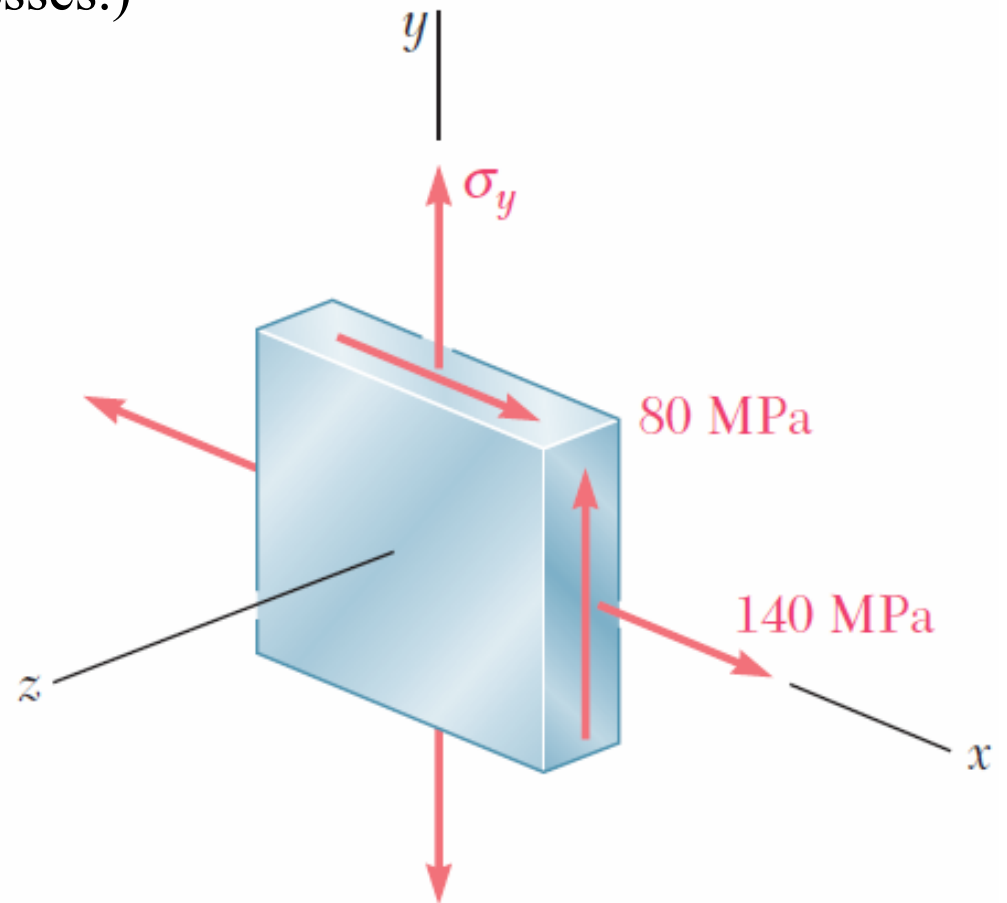


Key Answer: $16.5^\circ \leq \theta \leq 110.1^\circ$

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□ Problem 09

For the state of stress shown, determine the maximum shearing stress when (a) $\sigma_y = 40$ MPa, (b) $\sigma_y = 120$ MPa. (Hint: Consider both in-plane and out-of-plane shearing stresses.)

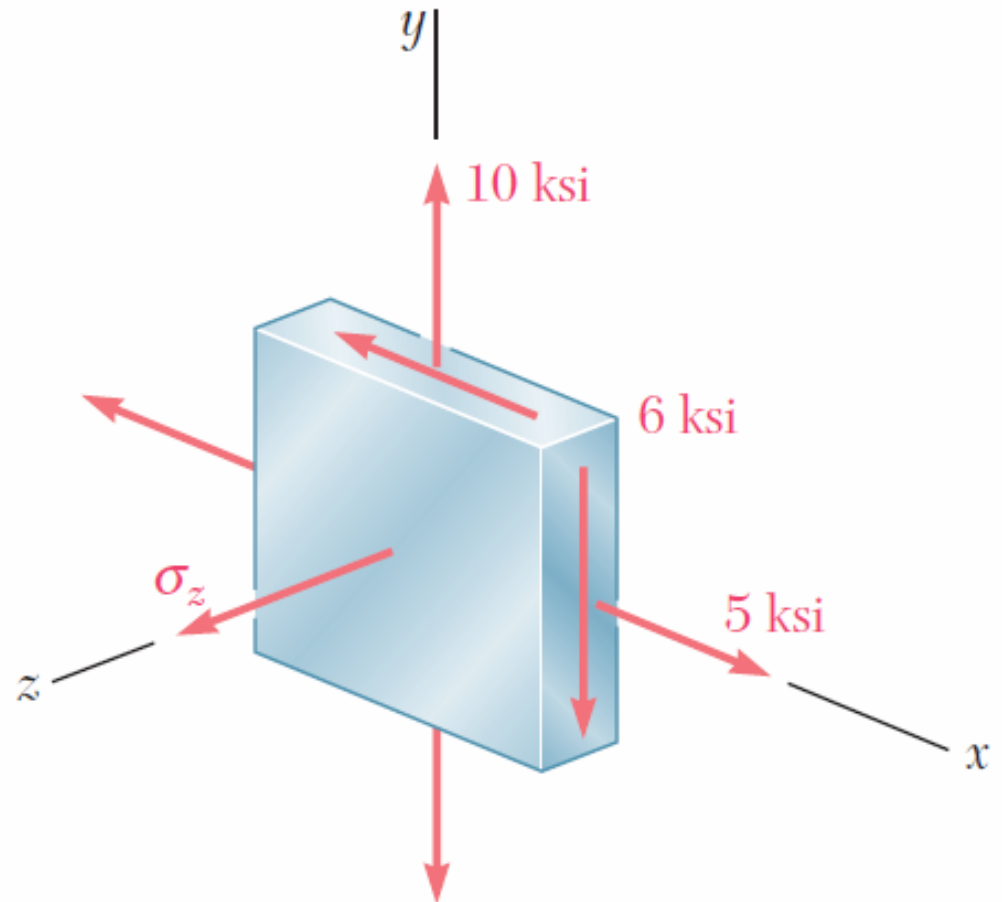


Key Answer: (a) 94.3 Mpa . (b) 105.3 Mpa

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□ Problem 10

For the state of stress shown, determine the maximum shearing stress when (a) $\sigma_z = +4$ ksi, (b) $\sigma_z = -4$ ksi, (c) $\sigma_z = 0$.



Key Answer: (a) 6.50ksi. (b) 9.00 ksi. (c) 7.00 ksi.

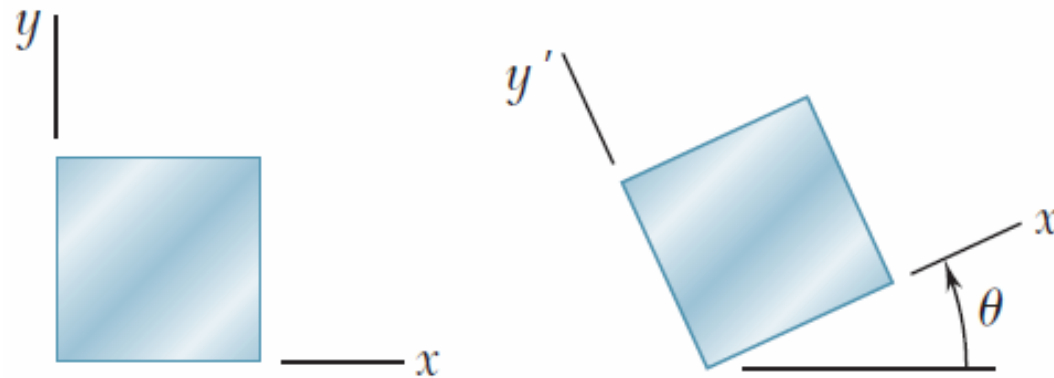
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□ Problem 11

For the given state of plane strain, determine the state of plane strain associated with axes x' and y' rotated through the given angle θ .

(a) $\varepsilon_x = -500\mu$, $\varepsilon_y = 250\mu$, $\gamma_{xy} = 0$, $\theta = 15^\circ$

(b) $\varepsilon_x = 0$, $\varepsilon_y = 320\mu$, $\gamma_{xy} = -100\mu$, $\theta = 30^\circ$



Key Answer:

(a) $\varepsilon_{x'} = -450\mu$, $\varepsilon_{y'} = 199.8\mu$, $\gamma_{x'y'} = 375\mu$

(b) $\varepsilon_{x'} = 36.7\mu$, $\varepsilon_{y'} = 283\mu$, $\gamma_{x'y'} = 227\mu$

Homework-06

□ Problem 12

The following state of strain has been measured on the surface of a thin plate. Knowing that the surface of the plate is unstressed, determine (a) the direction and magnitude of the principal strains, (b) the maximum in-plane shearing strain, (c) the maximum shearing strain. (Use $\nu = \frac{1}{3}$)

$$(I) \varepsilon_x = -260\mu, \varepsilon_y = -60\mu, \gamma_{xy} = 480\mu$$

$$(II) \varepsilon_x = 30\mu, \varepsilon_y = 570\mu, \gamma_{xy} = 720\mu$$

Key Answer:

$$(I) (a) 33.7^\circ, 56.3^\circ; -420\mu, 100\mu, 160\mu, (b) 520\mu, (c) 580\mu$$

$$(II) (a) -26.6^\circ, 64.4^\circ; -150\mu, 750\mu, -300\mu, (b) 900\mu, (c) 1050\mu$$

Homework-06

□ Problem 13

For the given state of plane strain, use Mohr's circle to determine (a) the orientation and magnitude of the principal strains, (b) the maximum in-plane strain, (c) the maximum shearing strain.

$$(I) \ \varepsilon_x = 60\mu, \ \varepsilon_y = 240\mu, \ \gamma_{xy} = -50\mu$$

$$(II) \ \varepsilon_x = -180\mu, \ \varepsilon_y = -260\mu, \ \gamma_{xy} = 315\mu$$

Key Answer:

$$(I) \ (a) \ 7.8^\circ, \ 97.8^\circ; \ 56.6\mu, \ 243\mu, \ 0, \ (b) \ 186.8\mu, \ (c) \ 243\mu$$

$$(II) \ (a) \ 37.9^\circ, \ 127.9^\circ; \ -57.5\mu, \ -383\mu, \ 0, \ (b) \ 325\mu, \ (c) \ 383\mu$$

Homework-06

□ Problem 14

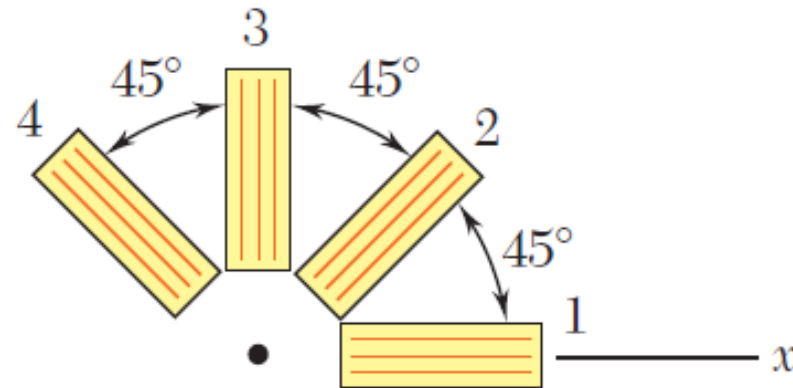
The rosette shown has been used to determine the following strains at a point on the surface of a crane hook:

$$\varepsilon_1 = 420 \times 10^{-6} \text{ in/in}$$

$$\varepsilon_2 = -45 \times 10^{-6} \text{ in/in}$$

$$\varepsilon_4 = 165 \times 10^{-6} \text{ in/in}$$

(a) What should be the reading of gage 3? (b) Determine the principal strains and the maximum in-plane shearing strain.



Key Answer:

(a) $-300 \times 10^{-6} \text{ in/in}$ (b) $435 \times 10^{-6} \text{ in/in}$, $-315 \times 10^{-6} \text{ in/in}$, $750 \times 10^{-6} \text{ in/in}$.

Homework-06

□ Problem 15

A centric axial force P and a horizontal force Q_x are both applied at point C of the rectangular bar shown. A 45° strain rosette on the surface of the bar at point A indicates the following strains:

$$\varepsilon_1 = -60 \times 10^{-6} \text{ in/in}$$

$$\varepsilon_2 = -240 \times 10^{-6} \text{ in/in}$$

$$\varepsilon_3 = 200 \times 10^{-6} \text{ in/in}$$

Knowing that $E = 29 \times 10^6 \text{ psi}$ and $\nu = 0.3$, determine the magnitudes of P and Q_x .

Key Answer: $P = 69.6 \text{ kips}$; $Q = 30.3 \text{ kips}$.

