Mechanics of Materials

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

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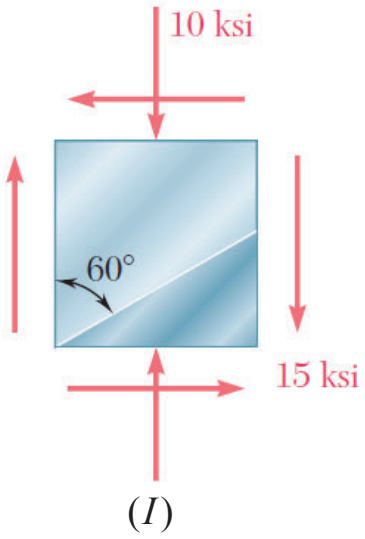
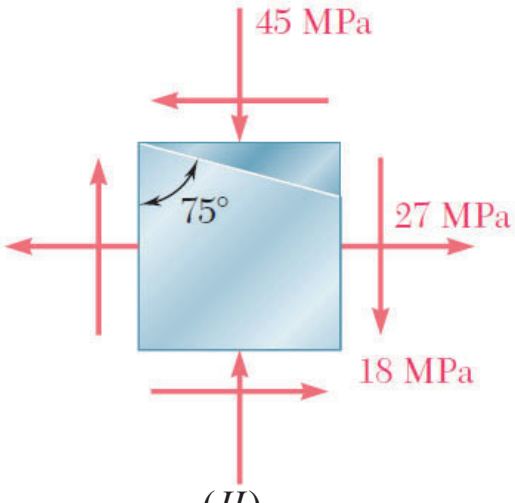
Homework-06

❑ 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.



(*I*)



(*II*)

Key Answer:

I. $\sigma = 5.49\ ksi\ ;\ \tau = 11.83\ ksi.$

II. $\sigma = -49.2\ Mpa\ ;\ \tau = 2.41\ Mpa.$

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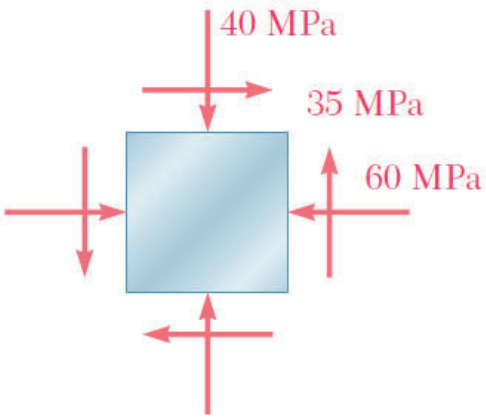
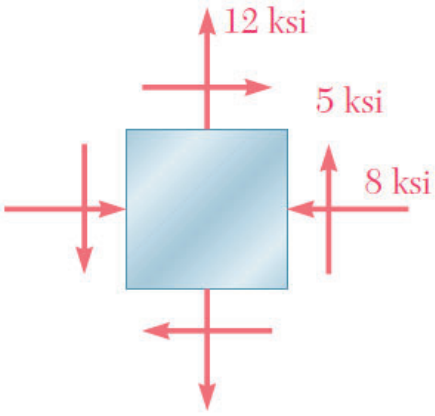
❑ Problem 02

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



(I)



(II)

Key Answer: $I.\quad (a)-37.0^{o}\ ,53.0^{o}\quad (b)-13.60Mpa\ ,-86.4Mpa$

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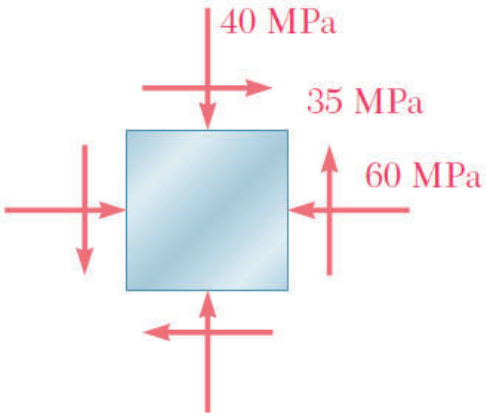
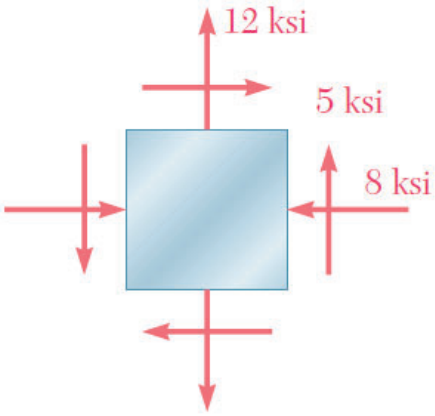
❑ Problem 03

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.



(I)



(II)

Key Answer:

$I.\quad (a)\ 8.0^{o}\ ,98.0^{o}\quad (b)\ 36.4Mpa\ ,-50.0Mpa$

$II.\quad (a)\ 31.7^{o}\ ,121.7^{o}\quad (b)\ 11.18ksi\ ,2.00ksi$

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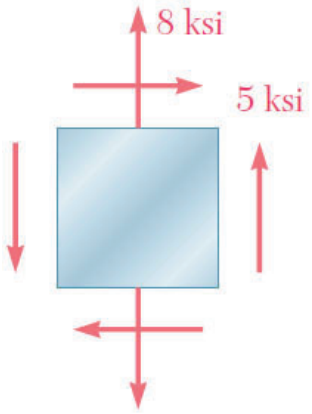
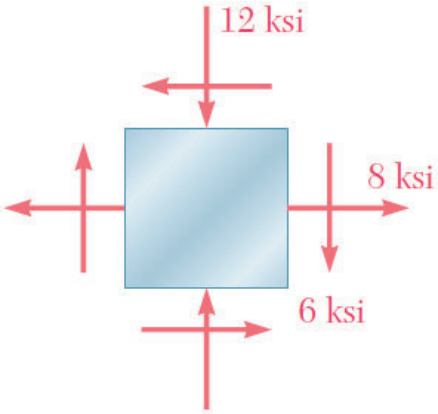
❑ Problem 04

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

(I)



(II)



Key Answer:

$$I.\begin{cases}(a)\quad \sigma_{x'} = -2.40\ ksi\ ;\ \tau_{x'y'} = 0.15\ ksi\ ;\ \sigma_{y'} = 10.40\ ksi \\ (b)\quad \sigma_{x'} = 1.95\ ksi\ ;\ \tau_{x'y'} = 6.07\ ksi\ ;\ \sigma_{y'} = 6.05\ ksi\end{cases}$$

$$II.\begin{cases}(a)\quad \sigma_{x'} = 9.02\ ksi\ ;\ \tau_{x'y'} = 3.80\ ksi\ ;\ \sigma_{y'} = -13.02\ ksi \\ (b)\quad \sigma_{x'} = 5.34\ ksi\ ;\ \tau_{x'y'} = -9.06\ ksi\ ;\ \sigma_{y'} = -9.34\ ksi\end{cases}$$

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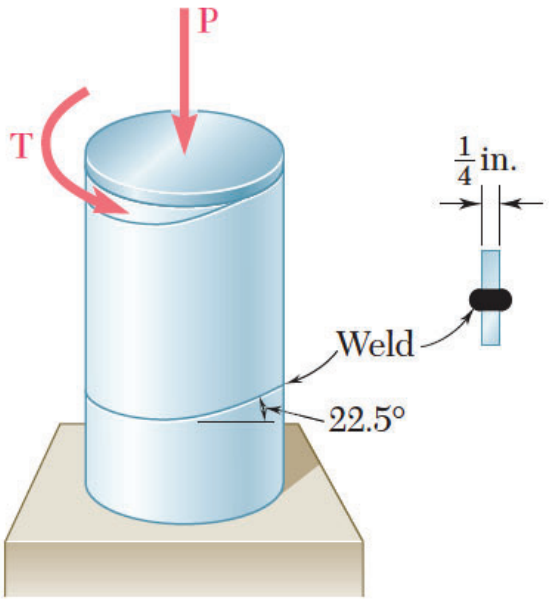
❑ Problem 05

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^o 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: $\sigma = -4.76\ ksi\ ;\ \tau = -0.467\ ksi\ .$

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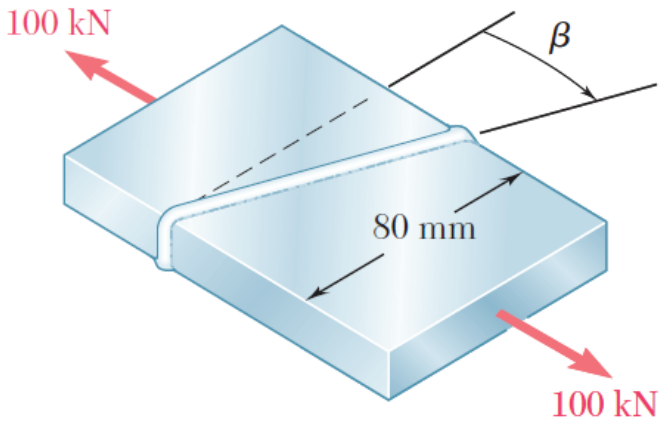
❑ Problem 06

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 $\beta = 25^o$, 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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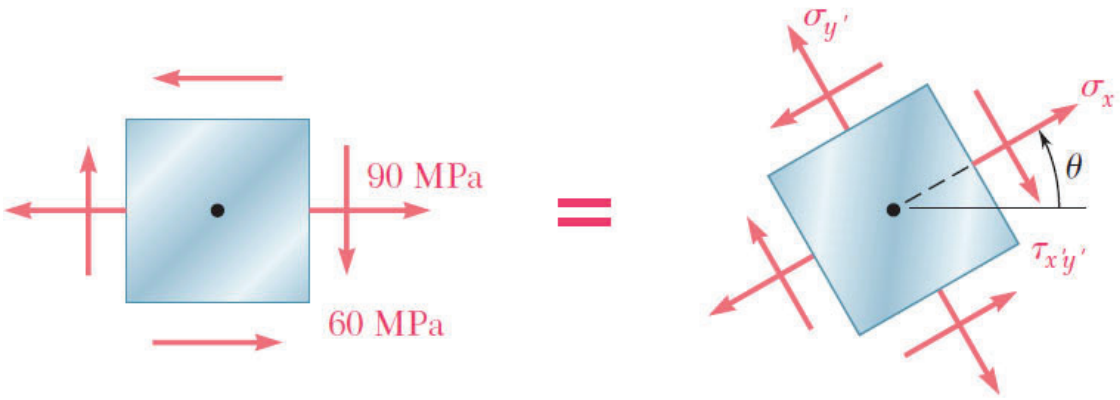
❑ Problem 08

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: $16.5^o \le \theta \le 110.1^o$

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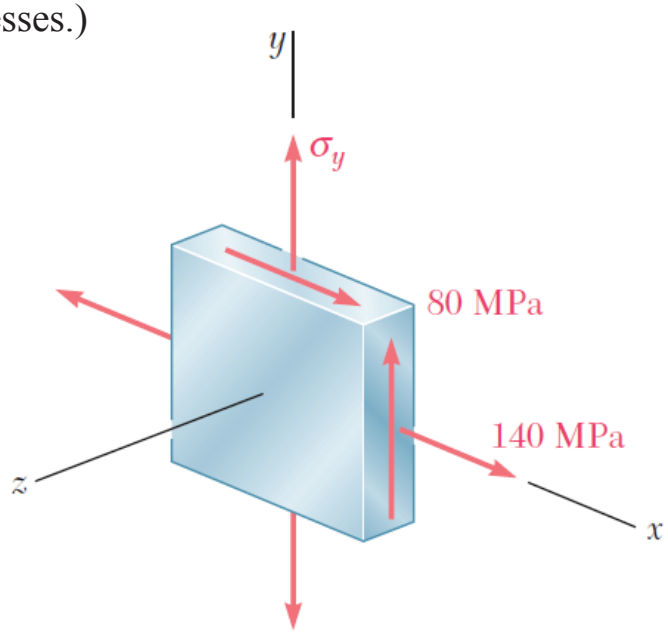
❑ Problem 09

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



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

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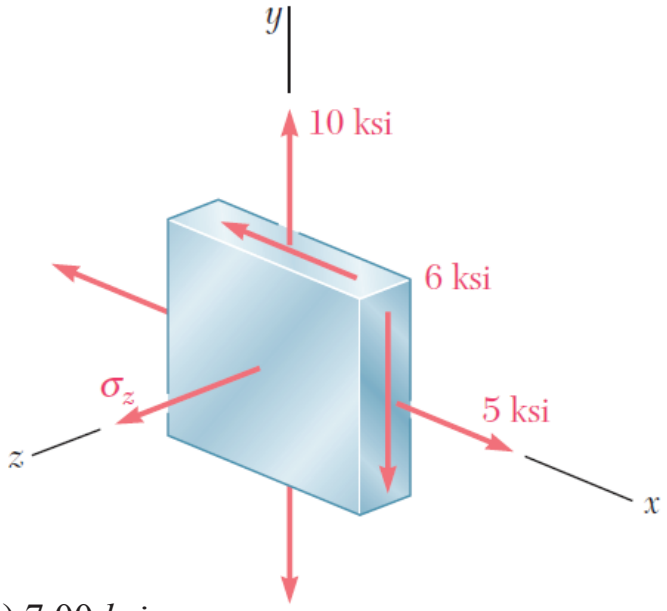
❑ Problem 10

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



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

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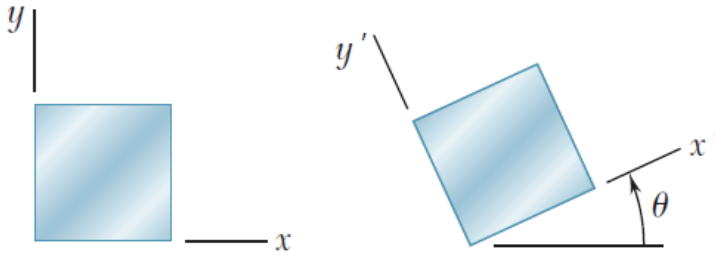
❑ Problem 11

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*) $\varepsilon_x = -500\mu$, $\varepsilon_y = 250\mu$, $\gamma_{xy} = 0$, $\theta = 15^o$

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



Key Answer:

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

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

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❑ 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 $\upsilon = \frac{1}{3}$)

$$(I)\ \varepsilon_x = -260\mu\ ,\ \varepsilon_y = -60\mu\ ,\ \gamma_{xy} = 480\mu$$
$$(II)\ \varepsilon_x = 30\mu\ ,\ \varepsilon_y = 570\mu\ ,\ \gamma_{xy} = 720\mu$$

Key Answer:

$$(I)\ (a)\ 33.7^o\ ,\ 56.3^o\ ;\ -420\mu\ ,\ 100\mu\ ,\ 160\mu\ ,\ (b)\ 520\mu\ ,\ (c)\ 580\mu$$
$$(II)\ (a)\ -26.6^o\ ,\ 64.4^o\ ;\ -150\mu\ ,\ 750\mu\ ,\ -300\mu\ ,\ (b)\ 900\mu\ ,\ (c)\ 1050\mu$$

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❑ 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:

$$(I)\ (a)\ 7.8^o\ ,\ 97.8^o\ ;\ 56.6\mu\ ,\ 243\mu\ ,\ 0\ ,\ (b)\ 186.8\mu\ ,\ (c)\ 243\mu$$
$$(II)\ (a)\ 37.9^o\ ,\ 127.9^o\ ;\ -57.5\mu\ ,\ -383\mu\ ,\ 0\ ,\ (b)\ 325\mu\ ,\ (c)\ 383\mu$$

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❑ Problem 14

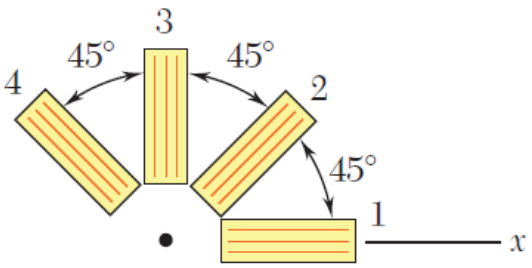
The rosette shown has been used to determine the following strains at a point on the surface of a crane hook:

$$\varepsilon_1 = 420\times10^{-6}\ in/in$$

$$\varepsilon_2 = -45\times10^{-6}\ in/in$$

$$\varepsilon_4 = 165\times10^{-6}\ in/in$$

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



Key Answer:

$(a)\ -300\times10^{-6}\ in/in\ (b)\ 435\times10^{-6}\ in/in\ ,-315\times10^{-6}\ in/in\ ,750\times10^{-6}\ in/in.$

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❑ Problem 15

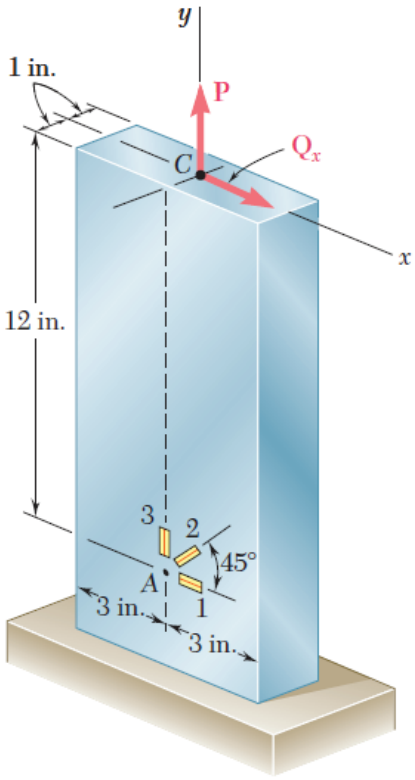
A centric axial force P and a horizontal force Q_x are both applied at point C of the rectangular bar shown. A 45^o strain rosette on the surface of the bar at point A indicates the following strains:

$$\varepsilon_1 = -60\times10^{-6}\ in/in$$

$$\varepsilon_2 = -240\times10^{-6}\ in/in$$

$$\varepsilon_3 = 200\times10^{-6}\ in/in$$

Knowing that $E = 29\times10^{6}\ psi$ and $v = 0.3$, determine the magnitudes of P and Q_x.



Key Answer: P =69.6 kips; Q =30.3 kips.