Name..Student I.D................................

Department of Mining and Materials Engineering

Faculty of Engineering

Prince of Songkla University

Mid-term Exam for Semester: 2 Academic Year: 2013

Date: January 5, 2014 Time: 09.00-12.00

Subject: 237-221 Mechanical Behavior of Materials Room: S817

Instruction

1. There are 4 problem sets. Please do all of them. Write your answers in the space provided. If you need more space, you can write on the back of paper.
2. Text books, course notes and other studying materials are not allowed.
3. Dictionary, calculator, and stationery are allowed.
4. This mid-term exam is accounted for 25% of the total grade.

Asst. Prof. Dr. Thawatchai Plookphol

Problem No.	Full Score	Student's Score
1.	25	
2.	25	
3.	25	
4.	25	
Total	100	

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1. Please explain the following terms:
   1.1 Isotropic material (5 points)

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   1.2 Homogenous material (5 points)

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   1.3 Hook's law (5 points)

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   1.4 Plane stress condition (5 points)

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   1.5 Principal stress (5 points)

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2. A 3-D state of stress is given by

$$\overline{\overline{\sigma}} = \begin{bmatrix} 100 & 50 & 0 \\ 50 & 200 & 0 \\ 0 & 0 & -100 \end{bmatrix} \text{ MPa.}$$

Determine the following:

2.1 The three principal stresses (15 points)

2.2 The maximum shear stress (5 points)

2.3 Draw 3-D Mohr's circles from the principal stresses and label the principal stresses and the maximum shear stress (5 points)

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3. A spherical pressure vessel made of steel (E = 200 GPa, ν = 0.3) has a radius (r) of 0.5 m and wall thickness (t) of 4×10^{-3} m. A strain gage was attached on the outer surface of the vessel in the circumferential direction. The strain gage indicates $\varepsilon_1 = \varepsilon_2 = 0.0002$.
Based on the theory of elasticity,
3.1 Calculate the internal pressure (p) in the vessel. (15 points)
3.2 Determine the radial strain (ε_3). (5 points)
3.3 Estimate the thickness of the vessel at the internal pressure p. (5 points)

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4. Nickel single crystal has compliance (S) constants of

$S_{11} = 7.3$ TPa^{-1}
$S_{12} = -2.7$ TPa^{-1}
$S_{44} = 8.0$ TPa^{-1}.

4.1 Calculate Young's modulus (E) in the [100] and [111] directions. (20 points)
4.2 What conclusion can be drawn from the result in 4.1? (5 points)

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Formula

For 3-D stress:

$$\det\begin{bmatrix} \sigma-\sigma_{xx} & -\tau_{yx} & -\tau_{zx} \\ -\tau_{xy} & \sigma-\sigma_{yy} & -\tau_{zy} \\ -\tau_{xz} & -\tau_{yz} & \sigma-\sigma_{zz} \end{bmatrix}=0$$

$$I_1=\sigma_{xx}+\sigma_{yy}+\sigma_{zz}$$

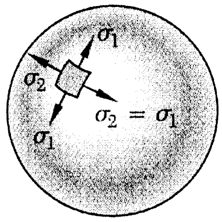
$$I_2=\sigma_{xx}\sigma_{yy}+\sigma_{yy}\sigma_{zz}+\sigma_{zz}\sigma_{xx}-\tau_{xy}^2-\tau_{yz}^2-\tau_{zx}^2$$

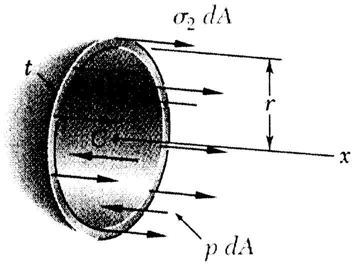
$$I_3=\sigma_{xx}\sigma_{yy}\sigma_{zz}+2\tau_{xy}\tau_{yz}\tau_{zx}-\sigma_{xx}\tau_{yz}^2-\sigma_{yy}\tau_{zx}^2-\sigma_{zz}\tau_{xy}^2$$

$$\sigma^3-I_1\sigma^2+I_2\sigma-I_3=0$$

For thin-walled spherical pressure vessel, plane stress condition is assumed,

$$\sigma_3=0,\ \varepsilon_3\neq 0$$





$$\sigma_1=\sigma_2=\frac{pr}{2t}$$

$$\sigma_3=0$$

where,

p = internal pressure

r = radius

t = thickness

From the theory of elasticity,

$$\varepsilon_1=\frac{1}{E}(\sigma_1-\nu\sigma_2)$$

$$\varepsilon_2=\frac{1}{E}(\sigma_2-\nu\sigma_1)$$

$$\varepsilon_3=-\frac{\nu(\sigma_1+\sigma_2)}{E}$$

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For a cubic crystal:

$$\frac{1}{E} = S_{11} - 2\left[(S_{11} - S_{22}) - \frac{1}{2}S_{44}\right](l^2m^2 + m^2n^2 + l^2n^2)$$

Direction cosines :

$$l = \frac{x}{\sqrt{(x^2 + y^2 + z^2)}}$$

$$m = \frac{y}{\sqrt{(x^2 + y^2 + z^2)}}$$

$$n = \frac{z}{\sqrt{(x^2 + y^2 + z^2)}}$$