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

Department of Mining and Materials Engineering

Faculty of Engineering

Prince of Songkla University

Mid-term Examination for Semester: 2 Academic Year: 2004

Date: December 20, 2004 Time: 13.30-16.30

Subject: 237-508 Structures and Mechanical Properties of Materials Room: R300

Instruction

1. There are 2 problem sets. Please do both of them and write your answers on the space provided after each problem set. If you need more space, you can write the answer on the back of the problem set.
2. Only two (2) pieces of A4-size note are allowed. You may write on both sides of them. Please return them with your answers.
3. Dictionary, calculator, and stationery are also allowed.
4. Text books and other studying materials are not allowed.
5. This mid-term exam is accounted for 30% of the total grade point.

Dr. Thawatchai Plookphol

Problem No.	Full Score (points)	Student's Score (points)
1.	30	
2.	30	
Total	60	

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1. The 3-D stress state is given below

$$\sigma_{ij} = \begin{bmatrix} 8 & 0 & -4 \\ 0 & 12 & 0 \\ -4 & 0 & 2 \end{bmatrix} \quad \text{MPa.}$$

(a) Determine the principal stresses. (15 points)

(b) On a particular plane with normal $\hat{n} = \frac{1}{\sqrt{6}}\hat{x}_1 + \frac{1}{\sqrt{6}}\hat{x}_2 + \frac{2}{\sqrt{6}}\hat{x}_3$, calculate the normal stress (σ) and shear stress (τ) acting on this plane. (15 points)

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

Where, $I_1 = \sigma_{11} + \sigma_{22} + \sigma_{33}$

$$I_2 = (\sigma_{11}\sigma_{22} - \sigma_{12}\sigma_{21}) + (\sigma_{22}\sigma_{33} - \sigma_{23}\sigma_{32}) + (\sigma_{11}\sigma_{33} - \sigma_{13}\sigma_{31})$$

$$I_3 = \sigma_{11}(\sigma_{22}\sigma_{33} - \sigma_{23}\sigma_{32}) + \sigma_{21}(\sigma_{13}\sigma_{32} - \sigma_{12}\sigma_{33}) + \sigma_{31}(\sigma_{12}\sigma_{23} - \sigma_{13}\sigma_{22})$$

$$\overline{S} = \overline{\overline{\sigma}} \cdot \hat{n} \quad \text{or} \quad S_i = \sum_{j=1}^{3} \sigma_{ij} n_j$$

$$S^2 = S_1^2 + S_2^2 + S_3^2$$

$$\sigma = S_1 \cdot n_1 + S_2 \cdot n_2 + S_3 \cdot n_3$$

$$S^2 = \sigma^2 + \tau^2$$

Where,

S = Total stress acting on the plane,
σ = Normal stress acting on the plane,
τ = Shear stress acting on the plane,
n_1, n_2, n_3 are direction cosines.

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2. A copper single crystal (cubic) experiences the stress state

$$\sigma_{ij} = \begin{bmatrix} 10 & -8 & 4 \\ -8 & 20 & 0 \\ 4 & 0 & 5 \end{bmatrix} \text{ MPa}$$

Some elastic constants of copper are given below

$$E_{11} = 66.7 \text{ GPa}, \qquad G_{12} = 75.2 \text{ GPa}, \qquad \nu_{12} = 0.42$$

(a) Determine the compliance matrix $[S]$ (i.e. compliance tensor) (15 points)
(b) Determine the engineering strain in the copper sample by assuming deformation is linear elastic. (15 points)

Hint: $S_{11} = \frac{1}{E_{11}}, \qquad S_{12} = -\frac{\nu_{12}}{E_{11}}, \qquad S_{44} = \frac{1}{G_{12}}$

$$[\varepsilon] = [S][\sigma] \qquad \text{or}$$

$$\varepsilon_{ij} = S_{ijkl}\sigma_{kl}$$

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