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: 2011

Date: December 22, 2011 Time: 9.00-12.00

Subject: 237-508 Structures and Mechanical Properties of Materials Room: S203

Instructions

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 and other studying materials are not allowed.
3. Dictionary, calculator, and stationery are also allowed.
4. This mid-term exam is counted for 25% of the total grade.

Asst. Prof. Dr. Thawatchai Plookphol

Problem No.	Full Score (points)	Student's Score (points)
1.	20	
2.	40	
3.	10	
4.	10	
Total	80	

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1. Explain the following terms:

1.1 Homogenous solid (2 points)

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1.2 Isotropic solid (2 points)

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1.3 Anisotropic solid (2 points)

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1.4 Principal stress (2 points)

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1.5 Stress invariant (2 points)

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1.6 Fatigue endurance limit (2 points)

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1.7 Low cycle fatigue (2 points)

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1.8 High cycle fatigue (2 points)

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1.9 Threshold stress intensity factor range (2 points)

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1.10 Paris' law (2 points)

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2. The three-dimensional state of stress is given by

$$\overline{\overline{\sigma}} = \begin{bmatrix} 8 & 0 & -4 \\ 0 & 12 & 0 \\ -4 & 0 & 2 \end{bmatrix} \text{ MPa.}$$

2.1 Determine the three principal stresses. (15 points)
2.2 Calculate the maximum shear stress. (5 points)
2.3 Determine the normal stress (σ) and shear stress (τ) acting on a plane with normal $\bar{n} = \left(\frac{1}{\sqrt{6}}, \frac{1}{\sqrt{6}}, \frac{2}{\sqrt{6}}\right)$. (20 points)

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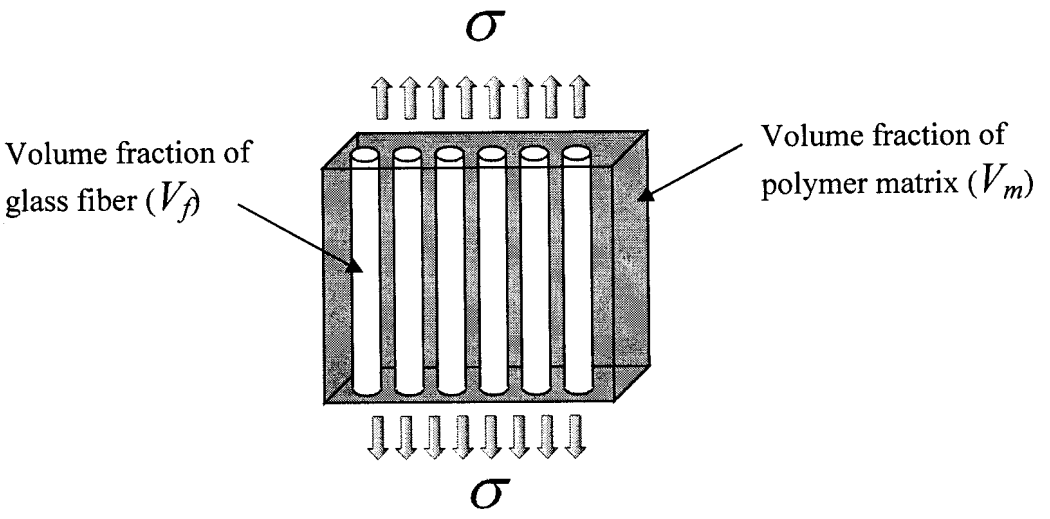
3. A glass fiber reinforced polymer (GFRP) composite model is shown in the figure below.



σ is the applied stress,

σ_m is the stress in the polymer matrix,

σ_f is the stress in the glass fiber,

ε is the total strain of the composite,

ε_m is the strain of the polymer matrix, and

ε_f is the strain of the glass fiber.

3.1 Write an equilibrium equation of stress. (5 points)

3.2 Write a compatibility equation of strain. (5 points)

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4. Explain the kinetic processes of grain boundary sliding in crystalline solid in term of equilibrium and compatibility equations (10 points)

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Formula

For 3-D stress:

$$det\begin{bmatrix} \sigma_{11}-\sigma & \sigma_{12} & \sigma_{13} \\ \sigma_{21} & \sigma_{22}-\sigma & \sigma_{23} \\ \sigma_{31} & \sigma_{32} & \sigma_{33}-\sigma \end{bmatrix} = 0$$

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

where,

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

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

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

$$\overline{S} = \overline{\overline{\sigma}} \cdot \hat{n}$$

$$S_i = \sum_{j=1}^{3} \sigma_{ij} n_j$$

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

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

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

where,

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