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: 2010

Date: December 19, 2010 Time: 09.00-12.00

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

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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. | 30 | |
| 2. | 10 | |
| 3. | 20 | |
| 4. | 30 | |
| Total | 90 | |

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1. Tensile test data of aluminum alloy is given by

| | |
|---|---|
| Original gage length ($l_0$): | 50 mm |
| Original gage diameter ($D_0$): | 10 mm |
| Max load: | 20,000 N |
| Extension at max load: | 5 mm |
| Load at failure: | 15,000 N |
| Extension at failure: | 7 mm |

Calculate the following:

1.1 Ultimate tensile strength (UTS). (5 points)

1.2 Engineering strain at max load. (5 points)

1.3 True stress and true strain at max load. (10 points)

1.4 Tensile strength at failure. (5 points)

1.5 Ductility in term of % elongation. (5 points)

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2. The 2-D state of stress is given by

$$\begin{bmatrix} \sigma_x & \tau_{xy} \\ \tau_{yx} & \sigma_y \end{bmatrix} = \begin{bmatrix} 270 & 320 \\ 320 & -210 \end{bmatrix} \text{ MPa}$$

Determine the shear stress $\tau_{y'x'}$ for the $x'$ axis inclined at $\theta = 30^\circ$ to the $x$ axis. (10 points)

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3. The 3-D state of stress is given by

$$\overline{\overline{\sigma}} = \begin{bmatrix} 0 & 0 & 300 \\ 0 & -400 & 0 \\ 300 & 0 & -800 \end{bmatrix} \text{ MPa.}$$

Determine the following:

3.1 The three principal stresses (15 points)

3.2 The maximum shear stress (5 points)

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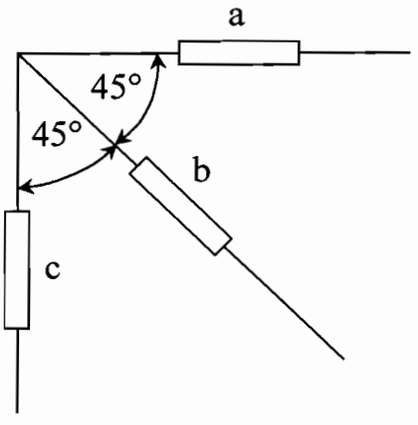
4. In a nylon part, the normal strains at a free surface are measured along the three directions as shown below:




$$\varepsilon_a = 0.1\times10^{-3}$$
$$\varepsilon_b = -0.2\times10^{-3}$$
$$\varepsilon_c = 0.4\times10^{-3}$$

4.1 Draw Mohr's circle of strain (10 points)
4.2 Determine the principal strains and their directions (15 points);
4.3 Examine the magnitude of the greatest shear strain (5 points).

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# Formula

For 2-D state of stress (Stress on oblique plane or plane stress)

$$\sigma_{x'x'} = \frac{\sigma_{xx} + \sigma_{yy}}{2} + \frac{\sigma_{xx} - \sigma_{yy}}{2} \cos 2\theta + \tau_{xy} \sin 2\theta$$

$$\sigma_{y'y'} = \frac{\sigma_{xx} + \sigma_{yy}}{2} - \frac{\sigma_{xx} - \sigma_{yy}}{2} \cos 2\theta - \tau_{xy} \sin 2\theta$$

$$\tau_{x'y'} = \frac{\sigma_{yy} - \sigma_{xx}}{2} \sin 2\theta + \tau_{xy} \cos 2\theta$$

$$\sigma_{\max,\min} = \sigma_{1,2} = \left( \frac{\sigma_{xx} + \sigma_{yy}}{2} \right) \pm \sqrt{\left( \frac{\sigma_{xx} - \sigma_{yy}}{2} \right)^2 + \left( \tau_{xy} \right)^2}$$

$$\tan 2\theta = \frac{2\tau_{xy}}{(\sigma_{xx} - \sigma_{yy})}$$

For 3-D state of stress:

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

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

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

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