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

Department of Mining and Materials Engineering
Faculty of Engineering
Prince of Songkla University

Final Examination for Semester: 2
Academic Year: 2011
Date: February 24, 2012
Time: 09.00-12.00
Subject: 237-508 Structures and Mechanical Properties of Materials
Room: R200

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 and course notes are not allowed.
3. Dictionary, calculator and stationery are allowed.
4. This final exam is counted for 30% of the total grade.

Asst. Prof. Dr. Thawatchai Plookphol

Problem No.	Full Score (points)	Student's Score (points)
1.	10	
2.	20	
3.	20	
4.	50	
Total	100	

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1. Explain the following terms:

1.1 Work hardening (2 points)

1.2 High cycle fatigue (2 points)

1.3 Paris' law (2 points)

1.4 Power-law creep (2 points)

1.5 Diffusional creep (2 points)

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2. A plate made of high strength steel is subjected to constant amplitude uniaxial fatigue load to produce stresses varying from σ_{max} = 200 MPa and σ_{min} = 50 MPa. The properties of steel are σ_{UTS} = 800 MPa and K_{IC} = 90 MPa$\sqrt{\text{m}}$. If the plate contains an initial through thickness edge crack of 1 mm, how many fatigue cycle will be required to break the plate. (20 points)

The fatigue crack growth data (Paris' law) is given by

$$\frac{da}{dN} = 1.2\times10^{-11}\left(\Delta K\right)^{2.7}$$

and

$$N_f = \frac{a_f^{-(p/2)+1} - a_i^{-(p/2)+1}}{\left(-\frac{p}{2}+1\right) A\sigma_r^p \pi^{p/2}\alpha^p}$$

At failure: $$K_{IC} = \alpha\sigma_{max}\sqrt{\pi a_f}$$

For an infinite wide plate, $\alpha = 1.12$

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3. An engineering component made of heat-resisting Fe-Cr-Ni-Co alloy S-590 is subjected to service temperature of 600 °C. The working life of the component was designed for 100,000 hours. According to the Larson-Miller data shown in Figure 3 below, what is the maximum stress the component can carry? (20 points)

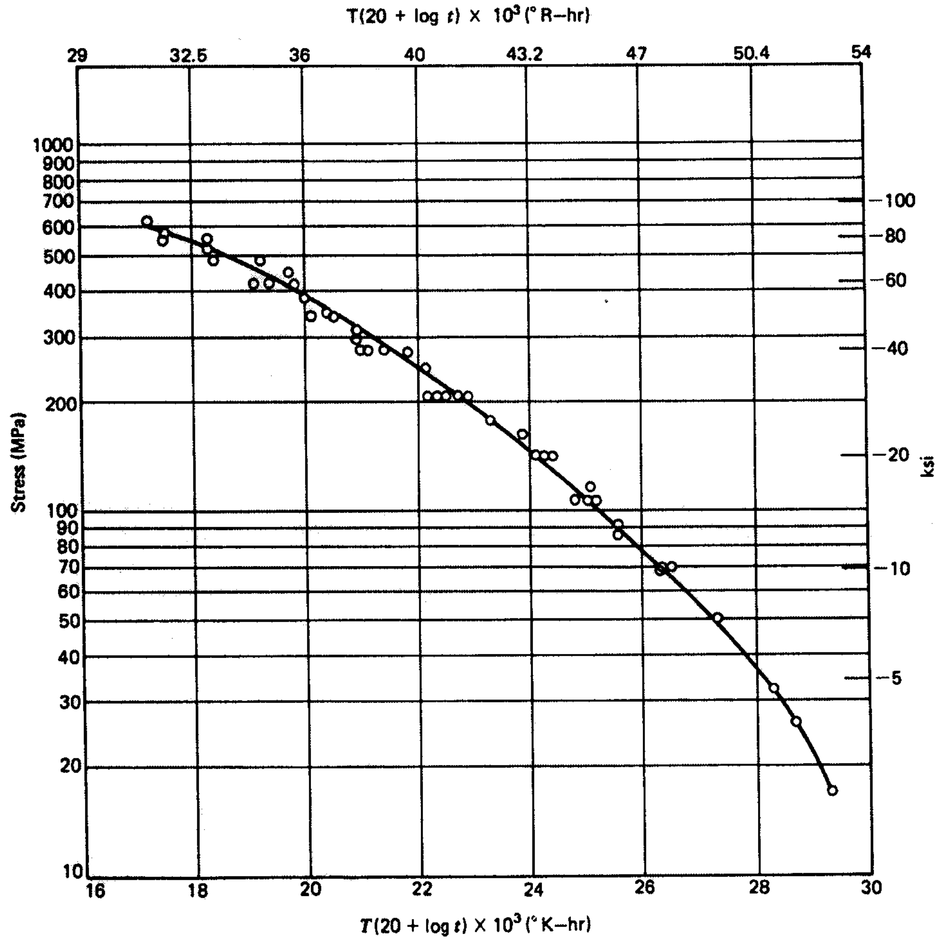

Figure 3 Larson-Miller Plot of Alloy S-590

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4. Result from creep tests of 7075-T651 aluminum alloy are shown in the tables below

Data from creep experiments performed at constant temperature, $T = 473$ K.

Creep Stress, σ (MPa)	Minimum Creep Rate, $\dot{\varepsilon}_{ss}$ (1/s)
80	3.5×10^{-8}
100	4.9×10^{-8}
120	1.6×10^{-7}
140	4.5×10^{-7}
160	6.5×10^{-7}

Data from creep experiments performed at constant stress, $\sigma = 100$ MPa.

Creep temperature, T (K)	Minimum Creep Rate, $\dot{\varepsilon}_{ss}$ (1/s)
423	3.6×10^{-9}
473	4.9×10^{-8}
523	6.1×10^{-6}

According to the power-law creep, the steady state creep rate can be expressed by

$$\dot{\varepsilon}_{ss} = A\sigma^n \exp(-\frac{Q_c}{RT})$$

where, A is the material constant,

σ is the creep stress,

n is the creep stress exponent,

Q_c is the activation energy for creep,

R is the universal gas constant (8.314 J/mole·K), and

T is the absolute temperature.

4.1 Determine the values of n and Q_c. (40 points)

4.2 What creep mechanism is dominant? Please explain (10 points)

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