Uva Wellassa University, Sri Lanka
End Semester Examination – September 2011

SCT 342-2 Structural Properties of Materials

Time: Two (02) hours

Total 05 Questions
Answer **four (04)** questions only

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01). i. What is meant by the mechanical behaviour of a material?

ii. How can the term *elastic deformation* be explained from an atomic perspective?

iii. A 380 mm long cylindrical rod having a diameter of 10 mm, is to be subjected to a tensile load. The rod is to experience neither plastic deformation nor an elongation of more than 0.9 mm when the applied load is 24,500 N. Which of the four materials listed below are possible candidates? Justify your choice.

Material	**Yield strength (MPa)**	**Modulus of elasticity (GPa)**
Copper	250	110
Aluminum alloy	255	70
Brass alloy	345	100
Steel aloy	450	207

iv. Explain the terms *nonlinear elastic behaviour* and *anelasticity* of materials.

(25 Marks)

02). i. Label *Elastic region, Plastic region, Proportional limit, Tensile strength, Region of the neck formation and Fracture point (F)* in a typical Engineering Stress-Engineering Strain plot.

ii. A cylindrical specimen of steel having an original diameter of 1.5 cm is tensile tested to fracture and found to have an engineering fracture strength of 460 MPa. If its cross-sectional diameter at fracture is 1.17 cm, calculate the ductility (in terms of percent reduction in area) and the true stress at fracture.

iii. What is toughness? Explain how to determine toughness of a material at *static (low strain rate) loading* conditions.

iv. What can be the impact of temperature increase on the *yield strength, tensile strength, modulus of elasticity* and *ductility* of a material?

(25 Marks)

03). i. Explain why *ductile fracture* is more preferred over the *brittle fracture* in application of materials.

ii Make a rough sketch to show the *variation of impact energy with temperature* (a typical curve for ductile to brittle transition) for steel showing this transition.

iii. What is *fractography*? What are the main information regarding fracture mechanisms that can be obtained from *fractographs*?

iv. Give an expression showing the relationship between the stress concentration factor and the geometrical factors of a surface crack. Calculate the fracture strength of a brittle material provided that the fracture occurs by the propagation of an elliptically shaped surface crack of length 0.83 mm and having a tip radius of curvature of 4.7 μm when a stress of 1GPa is applied.

(25 Marks)

04). i. What is *fatigue failure*? Explain the three distinct stages of *fatigue failure*.

ii. With the help of a rough sketch of a S–N curve explain the terms *Fatigue limit, Fatigue strength* and *Fatigue life.*

iii. Explain the three main stages of *creep mechanism* giving reasons for the typical behavior under each stage.

iv. A creep test was conducted for an alloy under a constant applied stress level at two different temperature levels of 800 K and 1100 K. The steady-state creep rates were 7.05×10^{-7} s^{-1} and 9.88×10^{-5} s^{-1} at 800 K and 1100 K, respectively. If the gas constant is 8.31 J mol^{-1} K^{-1}, calculate the activation energy for creep.

(25 Marks)

05). i. Draw a rough sketch to show the temperature dependence of the *heat capacity at constant volume (C_v)* for a solid material. Explain why C_v rises with increasing temperature at temperatures near 0 K.

ii. Briefly discuss the contributions from *lattice vibration* and *free electrons* to the thermal conductivity of *metals* and *nonmetals*.

iii. Express the relationship among the *Thermal Shock Resistance Parameter (TSR), fracture strength, coefficient of linear expansion, modulus of elasticity* and *thermal conductivity.* Based on this relation, what do you propose in order to acquire a material with higher resistance to *thermal shock.*

iv. A machine part is made from a metal rod with its axial motion restrained by rigid end supports. If the metal rod is stress free at 0 ^{0}C, what is the maximum temperature to which the rod can be heated without exceeding a compressive stress of 200 MPa. For this metal, the modulus of elasticity is 100 GPa and the magnitude of the linear coefficient of thermal expansion is 1.0×10^{-5} $^0C^{-1}$.

(25 Marks)