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University of Ruhuna- Faculty of Technology

Bachelor of Engineering Technology Honours
Level 2 (Semester I) Examination, June/July 2023
Academic Year 2021/2022

Course Unit: ENT 2152- Properties of Material and Their Applications Duration: 2 hours

Instructions to Candidates

- Answer **all (04)** questions.
- All symbols have their usual meaning.
- All the figures are attached in a separate document.

1. Carbonated beverage containers are produced by using different materials.

I. Write down five major requirements that you are considering when selecting materials for producing carbonated beverage containers.

(05 marks)

II. Write down interrelated components of the science and engineering of materials and briefly describe the interrelationship among those components.

(05 marks)

III. Explain the term **Order** of atoms or molecules.

(05 marks)

IV.

a) Sketch the unit cell arrangement for the following crystal structures.
   (i) Simple Cubic (SC)
   (ii) Face Centered Cubic (FCC)
   (iii) Body Centered Cubic (BCC)

(03 marks)

b) Calculate the Atomic Packing Factor (APF) for FCC crystal structure. Consider the unit cell edge length and the atomic radius are ***a and D,*** respectively.

(07 marks)

2.

I.

a) Define the term **Poison's ratio**.

(02 marks)

b) A tensile stress is to be applied along the long axis of a cylindrical brass rod that has a diameter of 10 mm shown in following Figure No. 1 (refer to the attachment). Determine the magnitude of the load required to produce a 2.5×10^{-3} mm change in diameter if the deformation is entirely elastic.
The value of **Poisson's ratio** for brass is 0.34 and **the modulus of elasticity**, is 97 GPa.

(10 marks)

c) A cylindrical specimen of steel having an original diameter of 14.2 mm is tensile tested to fracture and found to have an engineering fracture strength σt of 630 MPa. If its cross-sectional diameter at fracture is 10.4 mm, determine the ductility in terms of percentage reduction in area.

(05 marks)

II. Briefly describe the terms **ductile fracture** and **brittle fracture**.

(05 marks)

III. Heat treatment processes are controlled heating and cooling operations used to bring about a desired change in the physical properties of a metal. Compare annealing and quenching methods.

(03 marks)

3. Lead-tin phase diagram is a binary eutectic system. Consider the phase diagram for lead-tin in Figure No. 2 (refer to the attachment).

I. Determine the followings for a 30 wt% Sn and 70 wt% Pb alloy at 150 °C. At this temperature densities of Pb and Sn are 11.23 and 7.24 g/cm^3, respectively. (Consider Point A)

a) What phases are present? (01 mark)

b) What are the compositions of phases? (02 marks)

c) Calculate the relative amount of each phase present in terms of Mass fraction and Volume fraction.

(14 marks)

II.

a) Draw the microstructure related to point B in Figure No. 2 (refer to the attachment).

(02 marks)

b) Briefly describe the microstructure in **part a**.

(04 marks)

c) Write down the eutectic equation for the point B.

(02 marks)

4. Fiber-reinforced composites (FRC) loaded in tension are usually incorporated with unidirectionally aligned continuous fibers.

I. Derive equations for the tensile elastic modulus of FRC with unidirectionally aligned continuous fibers in the following directions.

a) Parallel to the fiber axis. (05 marks)

b) Perpendicular to the fiber axis. (05 marks)

II. Using the derived equations in part (I) above, find the E_c (Composite elastic modulus) parallel to the axis of the fiber (E_1) and perpendicular to the fiber axis of the fiber (E_2), if $E_f = 500\ GPa\ , E_m = 50\ GPa, and\ V_f = 75\ \%$. (06 marks)

III. Toughness of a composite can be calculated using the following equation with the γ_F values of the matrix and fiber materials,

$$(\gamma_F)_c = (\gamma_F)_f \times V_f + (\gamma_F)_m \times (1 - V_f)$$

Estimate the toughness of C/Epoxy composite with 75% volume fraction of fibers. γ_F values of carbon and epoxy are 80 J/m^2 and 400 J/m^2, respectively. (03 marks)

IV. Tensile stress (σ_c) is applied along the fiber axis of FRC (discontinuous fibers composite) as shown in Figure No. 3 (refer to the attachment).

a) Draw the stress distribution graph on fiber. (03 marks)

b) Draw the shear stress distribution graph in the region BC of the fiber produces shear stresses at the fiber – matrix interface. (03 marks)

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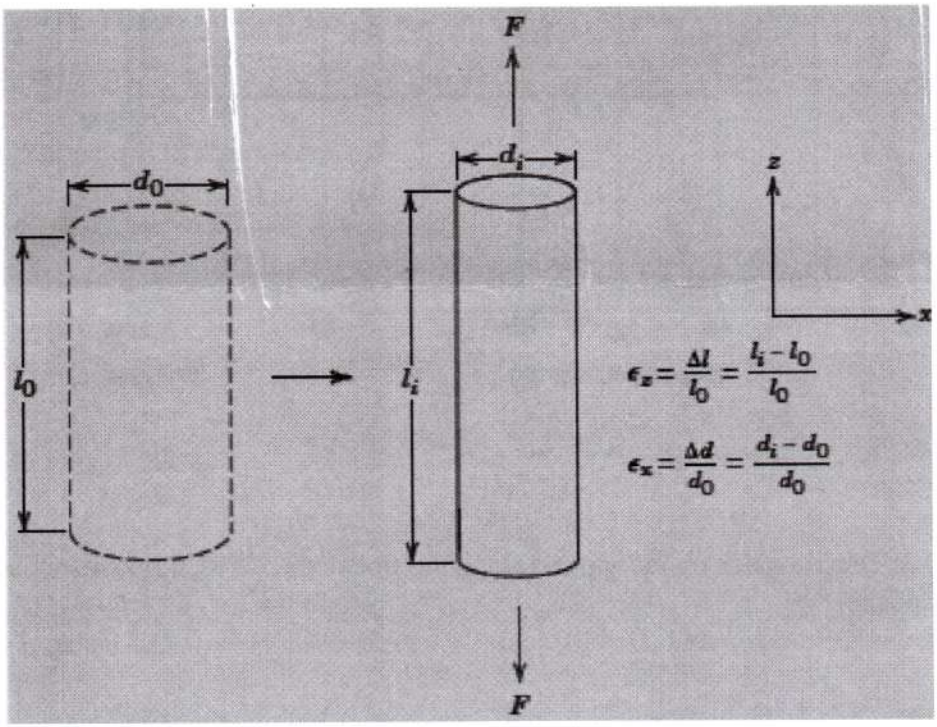
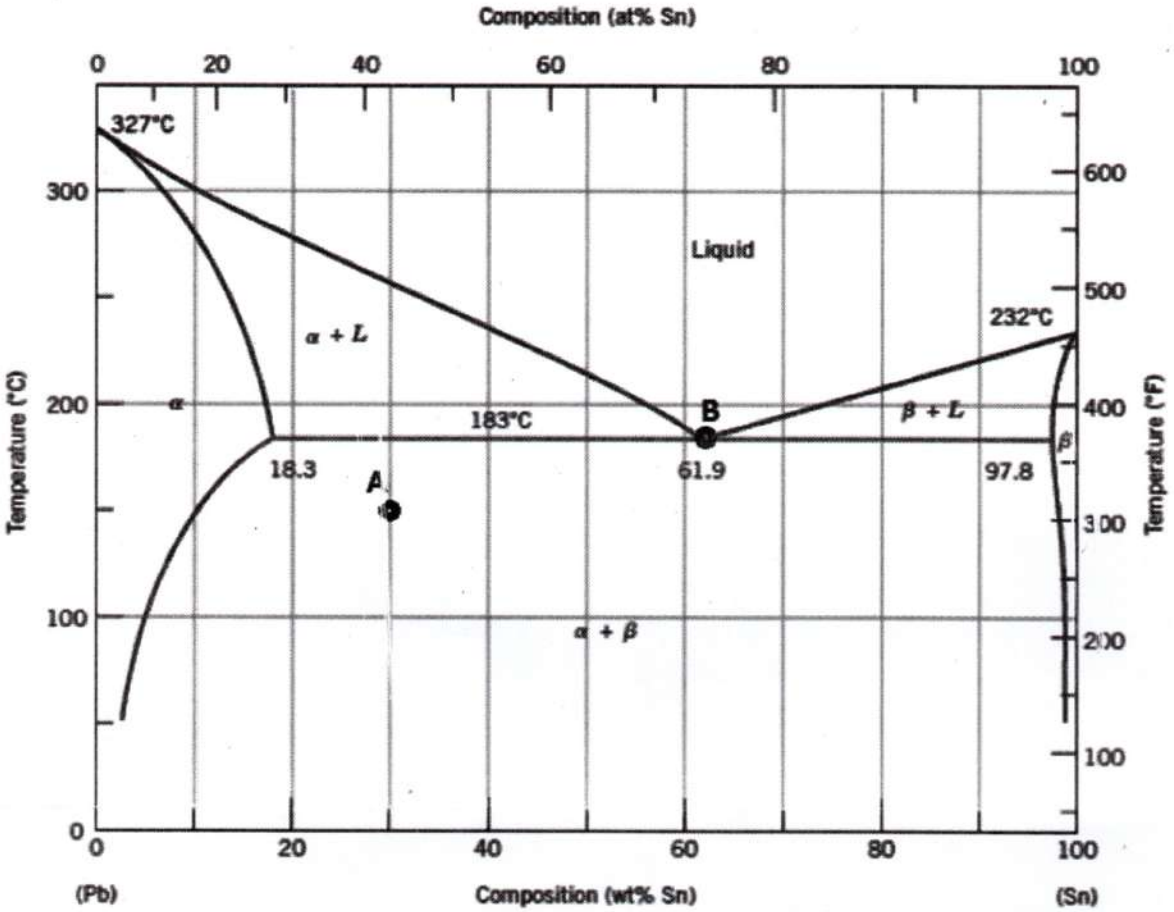
ENT 2152- Properties of Materials and Their Applications

Attachment I- Figures

Question 2 - Figure No 1



Question 3- Figure No 2



Question 4- Figure No 3: Tensile stress (σ_c) is applied along the fiber axis of FRC (discontinuous fibers composite)