Ref. No.: Ex/Met/PC/B/TS/222/2025

B.E. Metallurgical Engineering Second Year Second Semester - 2025

Subject: Testing of Materials

Time: 3 hours **(Answer all questions)** **Full Marks = 100**

Q. No.	Questions	CO
1	**Answer any two:** $(10 \times 2 = 20)$ **a.** Define hardness. How does it differ from strength and toughness in materials? Why is it important to have different hardness testing methods for materials characterization? Show by means of a sketch that in order to produce geometrically similar indentation in a Brinell test (d/D) must remain constant. **(1 + 2 + 4 + 3 = 10)** **b.** What is the primary objective of a compression test? How does it differ from a tensile test in terms of sample geometry and failure modes? Sketch and label a typical compressive stress-strain curve for a ductile material (e.g., aluminum). Why can't compression tests be used to determine the ultimate tensile strength (UTS) of a material directly? **(3 + 3 + 2 + 2 = 10)** **c.** What is the significance of introducing notch in standard impact specimens like Charpy and Izod? Explain how temperature affects the impact toughness of BCC and FCC metals. Discuss how the grain size affects the impact transition temperatures of high strength steel. **(3 + 4 + 3 = 10)**	CO1
2	**Answer any four**: $(5 \times 4 = 20)$ **a.** Meyer's hardness is calculated as $P = Kd^n$, where P = load, d = indentation diameter, K, and n are constants. What does the exponent "n" (Meyer's index) indicate about a material's work-hardening behavior? How does temperature affect hardness measurements of Materials. **b.** Write down the constitutive equation correlating strain, strain rate, and temperature and explain how the individual terms of this equation can be experimentally determined to relate to the tensile flow stress of a material. **c.** Describe how errors in test setup (misalignment, surface finish, temperature variation) can lead to incorrect interpretation of impact energy absorption capacity of materials.	CO2

	d. How does the mean stress affect the fatigue life of a component? What is the significance of Goodman diagram in this context? **e.** Explain why creep testing must be conducted at elevated temperatures (often >0.4–0.5 * T_m). What happens to creep behavior at lower temperatures?	
3	**Answer any two:** (10 × 2 = 20) **a.** What is necking? Explain the phenomenon of necking in a tensile test sample in the light of plastic instability. Flow properties of materials are dependent on strain rate and temperature of testing-justify. **(2 + 4 + 4 = 10)** **b.** What does a rough, fibrous fracture surface indicate about the material's performance under impact loading? What about a shiny, granular surface? How would you identify the origin of a fatigue crack from the fracture surface, and what does this tell you about the component's operating conditions? **(3 + 2 + 5 = 10)** **c.** Define creep. Under what service conditions is creep likely to be a critical failure mechanism? Draw and illustrate the idealized shape of a creep curve under constant stress test. Why are strain vs. time curves important in evaluating creep behavior instead of stress vs. strain plots? **(2 + 2 + 3 + 3 = 10)**	CO3
4	**Answer any two:** (10 × 2 = 20) **a.** What is the fundamental difference between destructive and non-destructive testing? How does the selection of an NDT method depend on material type and defect location? Why is radiography suitable for detecting internal voids but less effective for thin cracks parallel to the radiation beam? **(3 + 3 + 4 = 10)** **b.** Define micro-indentation testing. How does it differ from macro-indentation (e.g., Brinell/Rockwell)? A load of 50 mN creates an intent with diagonal length = 12 μm in a Vickers micro-indentation test. Calculate the hardness (HV). **(2 + 4 + 4 = 10)** **c.** A surface crack is detected via liquid penetrant testing. List 3 factors affecting crack visibility. Analyze a case where visual inspection failed to detect stress corrosion cracking. Select the best NDT method to detect internal cracks in a welded pipe. Justify your choice. **(3 + 3 + 4 = 10)**	CO4

5	**Answer any two**: (10 × 2 = 20) **a.** A cylindrical Al-6061 specimen (initial height = 20 mm, diameter = 10 mm) is compressed to 15 mm height (assume no barreling has occurred). (*i*) Calculate true strain and engineering strain. (*ii*) If the flow stress at this strain is 200 MPa, what is the required compressive load? Compare the fracture patterns of a brittle material (e.g., cast iron) and a ductile material (e.g., Al-6061) in compression testing. Give two real-world examples where compressive strength data is critical for material selection. **(3 + 3 + 2 + 2 = 10)** **b.** (*i*) When a 3000 Kg load is applied to 10 mm diameter in a Brinell test of a steel, an indentation of 3.1mm is produced. Estimate the tensile strength of the steel. (*ii*) A steel component undergoes cyclic stress between 200 MPa (tensile) and 50 MPa (compressive). Calculate the stress amplitude, mean stress, and R-ratio. **(5 + 5 = 10)** **c.** Why is fatigue testing conducted using cyclic loading instead of static loading? What real-world applications demand this test? How do you use an S–N curve to predict service life, and what are the limitations of this approach in variable loading environments? **(4 + 2 + 4 = 10)**	CO5