Ex/ME/5/T/413B/2025

BACHELOR OF ENGINEERING (MECHANICAL ENGG.) FOURTH YEAR FIRST SEMESTER EXAM 2025

DESIGN METHODOLOGY FOR FRACTURE FATIGUE AND CREEP

Time: **Three hours** Full Marks: **100**

Missing data, if any, are to be reasonably chosen.

Answer any Five (05) questions

1. a) What is the endurance limit? Discuss the factors that affect the endurance limit of a material. b) Explain the difference between Low Cycle Fatigue (LCF) and High Cycle Fatigue (HCF) with suitable diagrams and examples. c) A steel component is subjected to a completely reversed axial stress. The fatigue strength for 10^6 cycles is 250 MPa. Determine the life of the component if it is subjected to a stress amplitude of 200 MPa. Please assume suitable material properties and related information. *05+05+10*

2. a) What are the differences in the design procedures for components subjected to Low Cycle Fatigue (LCF) and High Cycle Fatigue (HCF)? b) Is there any common equation by which both LCF and HCF can be represented? If yes, deduce the expression. c) A shaft is subjected to low cycle fatigue with a total strain amplitude of 0.01. The material properties are as follows: Fatigue strength coefficient = 600 MPa, Fatigue ductility coefficient = 0.4, Fatigue strength exponent = -0.08, Fatigue ductility exponent = -0.5. Determine the total number of cycles to failure. Assume Young's Modulus E=210 GPa. *05+05+10*

3. a) What is cumulative damage in fatigue? b) What are theoretical stress concentration factor and fatigue stress concentration factor? How the fatigue stress concentration factor is estimated? c) A component is subjected to three levels of cyclic loading as given below. Check whether the component will fail or survive.

Stress Level (MPa)	Percentage of Total Cycles (%)	Cycles to Failure (N)
350	30%	5,000
300	40%	10,000
250	30%	20,000

05+07+08

4. a) Explain Griffith's Theory of Brittle Fracture and derive the expression for critical crack length in terms of stress and surface energy. b) Discuss the concept of fracture toughness and its importance in the design of components subjected to cracks. c) A brittle material has a surface crack of 5 mm. The material has a surface energy of γ=0.3 J/m^2 and a Young's modulus E=200 GPa. Calculate the critical stress required for the crack to propagate according to Griffith's law. *08+05+07*

5. a) What is $\mathcal{G}$ and prove that it is equal in load controlled and displacement controlled conditions? b) What is stress intensity factor? Write down the expression of the same with unit. c) What is R curve? Explain with neat sketch the stable and unstable crack growth. *10+05+05*

6. a) What is creep? With a neat sketch, explain creep curve with its different zones. b) Name the factors which influence the creep of a material. c) What is creep fatigue interaction? d) Define rupture strength and creep strength. *10+02+04+04*