GUJARAT TECHNOLOGICAL UNIVERSITY

BE-7 SEMESTER – OLD PAPER – S22 TO S26 – QUESTION BANK

Subject Name & Code: Advanced Machine Design - 3171925

Chapter 1: Fracture Mechanics (LEFM, Griffith, Fracture Modes, SIF, CTOD)

Repeated Questions:

1. LEFM and Griffith's Theory:

- **Q.** Define/Explain Linear Elastic Fracture Mechanics (LEFM), its application, and limitations. **(SUMMER 2022, part of 4 Marks; WINTER 2023, 3 Marks; WINTER 2024, part of 3 Marks; WINTER 2025 – LEFM approach, advantages, applications; SUMMER 2026, 3 Marks – limitations of LEFM)**
- **Q.** Explain Griffith's theory of fracture. **(SUMMER 2023, 4 Marks; WINTER 2023, 4 Marks)**

2. Fracture Modes, SIF and Fracture Toughness:

- **Q.** Explain the three modes of crack displacement with neat sketches. [Diagram required – refer to the original question paper] **(SUMMER 2022, 4 Marks; WINTER 2022, 4 Marks; WINTER 2023, 4 Marks; WINTER 2024, 4 Marks; WINTER 2025, 4 Marks – "various modes of fracture"; SUMMER 2026, 3 Marks – "three modes of fracture")**
- **Q.** Define Stress Intensity Factor (SIF) and Fracture Toughness (K_IC). Why is evaluating SIF important? **(SUMMER 2022, 3 Marks; WINTER 2022, 3 Marks; SUMMER 2023, 3 Marks; SUMMER 2024, 4 Marks; WINTER 2024, 7 Marks; WINTER 2025, 3 Marks – why evaluate SIF; WINTER 2025, 3 Marks – define fracture toughness, SIF, fatigue crack propagation; SUMMER 2026, part of 4 Marks – SIF)**

3. Crack Tip Opening Displacement (CTOD):

- **Q.** Derive the relationship between Crack Tip Opening Displacement (CTOD) and SIF (K_I) for small-scale yielding. **(WINTER 2022, 7 Marks; SUMMER 2024, 7 Marks; WINTER 2024, 7 Marks; SUMMER 2026, 7 Marks OR)**

4. SIF Numericals:

- **Q.** Numerical on calculating SIF for a center-cracked plate. **(SUMMER 2022, 7 Marks; WINTER 2022, 7 Marks)**

Other Important Questions:

1. Deformation and Types of Fracture:

- **Q.** What is deformation in material? Explain two types of deformations in brief. **(SUMMER 2023, 3 Marks)**
- **Q.** Explain types of fracture in brittle and ductile materials. **(WINTER 2025, 3 Marks OR)**

2. Griffith's Approach and Crack Behaviour:

- **Q.** Discuss Griffith's explanation on "stress concentration at the tip of a crack" with a figure. [Diagram required – refer to the original question paper] **(SUMMER 2023, 4 Marks)**
- **Q.** Using the Griffith approach, justify that critical stress required to advance a crack for plane stress cases is a function of modulus E, surface energy γ, crack length a. **(SUMMER 2026, 7 Marks OR)**
- **Q.** Explain the concepts of (a) Crack resistance (b) Stable and unstable crack growth. **(WINTER 2023, part of 7 Marks)**

3. Critical SIF and CTOD:

- **Q.** Critical SIF of a material depends on many factors? Discuss. **(WINTER 2022, 3 Marks)**

- **Q.** Discuss the concept of Crack Tip Opening Displacement as a fracture characterizing parameter indicating when it would be used. **(WINTER 2025, 4 Marks)**

4. Fracture Mechanics Numericals:

- **Q.** For the C-frame as shown in Figure 1, calculate the safe load… [Diagram required – refer to the original question paper] **(SUMMER 2023, 7 Marks)**
- **Q.** A wide plate of mild steel is subjected to a uniform tensile load… Calculate the critical crack length… (K_IC numerical) **(SUMMER 2022, 7 Marks)**

Chapter 2: Surface Wear, Lubrication, Contact Fatigue and Fretting

Repeated Questions:

1. Wear:

- **Q.** Explain different types of wear (Adhesive, Abrasive, Corrosive) in detail. **(WINTER 2023, 7 Marks; SUMMER 2024, 4 Marks; WINTER 2024, 4 Marks; WINTER 2025, 3 Marks – "What is Wear? Explain various types of wear in brief."; SUMMER 2026, 7 Marks – "Compare in detail with examples adhesive and abrasive wear.")**

2. Lubrication and Friction:

- **Q.** Explain Hydrodynamic, Hydrostatic, and Elastohydrodynamic Lubrication. **(SUMMER 2022, 3 Marks; WINTER 2024, part of 3 Marks; WINTER 2025, 7 Marks OR – hydrostatic and elasto-hydrodynamic lubrication in detail)**
- **Q.** Discuss the effect of roughness, velocity, and lubrication on friction. / Explain the effects of lubrication, velocity and roughness on friction. **(SUMMER 2022, 4 Marks; WINTER 2024, 4 Marks; WINTER 2025, 7 Marks)**

3. Surface Fatigue and Fretting:

- **Q.** Describe the consequences of surface fatigue and factors to control it. **(WINTER 2022, 3 Marks; SUMMER 2024, 4 Marks; WINTER 2024, 3 Marks; WINTER 2025, 3 Marks – three ways for designing to avoid surface failure)**
- **Q.** Define fretting and distinguish between fretting fatigue, wear, and corrosion. **(WINTER 2022, 4 Marks; WINTER 2024, 7 Marks)**

4. Contact Stress and Wear Numericals:

- **Q.** Numerical on calculating maximum contact stress for spherical/ball contact (Hertzian Contact). **(SUMMER 2022, 7 Marks; WINTER 2022, 7 Marks; SUMMER 2024, 7 Marks; WINTER 2024, 7 Marks)**
- **Q.** A pin-on-disk friction testing apparatus… Compute the wear coefficients. (Wear numerical) **(SUMMER 2022, 7 Marks; WINTER 2024, 7 Marks)**

Other Important Questions:

1. Surface Failure and Wear Basics:

- **Q.** List five general categories of surface failure and explain any one in brief. **(SUMMER 2023, 3 Marks)**
- **Q.** Explain design precautions to avoid surface failure. **(WINTER 2023, part of 7 Marks)**
- **Q.** What is wear? Explain any one mechanism in detail. **(SUMMER 2022, 4 Marks)**

2. Surface Fatigue and Fretting:

- **Q.** What is Surface Fatigue Strength, and how is it determined? Explain. **(WINTER 2025, 3 Marks OR)**
- **Q.** Explain: (i) Surface fatigue damage **(SUMMER 2026, part of 4 Marks)**
- **Q.** Define (1) Fretting fatigue and (2) Fretting wear. **(SUMMER 2024, 3 Marks)**

3. Contact Stress Numerical:

- **Q.** Numerical on calculating the size of the contact patch for cylindrical contact (e.g., crane wheel on rail). **(SUMMER 2023, 4 Marks)**

Chapter 3: Creep and Damping

Repeated Questions:

1. Creep Curve, Stress Relaxation and Types of Creep:

- **Q.** Define creep. Explain the three stages of a creep curve with a diagram. / Draw and explain the strain vs. time behavior during creep under constant force. / Draw a creep curve "strain versus time" and write three points of discussion on it. [Diagram required – refer to the original question paper] **(SUMMER 2022, 3 Marks; WINTER 2022, 3 Marks; SUMMER 2023, 3 Marks OR – strain vs time behaviour during creep; SUMMER 2024, 4 Marks OR – draw creep curve and discuss; WINTER 2025, 3 Marks – define creep and explain creep curves; SUMMER 2026, 4 Marks – creep curves and stress relaxation)**
- **Q.** Explain stress relaxation. **(SUMMER 2022, 4 Marks OR; WINTER 2024, 3 Marks; SUMMER 2026, 4 Marks – creep curves and stress relaxation)**
- **Q.** Explain: (i) Transient creep (ii) True stress (iii) Steady-state creep. **(SUMMER 2022, 3 Marks OR; WINTER 2023, 3 Marks; SUMMER 2026, 3 Marks OR – types of creep)**

2. Creep Parameters:

- **Q.** Explain the Larson-Miller parameter for creep deformation and life estimation. **(SUMMER 2022, 4 Marks; SUMMER 2023, 7 Marks OR; SUMMER 2024, 4 Marks; WINTER 2024, 4 Marks; WINTER 2025, 7 Marks – Sherby-Dorn and Larson-Miller parameters; SUMMER 2026, 3 Marks – Sherby-Dorn and Larson-Miller creep parameters)**
- **Q.** Distinguish between Creep, Creep Rupture, and Stress Rupture. **(WINTER 2022, 3 Marks; SUMMER 2024, 3 Marks)**

3. Creep and Damping Failure:

- **Q.** Explain in brief: i. Failure due to Creep ii. Failure due to Damping. **(SUMMER 2023, 3 Marks; SUMMER 2026, 4 Marks – includes "Failure due to creep")**

4. Creep Numericals:

- **Q.** Numerical on using Larson-Miller/Sherby-Dorn parameters to find life or safe stress. **(SUMMER 2022, 7 Marks; SUMMER 2022, 7 Marks OR)**

Other Important Questions:

1. Creep Behaviour and Effects:

- **Q.** Explain creep deformation under varying stress. **(SUMMER 2023, 3 Marks)**
- **Q.** Refer to the Figure 5 and write three points on the effect of temperature on stress versus steady-state strain rate… [Diagram required – refer to the original question paper] **(SUMMER 2023, 3 Marks OR)**
- **Q.** Explain the factors affecting the creep. **(SUMMER 2026, 4 Marks OR)**
- **Q.** Write the three effects of creep on life of machine element. **(SUMMER 2026, 4 Marks OR)**

2. Damping:

- **Q.** Explain energy dissipation in material under damping. **(SUMMER 2023, 4 Marks OR)**

3. Creep Numerical:

- **Q.** If the Larson-Miller parameter for a given elevated temperature alloy was found to be 26,000, by how much would the rupture life of a sample be estimated to decrease if the absolute temperature of the test were increased from 1100 to 1250 K? Assume that the Larson-Miller constant is equal to 20. **(WINTER 2025 OR)**

Chapter 4: Fatigue Failure

Repeated Questions:

1. Cumulative Damage (Miner's Rule):

- **Q.** Explain the Palmgren-Miner rule (Linear Cumulative Damage Rule) for variable amplitude loading. **(WINTER 2022, 7 Marks; SUMMER 2024, 7 Marks; WINTER 2024, 7 Marks; SUMMER 2026, part of 7 Marks – Miner's rule for cumulative damage)**
- **Q.** Explain the cumulative damage concept with an S-N diagram. **(WINTER 2023, 3 Marks; WINTER 2023, 3 Marks OR; SUMMER 2026, part of 7 Marks – Miner's rule for cumulative damage)**
- **Q.** Numerical on fatigue life estimation using S-N data and Miner's rule. **(WINTER 2022, 7 Marks; SUMMER 2023, 7 Marks; SUMMER 2026 – work cycle life determination)**

2. Fatigue Types, S-N Curve and Life Approaches:

- **Q.** Distinguish between High-Cycle Fatigue (HCF) and Low-Cycle Fatigue (LCF). **(WINTER 2022, 3 Marks; WINTER 2023, 3 Marks OR; SUMMER 2024, 3 Marks OR; WINTER 2024, 3 Marks; SUMMER 2026, 3 Marks)**
- **Q.** Discuss the factors that affect the endurance limit/S-N curve. **(SUMMER 2022, 4 Marks; SUMMER 2024, 3 Marks; WINTER 2024, 4 Marks; WINTER 2024, 3 Marks; WINTER 2025, 4 Marks – variables affecting S-N curve; SUMMER 2026, 3 Marks OR – factors affecting S-N curves)**
- **Q.** Explain the strain-based approach to determine fatigue life. **(WINTER 2023, part of 7 Marks; SUMMER 2026, part of 7 Marks)**

3. Cycle Counting:

- **Q.** Explain the rain-flow cycle counting method. **(WINTER 2022, 4 Marks; SUMMER 2023, 7 Marks)**

4. Stress Concentration:

- **Q.** What is stress concentration? Explain terms theoretical stress concentration factor and fatigue stress concentration factor. Establish a relation between them. **(WINTER 2025; SUMMER 2026, 7 Marks)**

Other Important Questions:

1. Fatigue Initiation, Life and Loading:

- **Q.** Discuss the effect of material composition, operating temperature, and grain size on fatigue strength. **(SUMMER 2023, 3 Marks)**
- **Q.** Explain the crack initiation phase in detail. **(SUMMER 2023, 4 Marks)**
- **Q.** Draw and discuss any two types of mean zero stress-time patterns. [Diagram required – refer to the original question paper] **(SUMMER 2023, 4 Marks OR)**
- **Q.** Define fatigue life, enlist various fatigue life methods, and explain any one. **(WINTER 2023, 7 Marks)**
- **Q.** Explain fatigue crack propagation and life estimation for variable amplitude stress. **(WINTER 2023, 4 Marks OR)**
- **Q.** What is variable amplitude loading? Discuss stress amplitude in fatigue life? What is the difference between stress and stress amplitude? **(WINTER 2025, 4 Marks)**

2. S-N Curve, Notches and Design Considerations:

- **Q.** Why are results obtained from S-N curve unreliable? Give three reasons. **(WINTER 2025, 4 Marks OR)**
- **Q.** List down the factors that are to be considered while designing the components to avoid fatigue failure. **(WINTER 2025)**
- **Q.** Explain the concept of fatigue life reduction due to notches. How does the size and shape of the notch influence the fatigue life of a component? **(WINTER 2025)**

3. Failure Conditions and Models:

- **Q.** Derive the following condition for “failure is predicted to occur if (FIPTOI)”. **(SUMMER 2024, 7 Marks OR)**
- **Q.** What is the Fatemi-Socie model, and how does it integrate stress and strain-based approaches in fatigue analysis? **(WINTER 2025)**
- **Q.** Define: (i) Failure due to fatigue (ii) Failure due to creep. **(SUMMER 2026, 4 Marks – creep part also listed under Chapter 3)**

4. Fatigue Failure Numericals:

- **Q.** A machine component is subjected to a flexural stress… Determine the value of minimum ultimate strength according to 1. Gerber… (Fatigue failure criteria numerical) **(WINTER 2023, 7 Marks OR)**
- **Q.** A circular bar of 500 mm length is supported freely at its two ends. It is acted upon by a central concentrated cyclic load having a minimum value of 20 kN and a maximum value of 50 kN. Determine the diameter of bar by taking a factor of safety of 1.5, size effect of 0.85, surface finish factor of 0.9. The material properties of bar are given by: ultimate strength of 650 MPa, yield strength of 500 MPa and endurance strength of 350 MPa. Take Fatigue stress concentration factor as 1. Compare the design according to Goodman's formulae and Soderberg's formulae. **(SUMMER 2026)**

Chapter 5: Theories of Elastic Failure and Multiaxial Stresses

Repeated Questions:

1. Theories of Elastic Failure:

- **Q.** What are the important theories of elastic failure? Explain why they are required. **(SUMMER 2022, 3 Marks; SUMMER 2024, 3 Marks; WINTER 2024, 3 Marks; SUMMER 2026, 4 Marks)**
- **Q.** Explain the Maximum Principal Strain theory. **(SUMMER 2022, 3 Marks; SUMMER 2024, 3 Marks; WINTER 2025, 4 Marks OR)**

2. Multiaxial Stresses:

- **Q.** What are simple multiaxial stresses and complex multiaxial stresses? **(WINTER 2023, 4 Marks; SUMMER 2026, 3 Marks OR)**
- **Q.** Explain Sines method for fluctuating simple multiaxial stresses. **(SUMMER 2023, 4 Marks; WINTER 2023, 7 Marks; SUMMER 2026, 3 Marks)**

3. Bolt Design Numerical:

- **Q.** Numerical on bolt design using Maximum Shear Stress Theory and Distortion Energy Theory under combined loading. **(SUMMER 2022, 7 Marks; SUMMER 2024, 7 Marks OR; WINTER 2024, 7 Marks OR)**

Other Important Questions:

1. Multiaxial Stress Effects and Fatigue:

- **Q.** Explain the effect of complex multiaxial stress on a machine element. **(SUMMER 2023, 4 Marks)**
- **Q.** Explain Linear Elastic Fracture Mechanics for fatigue crack growth under multiaxial loading. **(SUMMER 2023, 7 Marks OR)**
- **Q.** What is multiaxial fatigue, and why is it important in the design and analysis of mechanical components? How do you calculate the fatigue life of a component subjected to multiaxial loading? **(WINTER 2025)**

2. Multiaxial Stress Numerical:

- **Q.** A hollow cylindrical 4340 steel member… determine the principal stresses σ_1, σ_2, and σ_3. (Multiaxial stress numerical) **(SUMMER 2023, 7 Marks)**

Chapter 6: Mechanical Housing, Seals and Mounting

Repeated Questions:

1. Mechanical Housing:

- **Q.** What is Mechanical Housing? Explain its functions/importance. **(SUMMER 2022, 4 Marks; WINTER 2023, 3 Marks; WINTER 2024, 3 Marks)**
- **Q.** Differentiate between Split and Non-split Housing. **(SUMMER 2023, part of 7 Marks; SUMMER 2024, 4 Marks; WINTER 2024, 4 Marks; SUMMER 2026, part of 7 Marks OR – "Split Housing")**
- **Q.** Explain housings split at right angle to the axes of the shafts with a suitable example. **(WINTER 2022, 7 Marks; SUMMER 2024, 7 Marks)**
- **Q.** Discuss different types of materials used for Mechanical Housings. **(SUMMER 2024, 7 Marks; WINTER 2024, 7 Marks)**
- **Q.** Explain three-stage gear deformation under load attached with a foundation with a neat sketch. **(WINTER 2022, 4 Marks; SUMMER 2024, 4 Marks)**

2. Seals:

- **Q.** Explain Contact Seals and Non-Contact Seals. **(WINTER 2022, 7 Marks; SUMMER 2024, 7 Marks OR; SUMMER 2026, part of 7 Marks OR – "Non Contact Seals")**
- **Q.** What is Mechanical Seal? State the required properties of material for mechanical seal. / State the desirable properties of material for a mechanical seal. **(WINTER 2023, 3 Marks OR; SUMMER 2026, 4 Marks)**

Other Important Questions:

1. Housing Functions, Stresses and Mounting:

- **Q.** Write two main functions of housings. Write two most general materials used for housing. Write three points of difference between split housing and non-split housing. **(SUMMER 2023, 7 Marks)**
- **Q.** What is Mechanical Housing? Discuss stresses and deformation induced in housing. **(SUMMER 2026, 7 Marks)**
- **Q.** Discuss Design of Mounting Feet with suitable example. **(WINTER 2025, 7 Marks)**

2. Housing Seals:

- **Q.** Describe various types of housing seals. Discuss stresses and deformation induced in housing. **(SUMMER 2023, 7 Marks OR)**
- **Q.** Define functions of Mechanical Housing Seals. Enlist the different types of Mechanical Housing Seals. **(WINTER 2024, 7 Marks)**
- **Q.** What is the need for combined seals? **(WINTER 2022, 3 Marks)**
- **Q.** What is housing seal? Explain Contact seals, Noncontact Seals and Static Seals with figure. [Diagram required – refer to the original question paper] **(WINTER 2025, 7 Marks OR)**

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