



# GUJARAT TECHNOLOGICAL UNIVERSITY

**Master of Engineering**  
**Subject Code: 3720918**  
**FRACTURE MECHANICS**  
**SEMESTER: II**

**Type of course:** Program Elective

**Prerequisite:** Zeal to learn the Subject

**Rationale:** The objective of this course is to introduce the mathematical and physical principles of fracture mechanics and their applications to engineering design to develop the ability in students to compute the stress intensity factor, strain energy release rate, and the stress and strain fields around a crack tip for linear and non linear materials. It will also expand the students' knowledge on experimental methods to determine the fracture toughness and develop the students understanding on the design principle of materials and structures using fracture mechanics approaches.

**Teaching and Examination Scheme:**

| Teaching Scheme |   |   | Credits<br>C | Examination Marks |        |                 |        | Total<br>Marks |
|-----------------|---|---|--------------|-------------------|--------|-----------------|--------|----------------|
| L               | T | P |              | Theory Marks      |        | Practical Marks |        |                |
|                 |   |   |              | ESE (E)           | PA (M) | ESE (V)         | PA (I) |                |
| 3               | 0 | 2 | 4            | 70                | 30     | 30              | 20     | 150            |

**Content:**

| Sr. No.  | Content   | Total Hrs |
|----------|---|-----------|
| <b>1</b> | <b>Introduction to Fracture Mechanics:</b> Stress-Strain Curve, Elements of dislocation theory, Historical perspective, Stress Concentration effect of flaws, Fracture Mechanics approach to design, Effect of material properties on fracture, Cleavage, Brittle and Ductile fracture, ductile brittle transition, modes of fracture failure, Fatigue and stress corrosion cack growth, Damage tolerance.  | <b>06</b> |
| <b>2</b> | <b>Linear Elastic Fracture Mechanics:</b> An atomic view of fracture, Griffith Energy Balance, Energy release rate, instability and the R Curves, compliance, tearing modulus, Stress and Displacement field in isotropic elastic materials, Airy stress function, Westergard approach for different modes of fracture, Stress analysis of crack, Stress intensity factor (SIF), relation between K and global behaviour, Effect of finite size.  | <b>07</b> |
| <b>3</b> | <b>Elastic-Plastic Fracture Mechanics:</b> Crack tip deformation and plastic zone size, plane stress vs plane strain, effective crack length, Irwin plastic zone correction, Dugdale approach, effect of plate thickness, J Contour Integral: Relevance and scope, J as a path-independent line integral, J as a stress intensity parameter, Stress-Strain relations, J-Controlled fracture, Laboratory measurement of J, Crack Tip Opening Displacement (CTOD), Relationship between CTOD, K and G, Equivalence between CTOD and J, Determination CTOD from strip yield model, HRR Singularity | <b>12</b> |
| <b>4</b> | <b>Fatigue Fracture:</b> Introduction to fatigue, factors affecting fatigue performance, fatigue loading, constant and variable amplitude loading, some characteristics of fatigue crack, Paris Law   | <b>08</b> |
| <b>5</b> | <b>Experimental and Finite Element Estimates of Fracture</b>  | <b>10</b> |



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|---|
| <b>Mechanics:</b> Experimental determination of J-Integral, Critical Stress intensity factor and CTOD, Photo elasticity techniques, strain gage measurements, Fatigue crack initiation and propagation testing Preprocessing in Finite Element Method, Element selection and meshing of crack, Load application, constraints, preprocessing checks, processing the model, post processing |
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### Reference Books:

1. Anderson T.L., Fracture Mechanics Fundamentals and Applications, CRC Press, Second edition, 2005
2. Kumar Prashant, Elements of Fracture Mechanics, Tata McGraw Hill, India, Second edition, 2010
3. Hertzberg Richard W., Deformation and Fracture Mechanics of Engineering Materials, Wiley, Fifth Edition, 2012
4. Broek David, Elementary Engineering Fracture Mechanics, Kluwer Academic Publishers, Fourth revised reprint edition, 1999
5. Barsom John M. and Rolfe Stanley T., Fracture and Fatigue Control in Structures: Applications of Fracture Mechanics, ASTM USA, Third Edition, 1999
6. Sanford R.J., Principles of Fracture Mechanics, Printice Hall USA, 2003

### Course Outcome:

After learning the course the:

| Sr. No. | Course Outcome   | Percentage weightage |
|---------|--|----------------------|
| CO-1    | Students will be able to apply fracture mechanics theories to predict brittle fracture, identify and describe the basic fracture and fatigue mechanisms. | 20%                  |
| CO-2    | Students will be able to understand crack resistance and energy release rate for crack criticality.  | 10%                  |
| CO-3    | Students will be able to identify the plane stress and plane strain conditions based on the shape and size of plastic zones.                             | 20%                  |
| CO-4    | Students will be able to identify the cause of failure in brittle and ductile materials based on fracture surface observations.                          | 35%                  |
| CO-5    | Students will be able to apply experimental techniques to determine the critical values of parameters at crack tip.                                      | 15%                  |

### List of Experiments:

1. Experiments related to stress strain curve.
2. Experiments related to material properties.
3. Experiments related to topic no. 5 of syllabus.

### List of Open Source Software/learning website:

NPTEL Course