Course Type	Course Code	Name of Course	L	T	P	Credit
DC	NMEC519	Fracture Mechanics	3	1	0	4

Course Objective

- To make the students conversant with the fundamentals of crack propagation in materials and structures.
- This includes development of the concepts of strain energy release rate and the critical stress intensity factor, and their evaluation using experimental and numerical methods.

Learning Outcomes

Upon successful completion of this course, students will be able to:

- Determine the Strain Energy Release Rate and Stress Intensity Factors using energy approach and solving complex potential functions through theory of elasticity equations.
- Know the crack initiation and propagation direction in a mixed mode loading
- Appreciate the importance of plasticity at the crack tip and solve for effective SIF
- Calculate the nonlinear fracture parameters
- Determine the fracture parameters using experimental and numerical approaches
- Predict the life of the structure under fatigue loading conditions

Unit No.	Topics to be Covered	Lecture Hours (L+T)	Learning Outcome
1	Background and evolution of engineering fracture mechanics. Review of Theory of Elasticity, Stress concentration factor.	4+1	Students should be able to why fracture mechanics concept should be introduced in the conventional design approaches. Understand the mathematical equations from Theory of Elasticity, which will be employed in solving fracture problems
2	Energy approach: Energy release rate G, Griffith criterion, R- curve, Stable and unstable crack growth	4+2	Student will learn the to evaluate the fracture parameter and the condition for crack growth using the global energy approach.
3	Linear Engineering Fracture Mechanics (LEFM): William's asymptotic solution for crack bodies, Kolosoff-Mushkhelishvili (KM) potential funtions, Stress intensity factors (SIF), K_I, K_{II}, K_{III}, Determination of SIF, Westergaard's Approach, Fracture toughness, Relationship between G and K, SIFs for finite cracked bodies	9+3	Student will learn the concept of linear fracture mechanics and related theories. They will also learn the usage the complex potentials to evaluate the SIFs of infinite and finite crack bodies
4	Mixed-mode brittle fracture: Maximum Tangential Stress Criterion, Strain Energy Density Criterion.	3+1	The students will learn the crack initiation and crack growth direction criteria for a crack subjected to mixed mode loading conditions.
5	Inelastic deformation at the crack tip: Shape of plastic zone for plane stress and plane strain conditions, Effective Crack Length, Influence of plate thickness on the critical SIF, HRR-singularity	5+1	Students will be able to appreciate the importance the importance of plasticity at the crack tip. The effective SIF and the shape of plastic zone for plane stress and plane strain condition will be learned at the end of this module.
6	*J*-integral: Mathematical formulation and path independence, Application to engineering problems, Crack tip opening displacement (CTOD), Relationship between J and CTOD, Equivalence of G and J for elastic materials.	4+2	Students will get the knowledge non-linear fracture parameters.
7	Test methods: Determination of K_{IC}, Determination of J_{IC} Determination of G_{IC} and G_{IIC}.	4+1	Students will be able to know the samples dimensions and the experimental protocols to be followed

			for determining the fracture parameters.
8	Fatigue failure: Crack initiation and propagation, Paris Law, Effect of overload and crack closure.	3+1	Students will understand and analyze the material behavior under fatigue loading condition.
9	Finite element analysis of cracks in solids: Barsoum element, Stress and displacement method to methods to evaluate SIFs, Virtual Crack Extension (VCE), and Virtual Crack Closure Technique (VCCT)	4+1	Students will be able to extract the SIFs using various fracture mechanics based finite element tools.
10	Crack detection through NDT, Microstructural description of fracture.	2+1	Students will be able to know the NDT methods to detect the crack and analyze the crack propagation from SEM images
	Total	42+14	

Text books:

1. Fracture Mechanics: Fundamentals and Applications, T. L. Anderson, CRC Press, 4th edition (2017).
2. Elements of Fracture Mechanics, Prashant Kumar, Tata McGraw-Hill Publishing Company Ltd. (India), 2009

References books:

1. Fracture Mechanics, C. T. Sun and Z. H. Jin, Academic Press (Elsevier), 2012.
2. Elementary Engineering Fracture Mechanics, D. Broek, Springer; 4th edition (1982).
3. Fracture Mechanics: Lecture Notes in Applied and Computational Mechanics, Volume 62, Alan T. Zehnder, Springer, 2012.