FRACUTRE MECHANICS

Course Code	22MEMD2T5A	**M.Tech**	I Year	**Semester**	II
Course Category	Program Core	**Branch**	Machine Design	**Course Type**	Theory
Credits	3	**L-T-P**	3-0-0	**Prerequisites**	---
Continuous Internal Evaluation:	40	**Semester End Evaluation:**	60	**Total Marks:**	100

Course outcomes: At the end of the course, the student will be able to:

CO	**Statement**	**BTL**	**Units**
CO1	Understand the concept of crack subsequently leading to fracture failure, further analyze the mechanical components against fracture.	L2	1
CO2	Analyze and predict the fracture strength of mechanical components under different fracture modes.	L4	1,2
CO3	Application of fracture mechanics principles by Determining Fracture Parameters using Experimental Methods.	L3	1,3
CO4	Designing of mechanical components against fracture by Determining Fracture Parameters for the analysis of cracks in solids	L3	1,4

Contribution of Course outcomes towards achievement of programme outcomes & Strength of correlations (High:3, Medium: 2, Low:1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	3	2	1	1			2			1		2	3	2

CO 2	3	3	1	1			2			1		2	3	2
CO 3	3	3	1	1			2			1		2	3	2
CO 4	3	3	1	1			2			1		2	3	2

Syllabus		
Unit	**Contents**	**Mapped CO**
1	**INTRODUCTION:** Brittle and Ductile Fracture, Modes of Fracture Failure, Surface Energy, Griffith's Dilemma, Realization and Analysis. Energy Release Rate, Energy Release Rate of DCB Specimen, Anelastic Deformation at Crack-tip, Crack Resistance, Stable and Unstable Crack Growth, Critical Energy Release Rate.	**CO1**
2	**STRESS INTENSITY FACTOR:** Linear Elastic Fracture Mechanics (LEFM), Westergaard's Approach, Applications of Westergaard Approach, Crack in a Plate of Finite Dimensions, Edge Cracks, Embedded Cracks, The Relation between GI and KI , Critical Stress Intensity Factor, Bending and Twisting of Cracked Plates. Approximate Shape and Size of the Plastic Zone, Effective Crack Length, Effect of Plate Thickness.	**CO1** **CO2**
3	**J-INTEGRAL:** Definition of the J-Integral, Path Independence, Stress-Strain Relation, Experiments to Determine the CriticalJ-Integral, Comments on the Numerical Evaluation ofJ-Integral, A Simplified Relation for the J-Integral, Applications to Engineering Problems. **CRACK TIP OPENING DISPLACEMENT**: Relationship between CTOD, Kr and Gr for Small Scale Yielding, Equivalence between CTOD and J.	**CO1** **CO3**
4	**TEST METHODS:** KIC-Test Technique, Test Methods to Determine JIC, Test Methods to Determine GIC and GIIC, Determination of Critical CTOD. Fracture Parameters: Direct **METHODS TO DETERMINE FRACTURE PARAMETERS.** Indirect Methods to Determine Fracture Parameters. Mixed Mode Crack Initiation and Growth.	**CO1** **CO4**

Learning Resources

Text Book(s):

1. Elements of fracture mechanics, Kumar, Prashant, Tata McGraw-Hill Education, 2009.

References:

1. Fracture mechanics: fundamentals and applications. Anderson, Ted L., CRC press, 2017.
2. Elementary engineering fracture mechanics, Broek, David, Springer Science & Business Media, 2012.
3. Fracture and Fatigue control in Structures, S.T. Rolfe and J.M. Barson, Prentice Hall Inc. New Jersy, 1977.
4. Advanced Fracture Mechanics, M.F. Kanninen and C.H. Popelar, Oxford University Press, 1985.

Course coordinator: HOD

Code No: 22MEMD1T5A

PVP SIDDHARTHA INSTITUTE OF TECHNOLOGY
(Autonomous)

FRACUTRE MECHANICS

Duration: 3 Hours **Max. Marks: 60**

Note:
1. This question paper contains 4 essay questions with internal choice. Each question carries 14 marks and may have a, b, c as sub questions.
2. All parts of Question paper must be answered in one place
3. Use of approved design data book is permitted

		Blooms Level	CO	Max. Marks
	UNIT-1			
1.	Exemplify different types of fracture mode with neat sketch	**L2**	**CO-1**	**15**
	OR			
2.	Compare Brittle and Ductile Fracture behaviour with neat sketches	**L2**	**CO-1**	**15**
	UNIT-2			
3.	Determine the critical crack length in a centered-cracked plate, loaded in Mode I, if criticalstress intensity factor K1c = 60 MPa $\sqrt{m}$ and far field stress is 120 MPa	**L4**	**CO-1** **COI-2**	**15**
	OR			
4.	Distinguish the relation between the G_1 and K_1	**L4**	**CO-1** **COI-2**	**15**
	UNIT-3			
5.	A centre-cracked panel of width 2W = 500 mm and thickness B = 20 mm is pulled normal to the crack length (2a = 100 mm), with a far field stress σ'. Estimate the	**L3**	**CO-1** **CO-3**	**15**

	maximum σ that can be applied without causing the growth of the crackif, Jp = 400 kJ / m2• The material constants of the Ramberg-Osgood equation are known to be $n = 5$,.$\alpha = 5.4$, $\sigma_{ys}(=\sigma_0) = 520$ MP a and $\varepsilon_o = 0.00251$.			

OR

6.	Differentiate the J integral and CTOD methods	**L3**	**CO-1** **CO-3**	**15**

UNIT-4

7.	Illustrate the test methods to determine $J_{1c}$and its significance	**L3**	**CO-1** **CO-4**	**15**

OR

8.	Differentiate the specimens used for the characterization of fracture behaviour	**L3**	**CO-1** **CO-4**	**15**

I YEAR M. TECH (MACHINE DESIGN) SECOND SEMESTER

FRACUTRE MECHANICS

Micro syllabus

UNIT-I

Introduction: Brittle and Ductile Fracture, Modes of Fracture Failure, Surface Energy, Griffith's Dilemma, Realization and Analysis. Energy Release Rate, Energy Release Rate of DCB Specimen, Anelastic Deformation at Crack-tip, Crack Resistance, Stable and Unstable Crack Growth, Critical Energy Release Rate.

UNIT-II

Stress Intensity Factor: Linear Elastic Fracture Mechanics (LEFM), Westergaard's Approach, Applications of Westergaard Approach, Crack in a Plate of Finite Dimensions, Edge Cracks, Embedded Cracks, The Relation between GIand KI , Critical Stress Intensity Factor, Bending and Twisting of Cracked Plates. Approximate Shape and Size of the Plastic Zone, Effective Crack Length, Effect of Plate Thickness

UNIT-III

J-Integral: Definition of the J-Integral, Path Independence, Stress-Strain Relation, Experiments to Determine the CriticalJ-Integral, Comments on the Numerical Evaluation ofJ-Integral, A Simplified Relation for the J-Integral, Applications to Engineering Problems. Crack Tip Opening Displacement, Relationship between CTOD, Kr and Gr for Small Scale Yielding, Equivalence between CTOD and J.

UNIT-IV

Test Methods: KIC-Test Technique, Test Methods to Determine JIC, Test Methods to Determine GIC and GIIC , Determination of Critical CTOD.Fracture Parameters: Direct **Methods to Determine Fracture Parameters.**Indirect Methods to Determine Fracture Parameters.Mixed Mode Crack Initiation and Growth.

PVP22

Code No: **Duration: 3 Hours** **Max. Marks: 60**

PVP SIDDHARTHA INSTITUTE OF TECHNOLOGY (Autonomous)	
BRANCH: MECHANICAL ENGINEERING	REGULATION:PVP22
COURSE M.Tech	Subject: **FRACUTRE MECHANICS**
Subject Code: 22MEMD1T5A	Year and Semester:1 Year IIndsem
Question Bank	

Each Question carries 15 Marks as per PVP22 Regulations

UNIT-I

Q.No	Question	CO	Level
1	Explain the features of brittle and ductile fracture	CO1	L2
2	What are the different types of fracture modes explain with neat sketches	CO1	L2
3	How potent is a crack explain clearly	CO1	L2
4	Illustrate the damage tolerance	CO1	L2
5	Demonstrate energy release rate and its mathematical formulation	CO1	L2
6	Determine the critical energy release rate of a DCB specimen loaded in a tensile testing machine. The thickness of the DCB specimen is 30 mm, depth of each cantilever 12 mm and crack length 50 mm. It is made of a hardened steel with the modulus of 207 GPa and the crack is about to propagate at 15405 N pulling load	CO1	L2
7	Determine the shape of the DCB specimen if G1 is to remain constant with the growth of the crack. The specimen is loaded in the constant load mode. Determine the depth h of the specimen beyond the crack tip if thickness of the specimen remains constant (B = 30 mm). The initial crack length is 50 mm, modulus 207 GPa and depth of each cantilever 12 mm up to the initial crack length	CO1	L2
8	Illustrate the concept behind An elastic Deformation At Crack Tip	CO1	L2
9	Explain the crack resistance with neat sketch	CO1	L2
10	Explain the critical energy release rate with plane stress and plain strain approach	CO1	L2
UNIT-2			

1	Distinguish Linear Elastic Fracture Mechanics and its significance in the analysis of engineering materials analysis	CO1 CO2	L4
2.	Distinguish the Stress Intensity Factor and its significance in the analysis of engineering materials analysis	CO1 CO2	L4
3.	Distinguish Westergaard's Approach for three modes of fractures	CO1 CO2	L4
4.	Differentiate the response of edge crack and embedded crack behaviours	CO1 CO2	L4
5.	Differentiate the response of elliptical crack and semi elliptical crack behaviours	CO1 CO2	L4
6.	Distinguish the relation between GI And Kl	CO1 CO2	L4
7.	Why should we evaluate the SIF for a crack in a component? How does it help a designer	CO1 CO2	L4
8.	Illustrate the bending and twisting of Cracked Plates	CO1 CO2	L4
9.	Determine the critical crack length in a centered-cracked plate, loaded in Mode I, if criticalstress intensity factor K1c = 60 MPa m and far field stress is 120 MPa	CO1 CO2	L4
10	Why is an edge crack more dangerous than a centre crack of the same length a?	CO1 CO2	L4
UNIT-3			
1.	A centre-cracked panel of width 2W = 500 mm and thickness B = 20 mm is pulled normal to the crack length (2a = 100 mm), with a far field stress σ'. Estimate the maximum σ that can be applied without causing the growth of the crack if, Jp = 400 kJ / m2• The material constants of the Ramberg-Osgood equation are known to be n = 5,.α= 5.4, σys(=σ0) = 520 MP a and εo = 0.00251.	CO1 CO3	L3
2.	Differentiate the J integral and CTOD methods	CO1 CO3	L3
3.	Illustrate the reason for the path independence of J-integral	CO1 CO3	L3
4.	Determine the J-Integral for a component loaded in Mode I, with a far field stress of200 MPa and an edge crack of 40 mm length. The geometrical factors are β^2= 1.12 and H = 7; the material follows the Ramberg-Osgood relation with the material constants given as: E = 207 GPa, n = 6.8, and F = 1 x 1018 (MPa)	CO1 CO3	L3
5.	Consider an axially cracked pressured cylinder of steel (E = 207 GPa) with internal radius of 80 mm and wall thickness of 16 mm (Fig. 6.10). An axial crack of 3 mm depth has been identified on the inner surface of the cylinder. If the yield stress a0 of the material is 700 MPa, the hardening exponent n = 7, the material constant of Ramberg-Osgood relation α= 6.2 and Jp= 280J /m2, determine the maximum pressure that the cylinder can resist against the crack growth.	CO1 CO3	L3

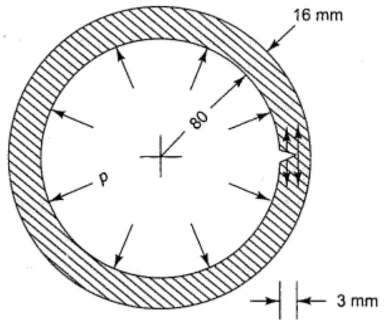

Fig.1 Axially cracked pressurized cylinder

6.	Differentiate the relationship Between CTOD, KI And GI For Small Scale Yielding	CO1 CO3	L3
7.	Illustrate the Equivalence Between CTOD AND J	CO1 CO3	L3
8.	Illustrate the features of Crack tip opening displacement	CO1 CO3	L3
9.	Why is the numerical evaluation of J_I usually simpler than the evaluation of GI or KI, in the case of the LEFM?	CO1 CO3	L3
10.	Path independence of the J-Integral is not valid for elastic-plastic materials. Why?	CO1 CO3	L3
UNIT-4			
1.	DistinguishK1c-Test Technique and the specimens recommended for the test	CO1 CO4	L3
2.	Illustrate the test methods to determine $J_{1c}$and its significance	CO1 CO4	L3
3.	Differentiate the specimens used for the characterization of fracture behaviour.	CO1 CO4	L3
4.	Illustrate the procedure of Measuring the Crack Length	CO1 CO4	L3
5	Illustrate the test Methods To Determine G_{Ic} And G_{IIc}	CO1 CO4	L3
6.	Illustrate the test method of Interlaminar G_{Ic}	CO1 CO4	L3
7.	Illustrate the test method of Interlaminar G_{IIc}	CO1 CO4	L3
8.	Illustrate the test method of determination of critical CTO D	CO1 CO4	L3
9.	Why are results of Charpy or Izod impact tests not useful in predicting loads that would grow an existing crack in a component with known geometry and boundary conditions?	CO1 CO4	L3
10.	Why are Charpy or Izod tests still popular in industries?	CO1 CO4	L3