Brief Guideline

Chapters	No of Lectures of 50 mins duration
1. Overview of Fracture Mechanics	3 – 5
2. Crack Growth and Fracture Mechanisms	3 – 4
3. Energy Release Rate	8 – 10
4. Stress Field in a Plate with Circular/ Elliptical Hole	3 – 5
5. Crack-tip Stress and Displacement Fields	8 – 10
6. SIF for Various Geometries and Loading	3 – 4
7. Evaluation of SIF by Experimental/ Numerical Methods	2 – 6
8. Modeling of Plastic Deformation at the Crack-tip	2 – 4
9. Fracture Toughness Testing	3 – 4
10. Crack Initiation and Life Estimation	3 – 5
11. Crack Arrest/Repair Methodologies	2 – 3
12. *J*-Integral	1 – 2
13. Mixed-mode Fracture	1 – 2
Total No. of lectures	42 – 65

DETAILED GUIDELINE OF CONCEPTS TO BE COVERED PER LECTURE

LECTURE	CONCEPTS TO COVER	SLIDES
1	Introduction, Tensile test, Bending of beams, Torsion, Buckling, yield criteria, Fatigue test, S-N diagrams, Conventional design, Spectacular failures	Chapter: 1 Overview of Fracture mechanics. Slides (1 – 12)
2	Recapitulation of Lecture 1, Closer look at Spectacular failures and Lessons learnt from them.	Chapter: 1 Overview of Fracture mechanics. Revision of Slides (1 – 12) and Slides (13 – 30)
3	Summary of failures, Fracture – bane or a boon?, Application of Fracture mechanics, basics of photoelasticity, Historical development, Healing of a crack, crack branching, Fracture mechanics – broad area covering several disciplines. LEFM.	Chapter: 1 Overview of Fracture mechanics. Slides (31 – 41)
4	EPFM, Range of LEFM/EPFM, Modes of loading, Information provided by Engineering Fracture Mechanics, New tests, Graphs of Fatigue life, residual strength. Engineering Fracture Mechanics – Holistic methodology, Fracture parameters. Typical failures – two case studies.	Chapter: 1 Overview of Fracture mechanics. Slides (42 – 54)
5	Typical failures examples (contd.) like bolts, aircraft, crankshaft, multiple radial cracks, interfacial crack etc. References/ books. Crack growth and fracture mechanisms.	Chapter: 1 Overview of Fracture mechanics. Slides (54 – 67) Chapter: 2 Crack growth and fracture mechanisms. Slides (1, 2)
6	Fatigue crack growth model, Striations, Beachmarks, stress corrosion cracking, Types of stress corrosion cracking, Active path dissolution, Hydrogen embrittlement, film induced cleavage, methods to prevent stress corrosion cracking.	Chapter: 2 Crack growth and fracture mechanisms. Slides (3 – 13)

LECTURE	CONCEPTS TO COVER	SLIDES
7	Creep, corrosion fatigue, liquid metal embrittlement. Fracture mechanisms, Brittle fracture, Transgranular and Intergranular, Ductile rupture-mechanism, crack particle in Al, Ductile fracture in Cu-Al-Mg.	Chapter: 2 Crack growth and fracture mechanisms Slides (14 – 26)
8	Energy release rate, Inglis soln, Griffith's dilemma, surface energy, Griffith's realization. Surface energy of common material, Elastic strain energy, strain energy in axially loaded member.	Chapter: 3 Energy release rate: Slides (1 – 12)
9	Strain energy stored in a member due to torsion, bending, Energy release rate, Advance of crack tip, surface energy as a function of load and displacement (constant load)	Chapter: 3 Energy release rate: Slides (13 – 17)
10	Strain energy as a function of load and displacement (contd.), General loading, strain energy in the presence of a crack, Relaxation analogy, Variation of surface and strain energy.	Chapter: 3 Energy release rate: Slides (17 – 23)
11	Variation of surface and strain energy in fixed grips. Validation of Griffith's approach. Energy release rate.	Chapter: 3 Energy release rate: Slides (23 – 27)
12	Energy release rate in terms of change in potential energy – constant load and displacement, compliance approach for constant load and constant displacement.	Chapter: 3 Energy release rate: Slides (28 – 36)

LECTURE	CONCEPTS TO COVER	SLIDES
13	Energy release rate by compliance approach, Energy release rate for edge crack subjected to moment. Necessary and sufficient conditions for fracture.	Chapter: 3 Energy release rate: Slides (37 – 39) and 57
14	Graphical representation of fracture of brittle material, Crack branching, γ curve, shadow photograph of crack branching, simplified model of crack-branching. Irwin's-Orowan extension of Griffith analysis	Chapter: 3 Energy release rate: Slides (58 – 64)
15	Resistance to crack growth in high strength alloys. Strength of Materials, Theory of elasticity.	Chapter: 3 Energy release rate: Slides (64 – 66). Chapter: 4 Stress Field in a plate with circular/elliptical hole: Slides (1 – 11).
16	Review of governing equations, displacement formulation, stress formulation, Solution to plane elastic problems, Forms of ϕ in Cartesian co-ordinates, Beam under uniformly distributed load.	Chapter: 4 Stress Field in a plate with circular/elliptical hole: Slides (12 – 24).
17	Forms of ϕ in polar coordinates. Cases: Axisymmetric. Asymmetric, Hertz contact problems, Stress concentration in a plate with a hole. Principle of superposition.	Chapter: 4 Stress Field in a plate with circular/elliptical hole: Slides (25 – 32).
18	Principle of superposition (problem I and problem II) variation of stresses. Plate with an elliptical hole, solution.	Chapter: 4 Stress Field in a plate with circular/elliptical hole: Slides (33 – 47).

LECTURE	CONCEPTS TO COVER	SLIDES
19	Crack tip stress and displacement fields: Analytic function, Cauchy Riemann conditions, modes of loading, Westergaard function, Mode I – Airy's stress function.	Chapter: 5 Crack-tip stress and displacement field. Slides (1 – 10)
20	Compatibility conditions, Airy's stress function – summary, Boundary conditions.	Chapter: 5 Crack-tip stress and displacement field. Slides (11 – 19).
21	Boundary conditions continued. Origin shifting, Mathematical definition of stress intensity factor, Very near-tip stress field equations.	Chapter: 5 Crack-tip stress and displacement field: Slides (20 – 26).
22	Very near-tip stress field equations (contd), Suitability of Westergaard's solution for practical problems. Role of Photoelasticity. Basics of Photoelasticity. Plot of Theoretical Isochromatics. Experimental Isochromatics for short crack.	Chapter: 5 Crack-tip stress and displacement field: Slides (26 – 30). Basics of photoelasticity – Link on photoelasticity.
23	Features of experimentally observed crack-tip isochromatics. Modified Westergaards equation (Irwin's modification), Modification of Tada,Paris,and Irwin. Displacement field (Mode I) derivation.	Chapter: 5 Crack-tip stress and displacement field: Slides (31 – 35).

LECTURE	CONCEPTS TO COVER	SLIDES
24	Displacement field – Mode I contd., plane stress, plane strain. Summary Displacement field in polar coordinates, combined expression of displacement field for both plane stress and plane strain.	Chapter: 5 Crack-tip stress and displacement field: Slides (36 – 45)
25	Crack opening displacement, Energy release rate (based on displacement of crack faces).	Chapter: 5 Crack-tip stress and displacement field: Slides (46 – 48). Chapter 3: Energy release rate Slides (47– 48).
26	Relation between K_{I} and G_{I} (Plane stress).	Chapter 3: Energy release rate Slides (51– 55).
27	Very near-tip stress field (Mode II) Stress and displacement field. Origin shifting, very near-tip displacement field. General application for displacement field. Generalized Westergaard solutions, Muskhelishvili Approach, Stress function *Y*.	Chapter: 5 Crack-tip stress and displacement field: Slides (49 – 58).
28	Stress field in terms of ψ and *Y*, Particular cases: Westergaard, Irwin and Generalized Westergaard.	Chapter: 5 Crack-tip stress and displacement field: Slides (59 – 64).
29	William's eigen function approach, boundary conditions, Williams stress function for Modes I and II.	Chapter: 5 Crack-tip stress and displacement field: Slides (65 – 76).

LECTURE	CONCEPTS TO COVER	SLIDES
30	Williams approach (full solutions) Multi-parameter stress field equations. Isochromatics in Mode I.	Chapter: 5 Crack-tip stress and displacement field: Slides (77 – 79)
31	Isopachics (Mode I), Isochromatics (I+II) Isopachics (I+II) Displacement field (I+II) Mode III – Derivations.	Chapter: 5 Crack-tip stress and displacement field: Slides (80 – 92).
32	SIF for various geometries and loading. SIF evaluation based on stress function, Green's function approach, Infinite Strip.	Chapter: 6 SIF for various geometries and loading: Slides (1 – 5)
33	Evenly spaced collinear cracks in infinite plate, finite dimension plate, Edge crack, double edge crack, principle of superposition, internally pressurized crack.	Chapter: 6 SIF for various geometries and loading: Slides (6 – 10).
34	Crack from a riveted hole, SIF for embedded circular and elliptical flaw semi-elliptic surface crack, growth of surface crack, shallow surface crack, plastic zone correction, flaw shape parameter.	Chapter: 6 SIF for various geometries and loading. Slides (11 – 23).
35	Corner crack, Direct analysis of surface cracks, selection of fracture toughness. Modeling of plastic deformation at crack tip, Range of LEFM/EPFM, Small scale yielding, methods to evaluate plastic zone, material model, shape of plastic zone.	Chapter: 6 SIF for various geometries and loading. Slides (24 – 30). Chapter: 8 Modeling of plastic deformation at crack-ip: Slides (1 – 10 and slide 12).

LECTURE	CONCEPTS TO COVER	SLIDES
36	Effective crack length, Irwin's model (Elasto-plastic analysis), plane stress, plane strain. Dugdale's approach (Elastic analysis)	Chapter: 8 Modeling of plastic deformation at crack-tip. Slides (14 – 28a).
37	Plastic zone length, correction factor for crack length, classification of plane stress/plane strain, Evaluation of minimum thickness, Estimation of SIF, Variation of plastic zone. Slip planes in plane stress/strain.	Chapter: 8 Modeling of plastic deformation at crack-tip. Slides (29 – 43).
38	Fracture Toughness Testing. Toughness – a material property, Toughness as a function of thickness. Chevron notch. Fatigue pre-cracking, clip gauge to measure CMOD.	Chapter: 9 Fracture Toughness Testing: Slides (1 – 15)
39	Influence of specimen thickness, Measurement of load, Pop-in phenomenon. Measurement and acceptance criteria of crack length, Selection of specimen.	Chapter: 9 Fracture Toughness Testing: Slides (16 – 25)
40	Plane stress fracture toughness testing, Anti-buckling guides, panel width, Residual strength diagram, Verification.	Chapter: 9 Fracture Toughness Testing: Slides (26 – 35)
41	Lacuna of conventional fatigue test, crack growth curve, Paris law, Validation of Paris law.	Chapter:10 Crack Initiation and Life Estimation: Slides (1 – 14)

LECTURE	CONCEPTS TO COVER	SLIDES
42	Sigmoidal curve, Empirical relation for Sigmoidal curve, Effects of parameters on sigmodial curve, Crack closure, Influence of overload, Retardation models, Damage tolerance.	Chapter:10 Crack Initiation and Life Estimation: Slides (15 – 28).
43	Mixed Mode Cracking: Energy based criteria, maximum principal stress criterion.	Chapter: 13 Mixed-mode Fracture. Slides (1 – 11).
44	Strain energy density criterion. Path independent integral, J-integral, path independent, Elasto plastic behaviour.	Chapter: 13 Mixed-mode Fracture. Slides (12, 13). Chapter: 12 *J*-integral: Slides (1 – 8)
45	Experimental determination of J, HRR Field Experimental determination of K Irwin's Two parameter method.	Chapter: 12 *J*-integral: Slides (9 – 15) Chapter: 7 Evaluation of SIF by experimental/Numerical methods Slides (1 – 6)
46	Overdeterministic multi-parameter evaluation of stress/displacement field by Photoelasticity/Holography/Moiré.	Chapter: 7 Evaluation of SIF by experimental/Numerical methods Slides (7 – 21)
47	Evaluation of SIF by the method of Caustics, Strain gauges.	Chapter: 7 Evaluation of SIF by experimental/Numerical methods Slides (22 – 46). Only selected slides from this range.

LECTURE	CONCEPTS TO COVER	SLIDES
48	Numerical evaluation of SIF by Finite Elements – Overview.	Chapter: 7 Evaluation of SIF by experimental/Numerical methods Slides (47 – 65). Only selected slides from this range
49	Energy Release rate, *J* by FEM, Virtual Crack extension, Virtual crack closure.	Chapter: 7 Evaluation of SIF by experimental/Numerical methods Slides (66 – 85). Only selected slides from this range
50	Different philosophies for crack arrest, delay of crack reinitiation, patched crack, crack healing, crack stitching.	Chapter:11 Crack Arrest Methodologies: Slides (1 – 24). Only selected slides from this range

* The material given is comfortable for a 42 hrs, first level course on Fracture Mechanics. It allows a teacher to choose his/her topics relevant to the needs of the class. Certain portions of the course may also be given as self-study exercise to the students.

* A possible plan for 50 hrs lectures is given here. This information is based on actual class room experience.

* To do full justice to the material contained in the e-book at least 60 hrs of lectures is required.