Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech/ME/SEM-8/ME-823/2013

2013
FRACTURE MECHANICS

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following : $10 \times 1 = 10$

i) Method of crack identification is

a) ultrasonic crack detection

b) X-ray

c) magnetic flux method

d) all of these.

ii) More than 80% failures are caused by

a) UDL b) UVL

c) Fluctuating loads d) Point loads.

iii) Ways of failure are

a) Yielding b) Buckling

c) Fracture d) All of these.

iv) ..... is to measure the potency of a crack for ductile material.

a) G b) K

c) J_c d) CTOD.

v) In mixed mode condition studies are carried out in finding

a) Crack extension direction

b) Critical load

c) Stability of crack path

d) All of these.

vi) Two dimensional problems of fracture mechanics are solved through FEM by using

a) Triangular elements

b) Quadrilateral elements

c) Isoparametric elements

d) All of these.

vii) S-N curve is the relation of

a) Applied stress *vs*. Number of cycles

b) Stress *vs*. Strain

c) Number of cycles *vs*. Applied stress

d) None of these.

viii) Free energies develop because of

a) Atom is attracted by the neighbouring atoms

b) Atom is repulsed by the neighbouring atoms

c) Atoms close to the surface behave differently from an atom at the interior

d) All of these.

ix) To minimize stresses a design engineer should modify

a) Notches b) Cutouts

c) Keyways d) None of these.

x) Which one is the field equation ?

a) Equilibrium equations relating stress components

b) Strain-displacement relations

c) Stress-strain relations for the given material of the component

d) All of these.

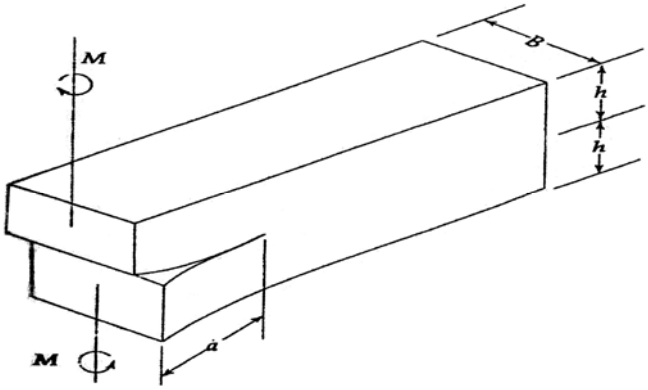
GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. Discuss with neat sketch the Intergranular and Transgranular Fractures.
3. Discuss about three modes of failure with neat sketch.
4. What is the 'Dilemma of Griffith' ? Discuss briefly.

5. Determine energy release rate for an edge crack loaded as shown in the figure below.



6. A large plate of 5 mm thickness, made of medium carbon steel (σ_{ys} = 350 MPa) with a through the thickness centre-crack of $2a$ = 40 mm length, is subjected to a stress of 150 MPa. Determine the effective crack length using Irwin's correction.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

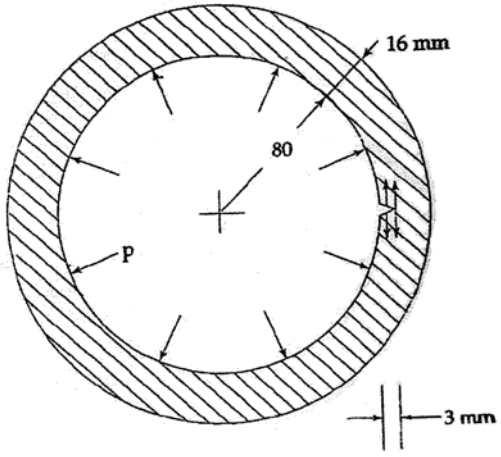
7. a) A steel plate (σ_{ys} = 350 MPa) of width 80 mm and thickness 5 mm has a centre-crack of $2a$ = 40 mm length. If the far field is 150 MPa, determine SIF and the length of the effective crack using Irwin's correction. 8

   b) Determine J-Integral (J_c) for a component loaded in mode I with a far field stress of 200 MPa and an edge crack of 40 mm length. The geometrical factors are β^2 = 1.12 and H = 7; the material follows Ramberg-Osgood relation with the material constants given as :

   E = 207 GPa, n = 6.8 and $F = 1 \times 10^{18}$ $(MPa)^{6.8}$ 7

8. a) 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 that can be applied without causing the growth of the crack if Jp = 400 kJ/m^2. The material constants of the Ramberg-Osgood equation are known to be n = 5, a = 5.4, σ_{ys} (= σ_0) = 520 MPa and ε_0 = 0.00251. 8

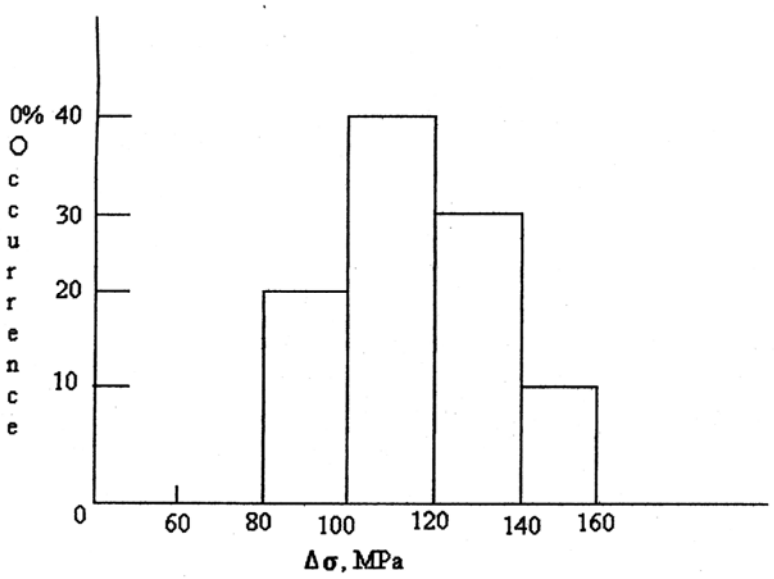
b) Consider an axially cracked pressured cylinder of steel (E = 207 GPa) with internal radius of 80 mm and wall thickness of 16 mm as shown in figure. An axial crack of 3 mm depth has been identified on the inner surface of the cylinder. If the yield stress σ_0 of the material is 700 MPa, hardening exponent n = 7, material constant of Ramberg-Osgood relation α = 6.2 and J_p = 280 J/m^2, determine maximum pressure that the cylinder can resist against crack growth. 7



9. a) Find the relation between CTOD, K_1 and $G1$ for small scale yielding. 8

   b) An edge crack, detected on a large plate, is of length 3.1 mm under a constant amplitude cyclic load having σ_{max} = 310 MPa and σ_{min} = 172 MPa. If the plate is made of a ferriate-perlite steel and K_{Ic} = 165 MPa $m^{1/2}$, determine (a) propagation life up to failure and (b) propagation life if the crack length a is not allowed to exceed 25 mm. 7

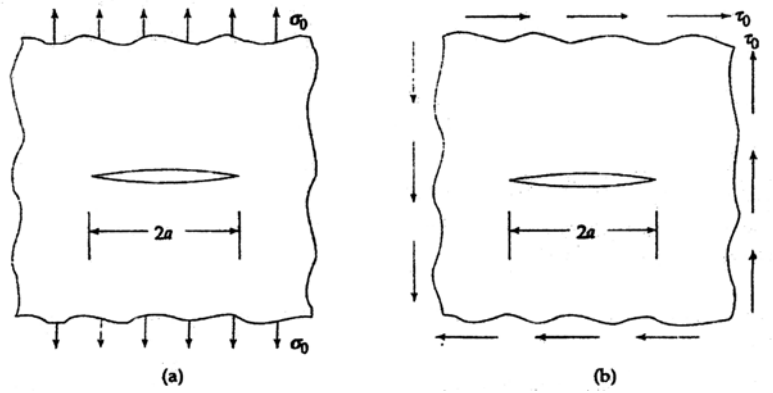
10. a) Fluctuating load on a critical component of an offshore structure is shown by a histogram in the figure given below. During a routine check-up, an edge crack of length 1.5 mm is detected. If the crack length is not allowed to exceed 25 mm, determine the remaining life of the component. Use Paris Law with material constants as $C = 6.0 \times 10^{-12}$ $(MPa)^{-3.2}$ $m^{-0.6}$ and $m = 3.2$. 7



b) Consider the finite plate of figure shown below with a centre crack of length $2a$. Find crack extension direction and critical condition for crack extension using SED criterion for –

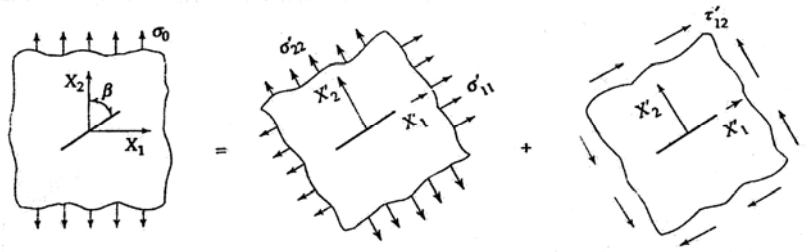
i) pure mode I loading and

ii) pure mode II loading. The critical stress intensity factor in mode I. Determine experimentally, K_{Ic} and Poisson's ratio of the material if $\nu = 0.3$. 8



11. Consider an infinite plate with a crack of length $2a$ = 80 mm, inclined at angle β with the applied tensile stress σ_0 as shown in figure. K_{Ic} of the material is known to be 40 MPa $\sqrt{m}$, elastic constants are E = 200GPa and υ = 0.3, and the plate is subjected to plain strain. (i) Determine initial crack extension direction using MTS and SED fracture criteria for β = 60°, (ii) the applied stress σ_0 corresponding to crack initiation using MTS and SED fracture criterion for

β = 60°, and (iii) relations θ_c *vs.* β and σ_0 *vs.* β for both fracture criteria for β varying between 10° and 90°.



$\sigma'_{11} = \sigma \cos^2 \beta$ $\tau'_{12} = \sigma \sin^2 \beta \cos \beta$

$\sigma'_{22} = \sigma \cos^2 \beta$