Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

A Constituent Institute of Manipal University, Manipal

VI SEMESTER B.TECH. (MECHANICAL & IP)
END SEMESTER EXAMINATION – APRIL / MAY 2017
SUBJECT: PROGRAM ELECTIVE - IV (FATIGUE AND FRACTURE, MME 4003)
REVISED CREDIT SYSTEM

Time: 3 Hour **Max. Marks: 50**

Note: (i) Answer all the questions
(ii) Missing data, if any, may be appropriately assumed
(iii) Assumptions made must be clearly mentioned

1A State and explain different fatigue failure modes 03

1B Compare stress-life and strain-life approaches. 03

1C A steel material has ultimate strength of 520 MPa, yield strength of 400 MPa, an endurance limit (rotating bending) of 250 MPa, true fracture strength of 760 MPa and modulus of elasticity of 200 GPa. 04
i) Determine the allowable zero to maximum (R=0) bending stress which can be applied on the smooth steel specimen for a life of 10^5 cycles using Marrow relation.
ii) What is the permitted bending stress for a life of 10^5 cycles if R = -1?

2A What is cyclic stress-strain curve and hysteresis curve? Derive an expression for the general hysteresis curve. 04

2B It is required to design a solid circular link made of 4340 steel. The link is to be subjected to a spectrum of axial loads. The S-N design data based on experimental test results is shown in Table below for completely reversed cyclic stresses. The actual link is to be subjected to the following spectrum of completely reversed loading during each duty cycle: 970 MPa for 1000 cycles, 550 MPa for 7500 cycles. 04

S (MPa)	N (cycles)	S (MPa)	N (cycles)
1037	3500	622	216000
968	7100	553	440000
898	14200	484	1980000
829	28000	470	Infinite

The duty cycle is repeated 2 times. After this, how many cycles at 970 MPa could be applied as per *Manson double linear damage rule*.

2C Load sequence influences fatigue life. Justify 02

3A What is Neuber's rule? A notched component has a theoretical stress concentration factor of 2.75. The component is loaded to cause a nominal stress of 230 MPa. Determine the resulting notch root stress and strain at this loaded state. The component is then unloaded to a nominal stress of 25 MPa. Determine the residual stress at the notch root when unloaded. The strain life properties for this material are σ_f' = 1000 MPa, ε_f' = 1.0, b = -0.08, c = -0.60. Modulus of elasticity of the material is 104 GPa. 05

3B Given below are the results of constant amplitude strain controlled tests on a high strength aluminum (E = 72.5 GPa). 05

Strain amplitude ($\Delta\varepsilon/2$)	Stress amplitude $\Delta\sigma/2$ (MPa)	Reversals to failure ($2N_f$)	Strain amplitude ($\Delta\varepsilon/2$)	Stress amplitude $\Delta\sigma/2$ (MPa)	Reversals to failure ($2N_f$)
0.0725	611	10	0.0123	470	620
0.0445	594	28	0.0082	445	2000
0.029	559	90	0.0056	394	8400
0.0182	525	284	0.0047	338	24800

Determine the following :

i) Strain life properties (σ_f' , ε_f' , b, c)
ii) Transition life

4A Explain Griffith's analysis of crack growth and derive an expression for critical crack length. 03

4B A steel plate of 120 x 10 mm cross section is subjected to a tensile load of 170 kN on the cross section. It consists of a through thickness center crack (in transverse direction w. r. t. loading direction) of critical size of 58 mm length (2a). This plate is replaced by another plate of same steel and cross section and it has a single edged through thickness crack of 30 mm length (a). Is the replaced plate safe, considering LEFM approach? If not safe, suggest your recommendations to have safe design. Geometry constant, f(α), for centre cracked plate and edge cracked plate may be assumed as 1 and 1.12 respectively. 03

4C How crack tip plasticity is addressed in thick and thin plates? A thin plate has an edge crack of 35 mm length and a far field stress of 300 MPa. If yield strength of the material is 900 MPa determine plastic zone size and effective crack length. Geometry constant, f(α), for edge cracked plate may be assumed as 1.12. 04

5A What is energy release rate and stress intensity factor? Establish the relation between them. 03

5B Discuss the effect of crack closure and overload in fracture mechanics 03

5C An edge crack of 3 mm was observed in a plate of width 320 mm. The fracture toughness of this material is 7000 MPa$\sqrt{}$mm. If crack growth is modeled as $da/dN = 10^{-13} (\Delta K)^3$, determine number of constant amplitude cycles of 0 to 350 MPa that the component may experience before failure. It is assumed that the crack size is negligible compared to the thickness. Geometry constant $\beta=f(\alpha)$ may be assumed as 1.12. 04