Reg. No. | | | | | | | | |

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

VI SEMESTER B.TECH. (MECHANICAL & IP ENGG)
END SEMESTER EXAMINATION, APRIL 2018
SUBJECT: PROGRAM ELECTIVE - IV (FATIGUE AND FRACTURE, MME 4003)
REVISED CREDIT SYSTEM

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

Instructions to Candidates:

- Answer **ALL** the questions.
- Additional data, if any required, may be appropriately assumed.
- Assumptions made must be clearly mentioned.

1A Compare safe-life and fail-safe fatigue design approaches. 03

1B Explain the phenomenon of creep fatigue in crystalline solids. 03

1C A smooth uniaxial rod of diameter 56 mm is subjected to a mean force of 180 kN. It is made from a steel material (S_y = 550 MPa, S_u = 670 MPa, S_f = 720 MPa, E = 200 GPa) which has completely reversed endurance strength of 300 MPa. Determine what is the allowable maximum and minimum fluctuating force that will not cause failure in 10^5 cycles according to the Gerber criterion. 04

2A Sketch a typical S-N diagram for the steel material indicating all the salient features. How S-N curves are determined in rotating bending test? 04

2B A shaft made of steel (S_u = 931 MPa, E = 205 GPa, a = 1240 MPa, b = $-$0.07) is repeatedly subjected to following block of axial load history. 04

Load Number	Max. Stress [MPa]	Min. Stress [MPa]	No. of Cycles Applied
1	500	-500	30
2	650	-500	10
3	650	0	100

If the shaft is smooth with a polished surface finish, how many blocks of this stress history can be applied before failure is expected? Use Miner's rule for damage estimation.

2C Write a note on Bauschinger effect. 02

3A A notched component made up of Copper-Aluminum alloy (σ_f' = 1000 MPa, ε_f' = 1.0, b = $-$0.08, c = $-$0.6, E = 104 GPa) has a theoretical stress concentration factor of 2.9 and notch sensitivity factor of 0.95. It is subjected to a cyclic loading of 230 MPa to 25 MPa. Predict the life using strain life approach. 05

3B Listed below are the strain-life properties for high and low strength steel. 05

Steel	σ_f' (MPa)	ε_f'	b	c	E (GPa)
Low strength (A)	800	1	−0.1	−0.5	200
High strength (B)	2700	0.1	−0.08	−0.7	200

Determine the following:

i) Transition life for both the steels
ii) Strain amplitude of both the steels for a life of 500 cycles.
iii) Strain amplitude of both the steels for a life of 3×10^4 cycles.
iv) How the results obtained in i), ii) and iii) could be used to select steels A & B
v) Did the materials A & B, cyclically harden or soften?

4A Explain crack tip plasticity? What is the effect of plate thickness on the size of plastic zone? 03

4B A steel material has critical stress intensity factor of 65 MPa √m, yield strength of 780 MPa, ultimate strength of 900 MPa and modulus of elasticity as 208 GPa. If edge cracked CT test specimens having thickness of 10 mm, 15 mm and 25 mm are available, which specimen do you consider to define the fracture toughness of steel? Justify. 03

4C How the concept of stress intensity factor is used to design parts having cracks? A steel plate (S_y = 300 MPa, E = 198 GPa, Fracture toughness = 28.3 MPa √m) of thickness 30 mm, width 120 mm and 2 m long (in tensile stress direction) is loaded with normal tensile stress of 50 MPa. If a 64 mm long central crack (in transverse direction w. r. t. loading direction) is present, estimate the tensile stress at which catastrophic failure will occur. Also, compare it with the yield strength of the material. Geometry constant f(α) may be assumed as 1. 04

5A Explain Griffith's analysis of crack growth and derive an expression for critical crack length. 03

5B A center crack detected on a large steel plate is of length 6 mm. It is assumed that the crack size is negligible as compared to the thickness of the plate and can be modelled as $da/dN = 7 \times 10^{-12} (\Delta K)^{3.2}$. The plate is subjected to constant amplitude fatigue loading of σ_{max} = 300 MPa and σ_{min} = 160 MPa. If the fracture toughness for steel material is 150 MPa √m, determine the crack length at failure and life of the component. Geometry constant β = f(α) may be assumed as 1.12. 04

5C With relevant sketches, explain the effect of an overload cycle on crack growth rate? 03