Reg. No.									

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

VI SEMESTER B.TECH. (MECHANICAL / IP ENGG)
END SEMESTER MAKE UP EXAMINATION, JUNE 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 Define fatigue and discuss various types of fatigue failure. 03

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

1C Sketch S-N curve for a steel (S_y = 490 MPa, S_u = 690 MPa, σ_f' = 850 MPa, E = 202 GPa) specimen for following cases. 04

i) 6 mm diameter, notch free, mirror polished finished, subjected to completely reversed bending.

ii) 50 mm diameter, notch free, mirror polished finish subjected to completely reversed axial loading.

iii) Compare both the S-N curves and comment on it.

2A Work cycle of a mechanical component subjected to completely reversed bending stress consists of following three components. 04

Load Number	Max. Stress [MPa]	Min. Stress [MPa]	Duration of load application
1	350	-350	85% of the total life time
2	400	-400	12% of the total life time
3	500	-500	3 % of the total life time

The material of the component is steel with an ultimate strength of 660 MPa and corrected endurance strength of 200 MPa. Determine life of the component by using Miner's rule.

2B An un-notched circular rod with a diameter of 10 mm is subjected to a constant amplitude bending at room temperature with a mean stress (S_m) of 200 MPa. The material is quenched and tempered alloy steel (S_u = 1240 MPa, S_y = 1070 MPa). The rod is commercially polished which gives a surface finish of the factor 0.87. Estimate the values of stress amplitude (S_a), maximum stress (S_{max}), minimum stress (S_{min}) and stress ratio (R), for a median fatigue life of 50,000 cycles by using Soderberg criterion. 04

2C What is cyclic stress-strain curve (CSSC)? List the methods of determining CSSC. 02

3A 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. 04

3B With relevant sketches explain basic modes of crack propagation in materials. 03

3C What is energy release rate and stress intensity factor? Establish a relation between them. 03

4A 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

4B Derive an expression for the general hysteresis curve. Also, explain what is transition life. 03

4C A thin plate has a center crack of 70 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), may be assumed as 1. 03

5A A notched steel component consists of a bar 25 mm wide and 6 mm thick with two semi-circular edge notches with radii of 2.5 mm. This gives the plate width at the reduced section of 20 mm. Determine the life of the component by using strain life approach when subjected to a fully reversed load with an amplitude of 69 MPa. The steel has an ultimate strength of 790 MPa. ($K_t = 2.42$, $E = 200$ GPa, $K' = 1065$ MPa, $n' = 0.123$, $b = -0.081$, $c = -0.67$, $\sigma_f' = 1165$ MPa, $\varepsilon_f' = 1.14$). 04

5B With relevant sketches explain cyclic hardening and cyclic softening of the material subjected to constant strain amplitude fatigue loading. 03

5C With neat sketch explain various stages of fatigue crack growth. 03