Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

VI SEMESTER B. TECH (MECHANICAL/IP ENGG.) END SEMESTER EXAMINATIONS, JUNE 2019

SUBJECT: PROGRAM ELECTIVE - IV (FATIGUE AND FRACTURE, MME 4003)

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Additional data, if any required, may be appropriately assumed.
- Use of fatigue and fracture data hand book is permitted

1A. Explain the factors which affect fatigue life. **03**

1B. With suitable sketch explain the plastic deformation process through slip and twinning. **03**

1C. A highly polished circular rod of 25 mm diameter is subjected to an axial cyclic stress of 140 to 640 MPa. The material is made of steel having ultimate strength of 950 MPa and yield strength of 760 MPa. Determine the life of rod using Soderberg and Goodman relation. Comment on the results obtained. **04**

2A. With relevant sketches explain cyclic hardening and softening of the material subjected to fatigue loading. **03**

2B. Explain the various phases of crack growth due to fatigue loading with suitable graph. **03**

2C. A large steel plate (Fracture toughness = 150 MPa $\sqrt{m}$) is subjected to constant amplitude fatigue loading of σ_{max} = 400 MPa and σ_{min} = 200 MPa. A centre crack of length 8 mm is detected on the plate. It is assumed that the crack size is negligible as compared to the thickness of the plate and can be modelled as $da/dN = 7.1 \times 10^{-12} (\Delta K)^{3.2}$. Determine the crack length at failure and life of the component. Geometry constant $\beta = f(\alpha)$ may be assumed as 1.12. **04**

3A. What is fatigue damage and how is it quantified? Explain the use of Macro Starkey's CDT. **03**

3B. Given a material with ultimate strength of 500 MPa, an endurance limit of 250 MPa and a fracture strength of 810 MPa, determine the allowable zero to maximum (R=0) stress which can be applied for 10^4 and 10^5 cycles. Make predictions using Goodman and Morrow relations. **04**

3C. Both ductile and brittle materials are influenced by the combined effect of notch and mean stress. Discuss. **03**

4A. What is energy release rate? Derive the expression for energy release rate for standard DCB specimen through compliance approach considering constant load. **03**

4B. A steel plate of 110 x 20 mm cross section is subjected to a tensile load of 220 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 60 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 32 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**

4C. A far field stress of 250 MPa acts on a thin plate having a centre crack of 50 mm length. If yield strength of the material is 850 MPa determine plastic zone size and effective crack length. Geometry constant, f(α), for edge cracked plate may be assumed as 1.12. **03**

5A. A metal has the monotonic tension properties E = 210 GPa, S_y (0.2 % offset) = 275 MPa, S_u = 550 MPa, σ_f = 1250 MPa, ε_f = 1.63, % RA = 75, n = 0.21 . Under cyclic loading will the material harden or soften. Calculate strain reached on the first half cycle for a stress amplitude of 120 MPa. Given that the material has the following cyclic properties. K^l = 1460 MPa, n^l = 0.287. Determine the stable total strain and plastic strain amplitude for a stress amplitude of 120 MPa. **05**

5B. Listed below are the strain-life properties for a high and low strength steel. **05**

Steel	σ_f^l (MPa)	ε_f^l	b	c	E (GPa)
Low strength (A)	760	1.1	-0.12	-0.6	200
High strength (B)	1670	0.5	-0.07	-0.7	200

For both the steels determine the following:

i) Transition life
ii) Strain amplitude for a life of 600 cycles.
iii) Strain amplitude for a life of 4 x 10^4 cycles.