Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

VI SEMESTER B. TECH (MECHANICAL/IP ENGG.) END SEMESTER EXAMINATIONS, APRIL 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.	With relevant sketches explain the stages of fatigue failure.	**03**
1B.	Sketch a typical S-N diagram for the steel material indicating all the salient features. Also discuss the influence of different types of mean stresses on the SN curve.	**03**
1C.	AISI 1020 hot rolled steel (S_y = 331 MPa, S_u = 448 MPa, σ_f = 500 MPa, E = 200 GPa) is used to make a smooth rod of diameter 48 mm [C_{size}=0.816] which is subjected to a mean axial force of 165 kN. The completely reversed endurance strength for the material in ideal conditions is 241 MPa. Estimate the allowable maximum and minimum fluctuating force that will not cause failure in 4×10^4 cycles according to the Goodman criterion.	**04**
2A.	Explain crack tip plasticity? What is the effect of plate thickness on the size of plastic zone?	**03**
2B.	With relevant sketches, explain the effect of an overload cycle on crack growth rate?	**03**
2C.	An edge crack detected on a large steel plate is of length 5 mm. It is assumed that the crack size is negligible as compared to the thickness of the plate and can be modelled as $da/dN = 7.1 \times 10^{-12} (\Delta K)^{3.2}$. The plate is subjected to constant amplitude fatigue loading of σ_{max} = 320 MPa and σ_{min} = 170 MPa. If the fracture toughness for steel material is 150 MPa $\sqrt{m}$, determine the crack length at failure and life of the component. Geometry constant $\beta = f(\alpha)$ may be assumed as 1.12.	**04**

<table>
<tr><td>3A.</td><td>Write a note on the safe life and damage tolerance design philosophies</td><td>04</td></tr>
<tr><td>3B.</td><td>AISI 4130 normalized steel (S_u = 668 MPa, E = 210 GPa, A = 1115 MPa, b = –0.08) is subjected to following block of axial load history.
<table>
<tr><th>Load Number</th><th>Max. Stress [MPa]</th><th>Min. Stress [MPa]</th><th>No. of Cycles Applied</th></tr>
<tr><td>1</td><td>450</td><td>-450</td><td>45</td></tr>
<tr><td>2</td><td>600</td><td>-400</td><td>20</td></tr>
<tr><td>3</td><td>500</td><td>0</td><td>100</td></tr>
</table>
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.</td><td>04</td></tr>
<tr><td>3C.</td><td>Explain the characteristics of theoretical stress concentration before and after the yield point using suitable sketch.</td><td>02</td></tr>
<tr><td>4A.</td><td>Explain Griffith's analysis of crack growth and derive an expression for critical crack length.</td><td>03</td></tr>
<tr><td>4B.</td><td>How the concept of stress intensity factor is used to design parts having cracks? 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.</td><td>04</td></tr>
<tr><td>4C.</td><td>A thin plate has an edge crack of 32 mm length and a far field stress of 280 MPa. If yield strength of the material is 750 MPa determine plastic zone size and effective crack length. Geometry constant, f(α), for edge cracked plate may be assumed as 1.12.</td><td>03</td></tr>
<tr><td>5A.</td><td>A notched component made up of aluminum alloy (σ_f' = 1150 MPa, ε_f' = 1.3, b = –0.08, c = –0.6, E = 107 GPa) has a theoretical stress concentration factor of 3.1 and notch sensitivity factor of 0.95. It is subjected to a cyclic loading of 245 MPa to 45 MPa. Predict the life using strain life approach.</td><td>05</td></tr>
<tr><td></td><td>PTO</td><td></td></tr>
</table>

5B. Given below are the results of constant amplitude strain controlled tests on a high strength aluminum (E = 80 GPa). **05**

Strain amplitude ($\Delta\varepsilon/2$)	Stress amplitude $\Delta\sigma/2$ (MPa)	Reversals to failure (2Nf)	Strain amplitude ($\Delta\varepsilon/2$)	Stress amplitude $\Delta\sigma/2$ (MPa)	Reversals to failure (2Nf)
0.0721	610	12	0.0117	468	615
0.0442	593	29	0.0075	442	1860
0.0286	558	93	0.0050	391	7680
0.0178	524	275	0.0036	335	22500

Determine the following :

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

ii. Transition life