Reg. No.

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

I SEMESTER M.TECH (CAAD) END SEMESTER EXAMINATIONS (MAKEUP), DECEMBER 2018

SUBJECT: FATIGUE OF MATERIALS [MME 5104]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions
- Missing data, if any, may be appropriately assumed
- Assumptions made must be clearly mentioned
- Fatigue Data Handbook is permitted

1A. Analyse the application of stress-life and strain-life approaches of fatigue phenomena. **5**

1B. A component undergoes a cyclic stress with a maximum value of 760 MPa and a minimum value of 280 MPa. The component is made of steel with an ultimate strength of 1125 MPa, yield strength 810 MPa, endurance limit of 530 MPa and has fully reversed stress at 1000 cycles as 900 MPa. Using Goodman relation, predict the life of component. Interpret the predicted life. Also fit an S-N equation. **5**

2A. Discuss the significance of multiaxial fatigue analysis with specific reference to critical plane approach in predicting the fatigue life. **5**

2B. What is transition life? At the transition life ($2N_t$) determine the stress and strain amplitude ($\Delta\sigma/2$, $\Delta\varepsilon/2$) in terms of the cyclic stress-strain properties (E, K', n') of a material. **5**

3A. What is damage? What are the postulates made in Cumulative Damage Theories **3**

3B. It is required to design a solid circular link made of 4340 steel heat treated to a hardness of Rockwell C-35. The link is to be subjected to a spectrum of axial loads and it is desired to design the member for a 99 % probability of survival. The 99% probability of survival 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 loading during each duty cycle: 98 kN for 1100 cycles, 53 kN for 7000 cycles and 29 kN for 50000 cycles. **7**

S (MPa)	N (cycles)	S (MPa)	N (cycles)
1161	100	760	55500
1106	1350	691	110000
1037	3500	622	216000
968	7100	553	440000
898	14200	484	1980000
829	28000	470	Infinite

The duty cycle is to be repeated 3 times during the life of the bar. Preliminary estimation show that cross section area of 100 mm^2 could be used for 99 % probability of survival. State whether this area is acceptable or not using *Manson double linear damage rule theory*. If not, suggest modified cross section with justification.

4A. Listed below are the strain-life properties for a high and low strength steel. **4**

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

How do you compare the application of above two steels from fatigue consideration?

4B. Steel (S_u = 800 MPa, S_y = 690 MPa) is used in the form of plate (80 mm x 10mm) with a notch. What amplitude of bending moment M_a will result in a life of 10^6 cycles if cycling is applied at notch mean stress value of 360 MPa. For smooth material $S_n = 900N^{-0.065}$. K_t = 1.9, K_f = 1.85. **6**

5A. Explain with reason as how various factors influence the endurance limit and fatigue life of materials. **5**

5B. Discuss i) Thermomechanical fatigue and ii) Fatigue life extension methods. **5**