Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

A Constituent Institute of Manipal University, Manipal

I SEMESTER M.TECH. (CAAD) END SEMESTER EXAMINATIONS

NOV/DEC 2017

SUBJECT: FATIGUE OF MATERIALS [MME 5104]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** questions.
- Additional data required, if any, may be appropriately assumed.
- Use of Fatigue Data Hand Book is permitted

1A. Discuss the characterization and mechanism of Fatigue **3**

1B. Justify the requirement for High and Low cycle fatigue approaches **3**

1C. A component subjected a cyclic load with a maximum value of 700 MPa and a minimum value of 250 MPa. The component is made of steel with an ultimate strength of 1100 MPa, yield strength 800 MPa, endurance limit of 500 MPa. This material experiences 1000 cycles when subjected to fully reversed stress of 900 MPa. Using Soderberg and Goodman relation, predict the life of component. Also fit an S-N equation. **4**

2A. Discuss the significance of sequence effect in fatigue loading. **2**

2B. How combined effect of notch and mean stress are addressed in ductile and brittle materials? Discuss. **3**

2C. 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. The S-N design data based on experimental test results is shown in Table for completely reversed cyclic stresses. The actual link is to be subjected to the following spectrum of loading during each duty cycle: 100 kN for 1100 cycles, 50 kN for 7000 cycles and 30 kN for 50000 cycles. **5**

S (MPa)	N (cycles)	S (MPa)	N (cycles)
1160	100	760	55500
1100	1400	690	110000
1030	3500	620	216000
970	7000	550	440000
900	14000	480	1980000
830	28000	460	Infinite

If cross section area of 98 mm^2 is used, what is the damage at the end of one duty cycle. As per Manson double linear damage rule, is this crack initiation or propagation?

3A. Discuss the applicability of Neuber's rule considering both monotonic and fatigue loading. **3**

3B. Derive the equation of general hysteresis curve. Mention the assumptions made. **3**

3C. 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. **4**

4A. Discuss the phenomenon of Stress relaxation. **2**

4B. Given below are the results of constant amplitude strain-controlled tests. The material has a modulus of elasticity, E of 202 GPa. **4**

Total strain amplitude ($\Delta\varepsilon/2$)	Stress amplitude $\Delta\sigma/2$ (MPa)	Reversals to failure ($2N_f$)
0.002	260	416700
0.005	370	15900
0.01	430	2670
0.015	440	990

Determine

i) Cyclic stress-strain properties (K', n')
ii) Strain-life properties (σ_f', ε_f', b, c)
iii) Transition life ($2N_t$)
iv) Fatigue life at strain amplitude ($\Delta\varepsilon/2$) of 0.0075

4C. A notched component has a theoretical stress concentration factor of 2.8. The component is loaded to cause a nominal stress, of 215 MPa. Determine the resulting notch root stress and strain. The component is then unloaded to a nominal stress of 30 MPa. Determine the residual stress at the notch root. The strain life properties for this material are E = 102 GPa, σ_f' = 1000 MPa, ε_f' = 1.0, b = -0.08, c = -0.60. **4**

5A. Discuss the different methods of improving weldment fatigue resistance. **3**

5B. Discuss the strain range partitioning model of life prediction in case of thermomechanical fatigue. **3**

5C. Analyse how multiaxial fatigue life is predicted using **4**
i) Stress based approach ii) Critical plane approach