Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

A Constituent Institute of Manipal University, Manipal

I SEMESTER M.TECH. (COMPUTER AIDED ANALYSIS & DESIGN)

END SEMESTER MAKE UP EXAMINATION – DEC. 2016/JAN. 2017

SUBJECT: FATIGUE OF MATERIALS (MME 5104)

REVISED CREDIT SYSTEM

(03/01/2017)

Time: 3 Hour **Max. Marks: 50**

Note: (i) Answer all the questions
(ii) Missing data, if any, may be appropriately assumed
(iii) Assumptions made must be clearly mentioned
(iv) Fatigue Data Handbook is permitted

1A. Analyse the application of stress-life and strain-life approaches of fatigue phenomena. 05

1B. Discuss the influence of different parameters on fatigue life prediction. Highlight the combined effect of notch and mean stress. 05

2A. A steel material has ultimate strength of 490 MPa, an endurance limit of 240 MPa and a true fracture strength of 805 MPa. Determine the allowable zero to maximum (R=0) stress which can be applied for 5 x 10^3, 10^4 and 10^5 cycles. Make predictions using Goodman, Geber and Marrow relations. 05

2B. 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 = $900N^{-0.065}$. K_t = 1.9, K_f = 1.85. 05

3A. 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. 07

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 shows 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.

3B. Explain the application of Rainflow cycle counting method to interpret a given variable amplitude loading for fatigue life prediction. 03

4A. Listed below are the strain-life properties for a high and low strength steel. 04

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. A metal has the monotonic tension properties E = 193 GPa, S_y (0.2 % offset) = 325 MPa, S_u = 650 MPa, σ_f = 1400 MPa, ε_f = 1.73, % RA = 80, n = 0.193 . Under cyclic loading, will the material harden or soften? 06

Calculate strain reached on the first half cycle for a stress amplitude of 200 MPa. Given that the material has the following cyclic properties. K' = 1660 MPa, n' = 0.287. Determine the stable total strain and plastic strain amplitude for a stress amplitude of 200 MPa. Determine the stress response for a strain amplitude of 0.01.

5A. Discuss the significance of critical plane approach in predicting the fatigue life under multiaxial loading. 04

5B. Explain the significance of hysteresis curve and cyclic stress strain curve. 03

5C. 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. 03