Reg. No.										

Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

I SEM. M.TECH. (Computer Aided Mechanical Design & Analysis) DEGREE END SEMESTER EXAMINATIONS, NOV / DEC 2015

SUBJECT: FATIGUE OF MATERIALS [MME 507]

Time: 3 Hours MAX.MARKS: 50

Instructions to Candidates:

- Answer **ANY FIVE FULL** questions.
- Additional data required, if any, may be appropriately assumed.
- Fatigue Design Data Hand Book is permitted

1A) An axial smooth specimen made of AISI 4340 steel is subjected to S_m = 200 MPa, S_a = 450 MPa, determine the life as per (4)

i) Goodman ii) Marrow iii) SWT relation.

1B) 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)

1C) Differentiate between ductile and brittle fracture based on the phenomena of slip. (2)

2A) How combined effects of notch and mean stress are addressed in case of i) brittle materials and ii) ductile materials subjected to high cycle fatigue? (4)

2B) Given below are the results of constant amplitude strain controlled tests on a high strength aluminum (E = 72.5 GPa) (4)

Total strain amplitude ($\Delta\varepsilon/2$)	Stress amplitude $\Delta\sigma/2$ (MPa)	Reversals to failure ($2N_f$)	Total strain amplitude ($\Delta\varepsilon/2$)	Stress amplitude $\Delta\sigma/2$ (MPa)	Reversals to failure ($2N_f$)
0.0725	611	10	0.0123	470	620
0.0445	594	28	0.0082	445	2000
0.029	559	90	0.0056	394	8400
0.0182	525	284	0.0047	338	24800

Determine the strain life properties (σ_f' , ε_f' , b, c) for this material. Discuss how well this material follows the four parameter model.

2C) Compare stress-life and strain-life approaches. (2)

3A) 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 mean moment of $M_m = 900N^{-0.065}$. K_t = 1.9, K_f = 1.85. (4)

3B) Explain the significance of hysteresis curve and then derive an expression for the equation of general hysteresis curve. (4)

3C) How fatigue behavior of materials is addressed at high temperatures? (2)

4A) 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 = 100 GPa, σ_f' = 1000 MPa, ε_f' = 1.0, b = -0.08, c = -0.60. (4)

4B) What is CSSC? Compare the features of different experimental methods of determination of CSSC. (4)

4C) Discus the effect of frequency on fatigue life estimation. (2)

5A) Explain multiaxial fatigue life estimation with reference to different approaches. (4)

5B) 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?

5C) How cyclic softening and cyclic hardening phenomena influences fatigue life of materials. (2)

6A) Explain with reason how mean strain and loading sequence affects fatigue life of materials in case of strain controlled loading. (3)

6B) 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.