IV B.Tech. II Semester Supplementary Examinations, July -2005
FATIGUE AND FRACTURE MECHANICS
(Aeronautical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) How the properties of materials and surface treatments improve the fatigue life of components?
   (b) Explain how shot peering improves fatigue life.
2. (a) The fatigue limit of a 1045 steel is about 300 MN/m^2 when the mean stress is zero. The tensile strength of this steel is 750 MN/m^2. Estimate the safe stress amplitude for this material when the mean stress is 250 MN/m^2.
   (b) Discuss a typical fatigue testing procedure. Explain how the effect of mean stress can be studied.
3. (a) Explain the reasons for well defined fatigue limit in certain materials.
   (b) The endurance limit of a steel member is 112 Mpa and the tensile strength is 385 MPa. What is the fatigue strength corresponding to a life of 70 x 10^3 cycles.
4. (a) Describe about stress fluctuations and cumulative damage in fatigue failure.
   (b) How cumulative fatigue is expressed?
   (c) Discuss woods theory of fatigue failure.
5. (a) Explain the mechanism of fatigue failure propagation.
   (b) Discuss the interactions between parallel edge dislocations.
6. (a) A relatively large plate of glass is subjected to a tensile stress of 40MPa. If the specific surface energy and modulus of elasticity for this glass are 0.3 j/m^2 and 69 Gpa, respectively, determine the maximum length of a surface flow that is possible with out fracture.
   (b) What advantage does the fracture mechanics approach afford the engineer in designing components compared to more traditional approaches.
7. (a) Explain the differences in terms of work of brittle fracture between glass and a metal? Explain.
   (b) A metallic plate of dimensions 2mm×50mm × 200mm, with one internal flow (size = 1mm) is loaded in tension. If its fracture load is 2500 kg, calculate work of fracture (G_c); and critical stress intensity factor (K_c), Assume plane stress condition. The modulus of the material is 30 GPa.
8. Identify and explain several problems a designer must recognize when dealing with fatigue loading as compared with static loading.

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Code No: NR422102 **Set No.2**

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Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
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1. Explain the following terms in connection with design of machine members subjected to variable loads.
   (a) Endurance limit.
   (b) Size factor.
   (c) Surface finish factor.
   (d) Notch sensitivity.
2. (a) Explain how the effect of notches on fatigue failure can be experimentally studied.
   (b) What are the potential locations for stress concentration in a given material? Explain them fully.
3. (a) Explain why fatigue strength is a statistical quantity.
   (b) Based on dislocation theory, explain how dislocations are multiplied and strain hardening occurs.
4. (a) Describe about stress fluctuations and cumulative damage in fatigue failure.
   (b) How cumulative fatigue is expressed?
   (c) Discuss woods theory of fatigue failure.
5. (a) Describe the conditions that increase the susceptibility of a metal component to failure by fatigue. How metal fatigue resistance can be measured?
   (b) Fatigue is effected by temperature Discuss the effects of high and low temperatures on it.
6. (a) A sample has a crack length of 2μ.m. The Young's modulus the sample is $70\text{GN}/m^2$ and the specific surface energy is $1\text{J}/m^2$ Estimate the fracture strength and compare it with its young's modulus.
   (b) A heat treated steel chisel and a glass window pane are both brittle. Explain why chisel is strong and the window pane is weak.
7. (a) Determine the critical crack length in a centered cracked plate loaded in mode. If critical intensity factor
   $K_{IC} = 60MPa\sqrt{m}$ and the far field stress is 120 Mpa.
   (b) Cite the significant differences between the following.

i. Stress intensity factor
ii. Plane stress fracture toughness
iii. Plane strain fracture toughness.

8. Determine the thickness of a 120mm wide uniform plate for safe continuous operation if the plate is to be subjected to a tensile load that has a maximum value of 250kN and a minimum value of 100KN. The properties of the plate material are as follows.

Endurance limit stress	:	225MPa
Yield point stress	:	300MPa
Factor of safety based on yield point	}	1.5

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Code No: NR422102 **Set No.3**

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Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
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1. The fatigue data for a ductile cast iron are given as follows:

Stress amplitude (S) (MPa)	Cycles to failure (N)
248	1×10^5
236	3×10^5
224	1×10^6
213	3×10^6
201	1×10^7
193	3×10^7
193	1×10^8
193	3×10^8

   (a) Make an S-N plot using the above data.

   (b) What is the fatigue limit for the alloy.

   (c) Determine the fatigue life for stress amplitudes of 230MPa and 175MPa.

   (d) Estimate fatigue strengths at 2×10^5 and 6×10^6 cycles.

2. (a) Why certain materials like ferrous alloys & Titanium alloys Exhibit a fatigue/endurance limit and many non-ferrous alloys do not exhibit? Explain properly.

   (b) What is a master diagram? Explain how a designer might utilize a master diagram.

3. (a) Explain why fatigue strength is a statistical quantity.

   (b) Based on dislocation theory, explain how dislocations are multiplied and strain hardening occurs.

4. (a) Explain the theory of Miners law.

   (b) Express Miners law in mathematical terms.

   (c) In a smooth bar rotating beam fatigue test, under fully reversed loading it is found that failure of a mild steel occurs on loading (at 1/4 cycle) at a stress of 420 MPa. At a stress amplitude of 210 MPa the number of cycles to failure is 10^6. How long a part will last at a stress amplitude of 280MPa if it is first subjected to a stress amplitude of 315 MPa for 1000 cycles.

5. (a) Explain the plastic blunting process in stage II fatigue crack propagation with the help of sketches.
   (b) Diffusion of Vacancies is not essential for fatigue failure'. Explain.
6. (a) Sketch typical fatigue fracture surface and explain.
   (b) Explain some of the methods of protection of materials from surface crack propagation.
7. (a) How does improved, alloy cleanliness develop the fracture toughness of the parts?
   (b) How does the micro-structure of the materials optimize the fracture toughness?
8. Identify and explain several problems a designer must recognize when dealing with fatigue loading as compared with static loading.

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Code No: NR422102 **Set No.4**

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(Aeronautical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Discuss the procedure for determining an S-N curve and draw the S-N curve for steel explaining its importance.
   (b) Discuss a typical fatigue testing procedure. Explain how the effect of mean stress can be studied.

2. (a) Explain how the effect of notches on fatigue failure can be experimentally studied.
   (b) What are the potential locations for stress concentration in a given material? Explain them fully.

3. (a) Explain the reasons for well defined fatigue limit in certain materials.
   (b) The endurance limit of a steel member is 112 Mpa and the tensile strength is 385 MPa. What is the fatigue strength corresponding to a life of 70 x 10^3 cycles.

4. (a) What is linear cumulative damage rule. What is the other name for this rule? Explain it fully.
   (b) What is the name of the theory which is used to explain cumulative fatigue damage? Explain the theory fully.

5. (a) Many metallic materials obey an equation of the type.
   $\frac{da}{dn} = R(\Delta k)^4$
   If the initial crack size is a_0 and that the final crack size is a_f, show that the total fatigue life may be increased much more by decreasing a_0 than by increasing the fracture toughness K_{IC}.
   (b) Why do fatigue failures often originate from the surface? Under what conditions would you expect the fatigue failures to initiate from the interior of the component.

6. (a) Why is a surface of a solid associated with surface energy (or free energy)? What is an approximate value of the free energy of surface of a metal
   (b) Actual energy required in a ductile material to create two new surfaces through the crack growth is several orders higher than the surface energy of solids. Why so?

7. (a) How does improved, alloy cleanliness develop the fracture toughness of the parts?

(b) How does the micro-structure of the materials optimize the fracture toughness?

8. Discuss in detail the historical remarks about fatigue failure with suitable examples.

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