UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2019/2020

COURSE NAME	:	FATIGUE AND FRACTURE MECHANICS
COURSE CODE	:	BDC 40403
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JULY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWERS **FIVE (5)** QUESTIONS FROM **SIX (6)** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

Q1 (a) Based on the Fracture Mechanics Approaches, please choose either true **(T)** or false **(F)** for statements below.

i. Do recognize that the presence of cracks or crack-like manufacturing and metallurgical discontinuities can significantly reduce the strength of a component or structure.
ii. Don't consider that fracture toughness depends much more on metallurgical discontinuities and impurities than does ultimate or yield strength. Low impurity alloys have better fracture toughness.
iii. Do expect doubling thickness or doubling ultimate strength of a component to double the fracture load. Cracks can exist and fracture toughness may drop appreciably with both thickness and ultimate strength increases.
iv. Do recognize the importance of distinguishing between plane stress and plane strain in fracture mechanics analysis as fracture toughness, crack tip plasticity, and LEFM limitations can be significantly different for the two conditions.
v. Don't neglect the importance of nondestructive flaw or crack inspection for both initial and periodic inspection periods.
vi. Don't note that most fatigue crack growth usually occurs in mode I even under mixed-mode conditions, and hence the opening mode stress intensity factor range ΔK_I is often the predominant controlling factor in FCG.
vii. Don't investigate the possibility of using LEFM principles in fatigue crack growth life predictions even in low strength materials; crack tip plasticity can be small even in low strength materials under fatigue conditions. If plasticity is large, EPFM may be required.
viii. Do consider the possibility of inspection before fracture. High fracture toughness materials may not provide appreciable increases in fatigue crack growth life, but they do permit longer cracks before fracture, which makes inspection and detection of cracks more reliable.

(8 marks)

(b) Describes the brittle failure, and its differences to ductile failure. In your answers, should be related to the **Figure Q1(b).**

(6 marks)

(c) The design philosophies for airframes have changed from the original safe-life approach into the fail-safe philosophy and recently into the damage tolerance concept. Please comments in this statement.

(6 marks)

Q2 (a) Define the following terms:

(i) Linear elastic fracture mechanics (LEPM)

(ii) Elastic-plastic fracture mechanics (EPFM)

(6 marks)

(b) A steel has 50mm wide plate of 7074-T8 alloy contaibs a central through-crack of length *2a* as shown in **Figure Q2(b).** If the K_c = 22.2 MPa√m and σ_y = 520 MPa.

(i) In an applied stress of 200 MPa, determine if the plate will fail by fracture with a crack half length *a* of 1 mm, 5 mm and 10 mm. Comments of these results.

(ii) Determine the critical crack size a_c below which the plate will not fracture under applied stress.

(iii) Determine the limiting crack size, a_y below which the plate will by yielding.

(14 marks)

Q3. (a) Why is need to determine the fracture toughness for J_{IC} and give example.

(6 marks)

(b) Explain details of the procedure to conduct the fracture toughness testing for J_{IC} of Magnesium alloy AZ31. The graph of the load versus load line displacement and fractography of crack growth Δa are shown in **Figure Q3**. Complete the **Table Q3** and obtain the value of the fracture toughness for J_{IC}. Procedure of testing should be included the J value interrupted displacement is given as below.

Given, $J = [2A/Bb]$ (J-integral) and $B,b \geq [\,25\,(J_{ic}/\sigma_f)]$ (plain strain condition)

(14 marks)

Table Q3: J-value of interrupted displacement

	Interrupted displacement (mm)			
	0.6	0.8	1.0	1.2
J-value [kJ/m^2]				
Δa [mm]				
SZW$_c$ [mm]				

Q4. (a) List of **Three (3)** criteria caused of fatigue failure.

(5 marks)

(b) The hot-rolled and normalized AISI 1045 steel data S-N curve is obtained from the conducted the fatigue test using the fatigue machine as tabulated in **Table Q4**.

(i) Explain how to conduct the fatigue test and the data is recorded as in **Table Q4.** The procedure should be included the parameter testing and the standard used of the testing.

(ii) Plot these data on log-log coordinates, and determine approximate value for the constants *A* and *B*. Use graph as shown in **Figure Q4b(ii)**.

(iii) Comments on your result, how to enhance the fatigue resistance.

(15 marks)

Table Q4b(ii)

σ_a, mm	N_f, cycle
524	257
459	1494
410	6749
352	19090
315	36930
270	321500
241	2451000

Q5 (a) Distinguishes of the S-N curve and fatigue crack propagation propagation rate, da/dN Vs ΔK

(8 marks)

(b) A centre-cracked plate made of AA 7075-T651 as shown in **Figure Q5(b).** A zero to maximum (R=0) cyclic force of P = 18.8 kN is applied causing the crack to grow. Crack growth measured at various crack lengths are given in **Table Q5(b)**. For F is given

$$F = \frac{1 - 0.5\alpha + 0.32\alpha^2}{\sqrt{1-\alpha}}$$

i. Determine ΔK for each crack length and then plot a da/dN versus ΔK using log log scale as shown in Figure Q5 b(i)

ii. Determine the coefficient, C and exponent, m of the Paris equation for stage II fatigue crack growth rate region

iii. Use the fracture mechanics concept, appraise the threshold region.

(12 marks)

Table Q5(b)

a, mm	da/dN, mm/cycle
7.32	1.76×10^{-4}
9.53	5.08×10^{-4}
12.07	1.27×10^{-4}
14.94	3.18×10^{-4}

Q6 (a) Sketch and describes the classification of basic bulk forming processes:-

(i) Rolling

(ii) Forging

(iii) Extrusion

(9 marks)

(b) Explain the effect of microstructure of forming processes on the fatigue behaviour of materials.

(11 marks)

- END OF QUESTIONS –

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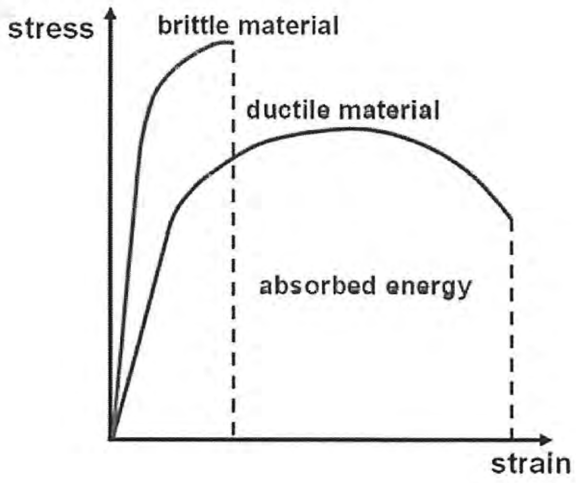
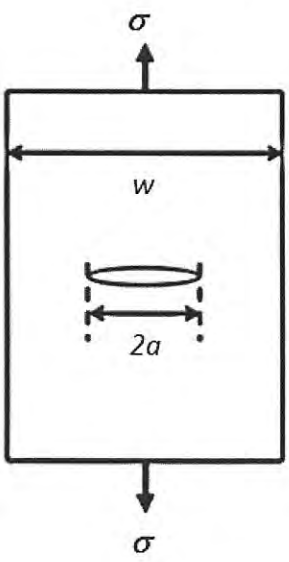


Figure Q1(b)



$$Y = \left\{\cos\left(\frac{\pi a}{W}\right)\right\}^{-\frac{1}{2}}$$

Figure Q2(b)

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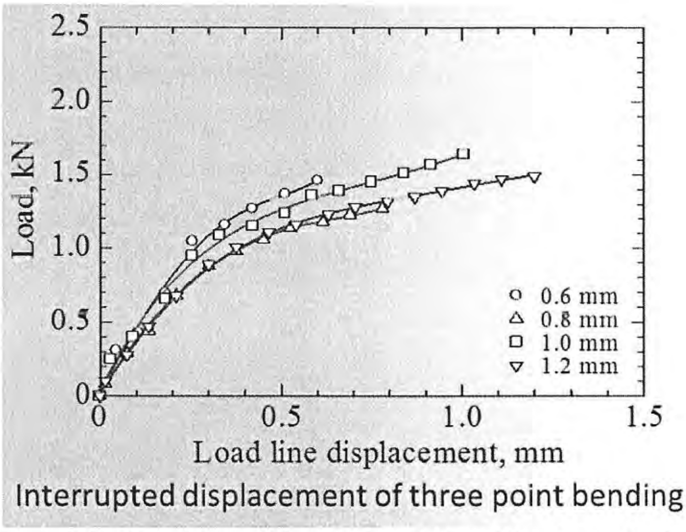
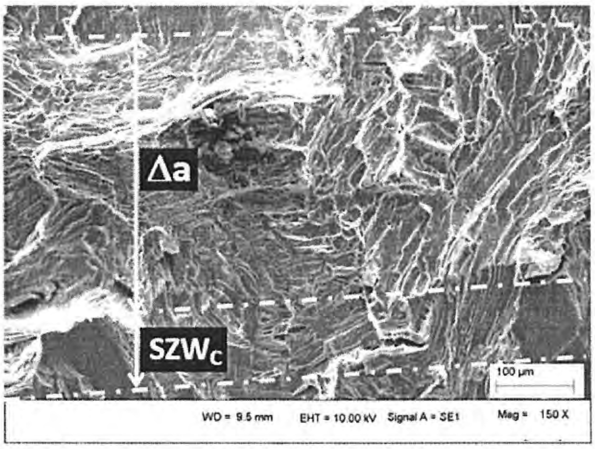


(a) Graph Load Versus Load Line Displacement



(b) Strecth zone, SZW_C and ductile crack growth Δa

Figure Q3

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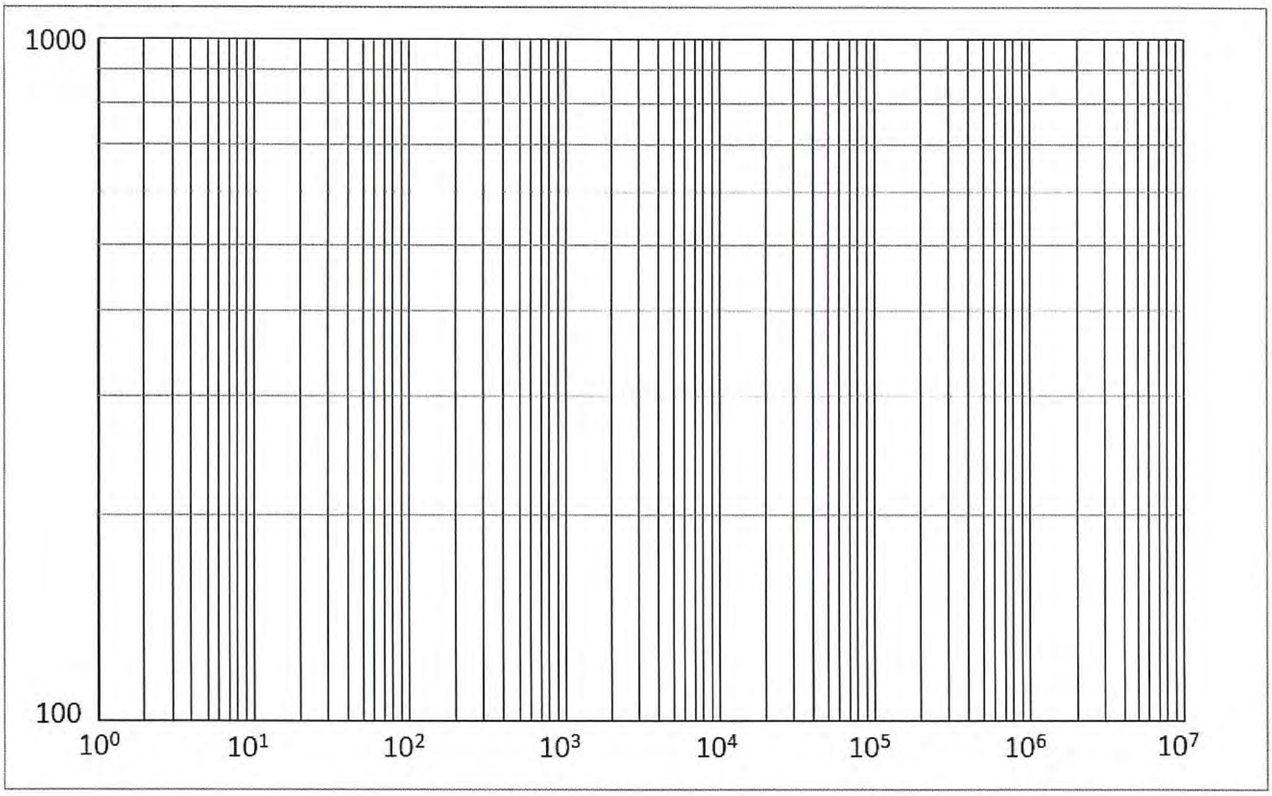

Figure Q4b (ii)

Note : Please use this graph for the anwer Q4b (ii)

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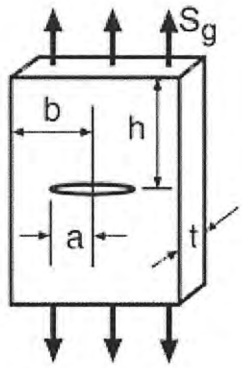

Figure Q5 (b)

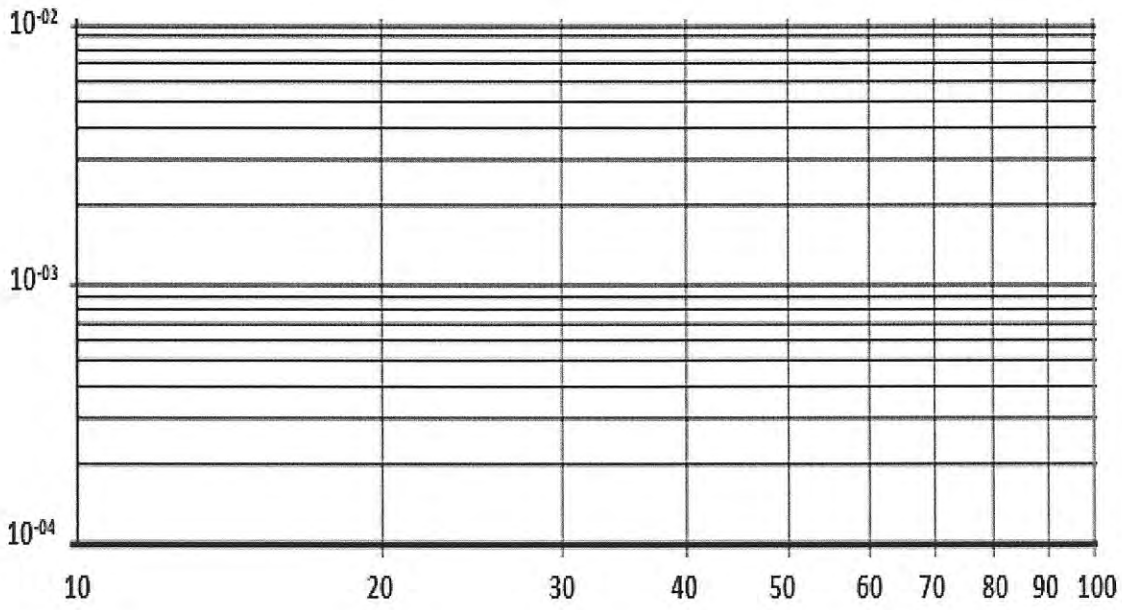

Figure Q5b (i)

Note : Please use this graph for the anwer Q5b (i)