UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: October 2019

Module Number: ME3206 **Module Name: Strength of Materials**

[Three Hours]

[Answer **all questions**, each question carries **12** marks]

State your assumptions clearly

Q1. a) Derive an expression for the theoretical fracture strength of a material.

[4.0 Marks]

b) Modulus of elasticity of steel is 2×10^{11} Pa. Calculate the theoretical fracture strength of steel.

[1.5 Marks]

c) Actual fracture strength of steel is 2.27×10^{8} Pa. Is there any difference between actual and theoretical fracture strength values of steel? If it is so, what are the reasons for that?

[1.5 Marks]

d) What are understood by Stress Intensity Factor and Critical Stress Intensity Factor (Fracture toughness)?

(Take: $K_I = \sigma\sqrt{\pi a} f(\alpha, a)$)

[2.0 Marks]

e) Suppose that a wing component on an aircraft is fabricated from an aluminum alloy that has a plane strain fracture toughness of 40 MPa $m^{1/2}$. During an experiment, a fracture has been occurred at 365 MPa when the maximum internal crack length is 2.5 mm. For this same component and same alloy, compute the stress level at which fracture will occur for a critical crack length of 4.0 mm.

[3.0 Marks]

Q2. a) What is the Griffith's criterion for fracture of brittle materials?

[3.0 Marks]

b) i) Using the above mentioned (Q2. a)) criterion, show the fracture strength of a material, $\sigma_f = \sqrt{\dfrac{8E\gamma_s}{\pi a(1+\upsilon)(1+k)}}$.

Where,

σ_f - Fracture strength of a material

E - Modulus of elasticity and

γ_s - Specific surface energy of a fractured surface

υ - Poisson's ratio

k - Stress intensity factor

ii) If $k = \frac{3-\upsilon}{1+\upsilon}$, derive an expression for fracture strength for plane stress conditions.

[4.0 Marks]

c) What are the reasons of difference between theoretical and actual values of γ_s ?

[2.0 Marks]

d) A relative large plate of a glass is subjected to a tensile stress (a plane stress) of 40 MPa. If the specific surface energy and modulus of elasticity for this glass are 0.3 Jm^{-2} and 69 GPa, respectively. Determine the maximum length of a surface flaw that is possible without fracture.

[3.0 Marks]

Q3. a) Briefly explain the "Fatigue failure of materials"?

[3.0 Marks]

b) What are the stages of fatigue failure?
Briefly explain them with suitable sketches.

[3.0 Marks]

c) State the Miner's law of cumulative fatigue.

[3.0 Marks]

d) **Figure Q3** shows a part of *S-N* curve of a Metallic material. Rotating shaft of a machine was fabricated by this metallic material. The shaft was operated as follows.

Stress (MPa)	Number of cycles operated (Under particular stress)
300	4×10^3
200	1×10^2

Due to a new requirement, operating stress was changed to a new value. It has failed after a further rotation of **7492 cycles**. What was the changed stress of the shaft?

[3.0 Marks]

Q4. a) Explain followings;

i) Stress at a point
ii) Normal and Shear Stresses
iii) Principal stress and principal planes

[6.0 Marks]

b) A cast iron block of 10 cm^2 cross-section carries an axial tensile load of 50kN. Calculate the magnitude of the normal and shear stresses on a plane whose normal is inclined at 30^o to the axis of the block. Also, determine the maximum shear stress in the block.

[6.0 Marks]

Q5. Part of a landing gear of an aeroplane is subjected to the following direct stresses in the x, y and z directions: 195 MPa, 35 MPa and -250 MPa, respectively. Due to different landing conditions there are also possibilities of two shear stresses present, one related to xz plane with a value of 30 MPa and another related to yz plane with a value of 65 MPa.

a) Draw the elemental cube showing the stresses acting.

[2.0 Marks]

b) Draw the separate Mohr's circles associated with xy, xz, and yz planes on a same graph-sheet.
(Clue: No need to consider shear stresses)

[4.5 Marks]

c) Using this information given above, determine the largest compressive stress associated with the system.
(Clue: Need to consider shear stresses)

[3.0 Marks]

d) Determine the angles relative to xyz co-ordinates of the largest compressive stress acts and make a sketch showing the direction of this stress.

[2.5 Marks]

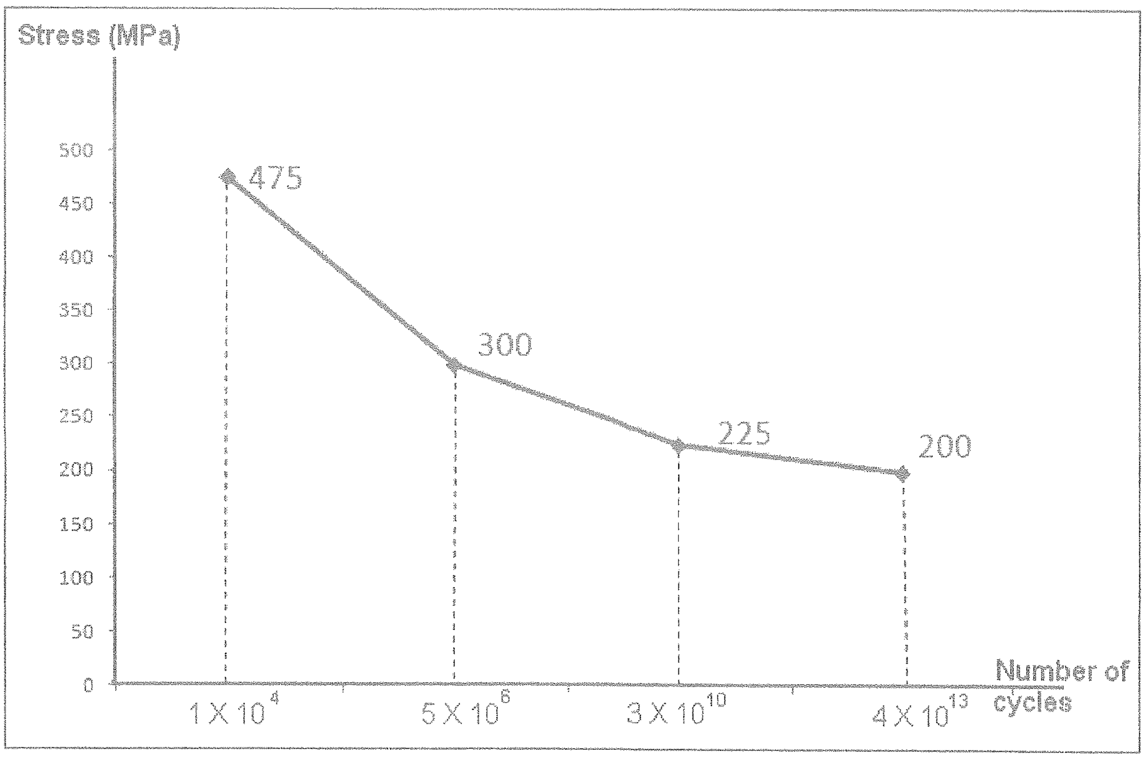

Figure Q3