UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: February 2023

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

[Three Hours]

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

(State the assumptions where necessary and correctly states the units)

Q1. a) Define the terms *principal plane* and *principal stress*.

[2.0 Marks]

b) Draw Mohr's circle for a member subjected to two direct stresses on mutually perpendicular planes.

[3.0 Marks]

c) A rectangular block of material is subjected to a tensile stress of 100 N/mm² on one plane and tensile stress of 40 N/mm² on a plane at right angles together with shear stresses of 60 N/mm² on the same planes.
Find:

i) The magnitude of principal stresses

[2.0 Marks]

ii) The direction of principal planes

[2.0 Marks]

iii) The magnitude of maximum shear stress

[1.0 Mark]

iv) The direction of planes of maximum shear stress

[1.0 Mark]

v) The normal stress on the planes carrying maximum shear stress

[1.0 Mark]

Q2. a) What is meant by stress concentration? Explain how its value can be reduced.

[1.0 Mark]

b) What is stress intensity factor (SIF)?

[1.0 Mark]

c) What is meant by fracture toughness?

[1.0 Mark]

A 3 mm thick and 10 cm wide tension panel containing an edge crack of 1 mm yielded at a load of 150 kN. However, at a load of 120 kN, another panel of same material cracked into two pieces when the crack was 5 mm long. With this information, calculate the yield stress and fracture toughness of the material.
SIF for the edge crack is $K_I = 1.12\,\sigma\sqrt{\pi a}$.

[4.0 Marks]

d) Derive an expression for the theoretical fracture strength of materials.

[3.0 Marks]

e) Modulus of elasticity of an alloy is 1.15×10^{11} Pa. Calculate the theoretical fracture strength of this alloy.

[1.0 Mark]

f) Actual fracture strength of above alloy is 1.3×10^8 Pa. Is there any difference between actual and theoretical fracture strength values of this alloy? If it so, what are the reasons?

[1.0 Mark]

Q3. a) What do you mean by fatigue in materials?

[2.0 Marks]

b) Write procedure that need to be followed while designing against fatigue?

[3.0 Marks]

c) What is an *S-N* curve? Explain the significant points in the curve.

[3.0 Marks]

d) Figure Q3 shows a part of *S-N* curve of a metallic material. Connecting rod of a machine was fabricated by this metallic material. The rod was used as follows.

Stress amplitude (MPa)	Number of cycles operated
300	4×10^3
200	1×10^2
475	1×10^2

Due to a new requirement, operating stress was changed to 225 MPa and continued until it fails. What is the total number of rotations at its failure?

[4.0 Marks]

Q4. a) Briefly describe the trans-granular and inter-granular fractures.

[2.0 Marks]

b) Briefly discuss three methods which are used to strengthen the metallic materials.

[3.0 Marks]

c) Differentiate Primary creep, Secondary creep, and Tertiary creep of materials.

[3.0 Marks]

d) Suggest and explain a method to perform a creep test for a thermoplastic material.

[4.0 Marks]

Q5. a) What is the reason for necessity of a statistical approach (Weibull analysis) for a brittle material?

[1.0 Mark]

b) State two assumptions that are made in this analysis.

[1.0 Mark]

c) Derive the equation,

$$P_f = 1 - \exp\left(-V\left[\frac{\sigma-\sigma_u}{\sigma_o}\right]^m\right).$$

Where,

P_f : Probability of failure
σ : Applied stress
σ_u : Threshold stress
σ_o : Normalizing factor
m : Weibull modulus

[2.0 Marks]

d) To find the mean strength of a given glass material, 16 samples with 6 mm diameter and 65 mm length were selected. Those samples were subjected to tensile testing. Fracture loads were measured and stresses were calculated.

Sample No.	Fracture Stress (MPa)	Sample No.	Fracture Stress (MPa)
1	126	9	99
2	144	10	108
3	65	11	128
4	120	12	11
5	80	13	115
6	66	14	72
7	70	15	62
8	58	16	58

i) Rearrange the terms in the equation (Q5. c)) to plot a linear graph.

[2.0 Marks]

ii) Plot the linear graph using above experimental data.

[4.0 Marks]

iii) Find the mean strength and Weibull modulus using above graph.

[2.0 Marks]

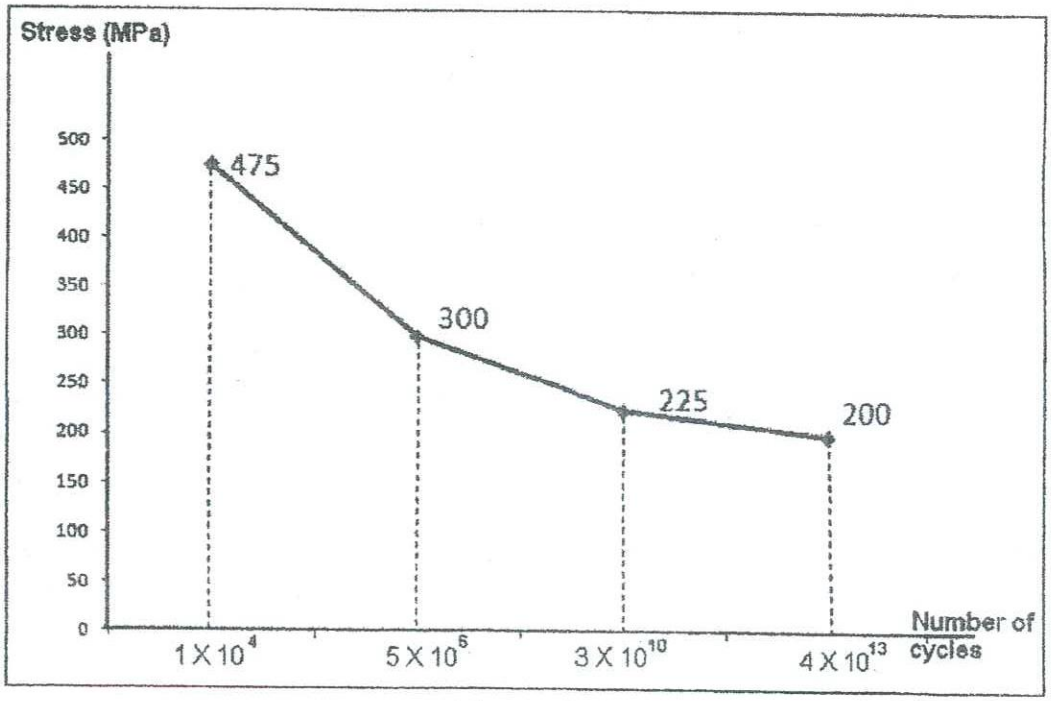

Figure Q3