UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: March 2026

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.**

[1.0 Mark]

c) Actual fracture strength of above-mentioned alloy in (Q1 b)) is 180×10^{7} Pa.

- Is there a difference between the actual and the theoretical fracture strength values of the alloy?
- If it is so, explain the reasons for this difference?

[1.0 Mark]

c) What do you understand by Stress Intensity Factor and Critical Stress Intensity Factor (Fracture toughness)?

(Clue - $K_I = \sigma\sqrt{\pi a} f(\alpha, a)$)

[2.0 Marks]

d) An edge cracked plate as shown in **Figure Q1** has the dimensions w=100 mm, t=5 mm, h=300 mm, and a remote tensile load of 100 kN is applied.
Determine,

i) The stress intensity factor K_I for a crack length of 15 mm, and

ii) The critical crack length a_c, for fracture if the material of the plate is AISI 4130 steel, which has a fracture toughness of K_{IC} = 100 MPa $m^{1/2}$.

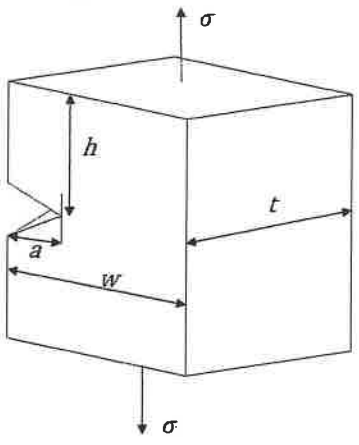

Figure Q1

[4.0 Marks]

Q2. a) State and explain the **Griffith's criterion** for fracture of brittle materials?

[3.0 Marks]

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

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

[4.0 Marks]

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

[1.0 Mark]

c) Theoretical value and actual values of γ_s have a difference. What are the reasons for such a difference and how do you overcome it by correcting the equation?

[1.0 Mark]

d) A relatively large plate of a glass is subjected to a tensile stress (a plane stress) of 40 MPa. 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) What do you understand by '**Fatigue' failure in materials**?

[2.0 Marks]

b) Describe the **stages of fatigue failure** with suitable sketches.

[3.0 Marks]

c) Explain the roles of the following stresses in fatigue failure?
i) Compressive stress
ii) Tensile stress

[2.0 Marks]

d) State the **Miner's Law of cumulative fatigue**.

[2.0 Marks]

e) **Figure Q3** shows a part of *S-N* curve of Metallic material. A rotating shaft made of this material has experienced the following loading. When it was used following rotations have been done.

Stress (MPa)	Number of cycles operated (Under particular stress)
400	4×10^3
160	1×10^2

The operating stress is later changed to 240 MPa. Determine the **remaining number of cycles (rotations)** before failure.

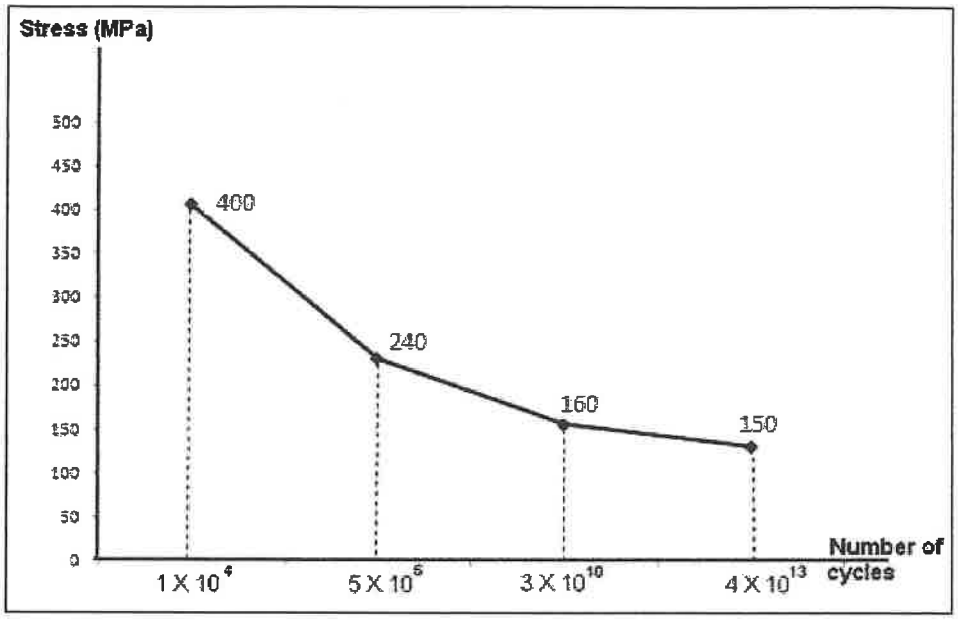

Figure Q3

[3.0 Marks]

Q4. a) For the state of plane stress shown in the Figure Q4., determine using the transformation equations,

i) Principal planes,

ii) Principal stresses, and

iii) Maximum shearing stress and the corresponding normal stress.

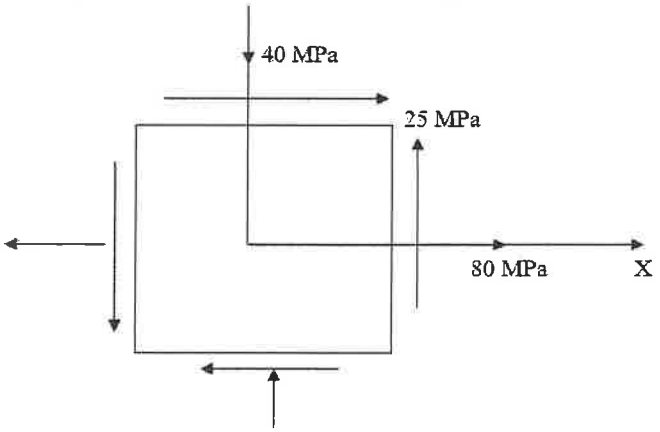

Figure Q4.

[6.0 Marks]

b) Draw the **Mohr's Circle** for the above Q4 a) state of stresses and mark the corresponding points and planes of the Q4 a) i), ii) and iii).

[3.0 Marks]

c) If the 40 MPa compressive stress is changed to a **tensile stress of the same magnitude**, while other stresses remain unchanged:
Determine the new values and directions of:

i) Principal planes
ii) Principal stresses
iii) Maximum shear stress

[3.0 Marks]

Q5. a) Briefly describe the **Transgranular** and **Intergranular Fracture**.

[2.0 Marks]

b) Discuss three methods used to strengthen the metals.

[3.0 Marks]

c) Explain two methods of reducing stress concentration.

[2.0 Marks]

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

[2.0 Marks]

e) Suggest and explain a suitable **creep testing method** for a metallic material.

[3.0 Marks]