UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: March 2022

Module Number: ME 7303 **Module Name: Solid Mechanics (N/C)**

[Three Hours]

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

Note: Clearly state any assumptions made in answering the questions. Use usual notations.

Q1. a) The forces due to the pressure of the fluid acting at the ends of the thin cylinder tend to burst the cylinder. The bursting will take place if the force due to fluid pressure is more than the resisting force due to circumferential stress set up in the material. Considering the limiting case, derive expressions for circumferential stress and longitudinal stress acting on a thin cylindrical shell due to the fluid pressure.

[2.0 Marks]

b) Consider a thin cylindrical shell subjected to an internal fluid pressure. The effect of the lateral strain is caused some changes in the dimensions of length and diameter of the shell. Derive an expression for the change in volume of the cylinder and hence, show that the change in volume is depend on the original dimensions of the cylinder and internal fluid pressure.

[6.0 Marks]

c) A spherical shell of internal radius and shell thickness are 1.0 m and 20 mm, respectively, is subjected to internal fluid pressure of 5.5 N/mm^2. The joint efficiency of the shell material is 75%.

i) Calculate the stress induced in the shell material as a result of internal fluid pressure.

[2.0 Marks]

ii) Find the change of stress in the shell material, if the joint efficiency is increased to 90%.

[2.0 Marks]

Q2. a) Briefly explain **three** applications of rotating discs.

[1.5 Marks]

b) Define the term "shape factor".

[1.5 Marks]

c) Briefly explain **two** methods of designing a cylinder in order to carry high internal fluid pressure.

[3.0 Marks]

d) A steel shear coupling in a metal working process is 25 mm radius. It is subjected to a torque of 0.9 kNm which is known to have shear yielding in the shaft. Determine the radial depth to which plasticity has penetrated if yielding shear stress is 90 MN/m^2.

[6.0 Marks]

Q3. Consider an I-section beam (**Figure Q3**) which is subjected to a bending moment.

a) Calculate the maximum elastic bending moment of the beam?

[3.0 Marks]

b) Derive an expression for the bending moment of the beam when it is deformed to the fully plastic condition.

[3.0 Marks]

c) Derive an expression for the shape factor of the I-section beam.

[3.0 Marks]

d) Calculate the value of shape factor for the I-section beam, if b=d/3 and $b_1=d_1/3=$ 0.3d.

You may use the Bending Formula $\frac{M}{I}=\frac{\sigma}{y}$

Moment of inertia of I-section $=\frac{1}{12}(bd^3-b_1d_1^3)$

[3.0 Marks]

Q4. To better understand the strain state for an old oil tanker, strain gages where attached to the surface of the tanker at the location shown (**Figure Q4**). With the help of the strain gage results, it was determined that the strains at that location were ε_x = 800 μ, ε_y = 600 μ, and γ_{xy} = 200 μ.

a) Using Transformation equations, what is

i) the principal direction and principal normal strains,

[2.5 Marks]

ii) maximum strain direction and the maximum shearing strain, and

[2.5 Marks]

iii) the strains at an angle of 60°?

[2.5 Marks]

b) By considering strain in the Z direction as 0 μ,

i) Draw the strain Mohr's circle corresponding to the Z-X plane.

[1.5 Marks]

ii) Draw the strain Mohr's circle corresponding to the Z-Y plane.

[1.5 Marks]

iii) Draw the 3D Mohr's circle of strain in this system.

[1.5 Marks]

Q5. a) i) Would changes in temperature affect your strain measurements? Explain.

[2.0 Marks]

ii) How would the Lead (Pb) resistance of the strain gauge affect your measurements?

[2.0 Marks]

b) i) Derive the equation for Gauge Factor (GF) of a strain gauge.

[2.0 Marks]

ii) Suppose a test specimen undergoes a substantial strain of 1000 με. What will be the change in electrical resistance of a strain gauge with a Gauge Factor GF = 2.

[2.0 Marks]

c) Why do we measure changes in resistance through a Wheatstone bridge? Would a Wheatstone bridge also compensate for temperature sensitivity discussed in question Q5 (a)? Explain how this is possible with.

[4.0 Marks]

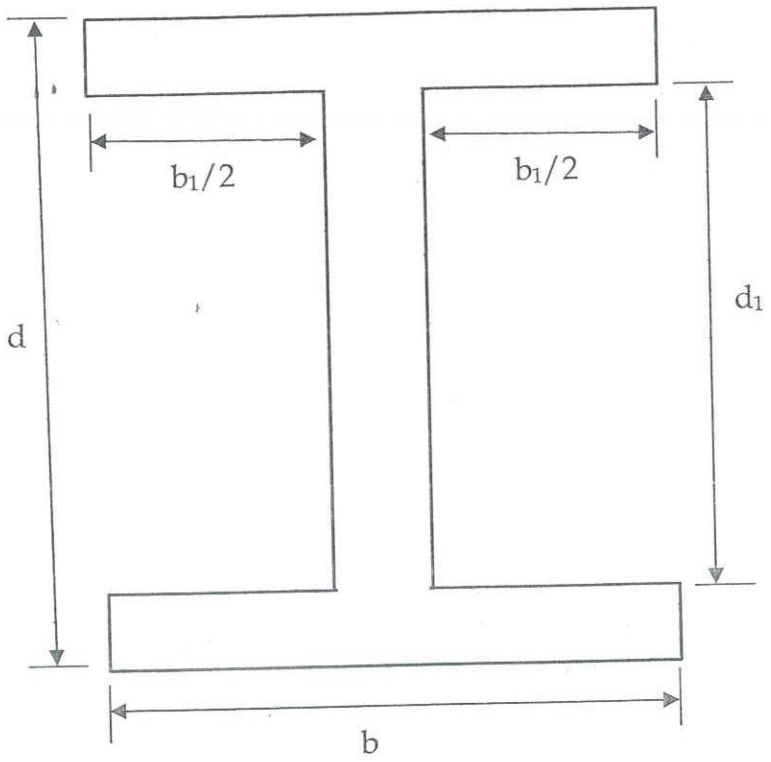

Figure Q3

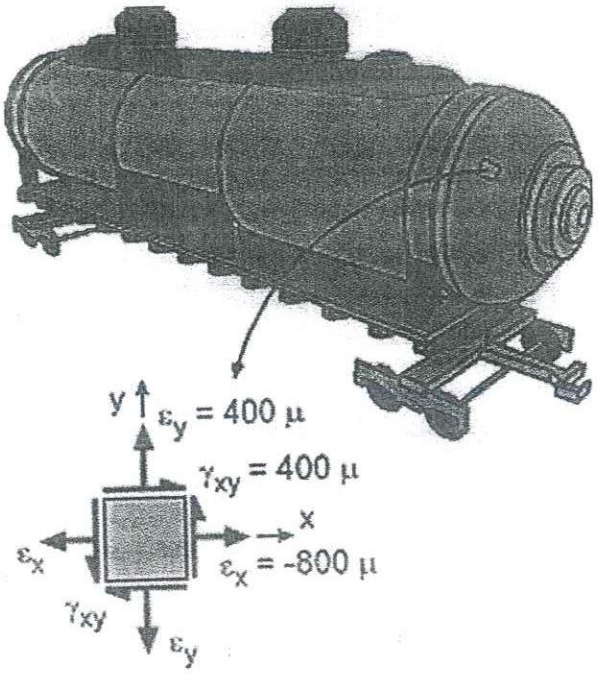

Figure Q4