UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: July 2017

Module Number: ME 7303 **Module Name: Solid Mechanics**

[Three Hours]

[Answer **all questions**, each question carries **12** marks]
(State your assumptions clearly)

Q1. a) What is the difference between a thin cylindrical shell and a thick cylindrical shell? Briefly explain two industrial applications of thick cylinders.

[1.5 Marks]

b) Consider a thin cylindrical shell subjected to an internal fluid pressure. Circumferential stress (σ_h) and longitudinal stress (σ_l) are given by $\frac{Pd}{2t}$ and $\frac{Pd}{4t}$, respectively. Where P, d, and t are internal fluid pressure, internal diameter of the cylinder, and thickness of the cylinder, respectively. The effect of the lateral strain is caused some changes in the dimensions of length and diameter of the shell.

i) Show that the volumetric strain which is caused by change in length and change in diameter of the cylinder, is equal to sum of longitudinal strain and twice of its circumferential strain ($\varepsilon_v = \varepsilon_l + 2\varepsilon_h$).

ii) 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.

[7.0 Marks]

c) A spherical shell, internal diameter and shell thickness are 1.6 m and 16 mm, respectively, is subjected to internal fluid pressure of 3.2 N/mm^2. Take joint efficiency as 80%.

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

ii) Find the change of stress in the shell material, if the joint efficiency is increased to 99%.

[3.5 Marks]

Q2. a) Consider a compound cylinder which is formed by shrinking a tube over another tube. Starting from Lame's equations, derive an expression for the initial difference in radii at the junction of compound cylinder for shrinkage.

[4.5 Marks]

b) A steel cylinder of 250 mm external diameter is to be shrunk on to another steel cylinder of 70 mm internal diameter. The diameter at the junction after shrinking is 140 mm, and the original difference in radii at the junction is 0.06 mm after shrinking.

i) Calculate the radial pressure at the junction. Take E= 2×10^5 N/mm^2

ii) Find the resultant hoop stresses setup across the section, when the compound cylinder is subjected to an internal fluid pressure of 75.8 N/mm^2.

[5.0 Marks]

c) A steel disc of uniform thickness and of diameter 800 mm is rotating about its axis at 2500 rpm. Determine the radial and circumferential stresses at the center and outer radius. Take density of the material as 7850 kg/m^3 and Poisson ratio as 0.3.

[2.5 Marks]

Q3. a) Define the term "shape factor".

[0.5 Marks]

b) Consider an I-section beam which is subjected to bending moment as shown in **Figure Q3**.

i) What is the maximum elastic bending moment of the beam?

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

iii) Determine the shape factor of the I-section beam using the dimensions shown in **Figure Q3**.

iv) Calculate the value of shape factor for the I-section beam, if d=3b and d_1 = $3b_1$= 0.9d.

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

Moment of inertia of I-section $= \frac{1}{12}(bd^3 - b_1 d_1^3)$

[9.0 Marks]

c) A mild steel hollow circular shaft of outer and inner radius are 16 cm and 10 cm, respectively, is subjected to a shear stress. Find the maximum torque which the shaft can transmit under fully elastic condition if the shear stress is not to exceed 40 N/mm^2.

Polar moment inertia of a hollow circular shaft $= \frac{\pi}{32}(d_{out}^4 - d_{in}^4)$

[2.5 Marks]

Q4. a) Explain the wheatson bridge configuration of electrical resistance strain gauges used to measure strains of loaded structures by means of neat sketches.

[4.0 Marks]

b) Write a description on "quarter bridge", "half bridge", and "full bridge" configurations considering applications, benifits & drawbacks comparing with each other configurations.

[4.0 Marks]

c) What is a strain gauge rosette? Why it is required to go for rosette analysis of strains in some industrial aplications? **Briefly explain.**

[4.0 Marks]

Q5. In a strain gauge rosette (**Figure Q5**), the three readings of strain gauges are $\epsilon_a, \epsilon_b, \epsilon_c$. The rosette is mounted in a way that strain gauge indicating the value is ϵ_a aligned with the x-axis.

a) Starting from the strain equation, $\epsilon_\theta = \epsilon_x \cos^2\theta + \gamma_{xy} \sin\theta . \cos\theta + \epsilon_y \sin^2\theta$, derive the equations for ϵ_x, ϵ_y, and γ_{xy} by means of ϵ_a, ϵ_b, and ϵ_c.

[2.0 Marks]

b) If the actual readings of the strain gauges are as $\epsilon_a = 60\ \mu\epsilon$, $\epsilon_b = 135\ \mu\epsilon$, $\epsilon_c = 264\ \mu\epsilon$
Draw the Mohr's **strain** circle for the state of strain.

[2.0 Marks]

c) Determine the principle strains and their planes.

[2.0 Marks]

d) Calculate the principle stresses using Generalized Hook's law and mark them on the corresponding Mohr's **stress** circle.

[4.0 Marks]

e) Find out the direct and shear stresses on a plane which is 30° apart from the x-axis.

$E = 200\,GN/m^2$, $\gamma = 0.3$ [2.0 Marks]

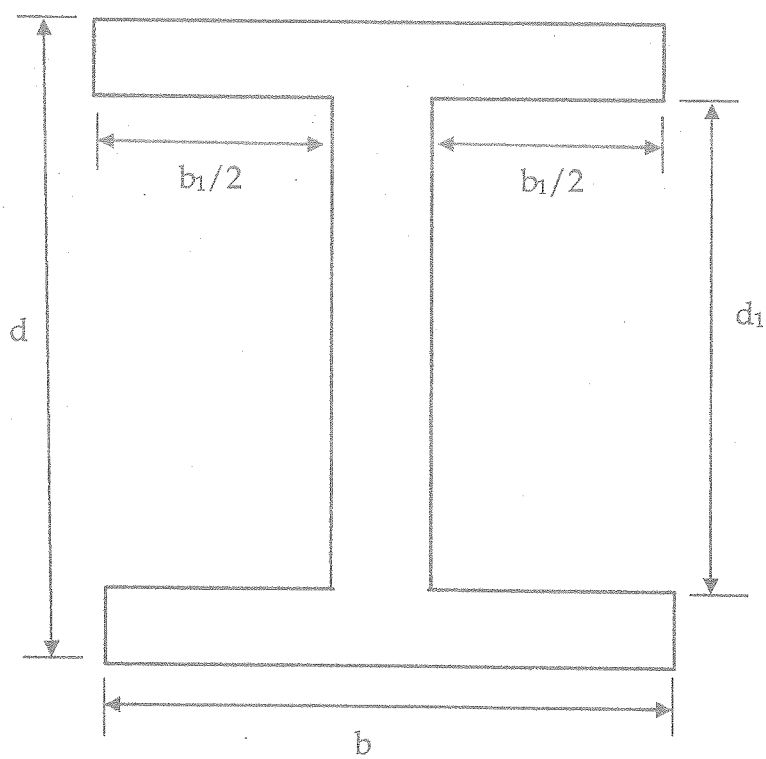

Figure Q3

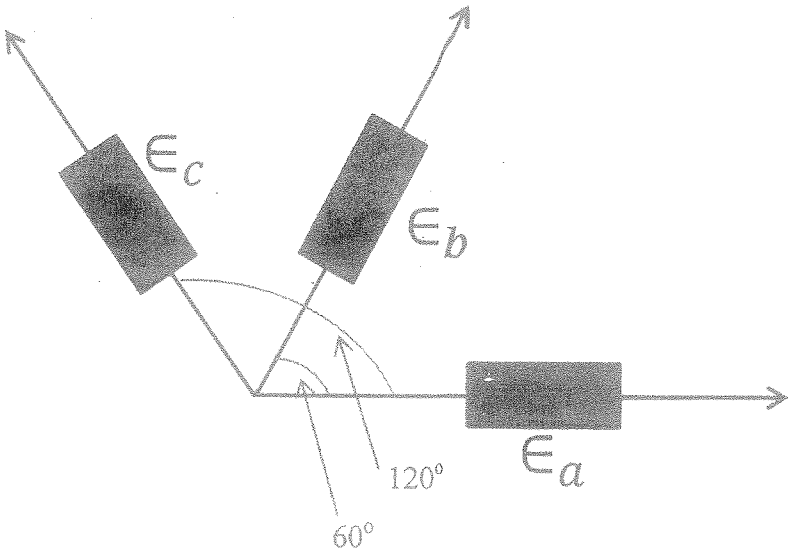

Figure Q5