UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: July 2016

Module Number: ME7303 **Module Name: Solid Mechanics**

[Three Hours]

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

Q1. a) In a cylinder, pressure is held with sliding piston at the two ends for this arrangement, and with axial symmetry, obtain the equation of equilibrium for an element of material.

[2.0 Marks]

b) A copper cylinder is 200 mm inner diameter and 400 mm outer diameter. If it is subjected to an internal pressure of 150 MPa,

i) Determine the radial and tangential stress distributions and show the results on a plot.

[3.0 Marks]

ii) Determine the maximum shear stress in the cylinder.

Assume cylinder has closed ends.

[1.0 Mark]

c) State the "Maximum Shear Stress Theory (Tresca criterion)".

[2.0 Marks]

d) Determine the internal pressure at which the cylinder mentioned in Q1. b) will yield according to the Tresca criterion. Yield strength of copper cylinder material is 70 MPa.

[2.0 Marks]

e) What are the methods of containing very high pressures in a thick walled cylinder? Briefly explain each method.

[2.0 Marks]

Q2. a) When a press or shrink fit is used between two cylinders of the same material, an interface pressure P_i is developed at the junction of the cylinder. Show,

$$P_i = \frac{E\delta}{b}\left[\frac{(c^2 - b^2)(b^2 - a^2)}{2b^2(c^2 - a^2)}\right]$$

Where,

E = Young's modulus
δ = Radial interference between the two cylinders
a = Inner radius of the inner cylinder
b = Outer radius of the inner cylinder and inner radius of the outer cylinder
c = Outer radius of the outer cylinder

[3.0 Marks]

b) The surface diameters of an open, steel compound cylinder are 100, 180 and 270 mm. The components are assembled with an interference of 0.05 mm prior to loading with an internal pressure of 50 MPa. Plot the tangential, radial and equivaient stress across the wall of each component after initial assembly and after loading.

[3.0 Marks]

c) If a single cylinder had been used in this application (refer part b)),

i) What pressure could it withstand if it was the same overall size and the equivalent stress was limited to 85 MPa?

[3.0 Marks]

ii) What outside diameter would it need to be contain the pressure of 50 MPa with a maximum equivalent stress of 85 MPa?

[3.0 Marks]

Q3. a) Figure Q3 shows a cross-section of a twisted shaft.

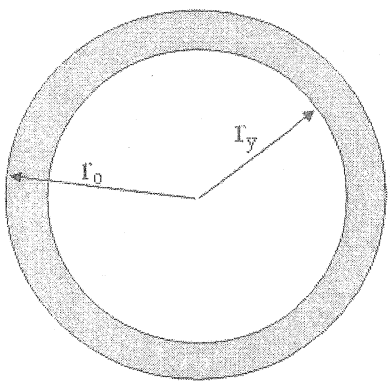

Figure Q3

You may use the Torsion formula $\left(\frac{T}{J}=\frac{\tau}{r}\right)$ and

Polar moment of area J (Solid shaft) $=\frac{\pi \cdot r^4}{2}$

What is the maximum elastic torque of the shaft?

[2.0 Marks]

b) With further increase in torque applied, plastic deformation penetrates deeper in to the shaft. Derive an expression for Torque when it is deform Elastically and Plastically, and subsequently for fully plastic condition.

[4.0 Marks]

c) Explain what is meant by the shape factor and derive the shape factor expression for above mentioned shaft.

[2.0 Marks]

d) A mild steel shear coupling in a metal working process is 45 mm diameter and 300 mm length. It is subjected to an overload torque of 2000 N.m which is known to have for shear yielding in the shaft. Determine the radial depth to which plasticity has penetrated.
(Yielding shear strength of material is 120 MPa)

[4.0 Marks]

Q4. a) Consider a **thin spherical shell** subjected to an internal pressure. Derive an expression to find stress in the shell material using the usual notation.

[3.0 Marks]

b) Derive expressions to find change in diameter and volume of above mentioned (Q4. a)) spherical shell.

[3.0 Marks]

c) A thin spherical shell of 1 meter diameter is subjected to an internal pressure of 10 kg/cm^2. Find the suitable thickness of the shell, if the tensile strength of the plate is 4000 kg/cm^2 and allowing a factor of safety of 4.

[3.0 Marks]

d) Find the change in diameter and volume of above mentioned (Q4. c)) spherical shell under such a stress.
(Modulus of elasticity and Poison's ratios of material are 200 GPa, 0.3 respectively)

[3.0 Marks]

Q5. a) Briefly explain with the aid of a general wheatson bridge configuration, the theory & the procedure of measuring strains of loaded structures by using electrical resistance strain gauges from the point of attaching the gauges with the structure.

[4.0 Marks]

b) *"When possible,the full bridge configuration is the best to use for strain measurement"*, justify above statement by considering its applications, benifits & drawbacks comparing with 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]