UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: March 2021

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

[Three Hours]

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

Q1. a) A compound thick cylinder can be made by shrinking one cylinder over another cylinder. Due to this, the inner cylinder is subjected to an initial compression and outer cylinder is subjected to an initial tension. In shrinking stage, inner cylinder is cooled and outer cylinder is heated. Then cylinders can be passed over each other due to thermal contraction and thermal expansion. When returning it in to room temperature, interference at the matting surface is created since it can't regain the original dimensions. Starting from the Lame's equation, show that the interference at the matting surface can be expressed by,

$$\frac{2r^*(a_1 - a_2)}{E}$$

where,

r^*	–	matting surface radius or radius at the junctions of two cylinders
a_1	–	integration constant for outer cylinder
a_2	–	integration constant for inner cylinder
E	–	modulus of elasticity.

[7.0 Marks]

b) A steel cylinder of 600 mm external diameter is to be shrunk to another steel cylinder of 300 mm internal diameter. The matting surface diameter is 400 mm and radial pressure at the junction is 35 N/mm^2. Calculate the original difference in radii at the junction.

Take the modulus of elasticity as 0.25 MN/mm^2.

[5.0 Marks]

Q2. a) A metal disc of diameter of 850 mm is rotating about its axis at 2400 rpm. Calculate the radial stress and circumferential stress at the center and the outer radius. Take the density of the metal as 8800 kg/m^3 and poison's ratio as 0.32.

[6.0 Marks]

b) If the above mentioned disc has a central hole of 200 mm diameter, determine;

i) Circumferential stress at inner radius and outer radius.

[3.0 Marks]

ii) Radius at which radial stress is maximum.

[1.5 Marks]

iii) Maximum radial stress.

[1.5 Marks]

Q3. a) Turning forces are always applied to transmit energy by rotation. Briefly explain two practical applications of turning forces.

[1.0 Mark]

b) A hollow metal shaft with internal diameter equal to half of the external diameter is to be replaced by a solid metal shaft of the same material. The external diameter of hollow shaft is 60 mm.

i) Determine the diameter of the solid shaft, if the maximum allowable shear stress is same for both shafts.

[3.0 Marks]

ii) Calculate the additional material requirement for solid shaft compared to hollow shaft.

[1.5 Marks]

c) Consider a thin spherical shell of wall thickness t which is subjected to an internal fluid pressure of P. Show that the volumetric strain of spherical shell due to internal fluid pressure is given by,

$$\frac{3Pd(1-v)}{4tE}$$

where,

d - internal diameter of the spherical shell

E - modulus of elasticity

v - poisons ratio.

[3.0 Marks]

d) A spherical shell of 1800 mm diameter is made up of 9 mm thick plate is subjected to an internal fluid pressure of 1.8 MN/m^2. Calculate the change in diameter and change in volume of the shell due to internal fluid pressure.
Take the modulus of elasticity of spherical shell material and Poisson's ratio as 2×10^5 MN/m^2 and 0.3, respectively.

[3.5 Marks]

Q4. 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.

[3.0 Marks]

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

[1.0 Mark]

c) i) Why do we measure changes in resistance through a Wheatstone bridge?

[2.0 Marks]

ii) Would a Wheatstone bridge also compensate for temperature sensitivity discussed in question Q4(a)? Explain how this is possible with.

[2.0 Marks]

Q5. a) A rectangular sheet $ABCD$ of dimensions a and b along X and Y directions, respectively, is stretched to a rectangle $AB'C'D'$, as shown in Figure Q5(a). Calculate the principle stains.

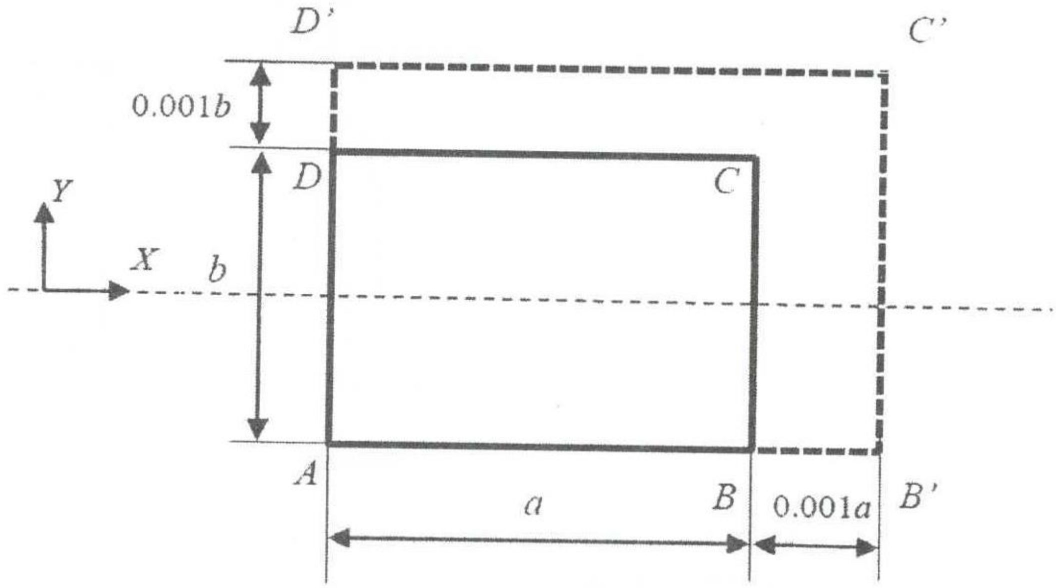

Figure Q5(a)

[5.0 Marks]

b) A tensile test is performed on a metallic specimen of diameter 8 mm and gauge length 50 mm (Figure Q5(b)). When the tensile load P reaches a value of 20 kN, the distance between the gauge marks increases by 0.09 mm. If the sample remains within the elastic limit, calculate the modulus of elasticity (in GPa) of the test metal.

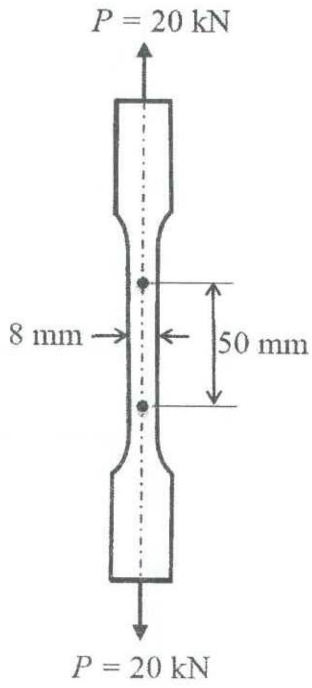

Figure Q5(b)

[4.0 Marks]

c) A stressed element is loaded as shown in Figure Q5(c). Determine the following,

i) Von-Mises stress,

[1.0 Mark]

ii) Maximum shear stress,

[1.0 Mark]

iii) Maximum normal stress.

[1.0 Mark]

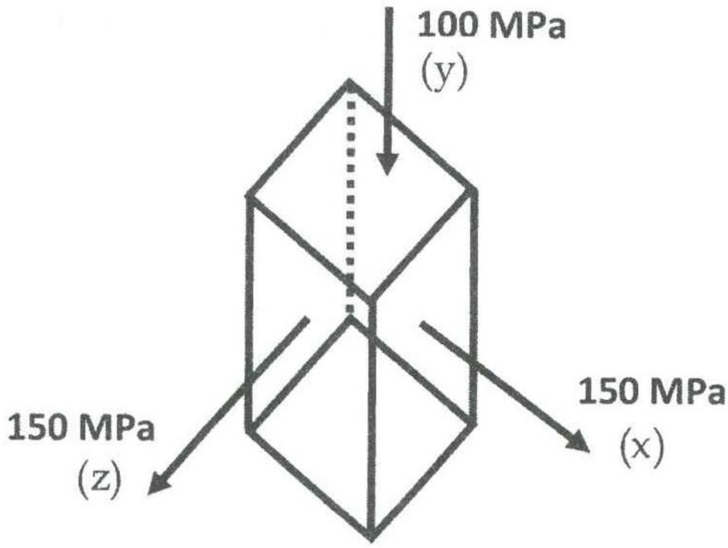

Figure Q5(c)