The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering

Study Programme	:	Bachelor of Technology Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX6230/ DMX6530 Mechanics of Materials**
Academic Year	:	2019/20
Date	:	07th October 2020
Time	:	1330 hours -1630 hours
Duration	:	**3 hours**

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **eight (08) questions and four (04) pages.**
3. **Answer any 05 questions only.** All questions carry equal marks.
4. Answer for each question should commence from a new page
5. Relevant charts/ equations are provided.
6. This is a Closed Book Test (CBT).
7. Answers should be in clear handwriting.
8. Do not use Red colour pen.

Question 01 – *(20 marks)*

(a) Explain the following terms

i. Stress tensor

ii. Volumetric strain

(b) What is meant by the term "index notation"?

(c) The state of stress at a point is given by,

$\sigma_{xx} = 100MPa \quad \sigma_{yy} = 45MPa \quad \sigma_{zz} = -80MPa$

$\sigma_{xy} = -45MPa \quad \sigma_{yz} = 33MPa \quad \sigma_{zx} = -75MPa$

Determine;

i. The magnitude of maximum principle normal strain

ii. The maximum principle shear strain at the point

The Young's Modulus is given as **207GPa** and Poisson's ratio is **0.3**.

Question 02 – *(20 marks)*

(a) Discuss five causes of fatigue failures and five methods by which the fatigue strength of materials can be increased.

(b) Write short notes on the following.

i. Stress relaxation
ii. Creep test
iii. Griffith crack theory

Question 03 – *(20 marks)*

(a) Write down all six independent stress components in terms of strains using the constants $\boldsymbol{E}$ and $\boldsymbol{\upsilon}$.

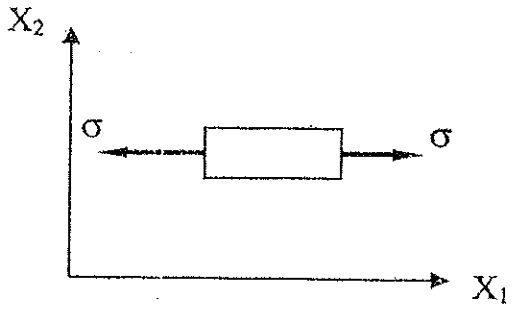

Figure Q03

(b) For an element subjected to a two-dimensional stress as shown in Figure Q03, verify that the Young's Modulus ***(E)*** and the Poisson's ratio ***(υ)*** are given by

$$E = \mu(3\lambda + 2\mu)/\,(\lambda + \mu) \quad \text{and} \quad \nu = \lambda/(\lambda + \mu)$$

Where;

λ and $\boldsymbol{\mu}$ are constants.

Question 04 – *(20 marks)*

(a) State the Airy's stress function for 2-D state of stress.

(b) The Airy's stress function $\emptyset = \boldsymbol{Ay^3 + By^2 + Cx}$ represents the 2-D plane stress beam problem shown in Figure Q04. The beam is unit thickness and depth '$\boldsymbol{t}$'. Determine the values of the constants *A,B*, and *C*.

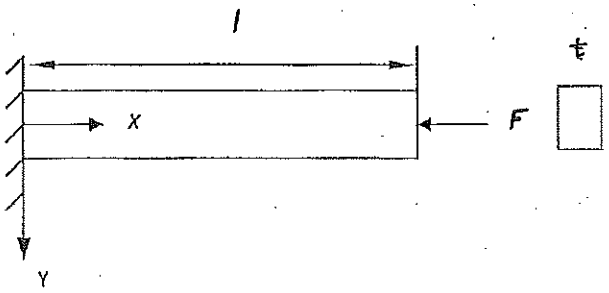

Figure Q04

Question 05 – *(20 marks)*

(a) Briefly discuss the following, underlining the main differences among them.

i. Plane Polarisation
ii. Circular Polarisation
iii. Elliptical Polarisation.

(b) Describe how you would use a polariscope to determine the principal stresses and the principal directions at different points in a given specimen.

(c) Describe the difference between isoclinics and ischromatics.

Question 06 – *(20 marks)*

(a) Determine the intensities of principal stress in a flat steel disc of uniform thickness having a diameter of 1m and rotating at a speed of ***2400 rpm***.
Take Poisson's ratio (υ) = **1/3** and the density of the material (ρ) = **7850 kg/m^3**.

(b) What will be the stresses if the disk has a central hole of **0.2m** diameter?
Note: The intensities of radial and circumferential (or hoop) stresses are given by:

$$\sigma_r = \frac{c_1}{2} + \frac{c_2}{r^2} - \left[\frac{3+\frac{1}{m}}{8}\right]\rho\omega^2 r^2$$

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Question 07 – *(20 marks)*

(a) By giving suitable examples describe how you would improve fatigue resistance in machine components.

(b) A structure is composed of circular members of diameter d. At a certain position along one member the loading is found to consist of a shear force of **10 kN** together with an axial tensile load of **20 kN**. If the elastic limit in tension of the material of the members is **270 MN/m^2** and there is to be a factor of safety of **4**, estimate the magnitude of ***d*** required according to,

i. the maximum principal stress theory,
ii. the maximum shear strain energy per unit volume theory.

Where; Poisson's ratio ν = ***0.283***.

Question 08 – (20 marks)

(a) Explain why electrical resistance strain gauges are very popular for strain measurements.

(b) Describe briefly how you would experimentally determine the principal stresses present in a machine element under the action of a complex stress system, with the aid of a strain gauge.

(c) The state of strain at a point on a bracket is measured using the strain rosette shown in Figure Q08.

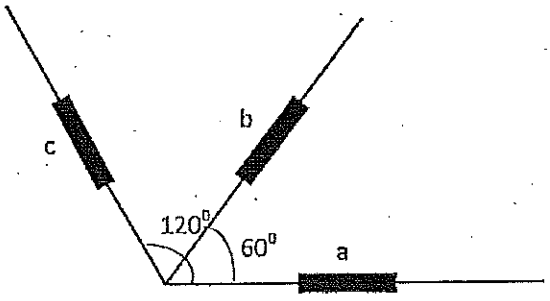

Figure Q08

The readings from the respective strain gauges are

$$\epsilon_a = 225 \times 10^{-3}, \epsilon_b = 220 \times 10^{-3}, \epsilon_c = 130 \times 10^{-3}$$

Determine the in-plane principal strains and the directions along which they act at the point under consideration.