THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA IN TECHNOLOGY – LEVEL 06
FINAL EXAMINATION 2009/2010
MEX 6330 – MECHANICS OF MATERIAL
DATE : 08TH APRIL 2009
TIME : 0930 HRS - 1230 HRS
DURATION : 03 HOURS

046

ANSWER ANY FIVE (05) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

Question 01:

Generalized Hook's Law for an isotropic body can be written in the usual notation as

$$\sigma_{ij} = \lambda \varepsilon_{kk} \delta_{ij} + 2\mu \varepsilon_{ij}$$

Where $\delta_{ij} = 1$ for $i = j$, $\delta_{ij} = 0$ for $i \neq j$ and λ *and* μ are constants dependant upon the material properties. Obtain the following relationships.

(a) $\upsilon = \dfrac{\lambda}{2(\lambda + \mu)}$ and $\mu = \dfrac{E}{2(1+\upsilon)}$ (you may consider the case of simple tension)

(b) $G = \mu$ (you may consider the case of pure shear)

(c) $E = 3K(1-2\upsilon)$, (you may consider the case of a cube subjected to three equal stresses σ , i.e volumetric stress = σ).

Question 02:

Describe any TWO of the following

(a) Failure of ductile and brittle materials

(b) Experimental determination of plane strain Fracture Toughness (K_{IC}) and the practical difficulties encounted in such determination

(c) Application of Fracture Mechanics in engineering design.

Question 03:

(a) List the main components of a plane polariscope and describe the functions of each of them.

(b) What is the difference between a plane polariscope and a circular polariscope?

(c) Briefly describe the two basic arrangements in circular polariscopes.

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

Question 04:

(a) List out the required properties of a strain gauge.
(b) What is the basic principle behind strain gauges?
(c) What are the uses of strain gauges?

(d)

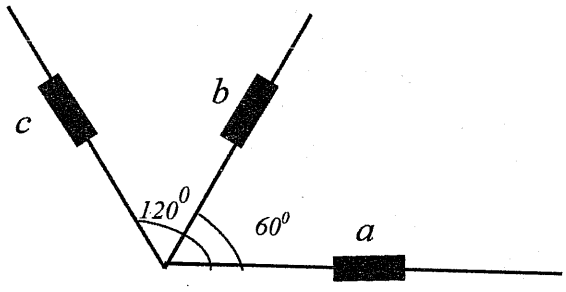


Fig.04

The state of strain at a point is measured using the strain rosette shown in Fig.04. The readings from the respective strain gauges are

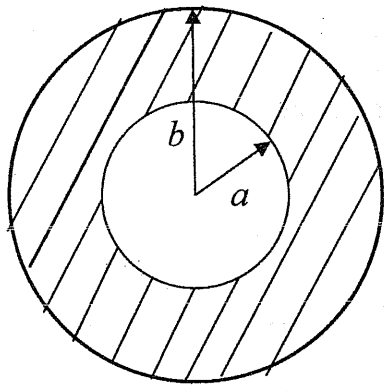
$\varepsilon_a = 60x10^{-6}, \varepsilon_b = 135x10^{-6}, \varepsilon_c = 264x10^{-6}$.

Determine

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

ii the principal stresses at the point.
the Young's Modulus and the Poisson's ratio of the material are 200GN/m^2 and 0.3 respectively.

Question 05:



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Fig.05

A long cylindrical pressure vessel with properties **E** and **ν** has a uniform cross section which is shown in Fig.05. Its ends are closed. It is subjected to an internal pressure '**p**'. Derive expressions for the three principal stresses at a distance '**r**' from the center.

If the material has a yield stress of σ_y and if it obeys Tresca's yield criterion, find the value of '**p**' at which yielding will start. Where would this occur? (Disregard the possibility of yielding at the ends).

Question 06:

(a) An alluminium alloy for an airframe component was tested in the laboratory under an applied stress which varied sinusoidally with time about a mean stress of zero. The alloy failed under a stress range ($\Delta\sigma$) of 280 MNm^{-2} after 10^5 cycles; under a range of 200 MNm^{-2}, the alloy failed after 10^7 cycles. Assuming that the fatigue behaviour of the alloy can be represented by $\Delta\sigma\left(N_f\right)^a = C$, where '$a$' and C are material constants, find the number of cycles to failure, 'N_f', for a component subjected to a stress range of 150 MNm^{-2}.

(b) An aircraft using airframe components has encountered an estimated 4x108 cycles at a stress range of 150 MNm^{-2}. It is desired to extend the airframe life by another $4x10^8$ cycles by reducing the stress performance of the aircraft. Find the decrease in stress range necessary to achieve this additional life.

Question 07:

(a) What is meant by the term "index notation"?
(b) List out the properties of the stress tensor.
(c) The state of stress at a point is given by,

$$\sigma_{xx} = 120MPa \qquad \sigma_{yy} = 55MPa \qquad \sigma_{zz} = -85MPa$$
$$\sigma_{xy} = -55MPa \qquad \sigma_{yz} = 33MPa \qquad \sigma_{zx} = -75MPa$$

Find the values of the three invarients and hence write down the equation to calculate the principal stresses.

Question 08:

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

(b) The Airy's stress function $\phi = Py^3 + Qy^2 + R$ represents the 2-D plane stress beam problem shown in Fig.Q8. The beam is of unit thickness and depth '$2a$'. Determine the values of the constants P, Q and R.

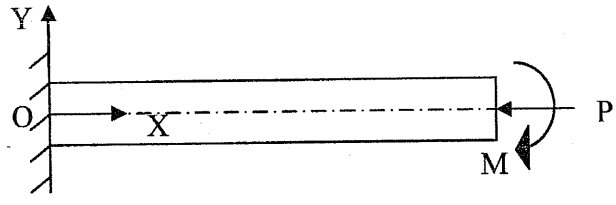


Fig.Q8

The fixed end boundary conditions for the beam at origin (point "O") are as follows. Both X,Y displacement as well as the gradient of the neutral axis are zero, and on Y-Z plane the X displacement is zero. Find the expressions for 'u' and 'v' (displacements in X and Y directions) as functions of x and y.

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