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MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

I SEM M. Tech. (CAAD) DEGREE END SEMESTER EXAMINATIONS
NOVEMBER 2018

SUBJECT: SOLID MECHANICS (MME 5101)
REVISED CREDIT SYSTEM

Time: 3 Hours Max. Marks: 50

Instructions to Candidates:
- Answer **ALL** questions.
- Missing data, if any, may be assumed appropriately.

1. a) Derive the cubic equation which gives the state of principal strain at a point in a body in the form, **[05]**

$$\epsilon^3 - J_1\,\epsilon^2 + J_2\,\varepsilon - J_3 = 0$$

Where, J_1, J_2 and J_3 are the strain invariants.

b) The state of stress at a point is characterized by the components,

σ_x = 12 MPa, σ_y = 4 MPa, σ_z = 10 MPa

T_{xy} = 3 MPa, T_{yz} = 0.0 MPa, T_{zx} = 0.0 MPa

Find the values of principal stresses and their directions. **[05]**

2. a) State and discuss the maximum distortion energy theory of failure and obtain the equation for estimating the distortion energy stored in a body subjected to three dimensional state of stress.
[06]

b) For the state of strain at a point in a solid shown below, determine the principal strains and the direction of maximum principal strain. **[04]**

$$[\varepsilon_{ij}] = 10^{-4}\begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & -4 \\ 0 & -4 & 3 \end{bmatrix}$$

3. a) Obtain the equation of equilibrium in radial direction of an axisymmetric solid in cylindrical coordinates.

[05]

b) The displacement field for a solid is given by, **[05]**

$$u = [(x^2 + y)i + (3x^2 + 4y^2 + z)j + (2x^2 + 4z)k]10^{-3}$$

Determine:

i) The state of strain at a point **P(40, 30, 20)** in the solid

ii) The strain field in the direction of **PQ** having direction cosines $\mathbf{n_x = 0.7}$, $\mathbf{n_y = 0.7}$ and $\mathbf{n_z = 0.15}$

iii) Direction of **P'Q'** after the deformation of solid

4. a) Let $\boldsymbol{\sigma_x = -5c, \sigma_y = c, \sigma_z = c, \tau_{xy} = -c, \tau_{yz} = \tau_{zx} = 0}$ where *c* = 1000 kPa. Determine the following: **[06]**

i) Principal shear stresses and corresponding normal stresses

ii) Octahedral stresses

b) Determine the diameter of a ductile steel bar, if the tensile load is 20,000 N, the torsional moment is 25,000 Nm and the bending moment is 30,000 Nm. Use a factor of safety N = 2, σ_y = 280,000 kPa and E = 207,000 kPa. Use maximum distortion energy theory. **[04]**

5. a) For the steel following data are applicable: **[06]**

E = 207 x 10^6 kPa, G = 80 x 10^6 kPa and ϑ = 0.3. For the state of strain at a point given below, determine the stress state and also evaluate Lame's coefficients.

$$[\epsilon_{ij}] = \begin{bmatrix} 32 & 0 & 160 \\ 0 & 864 & 24 \\ 160 & 24 & 240 \end{bmatrix} 10^{-3}$$

b) A cylindrical rod is subjected to a torque *T*. At any point P of the cross section, the following stresses occur

[04]

$$\boldsymbol{\sigma_x = \sigma_y = \sigma_z = \tau_{xy} = 0;\ \tau_{yz} = G\theta x;\ \tau_{zx} = -G\theta y}$$

Check whether these satisfy the equations of equilibrium. Also show that the lateral surface is free of load, i.e show that $\boldsymbol{T_x = T_y = T_z = 0}$.