Reg.No.										

MANIPAL INSTITUTE OF TECHNOLOGY
A Constituent Institute of Manipal University, Manipal

I SEM M. Tech. (CAAD) DEGREE END SEMESTER EXAMINATIONS
NOVEMBER/DECEMBER 2016

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 differential equations of equilibrium in Cartesian coordinates, giving the conditions to be satisfied by the stress components when they vary from point to point. **[05]**

   b) For the rectangular component small strain matrix shown below, determine the principal strains and the direction of the maximum principal strain. **[05]**

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

2. a) State and discuss the von Mises and Hencky theory of failure based on distortion energy and obtain the equation for evaluating von Mises stress at a point in a body subjected to three dimensional state of stress. **[06]**

   b) A cylindrical rod is subjected to a torque *T*. At any point P of the cross section, the following stresses occur **[04]**

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

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

3. a) Derive the cubic equation which gives the state of principal stress at a point in the body in the form, **[04]**

$$\sigma^3 - I_1 \sigma^2 + I_2 \sigma - I_3 = 0$$

Where, I_1, I_2 and I_3 are the stress invariants.

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

i) Principal stresses and their directions

ii) Maximum shear stress

iii) Octahedral stresses.

4. a) b) If the rectangular components of stress at a point are the same as in the matrix below, determine the unit normal of a plane parallel to the z axis on which resultant stress vector is tangential to the plane. **[04]**

$$[\tau_{ij}] = \begin{bmatrix} a & 0 & d \\ 0 & b & e \\ d & e & c \end{bmatrix}$$

b) Determine the diameter ***d*** of a circular shaft subjected to a bending moment ***M*** and a torque ***T***, according to following theories of failure: **[06]**

i) Maximum normal stress

ii) Maximum strain

iii) Maximum elastic energy.

Let ***N*** be the factor of safety, ***E*** be the modulus of elasticity and ***ϑ*** be the Poisson's ratio.

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

E = 207 x 10^6 kPa, G = 80 x 10^6 kPa and ϑ = 0.3. For the given strain state at a point, 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) Determine the diameter of a cold rolled steel shaft, 6 m long, used to transmit 35kW at 600 rpm. The shaft is simply supported at its ends in bearings. The shaft experiences bending due to its own weight also. Use a factor of safety 2. The tensile yield limit is 280 x 10^6 kPa and the shear yield limit is 140 x 10^6 kPa. Use the maximum shear stress theory. **[04]**