MASTER OF MECH. ENGG. EXAMINATION, 2017 (1st Semester)

STRESS AND DEFORMATION ANALYSIS

Time: Three hours

Full Marks: 100

Answer any *five* questions

1a) Comment on the statement 'stress field is a second order tensor with 9 components in 3D'. Does stress cause strain or does strain cause stress? What is meant by the state of stress of a point. Derive Cauchy's stress equation and discuss on traction vector.

b) At a point in a stressed body the Cartesian components or stresses are, $\sigma_{xx} = 60$ MPa, $\sigma_{yy} = 40$ MPa, $\sigma_{zz} = 20$ MPa, $\sigma_{xy} = 40$ MPa, $\sigma_{yz} = 20$ MPa and $\sigma_{xz} = 30$ MPa. Determine the normal and shear stresses on a plane whose outer normal has the direction cosines $l = 1/\sqrt{3}$, $m = 1/\sqrt{3}$ and $n = 1/\sqrt{3}$. Also compare the results obtained, by constructing Mohr's circles.

(2+2+2+4)+10

2 a) At a point in a stressed body the rectangular stress components are given by:

$$[\sigma] = \begin{bmatrix} 50 & 20 & 10 \\ 20 & 100 & 60 \\ 10 & 60 & 50 \end{bmatrix} \times 10^6 \text{Pa}$$

Transform the above set of Cartesian stress components into a new set of coordinates Ox'y'z' where the new axes are defined by the following direction cosines,

	x	y	z
x'	2/3	2/3	-1/3
y'	-2/3	1/3	-2/3
z'	-1/3	2/3	2/3

b) The displacement field for a body is given by $u = (x^2 + y^2 + 2) \times 10^{-4}$, $v = (3x + 4y^2) \times 10^{-4}$ and $w = (2x^3 + 4z) \times 10^{-4}$. What are the strain components at point (2, 2, 2). Show the change in result if strain displacement relationship is assumed to be linear. Also determine the strain of the point in the direction given by the direction cosines $l = 1/3$, $m = 2/3$, $n = 2/3$.

10+10

3a) Derive equation of equilibrium of a stressed isotropic linear elastic body under equilibrium.

b) The state of stress at any point in a body is given by $\sigma_{xx} = ax + by + cz$, $\sigma_{yy} = dx^2 + ey^2 + fz^2$, $\sigma_{zz} = gx^3 + hy^3 + iz^3$, $\sigma_{xy} = k$, $\sigma_{yz} = ly + mz$ and $\sigma_{zx} = nx^2 + py^2$. Determine the relations that the body force components F_x, F_y and F_z must satisfy.

c) Derive the planar stress fields that arise from the following stress functions (*a-d* constants): i) $\varphi = cy^2$, ii) $\varphi = ax^2 + bxy + cy^2$ and iii) $\varphi = ax^3 + bx^2y + cxy^2 + dy^3$.

d) The stress function defining the state of plane stress at a point in a body is given by the following polynomial of 5th degree (a_5-f_5 constants):

$$\Phi_5 = \frac{a_5}{20}x^5 + \frac{b_5}{12}x^4y + \frac{c_5}{6}x^3y^2 + \frac{d_5}{6}x^2y^3 + \frac{e_5}{12}xy^4 + \frac{f_5}{20}y^5$$

Determine the relevant stress components and state the relations between the constants.

5+5+6+4

4 a) Show that the stress surface of Cauchy completely defines the state of stress at a point

b) Derive displacement equations of equilibrium for isotropic materials.

c) Compute Lame's co-efficients λ and μ for steel having $E = 2.07 \times 10^{11}$ Pa and $\nu = 0.3$.

8+8+4

5 a) Prove that according to Von-Mises criterion, failure occurs when the octahedral shear stress is $(\sqrt{2}/3)$ times the yield stress in axial tension.

b) Explain the concept of effective stress and effective strain.

c) Sketch engineering and true/natural stress strain curves for a ductile material.

d) Define engineering stress, engineering strain, true stress and natural strain.

e) A tensile specimen with 10 mm initial diameter and 40 mm gage length reaches max load of 100 kN and fractures at 70 kN. The minimum dia. at fracture is 8 mm. Determine the engineering stress at max load, true stress and strain at fracture and engineering fracture strain.

6+3+2+3+6

6a) State variational principle and the theorem of stationery potential energy.

b) A taper bar with clamped boundaries at both ends is under a uniformly distributed axial loading, as shown in figure Q6. The complete details of geometry, (L, D, d) loading $f(x)$ and material specification of the bar is known. State the expressions of strain energy and work function and explain how the system governing equation can be derived from the above two expressions.

c) Assume deflection curve in the form $c_1\Phi_1 + c_2\phi_2$ and hence write the elements of stiffness matrix and load vector.

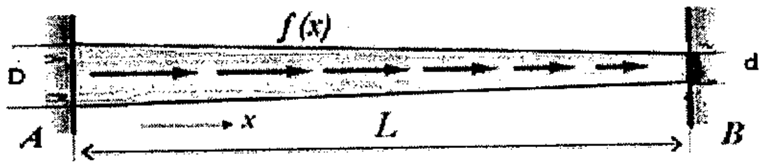

Figure – Q6

4+8+8

7a) Explain strain measurement principle for resistance strain gages.

b) Define bridge sensitivity and suggest methods to improve bridge sensitivity.

c) Explain the null and deflection method of strain measurement. How temperature effect is compensated by using dummy gauge.

d) Describe an experimental procedure for determination of Gage Factor.

4x5

8. Wtite short notes on:

i) Generalised Hooke's law

ii) Maxwell's stress function

iii) Material of resistance strain gauges

iv) Bifurcation points in elastic stability

4x5