U.S.N

P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belagavi)

First Semester, M.Tech. - Mechanical Engineering (MMDN)

Semester End Examination; Jan. - 2020

Theory of Elasticity

Time: 3 hrs *Max. Marks: 100*

Note: *i) Answer **FIVE** full questions, selecting **ONE** full question from each unit.*
ii) Missing data, if any, may be suitably assumed.

UNIT - I

1 a. Derive the expression for normal stress acting on an arbitrary plane. 14

b. At a point in a material, a resultant stress of 151 MPa acts in a direction, making angles of 52°, 79° and 40.13° with coordinate axes *x*, *y* and *z* respectively. Find the normal and shear stresses on the plane whose normal makes angles of 33°, 65° and 70° respectively with *x*, *y* and *z* axes. 6

2 a. Obtain the expression for stress induced in a body subjected to uniform temperature rise and the body is prevented from having any displacements. 10

b. A rectangular bar of cross section 30 mm × 25 mm is subjected to an axial tensile force of 180 kN. Determine the normal, shear and resultant stresses on a plane, whose normal has direction cosines $l = m = n = \frac{1}{\sqrt{3}}$. 10

UNIT - II

3. Derive the expression for change in length of a linear element. 20

4 a. Displacement field imposed on a body is given by $U = (xy\, i + 3x^2 j + 4k)10^{-2}$. A line PQ in the body has direction cosines *l*, *m* and *n* equal to 0.2, 0.8 and 0.555 respectively. If 'P' has coordinates (2, 1, 3) and PQ = ΔS. Find P′ Q′ after deformation. 10

b. Displacement field for a body is given by,

$$U = A(x^2 + y)i + A(y + z)j + A(x^2 + 2z^2)k$$

Where A = 10^{-3}. At a point P(2, 2, 3) two lines PQ and PR are considered with direction cosines $l_1 = m_1 = n_1 = \frac{1}{\sqrt{3}}$ and $l_2 = m_2 = \frac{1}{\sqrt{2}}$, $n_2 = 0$ respectively. Determine the angle between the lines before and after deformation. 10

UNIT - III

5 a. Explain Saint-Venant's Principle. 8

b. A cubical element is subjected to the following state of stress $\sigma_x = 100$ MPa, $\sigma_y = -20$ MPa, $\sigma_z = -40$ MPa, $\tau_{xy} = \tau_{yz} = \tau_{zx} = 0$. Assuming the material to be homogeneous and isotropic, determine the principal shear strains and octahedral shear strain, if E = 200 GPa, and $\gamma = 0.25$. 12

6 a. Explain principle of superposition. 8

b. The state of strain at a point is given by $\in_x = 0.001$, $\in_y = -0.003$, $\in_t = \gamma_{xy} = 0$, $\gamma_{xz} = -0.004$, $\gamma_{yz} = 0.001$. Determine the stress tensor at this point. Also find Lame's constant. 12

E = 210 GPa, $\gamma = 0.28$.

UNIT - IV

7 a. State and prove Maxwell reciprocal theorem. 10

b. Determine the support reaction for the propped cantilever shown in Fig. Q7(b). 10

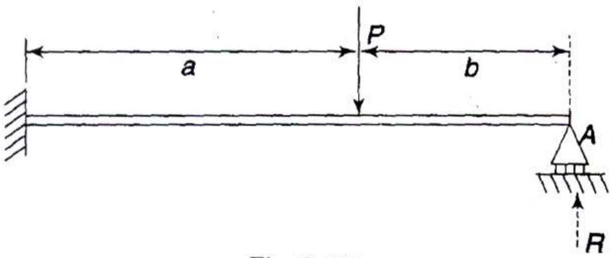

Fig. Q 7(b)

8 a. Explain Kirchhoff's theorem. 8

b. Three elastic members AB, BD and CD are connected by smooth pins as shown in Fig. Q8(b). All the members have same cross sectional area and are of same material. BD is 1 m long and members AD and CD are 2 m long each. Determine the deflection of 'D' under load W, if cross sectional area of each member is 100 mm^2. E = 200 GPa and load W = 10 kN. Use principle of virtual work. 12

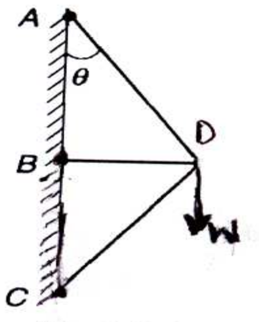

Fig. Q 8(b)

UNIT - V

9. Assuming a fourth degree polynomial function of,

$$\phi = \frac{A}{24}x^4 + \frac{B}{6}x^3 y + \frac{C}{2}x^2 y^2 + \frac{D}{6}xy^3 + \frac{E}{24}y^4$$ 20

Obtain the expressions for σ_x, σ_y and τ_{xy} for a narrow cantilever beam subjected to end load.

10. For a plane stress case, obtain the expressions for stresses and deformation, for a thick walled cylinder subjected to internal and external pressure. 20

* * *