Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE EXAMINATION(S), DECEMBER 2019

Course Code: ME202

Course Name: ADVANCED MECHANICS OF SOLIDS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any three questions, each carries 10 marks Marks

Databook is not permitted to use in the exam

1 a) Describe about the significance of stress invariants 2

b) Given the stress matrix

$$[\sigma] = \begin{bmatrix} 20 & 10 & 10 \\ 10 & 20 & 10 \\ 10 & 10 & 20 \end{bmatrix} \text{MPa}$$

(a) Determine the principal stresses and the direction cosines associated with the maximum principal stress. 5

(b) Determine the maximum shear stress. 1

(c) Determine the octahedral stresses 2

2 a) Write down the strain – displacement relation in Cartesian Coordinate system 2

b) The displacement field for a body is given by $\boldsymbol{u} = [2y^2\mathbf{i} + 4yz\mathbf{j} + (3 + 5z^2)\mathbf{k}]10^{-2}$ **.** Determine the strain tensor. 3

c) State the conditions under which the following is a possible system of strains

$\varepsilon_{xx} = a + b(x^2 + y^2) + x^4 + y^4$,

$\varepsilon_{yy} = \alpha + \beta(x^2 + y^2) + x^4 + y^4$, $\gamma_{xy} = A + Bxy(x^2 + y^2 - c^2)$, $\gamma_{yz} = 0$, $\gamma_{zx} = 0$ and $\varepsilon_{zz} = 0$. 5

3 a) For steel the Young's Modulus is 207x10^6 kPa and Rigidity Modulus is 80x10^6 kPa. For the strain tensor at a point, determine the stress tensor

$$[\varepsilon_{ij}] = \begin{bmatrix} 0.001 & 0 & -0.002 \\ 0 & -0.003 & 0.003 \\ -0.002 & 0.003 & 0 \end{bmatrix}$$ 5

b) State and explain Saint Venant's principle for end effects 3

c Write the constitutive relation for linear elastic isotropic material 2

4 a) Obtain the stress compatibility equation for plane stress problem in the presence of body force 5

b) Show that $\phi = x^4 y + 4x^2y^3 - y^5$ is a valid stress function and compute the stress 5

tensor for this case assuming a state of plane strain with Poisson ratio$\nu = 0.25$.

PART B

Answer any three questions, each carries 10 marks

5 a) Derive the compatibility equation in terms of stress function φfor polar co-ordinate system — 7

b) Write the equilibrium equation in polar coordinate system — 3

6 a) In a very thick cylinder with outer radius much larger than the inner radius a, subjected to an external pressure $P_o$and zero internal pressure, prove that the radial and tangential stress variations are $\sigma_r = P_0(1 - \frac{a^2}{r^2})and\sigma_\theta = P_0(1 + \frac{a^2}{r^2})$ — 10

7 a) Obtain the strain energy in terms of material properties for a shaft subjected to a torque T. — 5

b) For a given stress tensor at a point on a steel object with E= 207 x 10^6 kPa and G=80x10^6 kPa, determine the value of strain energy density. — 5

$$[\sigma] = \begin{bmatrix} 9 & 0 & 3 \\ 0 & -10 & 1 \\ 3 & 1 & 112 \end{bmatrix} \text{x}10^3 \text{ kPa}$$

8 a) Explain about unsymmetrical bending of beams. — 2

b) A beam symmetrical about y-z axis is subjected to a bending moment M, about an arbitrary axis in the y-z plane. Obtain the equation for flexural stress. — 8

PART C

Answer any four questions, each carries 10 marks

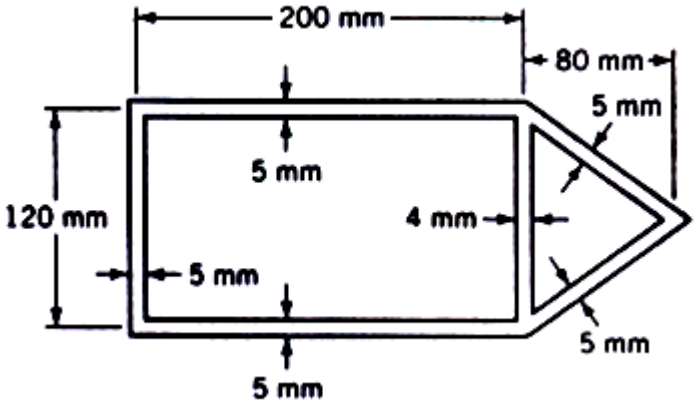
9 a) Verify that function $\psi(x, y) = Axy$ is a Saint Venant's warping function, where A is a constant. Find the general expression for slope of tangent at a point on the boundary curve of the bar with this warping function. Find out shape of the cross section and *J* integral. — 8

b Explain about centre of twist. — 2

10 a) Derive the governing equation and boundary condition for torsion of non circular cross section in terms of Prandtl stress function. — 8

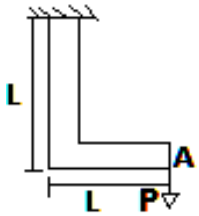
b) What is torsional rigidity? — 2

11 a) The aluminium (G=27GPa) hollow thin walled torsion member hasdimensions as shown below. Its length is 3m. If the member is subjected torque of 11KN-m, determine the maximum shear stress and angle of twist. — 10



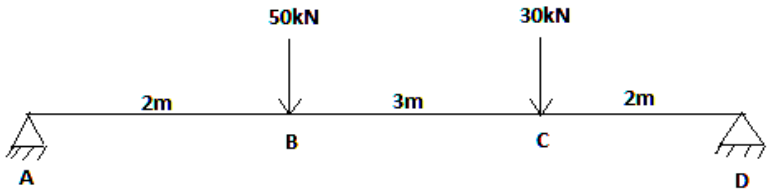
12 a) Based on the stress function approach, derive an expression for finding the maximum shear stress on a shaft of elliptical cross section? 10

13 a) A frame is subjected to a load P as shown in figure. The length of each leg is L. The frame has a constant flexural rigidity EI. If the effect of axial load is neglected, find the deflection at point A due to applied load P? 6



b) State and explain Castigliano's first and second theorem 4

14 a) 8



Using the principle of virtual work, find out the reactions at A and D

b) Explain Maxwell theorem 2

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