Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

Online End Semester Examination, December 2020

Course: Finite Element Method **Semester: VII**

Program: B. Tech ASE **Time 03 hrs.**

Course Code: ASEG 4003 **Max. Marks: 100**

Instructions: a) All questions are compulsory.

b) Assume any suitable value for missing data

SECTION A

1 .Each Question will carry 5 Marks and has sub-questions
2. Q1-Q5 are objective and true/false
3. Q6 is short answer type

S. No.		Marks	CO
Q 1	i) The determinant of an element stiffness matrix is always **(2 M)** a) one b) zero c) depends on size of [K] d) Two ii) In below choose which is the correct condition for axisymmetric element **(2 M)** a) Symmetric about axis b) Boundary conditions are symmetric about axis c) Loading conditions are symmetric about axis d) All the above iii) The diagonal element of stiffness matrix is always positive **(T/F) (1 M)**	5	CO1
Q2.	i) The sum of the derivative of shape function for an element in FEM is **(2 M)** a) 0 b) 1 c) 2 d) Infinite ii) The value of the Kronecker delta function : $\delta_{ij}\delta_{ij}$ is **(2 M)** a) 1 b) 0 c) 3 d) Infinite	5	CO1

	iii) Every continuous system has infinite degree of freedom **(T/F)** **(1 M)**		
Q3	i) A sphere under diametral compression is an example of **(2 M)** a) Plane stress b) Plane strain c) Axisymmetric d) None of the above ii) The size of [B] matrix for a 2D quad non-linear element is **(2 M)** a) 2 x 16 b) 1 x 18 c) 3 x 16 d) 2 x 18 iii) Symmetry of stress tensor is derived from moment equilibrium **(T/F)** **(1 M)**	**5**	**CO1**
Q4.	i) Which of the following is **NOT** true for FEM **(2 M)** a) FEM is an approximate method b) Equilibrium equation are derived at nodes c) Shape function has the property similar to Kronecker delta function d) The origin of natural coordinate system in a 2D isoperimetric formulation is at the corner node of an element ii) The total potential energy of an elastic body is defined as ________. (2 M) a) Strain energy - Work potential b) Strain energy + Work potential c) Strain energy + Kinetic energy - Work potential d) Strain energy + Kinetic energy + Work potentia iii) The conductive matrix for an element is symmetric while convective not **(T/F)** **(1 M)**	**5**	**CO1**
Q5	i) Reduction of any 3D problem to 2D depends on **(2 M)** a) Nature of loading b) Geometry type c) Material behaviour	**5**	**CO1**

	d) All of the above ii) If a body is in equilibrium then its total potential energy is **(2 M)** a) 0 b) Maximum c) Minimum d) Vary with time iii) Shape function has the property of Kronecker delta function **(T/F)** **(1 M)**		
Q6	Briefly explain importance of (not more than two line) a) Shape function in FEM **(2 M)** b) Isoparametric formulation in FEM **(3M)**	**5**	**CO2**
	SECTION B		
Q 7	The state of stress at any point in the material is given by the below stress tensor $\sigma_{ij} = \begin{bmatrix} 18 & 0 & 24 \\ 0 & -50 & 0 \\ 24 & 0 & 32 \end{bmatrix}$ Determine a) Principal stresses **(3M)** b) Deviotoric stress **(2M)** c) Von-mises stress **(2 M)** d) Traction vector at the plane whose direction cosines are $(1/\sqrt{2}, 1/\sqrt{2}, 0)$ (**3M)**	**10**	**CO3**
Q8.	The ***ij***th the element of the stiffness matrix [K] of a 2 d element is given by $\int_{-1}^{1}\int_{-1}^{1} \zeta^2\eta^2 d\zeta d\eta$ Evaluate the above integral using 3 point Gauss quadrature rule. Use below table for your refrenece.	**10**	**CO4**

<table>
<tr>
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<tr><th>Number of Points</th><th>Locations, x_i</th><th>Associated Weights, W_i</th></tr>
<tr><td>1</td><td>$x_1 = 0.000\ldots$</td><td>2.000</td></tr>
<tr><td>2</td><td>$x_1, x_2 = \pm 0.57735026918962$</td><td>1.000</td></tr>
<tr><td>3</td><td>$x_1, x_3 = \pm 0.77459666924148$</td><td>$\frac{5}{9} = 0.555\ldots$</td></tr>
<tr><td></td><td>$x_2 = 0.000\ldots$</td><td>$\frac{8}{9} = 0.888\ldots$</td></tr>
<tr><td>4</td><td>$x_1, x_4 = \pm 0.8611363116$</td><td>0.3478548451</td></tr>
<tr><td></td><td>$x_2, x_3 = \pm 0.3399810436$</td><td>0.6521451549</td></tr>
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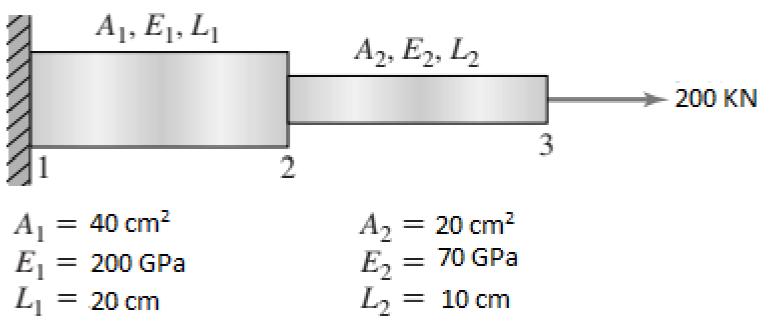
<td>Q9 .</td>
<td>Figure below depicts an assembly of two bar elements made of different materials. Determine the displacements at mid of each bar, element stresses, and the reaction force.


Following informations are there for your refrence.
$$K = \int_v B^T D B dv$$
$$\text{Surface force vector}, r_s = \int_s N^T t ds$$
$$\text{body force vector}, r_b = \int_v N^T b dv$$
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<td>CO3</td>
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<td>Q10.</td>
<td>For the 1D quadratic element with three nodes. Determine the following quantities In Natural Coordinate system
a) Shape function (3 M)
b) [B] matrix (Derivative of shape function matrix) (2M)
c) Element stiffness matrix (use 2 point Gauss quadrature rule) (5 M)
Note: Refer table in Q8 for more information</td>
<td>10</td>
<td>CO4</td>
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<td>Q11.</td>
<td>a) Why displacements are primary unknown (not load or stress or strain) for structure problem in FEM (5 M)</td>
<td>10</td>
<td>CO3</td>
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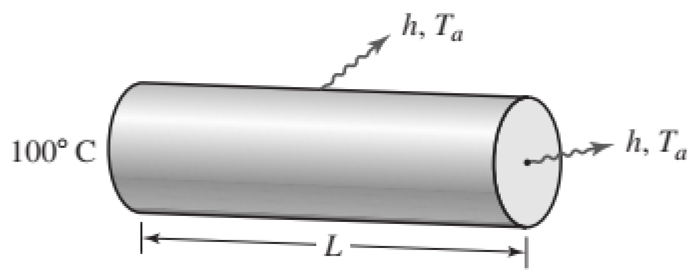
</table>

	b) What do you mean by convergence in FEM, state the difference between h and p method of convergence. (5 M)		
	SECTION-C		
Q12	Consider the circular heat transfer pin shown in Figure below. The base of the pin is held at constant temperature of 100 ^{0}C (i.e., boiling water). The tip of the pin and its lateral surfaces undergo convection to a fluid at ambient temperature Ta. The convection coefficients for tip and lateral surfaces are equal. Given *K*x = 380 W/m-^{0}C, L = 8 cm, h = 2500 W/m^2 - ^{0}C, d = 2 cm, Ta = 30 ^{0}C. Use a two element finite element model with linear interpolation functions (i.e., a two-node element) to determine the nodal temperatures and the heat removal rate from the pin. Assume no internal heat generation  Use bleow quatities to solve this problem, $K_c = \int_V B^T D B dv$ $K_h = \int_s h N^T N ds$ $f_Q = \int_v N^T Q dv$ $f_q = \int_s N^T q ds$ $f_h = \int_s N^T h T_\infty ds$	**20**	**CO5**