Roll No. | | | | | | | | | | |

ANNA UNIVERSITY (UNIVERSITY DEPARTMENTS)

B.E / B.Tech END SEMESTER EXAMINATIONS – NOV / DEC 2021

AERONAUTICAL ENGINEERING

AE 7603 – FINITE ELEMENT METHODS

(Regulation 2015)

Time: 3 Hours Answer ALL Questions Max. Marks 100

PART- A (10 x 2 = 20 Marks)

No.	Questions	Marks
1.	Give examples of classical methods for obtaining approximate solutions.	**2**
2.	Let y denote vertical beam displacement. What does the condition $y_{n+1} = - y_{n-1}$ represent?	**2**
3.	The nodes 1 and 2 of a planar truss element are located at (300, 0) and (0, 300) respectively. What are direction cosines for the given element?	**2**
4.	The stiffness matrix of a system can be obtained using which of the methods listed below? 1. Variational Methods 2. Energy theorems 3. Galerkin Formulation	**2**
5.	List the conditions that must be satisfied by an admissible (trial) function.	**2**
6.	A planar triangular element with 3 nodes gives (constant/linear) stress and (constant/linear) strain within the element.	**2**
7.	In a linear strain triangle, the variation of . . . . . . is quadratic.	**2**
8.	Identify the matrix given below.	**2**

	$$\frac{E}{(1+\nu)(1-2\nu)}\begin{bmatrix}1-\nu & \nu & 0\\ \nu & 1-\nu & 0\\ 0 & 0 & 0.5-\nu\end{bmatrix}$$	
9.	If heat flux due to convection is written as $q = h\,(T - T_{\textbf{ambient}})$, what is the standard unit for the convection coefficient *h*?	**2**
10.	Observe the following boundary condition : $-\,q_N = -\,h\,(T_N - T_{ambient})$ What does the given boundary condition represent?	**2**

PART- B (5 x 13 = 65 Marks)

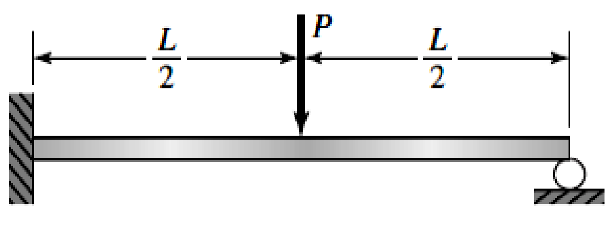
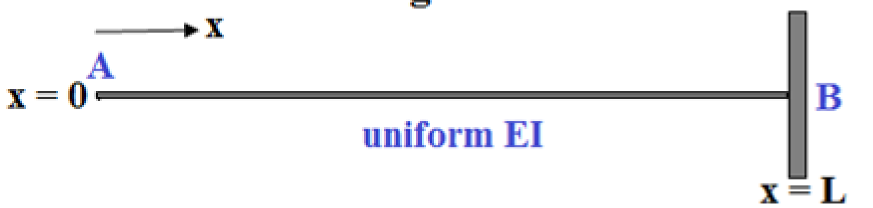
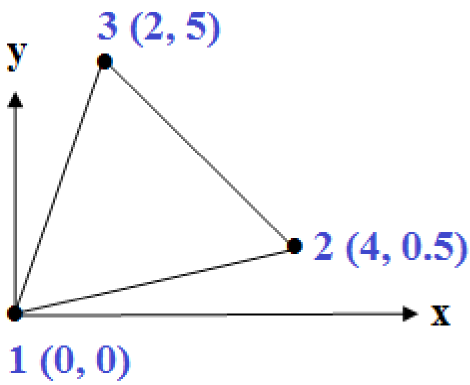
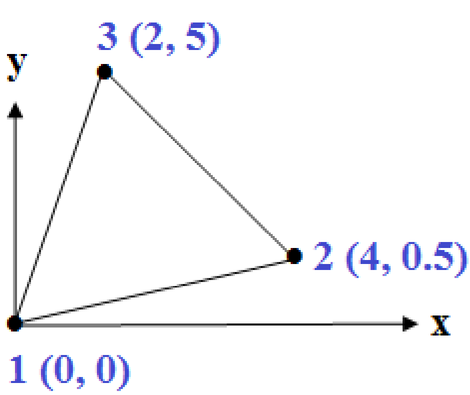
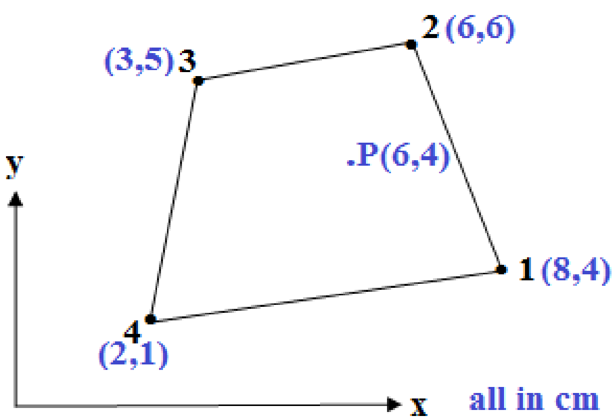
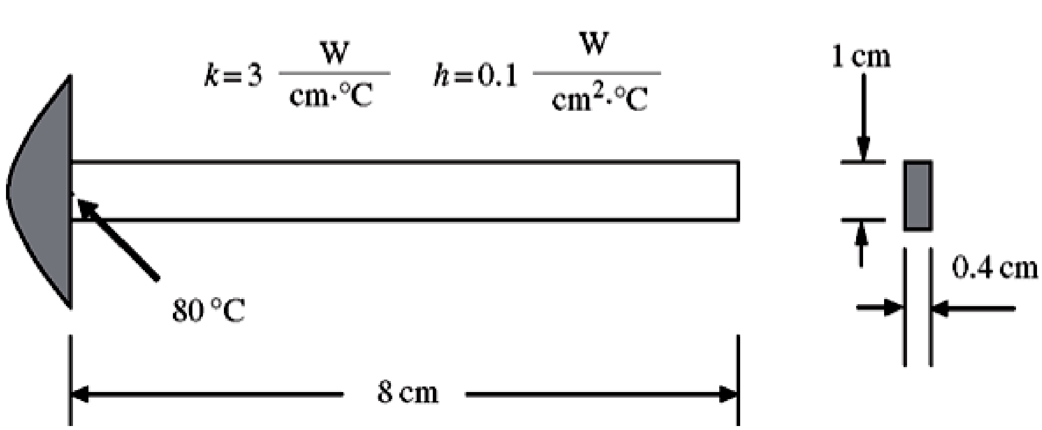
No.	Questions	Marks
11.	(a)  **Figure 1** The deflection curve for the beam given above in Figure 1 is to be determined using the Rayleigh-Ritz method.	**13**
	OR	
	(b) For the propped cantilever beam given in Figure 1, obtain the mid-point displacement using the finite difference method.	**13**
12.	(a) The propped cantilever beam given in Figure 1 is considered. Obtain the mid-point slope and deflection using the finite element method.	**13**
	OR	
	(b) A cantilever beam is indicated in Figure 2. Evaluate the first natural frequency of transverse vibrations using the finite element method.	**13**

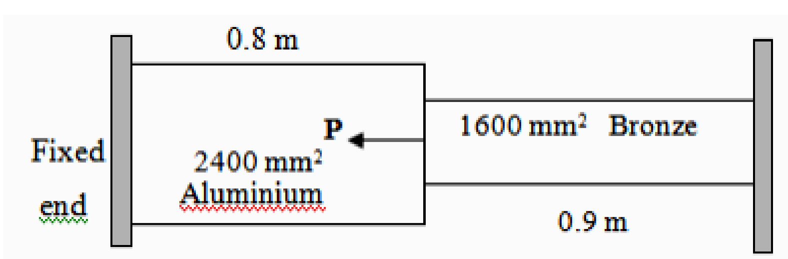
	Figure 2 	
13.	(a) Derive and obtain an expression for the strain-displacement matrix of a constant strain triangle finite element. Evaluate the strain-displacement matrix for the CST element given below in Figure 3.  Figure 3	13
	OR	
	(b) (i) Explain the principle of work equivalence.	3
	(ii) Refer Figure 3 which shows a constant strain finite element. Coordinates are all in cm. Derive and obtain the shape functions for the given element in the form N = k(a + bx + cy) where k = 1/19. If a force in the y-direction acts at the interior point (2,4) of the element, obtain the nodal load vector expression. Use the principle of work equivalence.  Figure 3	10

14.	(a) (i) Explain isoparametric formulation. An isoparametric finite element is given below in Figure 4 where the coordinates are given in cm. Indicate natural coordinates for the given element and write down the 4 shape functions in natural coordinates. (ii) The coordinates of an interior point P are (6,4) cm. Find the natural coordinates values of the point P. Evaluate the numerical values of the shape functions at P.  **Figure 4**	**13**
	OR	
	(b) Write notes on the following topics : • significance of the Jacobian matrix • numerical integration and its role in the finite element method • use of higher order elements	**13**
15.	(a) Explain the theory of 1-D heat transfer using the finite element method. List the assumption used. How are the element matrices formulated?	**13**
	OR	
	(b) The temperature distribution in the fin shown in Figure 5 is to be calculated using the finite element method. The 8 cm length fin is rectangular in cross-section having 0.4 cm width and 1 cm thickness. Assume that convection heat loss occurs only from the extreme right end surface of the fin where the ambient fluid is at a temperature of **20ºC.**	**13**

	Divide the fin into FOUR equal-length finite elements. O the principle of work equivalence btain the 5 x 5 set of finite element equations in matrix form. Next, write the reduced set of equations in matrix form from which nodal temperatures may be obtained. Mention the solution procedure. Actual solution for the nodal temperatures is not required. **Figure 5** 	

PART- C (1 x 15 = 15 Marks)

(Q. No 16 is Compulsory)

	Questions	
16.	Consider the composite stepped bar indicated in Figure A given below. Force P = 40 kN. Use E = 71 GPa and 83 GPa for aluminium and bronze respectively. Thermal expansion coefficient values for aluminium and bronze are 23 x 10^{-6}/°C and 19 x 10^{-6}/°C respectively. The given stepped bar is also subject to a 90°C temperature rise. Using four finite elements, obtain the assembled stiffness matrix and the global load vector. Determine the mid-length displacement of the bar, element stresses and strains.  Figure A	**15**