Birla Institute of Technology & Science, Pilani
Work Integrated Learning Programmes Division
First Semester 2022-2023

Mid-Semester Test
(EC-2 Regular)

Course No.	: DE ZG513
Course Title	: Finite Element Method
Nature of Exam	: Open Book
Weightage	: 30%
Duration	: 2 Hours
Date of Exam	: 24/09/2022 (FN)

No. of Pages = 2
No. of Questions = 4

Note to Students:
1. Please follow all the *Instructions to Candidates* given on the cover page of the answer book.
2. All parts of a question should be answered consecutively. Each answer should start from a fresh page.
3. Assumptions made if any, should be stated clearly at the beginning of your answer.

Q.1. Considering thermal conduction and convection through a fin shown in Figure 1, compute the temperature (T) across the fin for the given length (L), thermal conductivity (K), area of cross section (A), film coefficient (β), and perimeter of cross section (P) using two 3-node line elements. You may use the Matlab software for computations. **[7 marks]**

GDE: $-\frac{d}{dx}\left(KA\frac{dT}{dx}\right) + P\beta T - P\beta T_\infty = 0$ $\quad 0 < x < L$

BC: $T(x)|_{x=0} = 300°C, \quad T(x)|_{x=L} = 30°C$

Given $K = 370\ W/mK, A = 10^{-5}m^2, \beta = 30\ W/m^2°C, T_\infty = 30°C, L = 0.25m$
Perimeter $P = 12 \times 10^{-3}m$

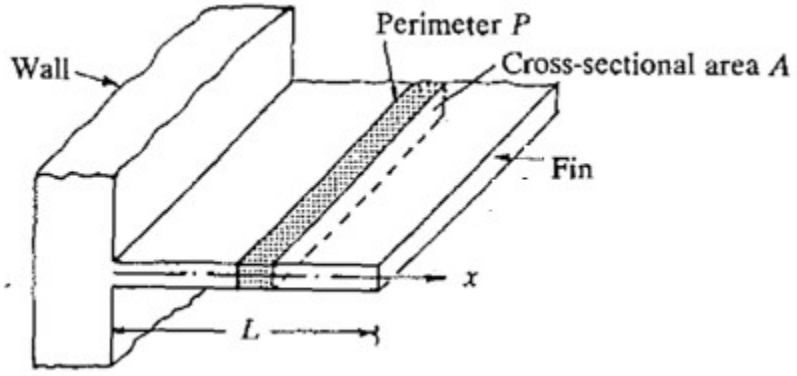

Figure 1

Q.2. A pin-jointed truss structure is loaded by a point load F (= 7071 N) as shown in Figure 2. The Young's modulus (E) is 100 GPa and the cross-sectional area (A) is 100 mm^2. Take the length (L) as 1 m.

a. Write the generalized stiffness matrix and load vector at element level. **[2 marks]**
b. Write the generalized stiffness matrix and load vector at global level. **[3 marks]**
c. Find out the unknown displacements and reaction forces **[4 marks]**

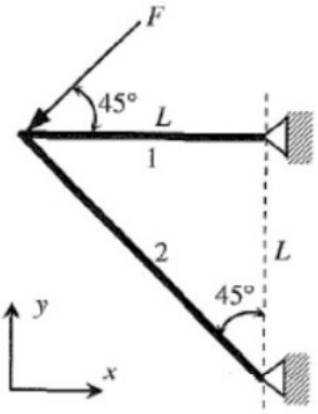

Figure 2

Q.3. Degrees of freedom of a stepped bar are constrained as shown in Figure 2. Each one of three segments of the stepped bar is made of a different material and must be taken as one element. Cross-sectional area, Young's modulus, and coefficient of thermal expansion of each material are shown in Figure 2. The temperature of the shaft is raised to +85°C. You may use Matlab to compute the following in each element or segment of the stepped bar.

a. Global matrix equations **[3 marks]**
b. nodal displacements and reaction forces and **[2 marks]**
c. element stresses **[2 marks]**

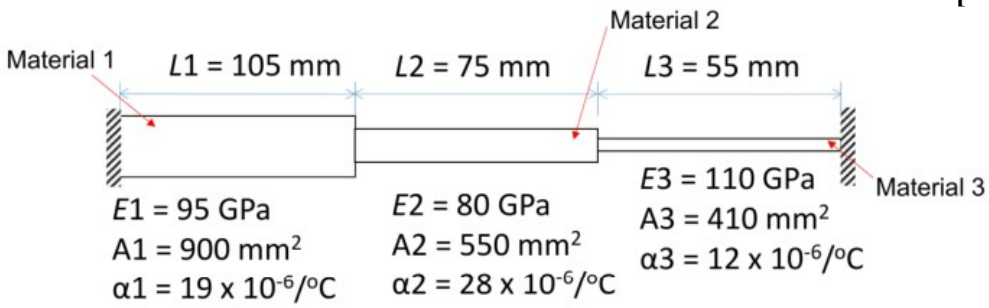

Figure 3

Q.4. Solve the following differential equation for axial deformation of a bar of length 12mm using Galerkin Weighted Residual method **[7 marks]**

$$\frac{d^2u}{dx^2} = -0.75(4-x)^2$$

One end of the bar is fixed whereas the displacement is 12 mm at the other end of the bar.

You may use Matlab for computations. Use the trial function $\hat{u}(x) = c_0 + c_1 x + c_2 x^2$

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