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

Comprehensive Examination
(EC-3 Regular)

Course No.	: DE ZG513
Course Title	: Finite Element Method
Nature of Exam	: Open Book
Weightage	: 40%
Duration	: 2 ½ Hours
Date of Exam	: 26/11/2022 (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. Using two equal linear bar elements for a bar fixed at one end and supported by a spring of stiffness k_s at the other end shown in Figure 1, answer the following questions

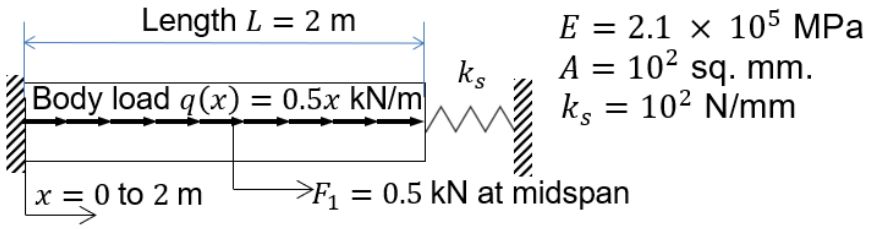


Figure 1

a) Derive the element level force vector for a generic element **[4 marks]**
b) Write the element level equations in matrix form **[2 marks]**
c) Write global matrix equations, apply BCs and show partitioning **[3 marks]**
d) find the primary and secondary unknowns **[3 marks]**
e) find the stress and strain in each element **[2 marks]**

Q.2. A beam of length L (=1m) and square cross section (of side 10 mm) is shown in Figure 2. Calculate the primary and secondary variables by using four beam elements. Young's modulus E = 200 GPa and Poisson's ratio = 0.3. The nodes must be numbered as shown in Figure 2. Use Matlab software for computations. **[10 marks]**

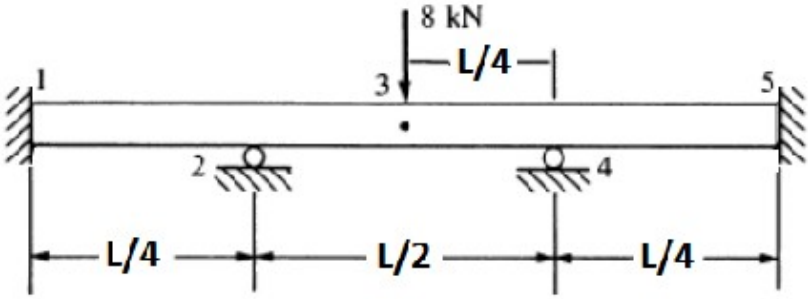


Figure 2

Q.3. Solve the Poisson equation $-\nabla^2 u=2$ in domain Ω shown in Figure 3 with two boundary conditions, one, $u=0$ on Γ_1, and the other, $\partial u/\partial n =0$ on Γ_2. Ω is in the first quadrant bounded by the parabola, whose equation is $y=1-x^2$, and the coordinate axes. Γ_1 and Γ_2 are the boundaries of the 2D domain. Compute the primary and secondary unknowns using Matlab software. **[10 marks]**

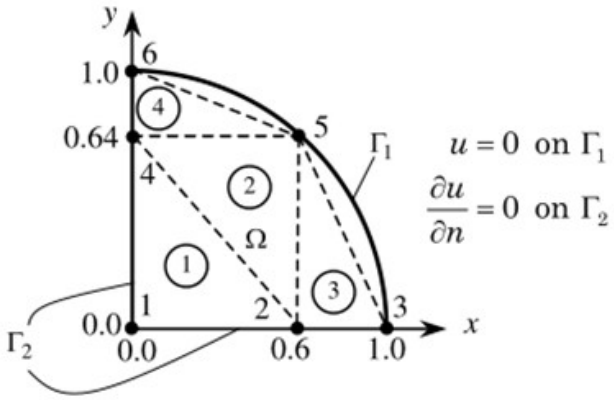
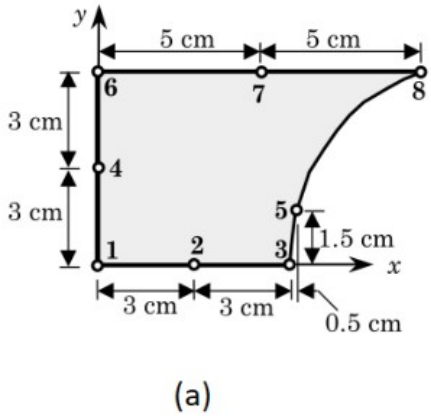


Figure 3

Q.4. For quadratic quadrilateral element shown in Figure 4a, the corresponding master element and the respective shape functions are shown in Figure 4b.

a) What are the geometry transformations equations for the coordinates x and y. **[4 marks]**

b) What is the Jacobian matrix for the transformation from the global to natural coordinate system **[2 marks]**



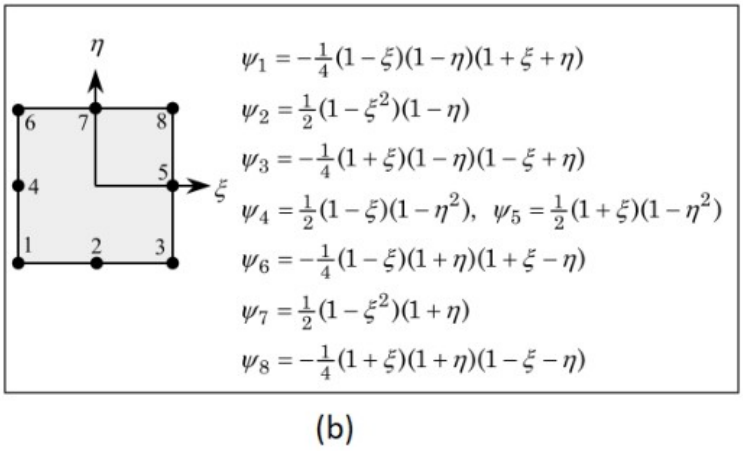


Figure 4

****