2

B.Sc Engg.(ME)/6th Sem 16 May, 2024 (Thursday)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING (MPE)

Semester Final Examination | Summer Semester: A.Y. 2022-2023
Course No.: ME 4637 | Time: 3 hours
Course Title: Computational Mechanics | Full Marks: 150

There are 6 (Six) Questions. Answer all of them.

Marks in the Margin indicate full marks. Programmable calculators are not allowed.

Assume reasonable values for missing data (if any).

1. Following is the 1D *Convection-Diffusion equation* (25) CO2 PO5

$$3\frac{d^2\varphi}{dx^2} = 75\frac{d\varphi}{dx} - 8x$$

Using Finite Difference Method, write a program to obtain the solution (without up-winding scheme).
Discuss why instability occurs in the solution? How this instability can be improved?

2. Consider the *Unsteady diffusion equation* (25) CO2 PO5

$$\frac{\partial\varphi}{\partial t} = 3\frac{\partial^2\varphi}{\partial x^2}$$

Assuming the necessary boundary conditions and initial conditions, write a program using Implicit Euler with grid spacing 0.1 to solve on a 5-node grid.

3. Following is the 1D *Diffusion* equation (25) CO2 PO5

$$3\frac{d^2\varphi}{dx^2} = 2x^2$$

Assuming the necessary boundary conditions and initial conditions, write a program to solve this equation on a 4 grid cells. Use Finite volume Method.

4. a) Determine the global stiffness matrix for the following multi-element system shown in **Figure 1** (5) CO1 PO2

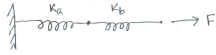

Figure 1

b) Consider a 3-spring system as shown in **Figure 2.** Parameter values are k_a = 500 N/m, k_b=100N/m, k_c = 250 N/m, F_3= 100 N, F_4 = 50 N. Use Direct Stiffness method to compute deformation of all nodes. (15) CO1 PO2

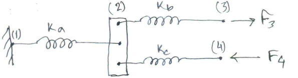

Figure 2

5. a) Consider the following 2D assembly of truss and spring elements in **Figure 3.** For Elements a and c: (20)
$E = 40 \times 10^6$ psi, $A = 2$ in^2, $L = 5$ ft. CO1
Element b: $k = 250{,}000$ lb/in. PO2
Compute deformation (in x and y directions) of node 1.

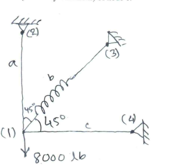

Figure 3

b) A 6m rod shown in **Figure 4** with constant cross sectional area 0.5m^2, is having thermal generation $S(x) = x^2/5$ across its length. Boundary conditions given in the figure. Thermal conductivity for the rod is K = 2 J/m.°C.s. (15) CO1 PO2
Compute the *weak form* (quadratic solution) for the distribution of Temperature in the rod, T(x)

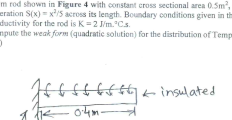

Figure 4

6 a) **Figure 5** shows a 2-element beam but replacing a pin support with a spring. A downward force of 60 kN has been applied at node 3. Property values are E = 210 GPa, $I = 2\times10^{-4}$ m^4, k = 200 kN/m. Compute Deformations at each node of the assembly. (10) CO1 PO2

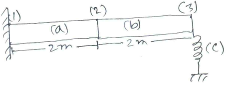

Figure 5

b) Beam shown in **Figure 6** is under ramp loading with w(x) =5000x N/m. Using work equivalence theorem, convert this distributed loading to the concentrated loads at the end points. (10) CO1 PO2

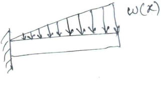

Figure 6