Sixth Semester B.E. Degree Examination, December 2011
Modelling and Finite Element Analysis

Time: 3 hrs.

Max. Marks:100

Note: *Answer any FIVE full questions, selecting at least TWO questions from each part.*

PART – A

1 a. Write the equilibrium equation for 3-D state of stress and state the terms involved. **(04 Marks)**
   b. Solve the following system of equations by Gaussian elimination method :
   $$x_1 + x_2 + x_3 = 6$$
   $$x_1 - x_2 + 2x_3 = 5$$
   $$x_1 + 2x_2 - x_3 = 2.$$
   (08 Marks)
   c. Determine the displacements of holes of the spring system shown in the figure using principle of minimum potential energy. **(08 Marks)**


Fig.Q.1(c).
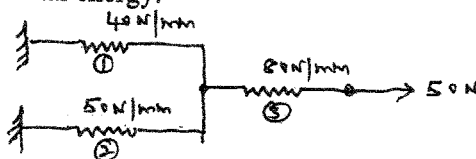
2 a. Explain the discretization process of a given domain based on element shapes number and size. **(06 Marks)**
   b. Explain basic steps involved in FEM with the help of an example involving a structural member subjected to axial loads. **(08 Marks)**
   c. Why FEA is widely accepted in engineering? List various applications of FEA in engineering. **(06 Marks)**

3 a. Derive interpolation model for 2-D simplex element in global co – ordinate system. **(10 Marks)**
   b. What is an interpolation function? Write the interpolation functions for :
   i) 1 – D linear element ; ii) 1 – D quadratic element.
   iii) 2 – D linear element ; iv) 2 – D quadratic element.
   v) 3 – D linear element. **(06 Marks)**
   c. Explain "complete" and "conforming" elements. **(04 Marks)**

4 a. Derive shape function for 1 – D quadratic bar element in neutral co-ordinate system. **(08 Marks)**
   b. Derive shape functions for CST element in NCS. **(08 Marks)**
   c. What are shape functions and write their properties. (any two). **(04 Marks)**

PART – B

5 a. Derive the body force load vector for 1 – D linear bar element. **(04 Marks)**
   b. Derive the Jacobian matrix for CST element starting from shape function. **(06 Marks)**
   c. Derive stiffness matrix for a beam element starting from shape function. **(10 Marks)**

6 a. Explain the various boundary conditions in steady state heat transfer problems with simple sketches. **(06 Marks)**
   b. Derive stiffness matrix for 1 – D heat conduction problem using either functional approach or Galerkin's approach. **(08 Marks)**
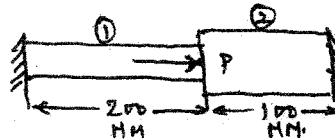
c. For the composite wall shown in the figure, derive the global stiffness matrix. **(06 Marks)**
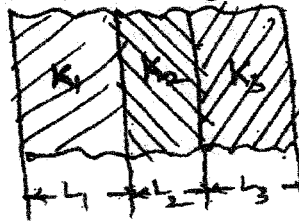
Take
$A_1 = A_2 = A_3 = A$

Fig.Q.6(c)

7 a. The structured member shown in figure consists of two bars. An axial load of P = 200 kN is loaded as shown. Determine the following :
   i) Element stiffness matricies.
   ii) Global stiffness matrix.
   iii) Global load vector.
   iv) Nodal displacements.

i) Steel $A_1 = 1000 \text{ mm}^2$
   $E_1 = 200$ GPa
ii) Bronze $A_2 = 2000 \text{ mm}^2$
   $E_2 = 83$ GPa. **(08 Marks)**

b. For the truss system shown, determine the nodal displacements. Assume E = 210 GPa and A = 600 mm² for both elements. **(12 Marks)**
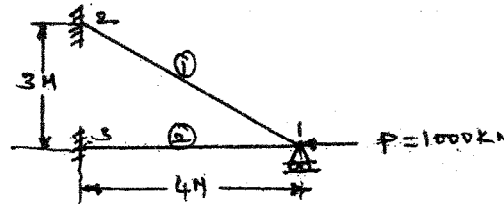

Fig.Q.7(b)

8 a. Determine the temperature distribution in 1 – D rectangular cross – section fin as shown in figure. Assume that convection heat loss occurs from the end of the fin. Take $k = \dfrac{3w}{\text{Cm}^\circ\text{C}}$,

$h = \dfrac{0.1w}{\text{Cm}^{2^\circ}\text{C}}$, $T_\infty = 20^\circ\text{C}$. Consider two elements **(10 Marks)**

$P_0 = 5kN/m$
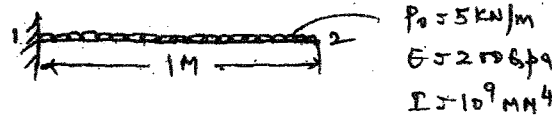$E = 2 \text{ ro } G_Pa$
$I = 10^9 \text{ MM}^4$

Fig.Q.8(a)

b. For the cantilever beam subjected to UDL as shown in Fig.Q.8(b), determine the deflections of the free end. Consider one element. **(10 Marks)**
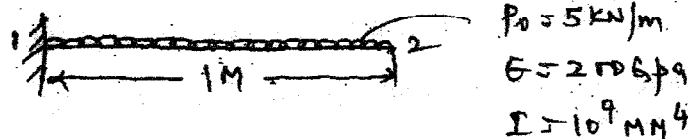

$P_0 = 5kN/m$
$E = 2 \text{ ro } G_Pa$
$I = 10^9 \text{ MM}^4$

Fig.Q.8(b)

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