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10MTP12

First Semester M.Tech. Degree Examination, December 2011
Finite Element Methods

Time: 3 hrs. Max. Marks:100

Note: *Answer any FIVE full questions.*

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

1 a. Explain steps involved to solve a continuum problem by FEM. **(06 Marks)**

b. A closed plastic container, used to serve coffee in a seminar room is made to two layers with an air gap between them. List all the heat transfer processes associated with the cooling of the coffee in the inner plastic vessel. What steps do you consider necessary for a better container design, so as to reduce the heat loss to ambient? **(06 Marks)**

c. Fig. Q1(c) shows an idealized incandescent lamp. The filament is heated to a temperature of 'T_f' by electric current. Heat is converted to surrounding 'gas' and is radiated to the wall, which also receives heat from the gas by convection. The wall in turn convects and radiates heat to the ambient at T_a. Formulate this heat transfer problem and arrive at the energy balance equation. **(08 Marks)**

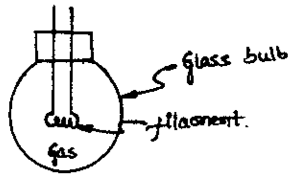
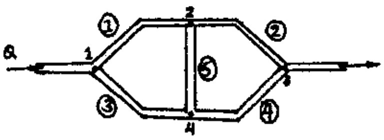


Fig.Q1(c)

2 a. Derive the shape functions for an 1 – D linear element. **(06 Marks)**

b. An incompressible fluid flows through a pipe network of circular pipes as shown in fig.Q2(b). If $0.1 m^3/s$ of fluid enters and leaves the pipe network, using a 4 node 5 – element model, calculate the nodal pressure and the volume flow in each pipe. The viscosity of the fluid is 1×10^{-2} NS/m^2. For the laminar flow, the resistance for the flow is given by $128\ \mu L/\pi D^4$. The details of the elements are given in table 2.1. **(14 Marks)**

Fig.Q2(b)

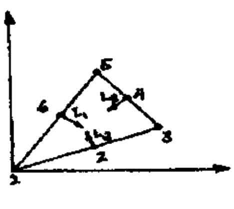


Element Number	Nodes	Diameter 'D' [cm]	Length, L(m)
1	1, 2	5	25
2	2, 3	5	25
3	1, 4	5	25
4	4, 3	5	25
5	2, 4	10	90

3 a. Derive the shape function for a 2 – D quadrilateral elemen, in the global co-ordinate system, using Lagrangian interpolation function. **(10 Marks)**

b. Calculate $\frac{\partial N_4}{\partial x}$ & $\frac{\partial N_4}{\partial y}$ at a point (1, 4) for the quadratic triangular element shown in fig. Q3(b).1, when the geometry is represented by a three noded triangle as shown in fig. Q3(b).2. **(10 Marks)**

Fig.Q3(b) 1.



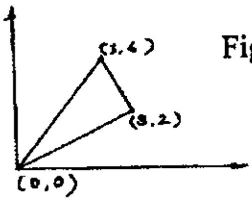


Fig.Q3(b) 2.

4 a. Derive an expression for the temperature distribution in terms of 'θ' and 'ζ' for a tip insulated long fin of uniform cross section. Assuming 1-D, state heat conduction without heat generation by Rayleigh Ritz method. **(10 Marks)**

b. A metallic fin with thermal conductivity K = 360w/m^{0}C. 0.1cm thick and 10cm long extends from a plane wall, whose temperature is 235^{0}C. Determine the temperature distribution and amount of heat transferred from the fin to the ambient air at 20^{0}C, with h = 9 w/m^2 0 C. Take width of fin to be 1m. **(10 Marks)**

5 A long bar of rectangular cross section, having thermal conductivity of 1.5w/m^{0}C is subjected to the boundary conditions as shown in fig. Q5. Two opposite sides are maintained at a uniform temperature of 180^{0}C. One side is insulated and the remaining side is subjected to a convection process with T_∞ = 25^{0}C and h = 50w/m2^{0}C. Determine the temperature distribution in the bar. **(20 Marks)**

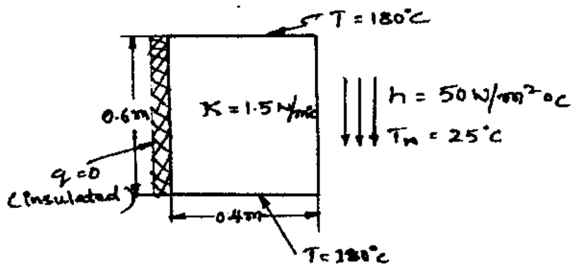
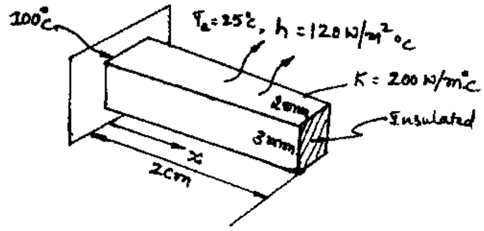


Fig.Q5.

6 a. Using Galerkin method, derive an expression for stiffness matrix, force vector and thermal load vector for 1D unsteady state heat conduction [Transient], using a linear element. **(06 Marks)**

b. Determine the temperature distribution in the fin shown in the fig.Q6(b), with respect to time by Crank – Nicolson method, assuming initial temperature of the fin equal to the atmospheric temperature 25^{0}C, if the base temperature is suddenly raised to a temperature of 100^{0}C and maintained at that value. Take a heat capacity of 2.42 × 10^{6}w/m^3 ^{0}C. **(14 Marks)**

Fig.Q6 (b).



7 a. Explain the development of thermal stresses in an Isotropic linear elastic material. **(06 Marks)**

b. In an heat exchanger equipment, a stepped bar is used to connect two plates [stationary]. Determine the nodal displacements at node 2, stresses in each material for an applied axial load P = 300kN at 20^{0}C, as shown in fig.Q7(b). Then the temperature raised to 60^{0}C. **(14 Marks)**

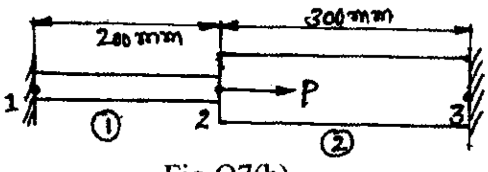


Fig.Q7(b)

(1) Aluminum	(2) Steel
$E_1 = 70 \times 10^9 N/m^2$	$E_2 = 200 \times 10^9 N/m^2$
$A_1 = 900\ mm^2$	$A_2 = 1200\ mm^2$
$\alpha_1 = 23 \times 10^{-6}/^0C$	$\alpha_2 = 11.7 \times 10^{-6}/^0C$

8 Write short notes on :

a. Mesh convergence
b. Flow in a lid driven cavity.
c. Mixed convection heat transfer
d. Buoyancy driven convection heat transfer. **(20 Marks)**

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