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(2) Answer any **four** questions from remaining **six** questions.
(3) Assumption made should be **clearly** stated and justified.
(4) **Figures** to the **right** indicate marks.

M.E.(M) M/c Design Sem II PIDC Finite Element Analysis

27/12/07
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1. The governing differential equation, representing steady laminar flow of a viscous fluid through a long circular cylindrical tube, is given as : 20

$$-\frac{1}{r}\frac{d}{dr}\left(\mu r \frac{dw}{dr}\right) = f_0.$$

Where, w is the axial component of velocity,
μ is the constant viscosity,
f_0 is the constant pressure gradient (which includes the combined effect of static pressure and gravitational force).

The Boundary conditions are–

(i) at $r = 0$, $r\frac{dw}{dr} = 0$ (ii) at $r = R_0$ $w = 0$

Using symmetry and two linear elements and using Rayleigh Ritz Method over general element, determine :

(i) Element Matrix Equation.
(ii) Global Matrix Equation.
(iii) Velocity Distribution.

Compare the velocity distribution with exact solution, at least at the nodes.
Write all the steps clearly, reflecting preprocessing, processing and post processing therein.

2. (a) State 'True' or 'False' and justify your answer in brief. Rectify the statement if it is wrong. 6
(i) Degrees of freedom is the primary variables for the element.
(ii) Weight function value is zero at a node where NBC is defined for all nonweak form type methods.
(iii) Node numbering has got no effect on the element or global matrix equations.

(b) Using any two methods out of : 14
(i) Collocation method.
(ii) Petrov – Galerkin method.
(iii) Galerkin method.

Solve the differential equation.

$$\frac{d^2u}{dx^2} = \cos \pi x \quad , \qquad 0 \le x \le 1$$

Boundary conditions are

(i) $u(0) = 0$ (ii) $\left.\frac{du}{dx}\right|_{x=1} = 0$

Compare the answer with the exact one at $x = 0{\cdot}25, 0{\cdot}5, 0{\cdot}75$ and 1.

3. (a) What are the advantages of weak form methods ? Compare these methods with the nonweak form methods. 5
(b) Solve the following equation by finite difference method (4 subintervals) or Ritz-method mapped over entire domain (2 parameters). 10

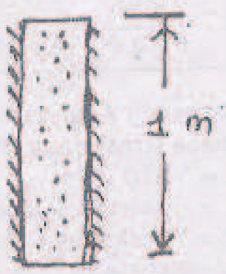
$$\frac{d^2u}{dx^2} - 16u + 3x^2 = 0, \quad 0 \le x \le 1$$

Boundary conditions :

$$u(0) = 0\ ; \quad \left.\frac{du}{dx}\right|_{x=1} = 1$$

Compare the answers with exact at salient points.
(c) Explain the sources of error, in brief. 5
What are the methods to reduce the error ?

4. Analyse completely any **two** : 20
(a) One dimensional fluid flow in porous medium.



Take 4 elements.

$$\text{EME : } \left(\frac{AK}{L}\right)^e \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \begin{Bmatrix} p_1^e \\ p_2^e \end{Bmatrix} = \begin{Bmatrix} q_1^e \\ q_2^e \end{Bmatrix}$$

K = permeability, cm/s
= 1·25 cm/s.

Fluid held at the top is 25 cm and that at the bottom is 2·5 cm. Area of cross-section is 5 cm^2.
Determine : (i) Fluid head distribution.
(ii) Velocity at the upper part.
(iii) Volumetric flow rate in upper part.

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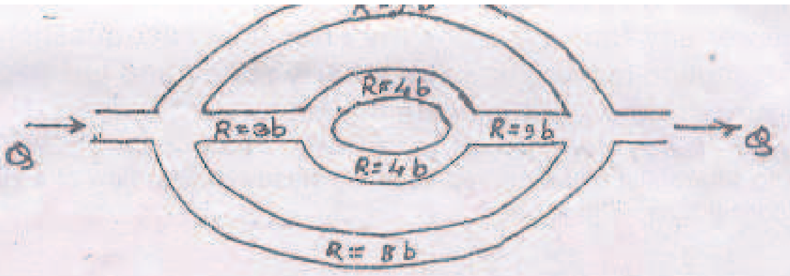
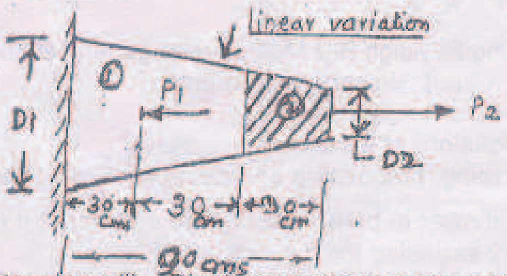


$$\text{EME}: \left(\frac{1}{R^e}\right)\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}\begin{Bmatrix} P^e_1 \\ P^e_2 \end{Bmatrix} = \begin{Bmatrix} Q^e_1 \\ Q^e_2 \end{Bmatrix}.$$

Write global Matrix equation. Assume suitable values of primary variables at entry and exit and solve for remaining.

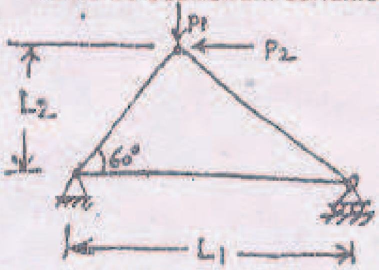
(c) Tapered bar :



D_1 = 12 cms
D_2 = 06 cms
P_1 = 20 kN
P_2 = 50 kN
E_i = 200 Gpa
E_i = 100 GPa

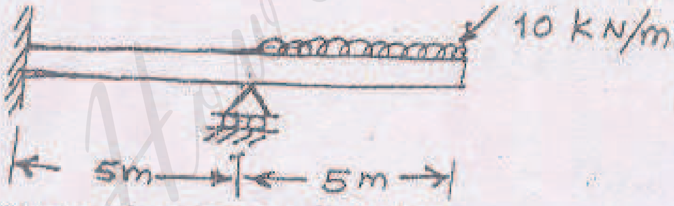
Determine : (i) Displacements at node points. (iii) Stresses and strains in the elements.
(ii) Reaction.

5. (a) Define : Transformation Matrix, Plane Truss, Semibandwidth, Aspect ratio. 6
(b) Analyse the plane truss for nodal displacements, reactions, elemental stresses and strains. Verify for force equilibrium conditions. 14



Data: L_1 = 0·6, L_2 = 0·4 m
P_1 = 5 kN, P_2 = 2 kN
E = 180 GPa, A = 6cm² for all elements.

6. (a) Using directly the Element Matrix Equation for beam element analyse the beam completely. 12



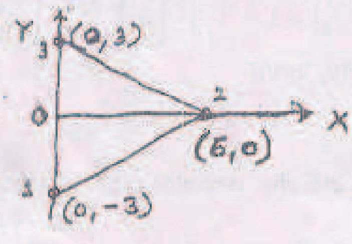
E = 100 GPa
$I = 4 \times 10^{-4}$ m⁴

(b) Find out [Mij] using Guass Quadrature Method. 8
i and j = 1, 2 .. ϕ_1, and ϕ_2 are Lagrange's linear shape function.

$$M_{ij} \int_0^{h_e} k^2 \phi_i \, \phi_j \, d\bar{x}$$

r	ξ	W
2	$\pm 1/\sqrt{3}$	1·0
3	0·0 $\pm\sqrt{0{\cdot}6}$	8/9 5/9

7. (a) Write a note on, any one : 10
(i) Plane stress problem using CST element. (ii) Transient Analysis used in FEM
(b) Evaluate stiffness matrix for the element shown, assuming plane stress case. Find element stresses. 10



E = 210 GPa
υ = poisson's ratio = 0·3
t = thickness = 1 cm
Co-ordinate in cms.
Nodal displacement :

U_1 = 0·0 V_1 = 0·005 cm	U_2 = 0·001 cm V_2 = 0·0	U_3 = 0·0 V_3 = 0·004 cm

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