Ref. No. *Ex/PG/CE/T/1210A/2024*

# M.E. CIVIL ENGINEERING FIRST YEAR SECOND SEMESTER EXAM 2024

## Sub: ADVANCED COMPUTER METHODS AND FINITE ELEMENT ANALYSIS

**Full Marks 100**

Time: **Three hours** **(60 marks for Part-I)**

**Use a separate Answer-Script for each part**

| No. of Questions | PART - I | Marks |
|---|---|---|

**Answer any TWO questions**

1\. a) How does material nonlinearity generate in the structural engineering problem? How can it be tackled in Finite Element Analysis of that problem?
b) What is 'strain hardening characteristics' of a material beyond yield point? Define the terms 'hardening parameter', 'initial modulus of elasticity' and 'tangential modulus of elasticity' and derive the relationship among them. How can these parameters be used to describe different 'strain hardening characteristics' of a ductile material?
c) Differentiate 'yield function and 'yield criterion'. What is the utility of 'yield criterion' in nonlinear finite element analysis?
d) Write short note on Von-Mises yield criterion and Tresca's yield criterion.
e) Where is 'flow vector' used in nonlinear finite element analysis? Find the elements of flow vector corresponding to Von-Mises yield criterion both in terms of normal and shear stress components as well as in terms of principal stress components?
f) Write the difference between 'tangential stiffness algorithm' and 'modified tangential stiffness algorithm' of nonlinear finite element analysis.
g) How does the 'residual force' influence the convergence in nonlinear finite element analysis?

Marks: 5+7+3 +5+6+ 2+2 = 30

2\. a) Derive the nonlinear stiffness matrix of one-dimensional **three-noded** bar element.
b) Use above-mentioned element for the solution of this problem: An one dimensional bar of **circular cross-section** is fixed at upper end and free at lower end. The diameter of its circular cross-section is 7mm and its length is 950mm. It is subjected to a vertically downward concentrated force of 18kN. Calculate the end deflection, strain and stress developed in it. The material behaviour is shown in Fig.1. Apply the load in **two steps** (i.e. **60% and 40%** of total). Perform maximum three iterations in each step.

Marks: 5+25 = 30

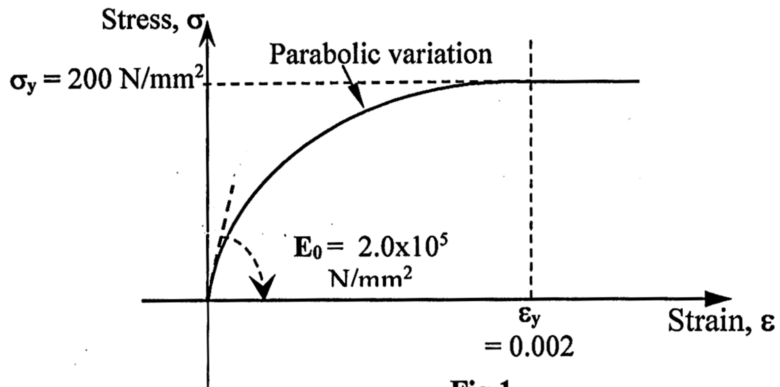


**Fig.1**

3\. a) Derive elasto-plastic constitutive relationship matrix $[D_{ep}]$ for plane stress problem. Write the expression to calculate the plastic strain increment in the elasto-plastic nonlinear finite element analysis.
b) For a plane stress problem, the stresses at a point are: $\sigma_x = 145 N/mm^2$, $\sigma_y = 275 N/mm^2$ and $\tau_{xy} = 130 N/mm^2$. Check whether the material at that point is yielded or not according to Von-Mises yield criterion if uniaxial yield stress of the material is $250 N/mm^2$. If it is yielded, then find flow vector and elasto-plastic constitutive relationship matrix $[D_{ep}]$ considering $H' = 300 N/mm^2$. Given $E = 2\times10^5 N/mm^2$ and $\nu = 0.3$.
c) Write the detailed steps for elasto-plastic nonlinear finite element analysis of two dimensional problem.

Marks: 10+10+ 10 = 30

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**Name of the Examinations: M.E. CIVIL ENGINEERING FIRST YEAR SECOND SEMESTER - 2024**

**Subject : ADVANCED COMPUTER METHODS AND FINITE ELEMENT ANALYSIS** **Time : 3 hours** **Full Marks : 100**

**Part II (40 Marks)**

**Instructions : Use Separate Answer scripts for each Part**

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Q1. Find the components of Material deformation gradient, Right Cauchy-Green deformation tensor and Lagrangian strain tensor for the Lagrangian description of motion (10)

$$x_1 = X_1 + X_3(e^t - 1)$$

$$x_2 = X_2 + X_3(e^t - e^{-t})$$

$$x_3 = X_3 e^t$$

Q2. Obtain the internal force vector and hence the non-linear stiffness matrix of the von Mises truss shown in Figure 1. Also identify the critical points along the λ - H curve under symmetric deformation (Assume S=2, E = 1 and $A_0$ = 1 for plotting the results). (25)

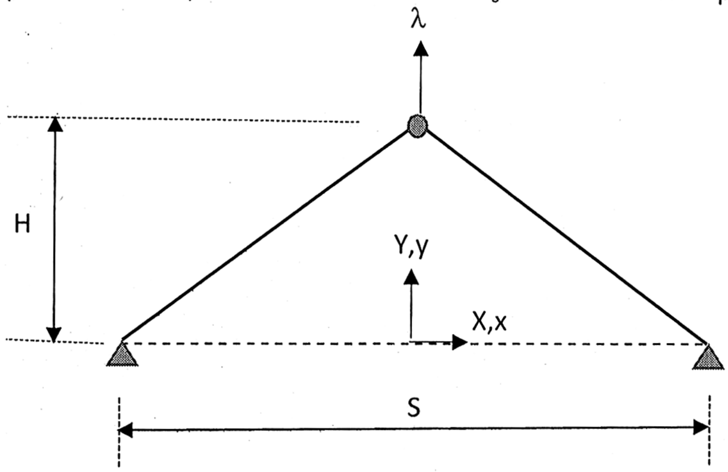


Figure 1

Q 3 Define (a) Shear locking (b) kinematic description of Euler and Timoshenko beam (5)