GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Quarter 1997

Computer Aided Engineering Ph.D. Qualifying Exam
EXAM AREA

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Assigned Number (DO NOT SIGN YOUR NAME)

- **Please sign your name on the back of this page—**

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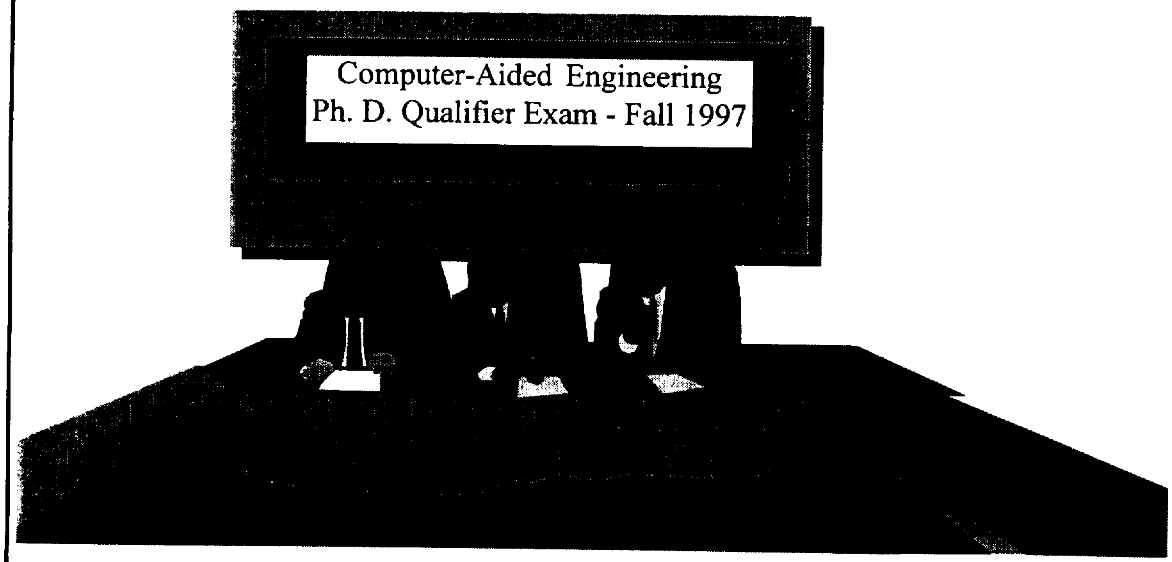
THE GEORGE W. WOODRUFF SCHOOL OF MECHANICAL ENG.

Bras, Fulton, and Sitaraman (Chair)

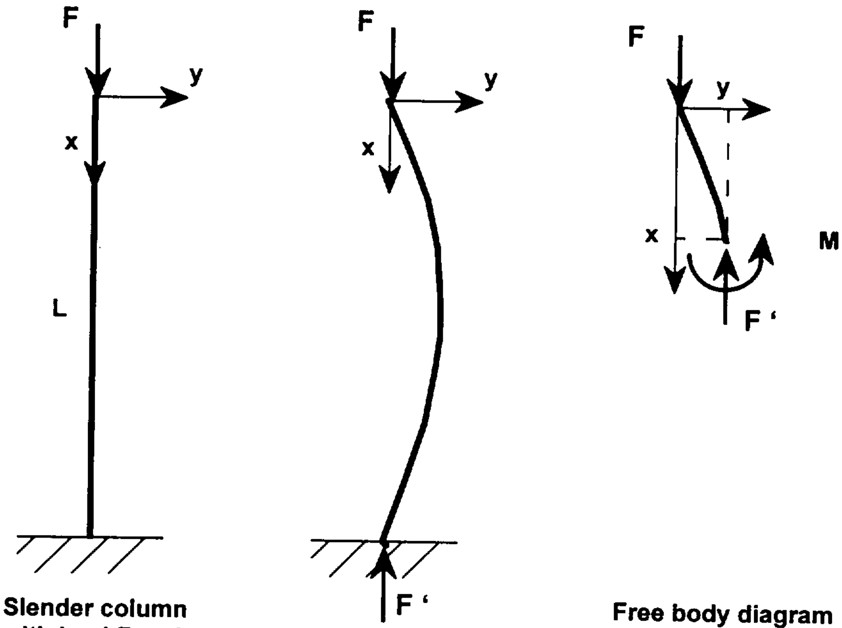


- Answer all questions.
- Make suitable assumptions when data is not available or when you do not follow a question. State your assumptions clearly and justify.
- Show all steps and calculations.
- ***During ORALS, you will be given an opportunity to tell us how CAE fits into your doctoral research. Please come prepared to make this opening statement.***

GOOD LUCK!

Problem 1

In the figure below, a slender column with length L subject to an axial load F is shown. The figure also includes the deflected column as well as the free body diagram.



Slender column with load F and length L

Deflection of slender column with load F and reaction force F '

Free body diagram of slender column with load F

The curvature of such a slender column subject to an axial load F can be modeled by

$$\frac{d^2y}{dx^2} = \frac{M}{EI} \qquad [1]$$

where $\frac{d^2y}{dx^2}$ specifies the curvature, M the bending moment, E is the modulus of elasticity, and I is the moment of inertia of the cross section about its neutral axis. The bending moment at a position x is $M = -F*y$. Substituting this in equation 1 gives

$$\frac{d^2y}{dx^2} + p^2 y = 0 \qquad [2]$$

where $p^2 = \frac{F}{EI}$

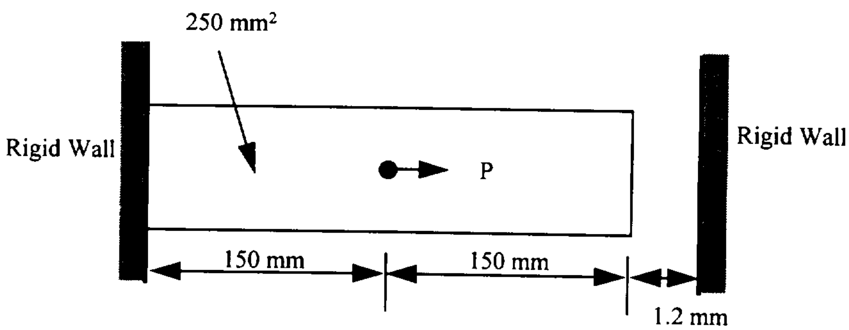
Questions:

a) What are the boundary conditions?
b) Find the eigenvalues for the axially loaded column by using the polynomial method and three interior nodes.
c) What are some other methods to solve this eigenvalue problem?

Problem 2

A load P=60,000 N is applied as shown in the Figure below. Assume E= 20,000 N/mm^2.

- Use Finite-Element Formulation.
- Assemble the global-stiffness matrix.
- Define the boundary conditions.
- Determine the displacements, stresses in the body, and the reaction forces.



Element Stiffness Matrix

$$[K] = \frac{EA}{L}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

where E, A, and L are the Modulus of Elasticity, Area of cross-section, and Length of the element respectively.

Problem 3

Develop and sketch a parametric cubic spline through the following four points. Calculate one intermediate point midway between points 3 and 4 to facilitate the sketch. The coordinates for the four points are:

	1	2	3	4
x	0	1	5	0
y	0	4	0	4

The ends of the curve are pointing in the x direction at both points 1 and 4.