Department of Applied Mechanics and Biomedical Engineering, Indian Institute of Technology, Madras.

Fundamentals of Finite Element Analysis (AM 5450)

Assignment 1 - Review of Linear Algebra and Calculus using MATLAB/PYTHON

Submission Date: 19 August 2024

Instructions:

I. Use scientific non-programmable calculator wherever necessary.

II. MATLAB commands/scripts used to prepare plots/figures/results should be attached with your answer in the google class room.

1) Scan all the pages of your hand-written answers, MATLAB scripts, output results, and figures into a PDF file. Find the solution of following system of linear simultaneous equations using MATLAB/PYTHON. Attach the MATLAB script and command window output in your answer.

$$\begin{aligned} 2x + 3y - z &= 5 \\ 4x + 4y - 3z &= 3 \\ -2x + 3y - z &= 1 \end{aligned}$$

2) Construct a polynomial $P_n(x)$ of order n using MATLAB/PYTHON.

$$P_n(x) = \sum_{n=0}^{n=k} a_n x^n$$

a) Display the polynomial when $k = 5$.

b) Compute up to 5th order derivative of the polynomial w.r.t. x by hand calculations. Verify your answer by computing the derivatives up to order 5 using MATLAB command `diff(f,x,n)`.

c) Compute the partial derivatives $\frac{\partial P}{\partial a_i}$ for all a_i terms in the polynomial constructed in part a).

3) Derive the Governing differential equation for the axial displacement $u(x)$ of a solid bar as shown in figure 1. Write the Dirichlet and Neumann boundary conditions.

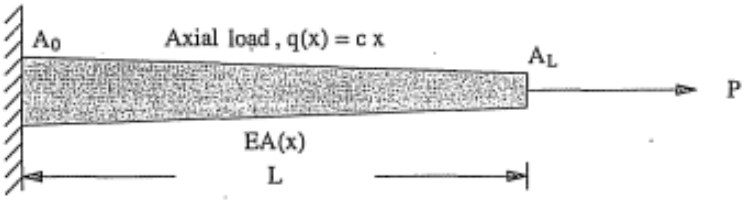

Figure 1 Axially loaded bar with linearly varying cross-section area A(x)

4) Find out the analytical expression for the exact solution of displacement field $u(x)$ and strain $u'(x) = du/dx$ for the axially loaded bar, if cross-section area remains constant along the length L.

   a) Assume E=200 GPa, Diameter of bar = 20 mm, L = 2 m, P = 2 kN, and c = 1 kN/m. Compute the displacement field $u(x)$ and strain $u'(x)$ using the analytical expression. Plot in two different MATLAB/PYTHON figures, the variation of along the length of the bar (x-axis).

   b) Compare the variation of displacement field $u(x)$ and strain $u'(x)$ for different values of c = 1, 3, 5, 7, and 9 kN/m. Assume same values for other parameters as mentioned in part a).