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CE 425 · Introduction to Finite Elements
2024-2025 Fall Semester
–Assignment 5–

Due: December 27, 2024

Finite Element Analysis of 1D Tapered Bar

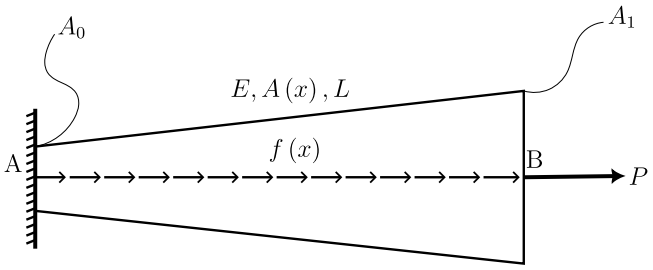

Figure 1: Tapered bar element subjected to concentrated load $P = 1$ kN and distributed axial load $f(x) = 1$ kN/m

In this assignment, you are expected to solve the same problem given in the previous assignment utilizing FEM. Answer the followings considering Figure 1 and the governing differential equation for the axial deformation of the tapered bar highlighted below.

Take $A_0 = 1$ m^2, $A_1 = 3$ m^2, E $= 100$ kPa, L $= 3$ m, $f(x) = 1$ kN/m and $P = 1$ kN.

Governing differential equation for the axial deformation of the tapered bar

1) Balance Equations

Linear Momentum $\quad \dfrac{\partial}{\partial x}\left(EA(x)\dfrac{\partial u}{\partial x}\right) + f(x) = 0 \quad \text{where} \quad x \in (0, L)$

2) Constitutive Equations

Stress Field $\quad \sigma = E\varepsilon$

3) Boundary Conditions

Traction $\quad EA(x)\dfrac{\partial u}{\partial x}\Big|_{x=L} = P \quad$ at $\quad x = L$

Displacement $\quad u(x)\Big|_{x=0} = 0 \quad$ at $\quad x = 0$

where $A(x) \coloneqq A_0 + \dfrac{A_1 - A_0}{L} x$.

a) Using 2-node linear elements, solve the problem by dividing it into $n_{el} = \{4, 8, 16\}$ elements of equal length.

b) Plot the displacement profile along the length of the member for each case and compare with the exact solution $u(x)$ that you have obtained in the previous assignment. Comment on findings.