

CS601: Software Development for Scientific Computing

Programming Assignment 2 - Finite Element Method

Due: 7/11/2022

The objective of this assignment is to gain exposure to computing a solution using the Finite Element Method and implementing the solution using C/C++.

Note: No late submissions will be accepted. You can work in teams of size at most two. It is of utmost importance that you maintain academic integrity. You can discuss the problem with friends and colleagues and refer to books, websites and any other literature/codes but you cannot copy the code. You should cite all the references you have used including your colleagues/friends help.

1 Problem Statement

Consider a rod with cross sectional area $A(x)$ and length L . The rod is subjected to a constant load $P = 5000$ N at $x = 0$. At $x = L$ the rod is fixed. The length of the rod is 0.5 m and the Young's modulus of the material of the rod is 70 GPa. Consider two problems:

1. The cross section of the rod is uniform with area $A(x) = A_0 = 12.5 \times 10^{-4} \text{ m}^2$.
2. The cross sectional area is given by the formula

$$A(x) = A_0(1 + x/L)$$

Here the cross section is not uniform, it increases linearly with x .

3. Write an Finite Element code to find the displacement at the nodal points on the rod. You need to discretize the rod into $N = 2, 8, 32, 128$ elements of equal length for problems in 1 and 2.
4. Find analytical solution of the problems stated above
5. Plot and compare your solutions, both analytical and Numerical. Write your observations. Plot the error: $\text{norm}(u_N - u_A)$ over the length of the rod. Here u_N represents numerical solution and u_A represents analytical solution.

Your code should have enough comments so that one can understand the main segments (like preprocessing, matrix assembly and post processing) of your code by reading the comments.

You need to submit your Mathematical formulation/calculations with the code.

2 What you need to submit

- a pdf file called `Report.pdf` containing the details from points 3, 4, and 5 mentioned in the problem statement. In addition, you should have an Appendix in this report. The appendix should contain all the code.
- Source code organized as per the directory structure discussed in class and in the previous assignment
- A `makefile` that builds your code. This makefile should also contain a rule with a target name `team`, which upon firing prints the team member details.
- A shell script called `runme` (note: no file extension) that executes the code. *You must tag your source code and submit as described in the previous assignment. The tag name to be used is: `cs601pa2submission`. All tag names are case-sensitive..*