CS601: Software Development for Scientific Computing

Programming Assignment 2 - Finite Element Method
Due: 9/11/2023

The objective of this assignment is to gain exposure to computing a solution using the Finite Element Method and implementing the solution using C++ with object-oriented approach.

Note: No late submissions will be accepted. You can work in teams of size at most three. 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 subproblems:

1. The cross section of the rod is uniform with area $A(x) = A_0 = 12.5 \times 10^{-4}$ 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. Plot your numerical slution. Write your observations.

2 What you need to submit

- a pdf file called `Report.pdf` containing 3 sections: 1) method - your Mathematical formulation/calculations for each of the sub-problems 2) experimental results corresponding to point 4 mentioned for each of the subproblems, 3) a) Appendix - screenshots of your execution showing execution time for each value of N and b) contain all the code.
- Source code organized as per the directory structure discussed in the class. Also, your source code must follow an object-oriented approach. 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. Codes without comments and not following object-oriented approach will attract 25% penalty.
- A `makefile` that builds and runs your code. This makefile should contain a rule with a target name `team`, which upon firing prints the team member details. The makefile should be written such that e.g. `make PROB=1 N=8` builds the code for sub-problem 1 and runs it with 8 elements. You can expect `PROB` to have values 1 and 2, while N can be any of 2, 8, 32, 128.

  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. Including binary files, temporary object files, files other than what is asked in the submission repository will attract 10% penalty.