Aims & Objectives for FEM Project

# Overarching Goals

The overarching goal of the project is to create a series of Jupyter Notebooks containing information that can be used as a part of a course to teach students about the Finite Element Method. These Jupyter Notebooks will be interactive, instructive, and detailed but with an emphasis on allowing the student to learn practically how the finite element method works. They will include executable code snippets, mathematical syntax, labelled diagrams, and visualisations of the solutions obtained. The end goal of the project would be for these Jupyter notebooks to form the basis of a module on the Finite Element Method which could be taught here at the University of Leeds.

# Mathematical content

The content of the notebooks will probably be split up into two parts: The mathematical, theoretically based side and the programming, practically based side. These two parts would not be physically separated, more so conceptually. They would appear in the same notebooks, often side by side. The mathematics would be primarily based off the book [The Mathematical Theory of Finite Element Methods Third Edition](C://Users/kyle-/Downloads/brenner-scott.pdf) by S.C. Brenner and L.R. Scott. I would like to start with a small revision of Linear Algebra and Differential Equations to refresh the students’ memories. The bulk of the content would cover the calculus behind Weakly-Formulated BVPs, Ritz-Galerkin Approximations, Piecewise Polynomial Spaces and Error Estimates. It wouldn’t go as deep as Brenner and Scott do, the information they provide is not completely necessary to understand how and why the finite element method works. However, the important mathematical foundations will be laid, as well as some explanations of the more nuanced linear algebra behind the scenes where necessary, such as Sobolev Spaces, Lebesgue Integration Theory, Hilbert Spaces, etc.

# Computing content

Then the practical side will use an industry-standard python package known as FEniCSx. It will heavily base off an excellent series of tutorials developed by [Jørgen S. Dokken](https://jorgensd.github.io/dolfinx-tutorial/), specifically revolving around DOLFINx. It includes many practical examples, from the Poisson Equation, Heat Equation, Elasticity and Stress equations and Navier Stokes equations. Here the efficiency and error estimates will be discussed as well, but not in too great detail.

# Deliverables

The main deliverable of the project will be the series Jupyter Notebooks, of which there will be approximately 4-6. However, there will also be some included PDFs, one which outline how to install and set up the project’s dependencies, one which will cover the necessary revision for the mathematical content and another which will include a brief revision of Python and some data visualisation using matplotlib and pandas. Of course, the other main deliverable will be the report itself which will detail the research and development process.

# Timeline

Currently I am in the research phase of the project, where I will obtain and compile the necessary information, sources, and tools I will need to create the notebooks. This phase will also allow me to finalise their contents. Then come Christmas, I will have created my project plan outlining the full scope, objectives, and timeline of the project. After Christmas, the development phase will begin. This will involve some user testing as well. I have 2 peers with a similar background to me who have volunteered to help test my notebooks. They will help evaluate the project from a student’s point of view, giving feedback on the quality, readability, pace, and structure of the notebooks. Ideally, I would also manage to find a lecturer or postgraduate researcher who would be willing to give feedback on the notebooks from the perspective of someone teaching it.