CHAPTER 01: INTRODUCTION

PREFACE

Working on FEM is my daily tasks as a structural engineer. These FEM works are mainly to use FEM software (in my case, FEMAP with NX/Nastran). If you ever use FEM software, I believe you know that to use FEM software and to understand FEM theory is a totally different thing. In fact, when I work with my colleagues especially young graduates, I found that only a fraction of them correctly understands what FEM is. Many of them can use the software, create FEM models, run the analysis, and plot the results in nice contour colors. Many of them speak about loading methods, constraints, and degree of freedom. However, often times FEM is a black box and they don't know what is going on in the software (or solver). It's like a driving a car. Many people can drive a car but not many people know how the engine and the powertrain drive the car move forward.

Therefore, I decided to teach FEM to my group. My structure group has 11 people (in 2014) and about half of them are recently graduated from colleges. I pulled my very old FEM textbook that I used it in my graduate school at Stanford University wishing I could just go over the books with my colleagues. I realized that the textbook was not helpful for FEM beginners. Then, I tried to search on the internet to see if I could find any good materials. There were some good ones and bad ones but none of them perfectly fit in my audiences (i.e., my colleagues). Therefore, I decided to create my own lectures, based on the textbook and my class notes took at Stanford, but with much more details and explanations, as well as omissions of non-essential mathematical proofs.

This textbook and web course together were created based on my lecture notes that I gave to my colleagues. Original one was my handwritten but I re-typed them to make it public on the web. I hope this course helps you to start your FEM career. I believe this course still needs improvement and I will really appreciate if you can provide me your feedbacks.

At last, I may over-simplify the explanation and sometimes my words may not be a correct statement in terms of pure mathematical terminologies. However, the ultimate goal is to provide a gateway to a fundamental of FEM. So, I'll consider that being too precise in wording and terminologies are somewhat off the topic here. For example, every FEM textbook talks about "strong form" and "weak form" of differential equations but I will not mention them here. If you are pursuing a master degree in FEM, you should know about these terms. However, for someone (like you, I believe) who just want to look at a little bit about inside of the black box (FEM), why do you need to be bothered by such terminologies? Once you get a basic idea about FEM from this course, then, please proceed with a formal textbook for more understanding.

MY GOALS

- To teach mathematical theory of FEM
- To explain the mathematics as easy as possible
- To provide hands-on experience to solve FEM problem (i.e., hand calculations)
- To have Excel FEM examples available to my audiences

However, I'm not going to go detail on pure mathematics itself. For example, we'll use integration by parts, but I'm not explaining the theory of integration by parts. This course is not about mathematics, so we'll just use such mathematics theory as a tool without proving it.

This course does not cover FEM programming either. Programming is another set of skills. I may add this topic later, but it will be too much if I cover this course now.

TARGET AUDIENCE

If you took FEM course in graduate school and have no issue understanding the theory, good bye. This place is for these who…

- use FEM software but want to know more about its theory

- recently started FEM work in your career without any previous knowledge
- graduated from engineering school but did not take FEM course
- is studying FEM in school but cannot understand what professor is talking
- took FEM course in school long time ago but the most of memories have gone
- took FEM course in school but only learned how to use software not theory

PREREQUISITE

Even though I try to explain as easy as possible, there is a certain level of mathematics and engineering knowledge required to understand FEM. While you reached this page on the internet, I believe you are a sort of structural engineer in mechanical, aerospace, or civil engineering. If you are a structural engineer and have such engineering degree, you should not have any problems to understand mathematics and engineering theory presented on my course. Here is a list of what you need to know.

- Basic Calculus (college level)
- Basic Linear Algebra (college level)
- Mechanics of Materials
- Excel (intermediate level)
- Advanced graduate-level mathematics is a plus, but not required

TEXTBOOK (recommended but not required)

- *"The Finite Element Method"* by Thomas J.R. Hughes (ISBN: 0-486-41181-8)

REFERENCES

1. Hughes, Thomas J.R., "The Finite Element Method, Linear Static and Dynamic Finite Element Analysis", Dover Publication, Inc., 2000
2. Hibbeler, R.C., "Mechanics of Materials, Third Edition", Prentice Hall, 1997