MEU55BM4 – 5BIO4 Finite Element Analysis [5 credits]

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Semester: 1

Module Organisation

Prerequisite Course(s): Foundation courses involving MATLAB (e.g. 2E11/3E2); Mechanics of Solids (3B3).

This course runs for 12 weeks during semester 1 (except during study/assignment week).

Semester	Start Week	End Week	Lectures		Labs/Tutorial	
			Per week	Total	Per week	Total
1	1	12	2	24	2	24
Total contact hours: 48						

Module Description

In this module, finite element (FE) theory and implementation will be introduced and thoroughly covered. The module will focus on linear elastic materials initially then subsequently cover more advanced non-linear materials encountered in bioengineering (e.g. anisotropic soft tissues, metal plasticity). The module will also include hands-on practical classes using MATLAB and a commercial finite element software.

Overall, this module will provide the student with the required theoretical basis underpinning finite element simulations, as well as the practical skills to use this simulation tool effectively and accurately.

Finite element modelling is wide-ranging in its application and is regularly employed across the engineering industry in areas such as biomedical engineering, manufacturing, aeronautical engineering, architecture, automotive, and civil engineering.

Intended Learning Outcomes

Upon completion of this modules students will be able to

- Perform analytical numerical solutions and also create the finite element code and implement it in Matlab for a range of solid mechanics problems, e.g. trusses, beams, frames, 2D plane strain/plane stress, thermal strain problem.
- Clearly demonstrate the matrix relationships between the forces and nodal displacements for different element types.

- Calculate the stiffness matrices for triangular and quadrilateral elements.

- Implement a linear and non-linear material model in a finite element code.

- Be able to critically evaluate the correct boundary/initial conditions for various problems

- Understand the requirements of computational grid/mesh generation for FE applications

- Gain hands-on user experience with well-known FE software packages

- Analyse different numerical techniques used to enhance the quality of the simulations

- Implement comprehensive post-processing of numerical simulation results

- Assess numerical results both quantitatively and qualitatively to improve accuracy

Teaching Strategies

Finite Element Modelling is an optional course which is offered to 5th year MAI students and graduate students and equips students to apply FE methods as a tool for design, analysis and engineering applications. The course material is presented in a series of lectures. The teaching material is supplemented by frequent laboratory sessions during which the students will apply the information provided during lectures to FE simulations using Matlab and existing College-licenced commercial FE software package(s). With a strong emphasis on understanding and application of the underlying methods, enthusiastic students will gain experience using commercial FE software packages by analysing well established FE problems as well as applying their knowledge to current research projects within the School of Engineering.

Assessment

Assignments (25%), Group project (25%), End of term written exam (50%)
Continuous assessments will include MATLAB based assignments throughout the semester and a project which will require the use of a commercial FE software package.

Note that there is currently no reassessment (i.e. repeat exams) of Year 5 modules.

Core Text

Introduction to Finite Element Analysis Using MATLAB® and Abaqus by Amar Khennane
http://mihanbana.com/dl/matlab-Abaqus-mihanbana.com.pdf

Recommended Reading:

A First Course in Finite Elements by Jacob Fish
Finite Element Analysis: theory and practice by M.J. Fagan