MPY308 : Clinical Engineering and Computational Mechanics

Semester : 1 Credits : 10

Taught by: Dr. A Narracott

Prerequisites: Physics, Engineering or Mathematics to level 2
Co-requisites: None

Brief Description (including aims of module)
The complexity of the geometry and boundary conditions of structures within the body are such that the physical governing equations rarely have closed-form analytical solutions. This module describes some of the numerical techniques that can be used to explore physical systems, with illustrations from biomechanics, biofluid mechanics, disease treatment and imaging processes. The techniques that will be used are the finite difference and finite element methods, and the fundamental concepts behind these techniques will be described. The lectures will be supported by hands-on sessions in which the student will apply commercial codes to investigate problems with a clinical focus.

Objectives
At the end of the course the student will:

- understand the role of numerical methods in the solution of real problems in biophysics and bioengineering;
- be able to construct simple finite difference schemes for the solution of particular systems of differential equations;
- understand the assumptions in the numerical schemes and the requirements for appropriate boundary conditions, constitutive equations and numerical formulations;
- have experience of the application of world-leading computational analysis software in problems in biomechanics, biofluid mechanics and biomedical applications of electricity and heat;
- have completed a mini-project using MATLAB, ANSYS or FLOTRAN to investigate a physical system;
- be aware of the requirements for comprehensive verification, validation and reporting of numerical solutions, and recognise these requirements in the production of a mini-project report;
- have a feel for the 'size' of a problem, the requirements for an appropriate numerical scheme, and understand how to go about choosing or developing software;

Outline Syllabus
- Introduction, objectives, history and development, commercial exploitation, research applications of numerical methods in biomechanics and biofluid mechanics
- Introduction to MATLAB, matrix manipulation. Presentation of results. Exercises.
- One-dimensional heat conduction. Solution by finite difference and finite element schemes. Extension to 2D and 3D. Shape functions. Galerkin weighted residuals.
- Laplaces equation. Numerical solution and practical applications.
- Symmetry and antisymmetry boundary conditions.
- Finite element formulation for 1D bar. Principle of virtual displacements.
- Introduction to ANSYS. Guided example problems with associated input files. Graphical and command-line approaches. Pre-processing, solution and post-processing phases.
- Practical aspects of finite element analysis.
- Finite element formulation for a 2D continuum. Parametric element formulations. Jacobian matrix. Computational implementation. Numerical integration.

Mathematics used in the Module

- Differential equations
- Numerical analysis
- Discretisation schemes – finite difference, finite element
- Matrices
- Differential heat equation
- Laplace’s equation
- Transformation of coordinate systems, Jacobian

Module Format

Lectures	11
Tutorials	11
Laboratory work	0
Private study	40

Main Text Books

Comprehensive printed notes are supplied, but an important element of this module is the ‘hands-on’ component, learning how to use modern, commercial, engineering analysis software.

Assessment

Mini-project	65%
Assignment 1	10 %
Assignment 2	25%