Mathematical Models

Thursdays 15.30-17.30

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Overview

Mathematics can be used to understand and quantify real-world phenomena

The idea is to form a mathematical model

– a system of mathematical equations which describe these phenomena

Once the model has been validated, it can be used to make predictions of how the system will behave

Perspective

This course will:

1. Focus on applications
2. Explain the origin and construction of mathematical models
3. Derive these models as ODEs and PDEs
4. Focus on constructing solutions to particular problems
5. Examine the practical implications of the model predictions

This is not an applied analysis or methods course!

Where mathematical models come from

1. Basic physical laws (eg conservation properties)
2. Observations of the system behaviour
3. Intuition of what might give “correct” behaviour

Problem driven: <u>not</u> maths driven

Breakdown of lectures

Semester 1: <u>Continuum mechanics</u>

- **Rational mechanics**

Penny Davies, University of Strathclyde

- **Fluid mechanics**

Peter Stewart & Nick Hill, University of Glasgow

Iain Stewart, University of Dundee

Although some of you may have taken courses in continuum mechanics before - this will include lots of ideas not covered in UG lectures (eg lubrication theory, non-Newtonian fluids etc)

Breakdown of lectures

Semester 1: Continuum mechanics

- **Rational mechanics**

Introduction to tensors
Kinematics
Balance laws
Cauchy’s theorem of stress
Constitutive laws

Breakdown of lectures

Semester 1: Continuum mechanics

- **Fluid mechanics**

General concepts in the theory of Newtonian fluids
Lubrication theory
Classical aerofoil theory
Hydrodynamic Stability theory

- Surface water waves
- Boundary layer theory

Continuum theory of non-Newtonian fluids, including Ostwalde-de Waele, Bingham, Herschel-Bulkley and comparisons with Newtonian fluids.

Breakdown of lectures

Semester 2: Mathematical Biology and Physiology

- **Mathematical Physiology**

Peter Stewart (University of Glasgow)
Radostin Simitev (University of Glasgow)

Airflow in the lungs
Blood flow in arteries and veins
Modelling of electrophysiology

Breakdown of lectures

Semester 2: Mathematical Biology and Physiology

- **Mathematical Biology**

Rachel Norman & Andy Hoyle (University of Stirling),
Dougie Spiers (University of Strathclyde),
Frits Veerman (University of Edinburgh)

Population modelling
Evolution
Age-structured models
Patterns and waves in Turing models

Prerequisites

- Basic linear algebra
- Vector calculus
- Introductory courses on ODEs and PDEs

No prior experience of continuum mechanics, mathematical modelling or biology is required!

Students who already have a knowledge of continuum mechanics can take Semester 2 without having taken Semester 1.

Come along and learn some new skills!

Assessment

- One assessment on each module divided into two parts:

Semester 1 (1) Continuum mechanics
(2) Fluid mechanics

Semester 2 (1) Mathematical physiology
(2) Mathematical biology