ES4A4-15 Biomedical Systems Modelling

24/25

Department
School of Engineering
Level
Undergraduate Level 4
Module leader
Neil Evans
Credit value
15
Module duration
10 weeks
Assessment
30% coursework, 70% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

ES4A4-15 Biomedical Systems Modelling

Module web page

Module aims

A wide variety of biomedical processes behave as dynamic systems where the system states vary in time, often in response to external stimuli or interventions. The aims of this module are to introduce techniques and computer tools for modelling, predicting, analysing and understanding dynamic behaviour in biomedical systems.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Biomedical based systems modelling: models of biomedical systems as initial value ordinary differential, algebraic, difference and partial differential equations with application of numerical

integration; use of empirical data and model validation.
Computer-aided modelling and simulation: application of continuous system simulation tools, e.g. MATLAB, Simulink, symbolic computation; application of appropriate control strategies.
Data driven modelling of biomedical systems: mass balance principles.
Qualitative analysis: steady state evaluation and linearisation of nonlinear systems; eigenvalue analysis and stiffness; model order reduction and pseudo steady state analysis; stability analysis, periodic solutions, limit cycles and bifurcation analysis; geometrical analysis of solutions.
Identifiability of system parameters: introduction via compartmental modelling; identifiability of the parameters of linear systems using theoretical approaches; comparison with practical problems; extension to the identifiability of nonlinear systems.
Parameter estimation: modelling of experimental data using linear and nonlinear regression/system identification; least squares approaches to parameter estimation.
Applications, to be taken from: pharmacokinetics/pharmacodynamics; tumour targeting; epidemiological modelling and control; modelling of the heart and circulation; heart rate variability; lung function modelling; biomechanics and the modelling of human motion; modelling using imaging data (PET, MRI etc.); muscle mechanics; control of cell volume and nerve impulses; neural systems (biological clocks); modelling and control of diabetes.

Learning outcomes

By the end of the module, students should be able to:

- 1. Develop physically based dynamic models of biomedical systems [M1, M2, M6].
- 2. Use analytical techniques to assess the qualitative behaviour of biomedical systems models [M3].
- 3. Contextualise and evaluate the role and use of continuous systems simulation in Biomedical Systems Modelling [M3].
- 4. Validate biomedical systems models from experimental data using a variety of methods and approaches [M2, M3].

Indicative reading list

“Pharmacokinetic-Pharmacodynamic Modelling and Simulation”, Bonate, P.L., 2011. 9781441994851

“Mathematical Modelling with Case Studies: Using Maple and MATLAB”, Barnes, B., Fulford, G.R. 2016, 9781482247725

"Compartmental Analysis in Biology and Medicine", Jacquez, J.A, 1996, 16657834, QH 324.3.J2

"Compartmental Models and Their Application", Godfrey, K.R, 1983, 9780122869709, QH 324.3.G6
"Modeling and Analysis of Dynamic Systems", Close, C.M., Frederick, D.K., Newell, J.C., 2014, 9781118899113, QA 435.C5

"Modeling and Simulation in Medicine and the Life Sciences", Hoppensteadt, F.C., Peskin, C.S., 2010, 9781441928719, QH 324.H6

"Understanding Nonlinear Dynamics", Kaplan, D., Glass, L., 2013, 9780387944401, QC 175.K2

Subject specific skills

TBC

Transferable skills

TBC

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Other activity	2 hours (1%)
Private study	118 hours (79%)
Total	150 hours

Private study description

118 hours guided independent learning

Other activity description

2 x 1hr revision class

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Students can register for this module without taking any assessment.

Assessment group DB

	Weighting	Study time
Biomedical Case Study	30%	
Biomedical Case Study (10 pages)		

	Weighting	Study time
ES4A4 Written Exam	70%	

- Answerbook Pink (12 page)
- Engineering Data Book 8th Edition
- Students may use a calculator

Feedback on assessment

- Model solutions to past papers.
- Support through advice and feedback hours.
- Formative assessment via two computer-based worksheets with associated drop-in sessions.
- Written feedback on Biomedical Case Study.
- Cohort-level feedback Biomedical Case Study.
- Cohort-level feedback on final exam.

Past exam papers for ES4A4

Availability

Courses

This module is Core for:

- Year 4 of UESA-H163 MEng Biomedical Systems Engineering
- Year 5 of UESA-H164 MEng Biomedical Systems Engineering with Intercalated Year
- Year 1 of TESA-H800 Postgraduate Taught Biomedical Engineering

This module is Optional for:

- Year 4 of UESA-H114 MEng Engineering
- Year 5 of UESA-H115 MEng Engineering with Intercalated Year

This module is Core option list A for:

- UESA-HH31 MEng Systems Engineering
  - Year 4 of HH31 Systems Engineering
  - Year 4 of HH35 Systems Engineering
- Year 5 of UESA-HH32 MEng Systems Engineering with Intercalated Year