

# ES4A4-15 Biomedical Systems Modelling

**22/23**

**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.
- 2. Use analytical techniques to assess the qualitative behaviour of biomedical systems models.
- 3. Contextualise and evaluate the role and use of continuous systems simulation in Biomedical Systems Modelling.
- 4. Validate biomedical systems models from experimental data using a variety of methods and approaches.

## 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 DA

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

|   | <b>Weighting</b> | <b>Study time</b> |
|---|------------------|-------------------|
| In-person Examination   | 70%              |                   |
| <ul style="list-style-type: none"> <li>• Students may use a calculator</li> <li>• Answerbook Pink (12 page)</li> <li>• Engineering Data Book 8th Edition</li> </ul> |                  |                   |

## **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 1 of TESA-H800 Postgraduate Taught Biomedical Engineering

This module is Optional for:

- Year 4 of UESA-H116 MEng Engineering with Exchange Year
- Year 5 of UESA-H115 MEng Engineering with Intercalated Year
- Year 4 of UESA-HH33 MEng Systems Engineering with Exchange Year

This module is Option list A for:

- Year 5 of UESA-H636 MEng Electronic Engineering with Intercalated Year
- Year 4 of UESA-H114 MEng Engineering
- Year 4 of UESA-H311 MEng Mechanical Engineering
- Year 4 of UESA-HH31 MEng Systems Engineering
- Year 5 of UESA-HH32 MEng Systems Engineering with Intercalated Year

This module is Option list B for:

- Year 5 of UESA-H636 MEng Electronic Engineering with Intercalated Year
- UESA-H311 MEng Mechanical Engineering

- Year 4 of H30G Mechanical Engineering with Business Management
- Year 4 of H30P Mechanical Engineering with Fluid Dynamics
- Year 4 of H30H Mechanical Engineering with Sustainability
- Year 4 of H30N Mechanical Engineering with Systems Engineering
- Year 4 of UCSA-G408 Undergraduate Computer Systems Engineering
- Year 5 of UCSA-G409 Undergraduate Computer Systems Engineering (with Intercalated Year)

This module is Option list C for:

- UESA-H311 MEng Mechanical Engineering
  - Year 4 of H311 Mechanical Engineering
  - Year 4 of H30J Mechanical Engineering with Appropriate Technology
  - Year 4 of H30L Mechanical Engineering with Automotive Engineering
  - Year 4 of H30M Mechanical Engineering with Robotics
- Year 4 of UESA-H316 MEng Mechanical Engineering
- Year 4 of UESA-H318 MEng Mechanical Engineering with Exchange Year
- Year 5 of UESA-H317 MEng Mechanical Engineering with Intercalated Year