**UNIVERSITY OF WARWICK**

**Proposal Form for New or Revised Modules (MA1 - version 7 - April 2014)**

| Approval information | |
|---|---|
| **Approval Type** | ☐ New module ☒ Revised module<br>☐ Discontinue module |
| **Date of Introduction/Change** | 2 October 2017 |
| **If new, does this module replace another? If so, enter module code and title:** | |
| **If revised/discontinued, please outline the rationale for the changes:** | The module is revised to update the MA1 |
| **Confirmation that affected departments have been consulted:** | Changes were made in consultations between the School of Engineering and WMG. |

| Module Summary | |
|---|---|
| **1. Module Code (if known)** | ES4A4 |
| **2. Module Title** | Biomedical Systems Modelling |
| **3a. Lead department:** | School of Engineering |
| **3b. Teaching Split (if known):** | 100% School of Engineering |
| **4. Name of module leader** | Dr Neil Evans |
| **5. Level** | UG: ☐ Level 4 (Certificate) ☐ Level 5 (Intermediate) ☐ Level 6 (Honours)<br>PG: ☒ Level 7 (Masters) ☐ Level 8 (Doctoral)<br>See Guidance Notes for relationship to years of study |
| **6. Credit value(s) (CATS)** | 15 credits |
| **7. Principal 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. |

| Module Summary | |
|---|---|
| **8. Principal Learning Outcomes** | By the end of the module the student should be able to:<br>1. Develop physically based dynamic models of biomedical systems.<br>2. Use analytical techniques to assess the qualitative behaviour of biomedical systems models<br>3. Contextualise and evaluate the role and use of continuous systems simulation in Biomedical Systems Modelling<br>4. Derive biomedical systems models from experimental data using different methods |
| **9. Timetabled Teaching Activities (summary)** | 30 x 1hr lectures<br>2 x 1hr revision classes<br>**TOTAL 32 Hours** |
| **10. Departmental Web-link** | http://www2.warwick.ac.uk/fac/sci/eng/eso/modules/year4 |
| **11. Other essential notes** | Advice and feedback hours are available for answering questions on the module, supplemented by an online forum. |
| **12. Assessment methods (summary)** | 2 hour Written examination (70%)<br>Worksheet 1 (5%)<br>Worksheet 2 (5%)<br>10 page Biomedical Case Study (20%) |

**For use by Strategic Planning and Analytics Office only - Do not fill in this section**

| Level | JACS3 Code | Teaching Split |
|---|---|---|
| | | *If not provided in 3b above* |

| External Credit Level | | Scheme | |
|---|---|---|---|

## Module Context

**13. Please list all departments involved in the teaching of this module. If taught by more than one department, please indicate percentage split.**

100% School of Engineering

**14. Availability of module**

| Degree Code | Title | Study Year | C/OC/ A/B/C | Credits |
|---|---|---|---|---|
| **H107** | **MEng Engineering (plus variants)** | **4** | **O** | |
| **H109** | **MEng Engineering with Intercalated Year (plus variants)** | **5** | **O** | |
| **H110** | **MEng Engineering with a Year in Research (plus variants)** | **5** | **O** | |
| **HH63** | **MEng Systems Engineering (plus variants)** | **4** | **O** | |
| **HH64** | **MEng Systems Engineering with Intercalated Year (plus variants)** | **5** | **O** | **15** |
| **HH65** | **MEng Systems Engineering with Year in Research (plus variants)** | **5** | **O** | |
| **H311** | **MEng Mechanical Engineering (plus variants)** | **4** | **O** | |
| **H312** | **MEng Mechanical Engineering with Intercalated Year (plus variants)** | **5** | **O** | |
| **H313** | **MEng Mechanical Engineering with Year in Research (plus variants)** | **5** | **O** | |
| **H800** | **MSc Biomedical Engineering** | **1** | **C** | |

**15. Minimum number of registered students required for module to run**

**1(Core)**

**16. Pre- and Post-Requisite Modules**

## Module Content and Teaching

**17. Teaching and Learning Activities** *(totals for module – please see guidance)*

| | |
|---|---|
| **Module duration (weeks)** | **10** |
| **Lectures** | **30x1hr** |
| **Seminars** | |
| **Tutorials** | **0** |
| **Project Supervision** | 0 |
| **Demonstration** | 0 |

| Module Content and Teaching | | |
|---|---|---|
| **Practical Class/Workshops** | 0 | |
| **Supervised time in studio/workshop** | 0 | |
| **Fieldwork** | 0 | |
| **External visits** | 0 | |
| **Work based learning** | 0 | |
| **Placement** | **0** | |
| **Year abroad** | **0** | |
| **Other activity** *(please describe): e.g. distance-learning, intensive weekend teaching etc.* | **2 x 1hr revision class**<br>**118 hours guided independent learning** | |
| **18. Assessment Method (Standard)** | | |
| **Type of assessment** | **Length** | **% weighting** |
| **Written Examinations** | 2 Hours | **70** |
| **Practical Examinations** | | |
| **Assessed essays/coursework** | Worksheet 1<br>Worksheet 2<br>Biomedical Case Study (10 pages) | **5%**<br>**5%**<br>**20%** |
| **18a. Final chronological assessment** *(please see guidance*) | **Examination** | |

**19. Methods for providing feedback on assessment.**

- Model solutions to past papers.
- Support through advice and feedback hours.
- Written feedback on both worksheets and Biomedical Case Study.
- Cohort-level feedback on both worksheets and Biomedical Case Study.
- Cohort-level feedback on final exam.

**20. Outline Syllabus**

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.

**21. Illustrative Bibliography**

"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

**22. Learning outcomes**

*Successful completion of the module leads to the learning outcomes. The learning outcomes identify the knowledge, skills and attributes developed by the module.*

*Learning Outcomes should be presented in the format "By the end of the module students should be able to..." using the table at the end of the module approval form:*

| Resources |
|---|
| **23. List any additional requirements and indicate the outcome of any discussions about these.** |
| |

| Approval | |
|---|---|
| **24. Module leader's signature** | Dr Neil Evans |
| **25. Date of approval** | Teaching Policy Committee meeting 22 March2017<br>Minute 308-16/17 |
| **26. Name of Approving Committee (include minute reference if applicable)** | School of Engineering and WMG Teaching Policy Committee |
| **27. Chair of Committee's signature** | Professor Gillian Cooke |
| **28. Head of Department(s) signature** | Professor Nigel Stocks |

| Examination Information | | |
|---|---|---|
| **A1. Name of examiner (if different from module leader)** | | |
| **A2. Indicate all available methods of assessment in the table below** | | |
| **% Examined** | **% Assessed by other methods** | **Length of examination paper** |
| **70** | **5% Worksheet 1**<br>**5% Worksheet 2**<br>**20% Biomedical Case Study 10 pages** | **2 hours** |
| **A3. Will this module be examined together with any other module (sectioned paper)? If so, please give details below.** | | |
| | | |
| **A4. How many papers will the module be examined by?** | ☒ 1 paper | ☐ 2 papers |
| **A5. When would you wish the exam take place (e.g. Jan, April, Summer)?** | **Summer** | |
| **A6. Is reading time required?** | ☐ Yes | ☒ No |
| **A7. Please specify any special exam timetable arrangements.** | | |
| Examinations for MSc and MEng students to be scheduled at the same time | | |
| **A8. Stationery requirements** | | |
| **No. of Answer books?** | **2** | |
| **Graph paper?** | **Y** | |
| **Calculator?** | **Y** | |
| **Any other special stationery requirements (e.g. Data books, tables etc)?** | **Engineering Data Book** | |
| **A9. Type of examination paper** | | |
| **Seen?** | ☐ Yes | ☒ No |
| **Open Book?** | ☐ Yes | ☒ No |
| **Restricted?** | ☐ Yes | ☒ No |

| Examination Information | |
|---|---|
| **If restricted, please provide a list of permitted texts:** | |

| LEARNING OUTCOMES | | |
|---|---|---|
| **(By the end of the module the student should be able to....)** | **Which teaching and learning methods enable students to achieve this learning outcome? (reference activities in section 17)** | **Which summative assessment method(s) will measure the achievement of this learning outcome? (reference activities in section 18)** |
| Develop physically based dynamic models of biomedical systems. | Lectures, examples classes | Examination and Biomedical Case Study |
| Use analytical techniques to assess the qualitative behaviour of biomedical systems models | Lectures, examples classes, worksheets | Examination, Worksheets and Biomedical Case Study |
| Contextualise and evaluate the role and use of continuous systems simulation in Biomedical Systems Modelling | Lectures, examples classes, worksheets | Examination, Worksheets and Biomedical Case Study |
| Derive biomedical systems models from experimental data using different methods | Lectures, examples classes, worksheets | Examination, Worksheets and Biomedical Case Study |