UWE Bristol University of the West of England

# MODULE SPECIFICATION

| Part 1: Information | | | |
|---|---|---|---|
| Module Title | Dynamical Systems | | |
| Module Code | UFMFK8-30-3 | Level | Level 6 |
| For implementation from | 2019-20 | | |
| UWE Credit Rating | 30 | ECTS Credit Rating | 15 |
| Faculty | Faculty of Environment & Technology | Field | Engineering, Design and Mathematics |
| Department | FET Dept of Engin Design & Mathematics | | |
| Module type: | Standard | | |
| Pre-requisites | Sets, Functions and Linear Algebra 2019-20 | | |
| Excluded Combinations | None | | |
| Co- requisites | None | | |
| Module Entry requirements | None | | |

**Part 2: Description**

**Overview**: This module is designed to further develop the introductory and fundamental concepts from levels 1 and 2, and to provide more advanced techniques capable of dealing with the complex problems encountered in many application areas.

**Educational Aims:** The module will develop modern Dynamical Systems theory which has become one of the most powerful and useful mathematical theories since its initial development by Henri Poincare at the end of the 19th century. The theory will be developed for nonlinear discrete-time dynamical systems and weakly nonlinear continuous-time dynamical systems.

The theory and techniques developed within this module continue to underpin contemporary work being conducted at the forefront of scientific research. They enable the mathematical scientist to investigate, understand and predict a huge range of modern applied problems in the physical, life and social sciences, as well as other areas within mathematics.

**Outline Syllabus:** Discrete-time Dynamical Systems:

Scalar maps:
Review of relevant Level 2 material;
Monotone sequences;
Bifurcation theory (simple, flip);

Period doubling cascades (Feigenbaum's constant);
Chaos (aperiodic orbits, Sarkovskii's Theorem, Period-3 Theorem)

Planar maps:
Linear maps (spectral solution and stability);
Classification of linear maps and phase planes;
Nonlinear maps (fixed points, cycles, stability);
Bifurcation theory (simple, flip, Neimark-Sacker)

Applications:
Dynamical systems concepts and techniques will be illustrated and contextualized via applications to the natural and social sciences (e.g. biology, physics, engineering, economics) as well as to other areas of mathematics (e.g. number theory, numerical methods).

Continuous-time Dynamical Systems:

Linear differential equations:
First and second order ordinary differential equations
Difference equations
Systems of first and second order differential equations
Matrix formulation, eigenvalues, eigenvectors
Partial differential equations

Nonlinear differential equations:
Introducing nonlinearity
Linearisation
Bifurcation analysis

Applications:
Possible applications and examples include: mass-spring systems and vibrating string, coupled pendulums and the vibrating ribbon, heat transfer and the heat equation, reaction-diffusion equations, traffic flows.

**Teaching and Learning Methods:** During the module, connections will be drawn between the underlying mathematical concepts and the methods & techniques used for problem solving in applications.

Teaching is delivered by means of lectures, tutorials, problems classes and computer lab sessions (where appropriate).

Scheduled learning includes lectures, tutorials, problems classes and workshops.

Independent learning includes hours engaged with essential reading, assignment preparation and completion etc. These sessions constitute an average time per level as indicated in the table below. Scheduled sessions may vary slightly depending on the module choices you make.

Contact Hours:

Scheduled teaching hours takes the form of:
Whole-group lectures, used to present new material;
Whole-group problems classes, used for contextualization in an applied setting or to present solutions to homework exercises.
Smaller-group tutorials, with activities designed to reinforce mathematical/computational skills or to provide an arena for students to ask individual questions and obtain help & advice.

Contact time: 72 hours
Assimilation and development of knowledge: 150 hours
Coursework preparation: 22 hours
Examination preparation: 56 hours
TOTAL: 300 HOURS

| Part 3: Assessment |
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| To prepare for assessment, students are expected to undertake self-directed learning in addition to the directed learning which supports taught classes.<br><br>Component A consists of a single 3-hour examination which assesses the student's understanding of fundamental concepts and techniques (e.g. key theorems, stability, bifurcation, contextual interpretation) relating to dynamical systems theory and its applications.<br><br>Component B consists of a single piece of summative coursework, in the form of take-home questions. The coursework will assess key aspects of discrete dynamical systems and may include applications.<br><br>The coursework is designed to encourage engagement with the module and students will receive feedback which will help them identify strengths and weaknesses for future development. A word count is inappropriate for such mathematical expositions, but a page count guide and/or limit will be provided in the coursework brief. The re-sit will be a new piece of coursework. |

| First Sit Components | **Final Assessment** | **Element weighting** | **Description** |
|---|---|---|---|
| Written Assignment - Component B | | 25 % | Written coursework |
| Examination - Component A | ✓ | 75 % | Summer written examination (3 hours) |
| Resit Components | **Final Assessment** | **Element weighting** | **Description** |
| Written Assignment - Component B | | 25 % | Written coursework |
| Examination - Component A | ✓ | 75 % | Summer written examination (3 hours) |

| **Part 4: Teaching and Learning Methods** | |
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| Learning Outcomes | On successful completion of this module students will achieve the following learning outcomes: |

| **Module Learning Outcomes** | **Reference** |
|---|---|
| Give clear definitions and state theorems precisely, with respect to dynamical systems theory | MO1 |
| Select and apply appropriate techniques to determine the long-term behaviour of a given dynamical system | MO2 |
| Select and apply appropriate techniques to determine the behaviour of a given dynamical system under parameter variation | MO3 |
| Interpret appropriate analyses in the context of dynamical systems theory and/or in an areas of application | MO4 |

Contact Hours

| **Independent Study Hours:** | |
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| Independent study/self-guided study | 228 |
| **Total Independent Study Hours:** | 228 |
| **Scheduled Learning and Teaching Hours:** | |
| Face-to-face learning | 72 |
| **Total Scheduled Learning and Teaching Hours:** | 72 |
| **Hours to be allocated** | 300 |
| **Allocated Hours** | 300 |

Reading List

*The reading list for this module can be accessed via the following link:*

https://uwe.rl.talis.com/modules/ufmfk8-30-3.html

| **Part 5: Contributes Towards** |
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| This module contributes towards the following programmes of study: |