Swansea University
Prifysgol Abertawe

# FACULTY OF SCIENCE AND ENGINEERING

## POSTGRADUATE STUDENT HANDBOOK

## MSC (FHEQ LEVEL 7)

# MATHEMATICS

## DEGREE PROGRAMMES

**SUBJECT SPECIFIC**
**PART TWO OF TWO**
**MODULE AND COURSE STRUCTURE**
**2022-23**

## DISCLAIMER

The Faculty of Science and Engineering has made all reasonable efforts to ensure that the information contained within this publication is accurate and up-to-date when published but can accept no responsibility for any errors or omissions.

The Faculty of Science and Engineering reserves the right to revise, alter or discontinue degree programmes or modules and to amend regulations and procedures at any time, but every effort will be made to notify interested parties.

It should be noted that not every module listed in this handbook may be available every year, and changes may be made to the details of the modules. You are advised to contact the Faculty of Science and Engineering directly if you require further information.

**The 22-23 academic year begins on 26 September 2022**

Full term dates can be found here

**DATES OF 22-23 TERMS**

26 September 2022 – 16 December 2022

9 January 2023 – 31 March 2023

24 April 2023 – 09 June 2023

**SEMESTER 1**

26 September 2022 – 27 January 2023

**SEMESTER 2**

30 January 2023 – 09 June 2023

**SUMMER**

12 June 2023 – 22 September 2023

## IMPORTANT

Swansea University and the Faculty of Science of Engineering takes any form of **academic misconduct** very seriously. In order to maintain academic integrity and ensure that the quality of an Award from Swansea University is not diminished, it is important to ensure that all students are judged on their ability. No student should have an unfair advantage over another as a result of academic misconduct - whether this is in the form of **Plagiarism**, **Collusion** or **Commissioning**.

It is important that you are aware of the **guidelines** governing Academic Misconduct within the University/Faculty of Science and Engineering and the possible implications. The Faculty of Science and Engineering will not take intent into consideration and in relation to an allegation of academic misconduct - there can be no defence that the offence was committed unintentionally or accidentally.

Please ensure that you read the University webpages covering the topic – procedural guidance here and further information here. You should also read the Faculty Part One handbook fully, in particular the pages that concern Academic Misconduct/Academic Integrity. You should also refer to the Faculty of Science and Engineering proof-reading policy and this can be found on the Community HUB on Canvas, under Course Documents.

**Welcome to the Faculty of Science and Engineering!**

Whether you are a new or a returning student, we could not be happier to be on this journey with you.

This has been a challenging period for everyone. The COVID-19 pandemic has prompted a huge change in society as well as how we deliver our programmes at Swansea University and the way in which you study, research, learn and collaborate. We have been working hard to make sure you will have or continue to having an excellent experience with us.

We have further developed some exciting new approaches that I know you will enjoy, both on campus and online, and we cannot wait to share these with you.

At Swansea University and in the Faculty of Science & Engineering, we believe in working in partnership with students. We work hard to break down barriers and value the contribution of everyone. Our goal is an inclusive community where everyone is respected, and everyone's contributions are valued. Always feel free to talk to academic staff, administrators, and your fellow students - I'm sure you will find many friendly helping hands ready to assist you.

We all know this period of change will continue and we will need to adapt and innovate to continue to be supportive and successful. At Swansea we are committed to making sure our students are fully involved in and informed about our response to challenges.

In the meantime, learn, create, collaborate, and most of all – enjoy yourself!

**Professor Johann (Hans) Sienz**
**Interim Pro-Vice Chancellor/Interim Executive Dean**
**Faculty of Science and Engineering**

| Faculty of Science and Engineering | |
|---|---|
| Interim Pro-Vice Chancellor/Interim Executive Dean | Professor Johann Sienz |
| Head of Operations | Mrs Ruth Bunting |
| Associate Dean – Student Learning and Experience (SLE) | Professor Paul Holland |
| **School of Mathematics and Computer Science**<br>**Head of School: Professor Elaine Crooks** | |
| School Education Lead | Dr Neal Harman |
| Head of Mathematics | Professor Vitaly Moroz |
| Mathematics Programme Director | Dr Kristian Evans |
| Year Coordinators | Year 0 – Dr Zeev Sobol<br>Year 1 – Dr Noemi Picco<br>Year 2 – Professor Jiang-Lun Wu<br>Year 3 – Dr Grigory Garkusha<br>Year 4/MSc – Professor Chenggui Yuan |

**STUDENT SUPPORT**

The Faculty of Science and Engineering has two **Reception** areas - Engineering Central (Bay Campus) and Wallace 223c (Singleton Park Campus).

Standard Reception opening hours are Monday-Friday 9am-5pm.

The **Student Support Team** provides dedicated and professional support to all studentsin the Faculty of Science and Engineering. Should you require assistance, have any questions, be unsure what to do or are experiencing difficulties with your studies or in your personal life, our team can offer direct help and advice, plus signpost you to further sources of support within the University. There are lots of ways to get information and contact the team:

**Email:** studentsupport-scienceengineering@swansea.ac.uk (Monday–Friday, 9am–5pm)

**Call:** +44 (0) 1792 295514 and 01792 6062522 (Monday-Friday, 10am–12pm, 2–4pm).

**Zoom:** By appointment. Students can email, and if appropriate we will share a link to our Zoom calendar for students to select a date/time to meet.

The current student **webpages** also contain useful information and links to otherresources:

https://myuni.swansea.ac.uk/fse/coe-student-info/

**READING LISTS**

Reading lists for each module are available on the course Canvas page and are also accessible via http://ifindreading.swan.ac.uk/. We've removed reading lists from the 22-23 handbooks to ensure that you have access to the most up-to-date versions. Access to print material in the library may be limited due to CV-19; your reading lists will link to on-line material whenever possible. We do not expect you to purchase textbooks, unless it is a specified key text for the course.

**THE DIFFERENCE BETWEEN COMPULSORY AND CORE MODULES**

**Compulsory modules** must be **pursued** by a student.

**Core modules** must not only be **pursued**, but also **passed** before a student can proceed to the next level of study or qualify for an award. Failures in core modules must be redeemed.

Further information can be found under "Modular Terminology" on the following link - https://myuni.swansea.ac.uk/academic-life/academic-regulations/taught-guidance/essential-info-taught-students/your-programme-explained/

# MSc (FHEQ Level 7) 2022/23
# Mathematics (MSc)
**MSc Mathematics**

**Coordinator: Prof C Yuan**

| Dissertation |
|---|
| **MA-D00**<br>**Mathematics Masters Dissertation**<br>**60 Credits**<br>**Prof C Yuan** |
| **Total 180 Credits** |

**Optional Modules**
Choose a maximum of 120 credits
Students must take 120 credits of taught modules, chosen either from the list below, or from Mathematics modules in other departments, such as Computer Science or Engineering.

| | | | | |
|---|---|---|---|---|
| **MA-M02** | Numerics of ODEs and PDEs | Prof IM Davies | TB2 | 15 |
| **MA-M08** | Machine Learning | Prof B Lucini | TB2 | 15 |
| **MA-M22** | Topology | Dr MD Crossley | TB1 | 15 |
| **MA-M45** | Cashflows and Interest Rates | Dr Z Sobol | TB1 | 15 |
| **MA-M46** | Assurance and Annuity | Dr Z Sobol | TB2 | 15 |
| **MA-M58** | Financial Mathematics in Discrete Time | Dr I Rodionova | TB1 | 15 |
| **MA-M59** | Financial Mathematics in Continuous Time | Prof E Lytvynov | TB2 | 15 |
| **MA-M64** | Markov Processes and Applications | Prof J Wu | TB1 | 15 |
| **MA-M65** | Risk and Survival Models | Dr DL Finkelshtein | TB2 | 15 |
| **MA-M75** | Dynamical Systems | Dr DL Finkelshtein | TB1 | 15 |
| **MA-M84** | Fourier Analysis | Prof E Lytvynov | TB1 | 15 |
| **MA-M86** | Calculus of Variations | Prof V Moroz/Prof ECM Crooks | TB2 | 15 |
| **MA-M93** | Lie Theory | Dr I Rodionova | TB2 | 15 |

# MA-D00 Mathematics Masters Dissertation

**Credits: 60 Session: 2022/23 September-June**

**Pre-requisite Modules:**

**Co-requisite Modules:**

**Lecturer(s):** Prof C Yuan

**Format:** 12

**Delivery Method:** Individual project supervision

**Module Aims:** A research project selected from an area of expertise of a member of staff in the Department of Mathematics. It will enable the students to develop an enquiring, analytical critical and creative approach to problem identification and solution. The project will typically focus on a subject area related to one of the taught modules in the MSc scheme.

**Module Content:** The student will study an area of mathematics related to the content of the taught part of the MSc scheme, drawing together material from different published sources, and their own investigations, to product a substantial written report on the topic.

**Intended Learning Outcomes:** At the end of this module, the student should be able to:
plan and undertake a significant project with a high degree of independence,
synthesize information and ideas;
independently evaluate alternative approaches to a given problem;
accurately report on and evaluate their own work, and work of others;
communicate complex mathematical ideas to both mathematicians and non-mathematicians.

**Assessment:** Report (100%)

**Assessment Description:** Written dissertation, subject to the regulations for an MSc dissertation as set out in the Swansea University Academic Regulations: http://www.swan.ac.uk/registry/academicguide/

**Moderation approach to main assessment:** Universal non-blind double marking

**Assessment Feedback:** Students will receive ongoing feedback during the meetings with their supervisor. The official result of the MSc dissertation will be communicated to the student by the University in the usual way. The student can receive individual feedback on their dissertation from their supervisor, informed by the views of both markers.

**Failure Redemption:** Resubmission of the dissertation, in accordance with the University regulations.

**Additional Notes:** Dissertation for the MSc Mathematics scheme. Only available to students on the MSc Mathematics programme.

Each student will be assigned a member of staff as a supervisor who will help to choose the topic to be studied, and guide the student. Each student will be required to produce a word-processed thesis of 15,000-20,000 words, based on topics covered in the taught part of the MSc scheme, and on published research in the field.

# MA-M02 Numerics of ODEs and PDEs

**Credits: 15 Session: 2022/23 January-June**

**Pre-requisite Modules:**

**Co-requisite Modules:**

**Lecturer(s):** Prof IM Davies

**Format:** 33 hours of traditional lectures, narrating and expanding upon the online notes.
11 hours of Matlab support and examples classes (alternating weekly)

**Delivery Method:**
The in-person lectures will focus on developing the theory and the implementation of that theory into practice. Weekly formative homework will supplement the understanding of key properties of methods and their behaviour (good or bad). The weekly Matlab worksheets will enable students to work the methods ‘for real’ as opposed to the ‘toy problems’ that can be worked by hand ( and calculator ).

**Module Aims:** This module is focused on numerical schemes suitable for the approximate solution of ODEs and PDEs. Whilst the methods may look different the underlying principles and convergence issues are remarkably similar. Many standard algorithms will be presented along with an analysis of their behaviour.

**Module Content:** - ODEs;
- overview of LMMs, weak instability, strong stability, boundary value problems.
- PDEs;
- finite difference representation of partial derivatives, explicit and implicit finite difference schemes, consistency, stability,
- convergence, finite element methods, finite difference methods for elliptic problems, iterative methods, non-flat boundaries.

**Intended Learning Outcomes:** At the end of this module students should be able to:

1) determine the properties of a linear multistep method
2) demonstrate a systematic understanding of appropriate methods for solving BVPs
3) analyse the nature of finite difference schemes
4) demonstrate extensive familiarity with algorithms suitable for numerical solution of PDEs

**Assessment:** Examination 1 (80%)
Coursework 1 (20%)
**Resit Assessment:** Examination (Resit instrument) (100%)

**Assessment Description:** Component 1 is a written, closed-book examination at the end of the module.
Component 2 is formed of a number of coursework assignments during the semester.

**Moderation approach to main assessment:** Universal second marking as check or audit

**Assessment Feedback:** For the homework assignments, students will receive feedback in the form of marks, model solutions, overall
feedback on the cohort performance, and some individual comments on their work.
For the exam, students will receive feedback in the form of marks and overall feedback on the cohort performance.
Further, individualised feedback, can be provided upon request.

**Failure Redemption:** closed book examination in August combined with existing coursework component

**Additional Notes:** This module is not available to students who have previously taken MA-302.
Available to visiting and exchange students.

# MA-M08 Machine Learning

**Credits: 15 Session: 2022/23 January-June**

**Pre-requisite Modules:**

**Co-requisite Modules:**

**Lecturer(s):** Prof B Lucini

**Format:** 44 hours consisting of a mixture of lectures and computer lab classes

**Delivery Method:** Lectures supported by regular computer lab sessions.

**Module Aims:** The module introduces basic concepts of machine learning and some of its popular methods in a practical manner from a mathematical perspective.

**Module Content:** - Concept of learning, linear perceptron
- Types of learning: supervised learning, reinforcement learning and unsupervised learning
- Use of probability in learning and noisy data
- VC dimension, generalization, complexity, bias-variance tradeoff
- Linear classification, linear regression, logistic regression, gradient descent and stochastic gradient descent
- Overfitting, regularization, cross validation
- Support vector machines, kernel methods
- Decision trees, random forests
- K-means clustering and mixture models
- Neural networks

**Intended Learning Outcomes:** At the end of this module, students should be able to:

1) Critically analyse the feasibility of approaches to machine learning .
2) Demonstrate a comprehensive understanding of the fundamental mathematical ideas behind the standard approaches to machine learning.
3) Apply a broad range of machine learning techniques to data sets using appropriate programming languages.
4) Analyse the strengths and weaknesses of a wide range of different approaches to machine learning.
5) Determine appropriate methods to apply to given data sets.

**Assessment:** Examination (60%)
Assignment 1 (40%)
**Resit Assessment:** Examination (Resit instrument) (100%)

**Assessment Description:** Component 1 is a written, closed-book examination at the end of the module.
Component 2 is formed of a number of coursework assignments during the semester.

**Moderation approach to main assessment:** Universal second marking as check or audit

**Assessment Feedback:** For the homework assignments, students will receive feedback in the form of marks, model solutions, overall feedback on the cohort performance, and some individual comments on their work.
For the exam, students will receive feedback in the form of marks and overall feedback on the cohort performance.
Further, individualised feedback, can be provided upon request.

**Failure Redemption:** Supplementary examination.

**Additional Notes:** Delivery of teaching will be on-campus. Continuous assessment will be submitted online.

Available to visiting and exchange students.

# MA-M22 Topology

**Credits: 15 Session: 2022/23 September-January**

**Pre-requisite Modules:**

**Co-requisite Modules:**

**Lecturer(s):** Dr MD Crossley

**Format:** 44

**Delivery Method:** Primarily on campus

**Module Aims:** This module explores the topological approach to continuity and the study of objects via their topological structure

**Module Content:** - Continuity by open sets;
- Topological spaces, examples of spaces and maps;
- Connectivity, compactness, the Hausdorff condition;
- Constructions: disjoint unions, products quotients;
- Homotopy and homotopy equivalence;
- Simplicial complexes and the Euler number;
- Homology

**Intended Learning Outcomes:** At the end of this module students should be able to:
1) check continuity for most functions, and construct complex proofs based on the topological approach to continuity
2) verify and apply topological properties such as connectedness
3) manipulate topological constructions such as products and quotients, and build proofs using these concepts
4) establish when functions are homotopic and prove properties involving homotopy concepts
5) calculate the Euler number of a cellular space, apply this in distinguishing spaces, and understand its relation with other topological properties such as vector fields
6) calculate and manipulate algebro-topological invariants such as simplicial homology groups

**Assessment:** Examination (80%)
Assignment 1 (20%)

**Assessment Description:** The summative assessment consists of one written, closed-book examination at the end of the module.
A number of homework assignments will be set during the semester, approximately weekly, constituting formative assessment in preparation for the final summative assessment event.

**Moderation approach to main assessment:** Universal second marking as check or audit

**Assessment Feedback:** Students will receive feedback in the form of marks and overall feedback on the cohort performance. Further, individualised feedback, can be provided upon request.

**Failure Redemption:** Supplementary examination.

**Additional Notes:** Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

This module is not available to students who have previously taken MA-322.
Available to visiting and exchange students.

# MA-M45 Cashflows and Interest Rates

**Credits: 15 Session: 2022/23 September-January**

**Pre-requisite Modules:**

**Co-requisite Modules:**

**Lecturer(s):** Dr Z Sobol

**Format:** 40 hours: 30 hours of lectures and 10 hours of examples classes.

**Delivery Method:** The module will be delivered on Bay Campus, with a mix of lectures and example classes underpinned with weekly formative homework.

**Module Aims:** This module covers a detailed analysis of cashflows and interest rates with actuarial applications.

It covers material relating to sections 1, 2 and 3 of the Institute and Faculty of Actuaries CM1 syllabus.

**Module Content:** i) Data Analysis

ii) Actuarial Modelling

iii) Generalised Cashflows

iv) Interest Rates

v) Present and Accumulated values

vi) Interest Functions

vii) Term Structures

viii) Equation of Value and applications

ix) Project Appraisal

**Intended Learning Outcomes:** At the end of this module, the student should be able to:
1) analyse and critically evaluate a selection of actuarial models,
2) analyse real world problems using specialist techniques and actuarial models,
3) demonstrate a systematic understanding and advanced skills in generalised cashflow models and their use,
4) demonstrate advanced skills with interest rates and interest functions in a range of settings,
5) analyse complex business scenarios using the equation of value.

**Assessment:** Examination (80%)
Coursework 1 (20%)
**Resit Assessment:** Examination (Resit instrument) (100%)

**Assessment Description:** Component 1 is a written, closed-book examination at the end of the module.
Component 2 is composed of a number of coursework assignments spread through the term.

**Moderation approach to main assessment:** Universal second marking as check or audit

**Assessment Feedback:** For homework assignments, students will receive feedback in the form of marks, model solutions, overall feedback on the cohort performance, and some individual comments on their work.

For the exam, students will receive feedback in the form of marks and overall feedback on the cohort performance.

Further, individualised feedback, can be provided upon request.

**Failure Redemption:** Supplementary examination.

**Additional Notes:** Available to visiting and exchange students.

# MA-M46 Assurance and Annuity

**Credits: 15 Session: 2022/23 January-June**

**Pre-requisite Modules:**

**Co-requisite Modules:** MA-M45

**Lecturer(s):** Dr Z Sobol

**Format:** 40 hours: 30 hours of lectures and 10 hours of examples classes

**Delivery Method:** The module will be delivered on Bay Campus, with a mix of lectures and example classes underpinned with weekly formative homework.

**Module Aims:** This module covers the actuarial pricing structure of life assurance and annuity contracts, including a variety of payment and premium structures as well as two-life policies. It covers material related to sections 4, 5 and 6 of the Institute and Faculty of Actuaries CM1 syllabus.

**Module Content:** i) Assurance and annuity contracts

ii) Payments – means and variances

iii) Two life policies

iv) Multiple transitions

v) Multiple decrements

vi) Future loss

vii) Gross premiums and reserves

viii) Death strains

ix) Future cashflows

**Intended Learning Outcomes:** At the end of this module, a student should be able to:
1) critically evaluate a range of assurance and annuity contracts,
2) demonstrate advanced skills with payments under various assurance and annuity contracts,
3) calculate using advanced techniques cashflows contingent upon the nature of transitions,
4) demonstrate advanced skills calculating gross premiums and reserves for assurance and annuity contracts and projecting future cashflows for a variety of typical contracts.

**Assessment:** Examination (80%)
Coursework 1 (20%)
**Resit Assessment:** Examination (Resit instrument) (100%)

**Assessment Description:** Component 1 is a written, closed-book examination at the end of the module.

Component 2 is formed of a number of coursework assignments during the semester.

**Moderation approach to main assessment:** Universal second marking as check or audit

**Assessment Feedback:** For the homework assignments, students will receive feedback in the form of marks, model solutions, overall
feedback on the cohort performance, and some individual comments on their work.

For the exam, students will receive feedback in the form of marks and overall feedback on the cohort performance.

Further, individualised feedback, can be provided upon request.

**Failure Redemption:** Supplementary Examination.

**Additional Notes:** Module available to visiting and exchange students.

# MA-M58 Financial Mathematics in Discrete Time

**Credits: 15 Session: 2022/23 September-January**

**Pre-requisite Modules:**

**Co-requisite Modules:**

**Lecturer(s):** Dr I Rodionova

**Format:** There be weekly delivery, with each week have 3 lectures and 1 examples class.

**Delivery Method:** The module will be delivered on Bay Campus, with a traditional mix of lectures and example classes underpinned
with weekly assessments of a formative/summative mix.

**Module Aims:** This module will introduce students to section 1 of the Institute and Faculty of Actuaries (IFoA) CS1 syllabus, section 3 of the IFoA CS2 syllabus and sections 4 and 6 of the IFoA CM2 syllabus.

This module serves as an introduction to the theory of martingales and their applications to a discrete-time dynamics of a financial market containing a bank account and several kinds of stocks. Special attention is paid to the applications of the theory of martingales to the absence of arbitrage in a discrete-time financial market and pricing and hedging of the options.

**Module Content:** - A first encounter with stochastic processes, filtration, the natural filtration of a stochastic process;
- Conditional expectation;
- Martingales, including submartingales and supermartingales;
- Stopping times and hitting times, optional sampling, optional stopping;
- Discrete time financial market, self-financing trading strategies;
- Discounted price processes, equivalent martingale measures and arbitrage opportunities;
- Contingent claim, European, American and Asian options, valuation and hedging, complete and incomplete markets;
- The binomial (Cox-Ross-Rubinstein) model;
- The Black-Scholes discrete-time pricing formula.

**Intended Learning Outcomes:** At the end of this module students should be able to:
1) Demonstrate a comprehensive knowledge of the theory of martingales;
2) Be able to systematically apply the optional stopping theorem to practical examples;
3) Demonstrate a comprehensive understanding of the main concepts of discrete-time models of financial markets;
4) Be able to systematically apply the theory of martingales to study of financial markets;
5) Demonstrate a comprehensive knowledge of the binomial model.

**Assessment:** Examination (80%)
Assignment 1 (20%)
**Resit Assessment:** Examination (Resit instrument) (100%)

**Assessment Description:** Component 1 is a written, closed-book examination at the end of the module.
Component 2 is formed of a number of coursework assignments during the semester.

**Moderation approach to main assessment:** Universal second marking as check or audit

**Assessment Feedback:** For the homework assignments, students will receive feedback in the form of marks, model solutions, overall feedback on the cohort performance, and some individual comments on their work.
For the exam, students will receive feedback in the form of marks and overall feedback on the cohort performance.
Further, individualised feedback, can be provided upon request.

**Failure Redemption:** Supplementary Examination.

**Additional Notes:** Available to visiting and exchange students

# MA-M59 Financial Mathematics in Continuous Time

**Credits: 15 Session: 2022/23 January-June**

**Pre-requisite Modules:**

**Co-requisite Modules:** MA-M58

**Lecturer(s):** Prof E Lytvynov

**Format:** There be weekly delivery, with each week have 3 lectures and 1 examples class.

**Delivery Method:** The module will be delivered on Bay Campus, with a traditional mix of lectures and example classes underpinned
with weekly assessments of a formative/summative mix.

**Module Aims:** This module will introduce students to sections 3, 4 and 6 of the Institute and Faculty of Actuaries CM2 syllabus.

This module serves as an introduction to the Black-Scholes model for the continuous-time dynamics of a financial market containing a bank account and several kinds of stocks. This theory is based on stochastic (Itô) calculus for Brownian motion. Special attention is paid to the applications of stochastic calculus to the absence of arbitrage in a financial market and pricing and hedging of the options.

**Module Content:** - Introduction to Brownian motion;
- Stochastic integral with respect to Brownian motion;
- Itô process and Itô formula;
- Product rule for Itô processes (integration by parts formula);
- Stochastic differential equations;
- Models of a financial market in continuous time;
- European call and put options, American call and put options;
- Put-call parity and other model-independent results;
- Self-financing trading strategies;
- Equivalent martingale measures and arbitrage opportunities;
- Attainability and completeness;
- Pricing and hedging of an option;
- The Black-Scholes pricing formulas for European call and put options;
- The Black-Scholes partial deferential equation;
- Dividend-paying stocks;
- The Garman-Kohlhagen pricing formulas;

**Intended Learning Outcomes:** At the end of this module students should be able to:
1) Systematically work with the Itô stochastic integral with respect to Brownian motion;
2) Demonstrate a comprehensive understanding of Itô's formula and be able to apply it for the purposes in financial mathematics;
3) Demonstrate comprehensive understanding of the main notions related to financial markets in continuous time;
4) Demonstrate understanding of the completeness of a financial market, hedging and pricing of attainable options with the help of the equivalent martingale measures;
5) Be able to derive the Black-Scholes partial differential equation by using stochastic calculus.

**Assessment:** Examination (80%)
Assignment 1 (20%)
**Resit Assessment:** Examination (Resit instrument) (100%)

**Assessment Description:** Component 1 is a written, closed-book examination at the end of the module.
Component 2 is formed of a number of coursework assignments during the semester.

**Moderation approach to main assessment:** Universal second marking as check or audit

**Assessment Feedback:** For the homework assignments, students will receive feedback in the form of marks, model solutions, overall feedback on the cohort performance, and some individual comments on their work.
For the exam, students will receive feedback in the form of marks and overall feedback on the cohort performance.
Further, individualised feedback, can be provided upon request.

**Failure Redemption:** Supplementary Examination.

**Additional Notes:** Available to visiting and exchange students

# MA-M64 Markov Processes and Applications

**Credits: 15 Session: 2022/23 September-January**

**Pre-requisite Modules:**

**Co-requisite Modules:**

**Lecturer(s):** Prof J Wu

**Format:** There be weekly delivery, with each week have 3 lectures and 1 examples class.

**Delivery Method:** The module will be delivered on Bay Campus, with a traditional mix of lectures and example classes underpinned with weekly assessments of a formative/summative mix.

**Module Aims:** The module will introduce students to section 3 of the Institute and Faculty of Actuaries CS2 syllabus. This module serves as an introduction to the theory of Markov processes, in both discrete and continuous times. A special attention is drawn to the theory of Markov chains and Markov jump processes (including the Poisson process) and their applications.

**Module Content: -** Stochastic processes, filtration, conditional expectation, independence.
- Stochastic process with prescribed finite-dimensional distributions.
- Kolmogorov's existence theorem.
- Markov semigroups of kernels.
- Markov processes.
- Markov chains.
- Poisson process.
- Markov jump process.
- Brownian motion, continuity of paths.

**Intended Learning Outcomes:** At the end of this module students should be able to:
1) demonstrate a comprehensive knowledge of the theory of stochastic processes, in particular, Markov processes;
2) demonstrate comprehensive understanding of Kolmogorov's construction of stochastic processes;
3) design and systematically employ Markov chain models;
4) derive and systematically use Kolmogorov’s differential equations for Markov processes;
5) demonstrate comprehensive knowledge of the construction and basic properties of Brownian motion and Poisson processes.

**Assessment:** Examination (80%)
Assignment 1 (20%)
**Resit Assessment:** Examination (Resit instrument) (100%)

**Assessment Description:** Component 1 is a written, closed-book examination at the end of the module.
Component 2 is formed of a number of coursework assignments during the semester.

**Moderation approach to main assessment:** Universal second marking as check or audit

**Assessment Feedback:** For the homework assignments, students will receive feedback in the form of marks, model solutions, overall feedback on the cohort performance, and some individual comments on their work.
For the exam, students will receive feedback in the form of marks and overall feedback on the cohort performance. Further, individualised feedback, can be provided upon request.

**Failure Redemption:** Supplementary Examination.

**Additional Notes:** Available to visiting and exchange students

# MA-M65 Risk and Survival Models

**Credits: 15 Session: 2022/23 January-June**

**Pre-requisite Modules:**

**Co-requisite Modules:** MA-M64

**Lecturer(s):** Dr DL Finkelshtein

**Format:** There be weekly delivery, with each week have 3 lectures and 1 lab/examples class.

**Delivery Method:** The module will be delivered on Bay Campus, with a traditional mix of lectures and lab/example classes underpinned with weekly assessments of a formative/summative mix.

**Module Aims:** This module will introduce students to sections 1, 2 and 4 of the Institute and Faculty of Actuaries CS2 syllabus.

The module covers insurance risk modelling based on loss and compound distributions, time series and their applications, survival models and the estimations of their distributions and transition intensities, and future mortality projection.

**Module Content:** - Loss distributions
- Compound distributions
- Risk modelling
- Copulas
- Extreme value
- Concepts of time series
- Applications of time series
- Survival models
- Estimation of lifetime distributions
- Maximum likelihood estimation
- Estimation of transition intensities
- Graduation
- Mortality projection

**Intended Learning Outcomes:** Learning Outcomes:
At the end of this module students should be able to:
- fit statistical distributions to datasets and calculate the goodness of fit,
- demonstrate a comprehensive understanding of copulas (both Gaussian and Archimedean),
- explain the central concepts and properties of time series (AR, MA, ARMA, ARIMA),
- develop appropriate deterministic forecasts from time series data,
- describe and systematically apply a two-state model, in the case of a single decrement,
- describe and systematically apply the Cox model for proportional hazards,
- derive maximum (partial) likelihood estimates for various quantities,
- calculate graduation estimates of transition intensities (or probabilities) and specify their properties.

**Assessment:** Examination (70%)
Assignment 1 (20%)
Assignment 2 (10%)
**Resit Assessment:** Examination (Resit instrument) (100%)

**Assessment Description:** Component 1 is a written, closed-book examination at the end of the module.
Component 2 is formed of a number of coursework assignments during the semester.
Component 3 is a lab test during the semester.

**Moderation approach to main assessment:** Universal second marking as check or audit

**Assessment Feedback:** For the homework assignments, students will receive feedback in the form of marks, model solutions, overall feedback on the cohort performance, and some individual comments on their work.
For the lab test, students will receive feedback in the form of marks, model solutions, overall feedback on the cohort performance, and some individual comments on their work.
For the exam, students will receive feedback in the form of marks and overall feedback on the cohort performance.
Further, individualised feedback, can be provided upon request.

**Failure Redemption:** Supplementary Examination.

**Additional Notes:** Available to visiting and exchange students

# MA-M75 Dynamical Systems

**Credits: 15 Session: 2022/23 September-January**

**Pre-requisite Modules:**

**Co-requisite Modules:**

**Lecturer(s):** Dr DL Finkelshtein

**Format:** 44 hours: Live Online Teaching. This will be a mixture of sessions which may include for example lectures, quizzes, exercises, examples classes.

**Delivery Method:** All programmes will employ a blended approach to delivery using the Canvas digital learning platform.

**Module Aims:** An introduction to the concepts and principles of dynamical systems from the analytical perspective. The course starts with the difference between discrete- and continuous time dynamical systems. It describes then the basic object of dynamical systems for the classical first-order differential equations, considers planar linear and non-linear systems, their phase portraits and classification. Applications in Biology, Mechanics and Physics will be considered.

**Module Content:** 1) Malthus and Verhulst models. Explosion and extinction, stationary and periodic solutions.
2) Second-order differential equations, eigenvalues end eigenvectors, linearity principle.
3) Phase portrait for planar systems.
4) Classification of planar systems.
5) Equilibria and their stability.
6) Bifurcations.
7) Infectious diseases, predator/prey and competitive systems.
8) Central force fields, two-body problems, the Lorenz attractor.

**Intended Learning Outcomes:** At the end of this module, the student should be able to:
1) describe the qualitative behaviour of the solution to a first-order differential equation with separable variables depending on the relations between parameters,
2) find and use eigenvalues and eigenvectors to describe the behaviour of a planar linear system,
3) depict and analyse the phase portrait for a planar (nonlinear) system and describes its behaviour accordingly,
4) classify equilibria of a planar (nonlinear) system,
5) explain the meaning of and study the stability of the equilibria of a planar system,
6) apply theoretical results to models in biology (e.g. infectious diseases, predator-preys, competitive systems), mechanics and physics, and draw conclusions about the long-time behaviour in such applications.

**Assessment:** Examination (80%)
Coursework 1 (20%)
**Resit Assessment:** Examination (Resit instrument) (100%)

**Assessment Description:** Examination: An open book online examination at the end of the module.

**Moderation approach to main assessment:** Universal second marking as check or audit

**Assessment Feedback:** For the exam, students will receive feedback in the form of marks and overall feedback on the cohort performance. Further, individualized feedback, can be provided upon request.
For the formative homework assignments, students will receive feedback in the form of marks, model solutions, overall feedback on the cohort performance, and some individual comments on their work.

**Failure Redemption:** Supplementary examination.

**Additional Notes:** Delivery of teaching will be on-campus. Continuous assessment will be submitted online.

This module is not available to students who have previously taken MA-375.
Available to visiting and exchange students.

# MA-M84 Fourier Analysis

**Credits: 15 Session: 2022/23 September-January**

**Pre-requisite Modules:**

**Co-requisite Modules:**

**Lecturer(s):** Prof E Lytvynov

**Format:** 44

**Delivery Method:** Primarily on campus

**Module Aims:** An introduction to Fourier Analysis

**Module Content:** Fourier series of periodic functions, convergence results for Fourier series, applications to ordinary and partial differential equations, orthogonal sets of functions, the Hilbert spaces l^2 and L^2, move convergence of Fourier series and more general orthogonal expansions, Fourier transform and its basic properties, decay of the Fourier transform and smoothness, the uncertainty principle, convolutions and the convolution theorem, applications to partial differential equations.

**Intended Learning Outcomes:** At the end of this module students should be able to:
1) demonstrate an extensive familiarity with pointwise convergence problems and results for Fourier series,
2) have a clear understanding of Hilbert spaces and their geometry,
3) develop the theory of convergence of Fourier series and more general orthogonal series expansions in a Hilbert-space setting,
4) demonstrate a thorough understanding of the definition and properties of the Fourier transform,
5) critically evaluate the convolution theorem for the Fourier transform,
6) demonstrate critical awareness of the use of Fourier series and the Fourier transform to solve (partial) differential equations.

**Assessment:** Examination (80%)
Assignment 1 (20%)
**Resit Assessment:** Examination (Resit instrument) (100%)

**Assessment Description:** The summative assessment consists of one written, closed-book examination at the end of the module.
A number of homework assignments will be set during the semester, approximately weekly, constituting formative assessment in preparation for the final summative assessment event.

**Moderation approach to main assessment:** Universal second marking as check or audit

**Assessment Feedback:** Students will receive feedback in the form of marks and overall feedback on the cohort performance. Further, individualised feedback, can be provided upon request.

**Failure Redemption:** Supplementary examination.

**Additional Notes:** Delivery of teaching will be on-campus. Continuous assessment will be submitted online.

This module is not available to students who have previously taken MA-384.
Available to visiting and exchange students.

# MA-M93 Lie Theory

**Credits: 15 Session: 2022/23 January-June**

**Pre-requisite Modules:**

**Co-requisite Modules:**

**Lecturer(s):** Dr I Rodionova

**Format:** 44

**Delivery Method:** Primarily on campus

**Module Aims:** This course provides an introduction to the theory of Lie groups and Lie algebras building on examples of matrix groups.

**Module Content:** Review of group theory,
Matrix Groups: O(n) SO(n) U(n) SU(n) Sp(n)
Matrix groups as manifolds
One parameter subgroups, the exponential mapping
Lie groups,
The Lie algebra of a Lie group - basic construction, properties.
The classification and representation problems
Lie groups in geometry, Symmetric spaces.

**Intended Learning Outcomes:** At the end of the module the student should be able to:
1) identify and work with the classical matrix groups
2) demonstrate a comprehensive knowledge of the properties of Lie groups
3) demonstrate a thorough knowledge of the properties of Lie algebras
4) explain the importance of Lie algebras in the study of Lie groups
5) apply the theory to advanced problems in geometry

**Assessment:** Examination (80%)
Assignment 1 (20%)
**Resit Assessment:** Examination (Resit instrument) (100%)

**Assessment Description:** The summative assessment consists of one written, closed-book examination at the end of the module.
A number of homework assignments will be set during the semester, approximately weekly, constituting formative assessment in preparation for the final summative assessment event.

**Moderation approach to main assessment:** Universal second marking as check or audit

**Assessment Feedback:** For the homework assignments, students will receive feedback in the form of marks, model solutions, overall
feedback on the cohort performance, and some individual comments on their work.
For the exam, students will receive feedback in the form of marks and overall feedback on the cohort performance.
Further, individualised feedback, can be provided upon request.

**Failure Redemption:** Supplementary examination.

**Additional Notes:** Delivery of teaching will be on-campus. Continuous assessment will be submitted online.

This module is not available to students who have previously taken MA-393.
Available to visiting and exchange students.