DEPARTMENT OF MATHEMATICS & STATISTICS

University of Strathclyde Science

INFORMATION FOR STUDENTS ENTERING YEAR 3 IN ACADEMIC SESSION 2026/27

(Supplement to Student Handbook)

Note: the information contained herein may be subject to change. (For example, the Department reserves the right to alter the list of modules available, the semester in which modules are delivered or degree course structures.)

9 September 2026

GENERAL INFORMATION

Year Co-ordinator: **Dr Matthias Langer**

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Advisor of Studies to BA Joint Degree students: **Dr Alexander Wray**

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DEGREE COURSES

MMath:	**Mathematics**	**(MM)**
	Mathematics and Statistics	**(MMS)**
BSc & BSc Honours:	**Mathematics**	**(M)**
	Mathematics and Statistics	**(MS)**
	Mathematics and Computer Science	**(MCS)**
	Mathematics and Physics	**(MP)**
	Mathematics, Statistics and Accounting	**(MSA)**
	Mathematics, Statistics and Economics	**(MSE)**
	Mathematics, Statistics and Finance	**(MSF)**
	Mathematics, Statistics and Business Analysis	**(MSBA)**
	Mathematics with Teaching/ Mathematics with Teaching (International)	**(MWT)**
	Data Analytics	**(DA)**
BA Joint Degrees:	**Joint with Mathematics and/or Statistics**	**(BA)**

PROVISIONAL REGISTRATION

Student Business asks students to select in advance a provisional curriculum for next session via PEGASUS. The facility to choose your Year 3 modules and submit them for approval is now available. Do not wait until the examinations have finished and you know your results.

The deadline for submitting a valid provisional curriculum is **Thursday, 30 April 2026**. Any delay in submitting a provisional curriculum may delay your registration for Year 3. Your provisional curriculum is not final — you will be able to submit changes to your curriculum before the start of the academic session in September, and even during the first two weeks of each semester.

During the course of the summer, provisional lecture times and rooms for each module will become available at:

https://www.strath.ac.uk/professionalservices/estates/timetables/

CALENDAR OF DATES (** PROVISIONAL **)

Year 3 modules (classes) are taught in two semesters each consisting of a Welcome/Consolidation & Development Week, an 11-week teaching block (including Revision), and a Formal Assessment Period (Examinations):

- **First Semester**

Welcome & Development Week:	Monday, 14 September – Friday, 18 September 2026
Teaching Block:	Monday, 21 September – Friday, 4 December 2026
	(Public holiday: Monday, 28 September 2026)
Formal Assessment:	Monday, 7 December – Friday, 18 December 2026

- **Second Semester**

Consolidation & Development Week:	Monday, 11 January – Friday, 15 January 2027
Teaching Block:	Monday, 18 January – Friday, 2 April 2027
	(Public holidays: 26 and 29 March 2027)
Formal Assessment:	Monday, 19 April – Friday, 21 May 2027

(Normally examinations are held in the diet immediately following the completion of the module.)

- **Resit Examination Diet**

Formal Assessment:	Wednesday, 28 July – Tuesday, 10 August 2027

Permission to resit an exam is not automatic, being subject to the approval of the appropriate Board of Examiners.

GENERAL INFORMATION: MATHEMATICS AND STATISTICS

Information for students about all the modules and courses provided by the Department of Mathematics and Statistics can be found via a class on Myplace called:

Mathematics & Statistics: Information for Current Students

All students on our degree courses are automatically enrolled for this class on Myplace.

COURSE REGULATIONS

General and Course Regulations for all BSc, BA (Bachelor) and MMath (Integrated Masters) degrees are published on the University website:

https://www.strath.ac.uk/studywithus/academicregulations/

Please read the regulations for your degree course carefully, in particular, the information about compulsory and optional modules available to you in Year 3, progress requirements and the award of degrees.

MMath & BSc HONOURS MATHEMATICS AND STATISTICS

The Department offers students on the BSc Honours Mathematics degree course the option of graduating with a BSc Honours degree in Mathematics **and Statistics** at the end of their fourth year. Similarly, MMath Mathematics students may opt for MMath Mathematics **and Statistics**. Generally, students cannot be registered on the Mathematics and Statistics degrees in Years 1–3 but have the option of transferring *after they have met the requirements for progress into Year 4.*

The option of graduating in Mathematics and Statistics will be available to students who have completed an appropriate amount of statistics as part of their degree course. (This is in order to achieve Royal Statistical Society accreditation.) For our degree structure, this involves students choosing at least 2 modules from MM354, MM357, MM358, MM360 and also some restrictions in Year 4.

BSc PASS DEGREE COURSES

Most students in Year 2 are currently registered on BSc Honours or MMath degree courses. If you are considering a BSc degree course (sometimes known as a BSc Pass degree) in Year 3 or are transferred down to a BSc degree course by the Faculty Examination Board, you will find the curriculum requirements in the appropriate course regulations. In BSc Pass degrees, your curriculum can include some lower level optional modules and electives in an subject area.

Any Year 2 students currently on a BSc Pass degree course can request to transfer into Honours provided they meet the appropriate criteria (e.g. overall credit total, passes in specific modules, etc.).

If you are transferred down to a BSc Pass degree by the Faculty Examination Board in June or August/September, but still allowed to progress into Year 3, you may have to resubmit a provisional curriculum, especially if you decide to choose low level optional or elective modules.

If you wish to discuss the BSc Pass degree option, or transfer up to BSc Honours, please contact the Year Co-ordinator.

BSc HONOURS MATHEMATICS WITH TEACHING (INCL. MWT INTERNATIONAL)

The Mathematics with Teaching degree involves:

- three 20 credit level 3 modules in semester 1,
- one 60 credit level 4 super-module, MM441, in semester 2.

The module MM441 comprises 60 credits chosen from modules MM407, MM408, MM409 and MM415. The 60 credit module will appear on your list of modules on PEGASUS automatically. When choosing your provisional curriculum for approval, you should submit your choice of three individual level 4 modules which will comprise MM441.

FACULTY EXAMINATION BOARD & PROGRESS INTO YEAR 4

The Science Faculty Examination Board meets in June, and again in August/September, to discuss the performance of every student in Years 1 to 3 on our degree courses. The Examination Board decides whether students are permitted to progress into subsequent years of study. These decisions are based on course regulations and very strict guidelines published by the Department and the University. The Faculty Board of Examiners also takes into account valid Personal Circumstances lodged with Student Business and/or recorded on PEGASUS.

Some of the Examination Board guidelines/course regulations and their implications for student progress are summarized below:

- In order to progress into Year 4 of Mathematics and Statistics BSc Honours degree courses, students require

  360 credits from the course curriculum **AND** ***a credit-weighted average mark of at least 40% in their level 3 (and above) modules at their first attempts***.

  The 360 credits must include an appropriate number at level 3 or above (often 120 credits) and any compulsory modules, as published in the University course regulations.

  Progress into Year 4 of MMath degree courses requires a credit weighted average mark of at ***least 60% in level 3 modules at the first attempt***.

- For any student who achieves at least 60 credits from the Year 3 curriculum, but fails to reach a total of 360 credits by September (or the appropriate number of level 3/level 4 credits), the registration status will normally be changed to ***Academic Assessment Only (previously Academic Suspension)***.

  This means that you do not progress into Year 4 in the following session, nor can you re-attend the Year 3 modules. Instead, you may be permitted to resit the final assessment in any outstanding module the following academic session.

  Note: You are entitled to **two** attempts at a module assessment. While the Exam Board may allow one or two extra attempts, it is not automatic.

- BSc Honours students who fail to obtain an average mark of 40% at the first attempt may be transferred from BSc Honours onto the corresponding BSc Pass degree course (or BSc Mathematics if appropriate).

  MMath students who fail to obtain an average mark of 60% at the first attempt may be transferred from MMath onto the corresponding BSc Honours degree course (if their average is at least 40%) or the appropriate BSc Pass degree (if their average is below 40%).

- Students who fail to achieve at least 60 credits from their Year 3 curriculum by September will be withdrawn from their degree course. (If appropriate, the student may be awarded the Diploma or Certificate of Higher Education.)

FINAL HONOURS ASSESSMENT

BSc Honours degrees (but not Pass degrees) are classified as:

I First, II(i) Upper Second, II(ii) Lower Second, III Third.

Final Honours assessment at the end of Year 4 is based on your **first assessed attempt in compulsory and specified modules at levels 3 and 4.**

The first requirement for the award of an Honours degree is successful completion of Year 4 in order to obtain 120 credits at level 4. On most courses (not Mathematics with Teaching (MwT)), 120 credits are awarded if a student's overall Year 4 average is at least 40%. For the MwT course, credits are obtained from each individual Year 4 module.

Given that this is achieved, the composite mark for Final Honours assessment, ***C***, is calculated using the Faculty of Science Honours assessment algorithm:

$$C = \frac{m \times L3 + 3n \times L4}{m + 3n}$$

where ***L3***, ***L4, m*** and ***n*** are, respectively, the level 3 average mark, level 4 average mark, number of level 3 credits attempted and number of level 4 credits attempted.

In most, **<u>but not all</u>**, of our degree courses, students attempt an equal number of level 3 and level 4 modules. (Normally 120 credits at level 3 in Year 3, 120 credits at level 4 in Year 4.) In this case, the Faculty algorithm simplifies significantly:

$$C = 0.25 \times L3 + 0.75 \times L4$$

The class of Honours awarded is based upon the guidelines in the table below.

C:	**<40**	**40 – 49**	**50 – 59**	**60 – 69**	**≥70**
degree:	**Pass**	**III**	**II(ii)**	**II(i)**	**I**

Borderline cases are given very careful consideration.

The 5-year MMath degree is awarded "with Distinction" or "with Merit", based upon performance in Years 4 and 5. Details will be provided to MMath students when provisionally registering for fourth year modules.

<u>Notes</u>

- It is **<u>the first attempts</u>** at examinations that are used for Final Honours assessment. Resits may be required to gain sufficient credits to proceed into Year 4, but normally resit marks will not play a role in Final Honours assessment.
- Under normal circumstances, there are **<u>no resits</u>** of Year 4 examinations. The award of Year 4 credits is based upon your overall year performance (or individual modules for the Mathematics with Teaching degree).
- BA Joint Degree students should consult their Business/HASS Adviser about degree classifications.

CHOICE OF CURRICULUM

To help you choose your Mathematics and Statistics level 3 modules (or modules), please consult the Myplace page

Mathematics & Statistics, Information for current students.

All students on our degree courses are registered for this class on Myplace. It contains information about all aspects of our modules, including background details on the topics covered. You can also consult with the lecturer currently in charge of a particular module if you want further information. When choosing your curriculum, please note the following points.

- You should ensure that you have taken or are taking any stated pre-requisites for a module.
- Ensure a reasonable split of modules between Semester 1 and Semester 2. In most cases this will be 60 credits in each semester. For some degree courses you have the option of choosing more than 60 credits in one semester (e.g. 70/50 or 80/40), but please be aware that, e.g. 80 credits in one semester may be very challenging.
- Student Business will allow you to amend your curriculum up to the end of the second week in each teaching semester. In other words, any provisional curriculum you submit in March is not final. Indeed, we suggest that you sample the lectures in all optional modules available to you at the start of each semester before making a final decision.
- Once it becomes available, check your provisional timetable to ensure that the lectures for your modules do not clash. (Do not focus on tutorial clashes at this stage — alternatives are often available.)

INFORMATION ON COMPULSORY AND OPTIONAL MODULES

The tables below contain information about the compulsory and optional modules for each Department of Mathematics and Statistics Honours and MMath degree course in Year 3.

- Normally students are expected to choose a curriculum of 120 credits in Year 3.
- All modules with leading digit "3" (e.g. MM351, MM303, CS308, PH352, …) are at level 3; modules with leading digit "4" are at level 4.
- This information is subject to change — refer to the Course Regulations document for the latest details. Information about all modules can be found at the University's Module Catalogue (or Class Catalogue):

  https://pegasus.mis.strath.ac.uk/modulecatalogue/#/find-modules
- MM modules in semester 1: MM351, MM352, MM353, MM354;
  MM modules in semester 2: MM303, MM306, MM355–MM360

<table>
<tr><th>Degree course</th><th>Compulsory modules</th><th>Optional modules</th></tr>
<tr><td>Mathematics
&
Mathematics and Statistics*
(BSc Hons & MMath)</td><td>MM351, MM352</td><td>80 credits (at most four 10-credit modules) from:
MM303, MM306, MM353, MM354, MM355, MM356, MM357, MM358, MM359, MM360*</td></tr>
<tr><td colspan="3">* Students intending to graduate with BSc Honours or MMath in Mathematics and Statistics have to choose at least 2 modules from MM354, MM357, MM358, MM360.</td></tr>
<tr><td>Mathematics with Teaching</td><td>MM351, MM352, MM353</td><td>60 credits from:
MM407, MM408, MM409, MM415
(This builds the super-module MM441 in semester 2.)</td></tr>
<tr><td>Mathematics and Computer Science</td><td>MM351, CS308</td><td>80 credits from:
MM303, MM306, MM353, MM356, MM359, CS310, CS312, CS316, CS317, CS378</td></tr>
<tr><td colspan="3">CS308 Building Software Systems (20 credits, semester 1)
CS310 Foundations of Artificial Intelligence (20 credits, semester 2)
CS312 Web Applications Development (20 credits, semester 1)
CS316 Functional Programming (20 credits, semester 1)
CS317 Mobile App Development (20 credits, semester 2)
CS378 Introduction to Human Computer Interaction (20 credits, semester 1)

Students have to choose at least 20 credits from MM303, MM306, MM353, MM356, MM359 and at least 20 credits from CS310, CS312, CS316, CS317, CS378.</td></tr>
</table>

<table>
<tr><th>Degree course</th><th>Compulsory modules</th><th>Optional modules</th></tr>
<tr><td>Mathematics and Physics</td><td>MM351, PH326, PH327, PH384</td><td>40 credits from:
MM306, MM353, MM356, MM359</td></tr>
<tr><td colspan="3">PH326 Condensed Matter Physics (20 credits, semester 1)
PH327 Gases, Liquids and Thermodynamics (20 credits, semester 2)
PH384 Quantum Physics and Electromagnetism (20 credits, full year)</td></tr>
<tr><td>Mathematics, Statistics and Accounting</td><td>MM351, MM352, AG308, AG309, AG310, AG311</td><td>40 credits (at most two 10-credit modules) from:
MM306, MM353, MM354, MM357, MM358, MM360, AG314**</td></tr>
<tr><td colspan="3">AG308 Auditing and Assurance (10 credits, semester 2)
AG309 Governance and Accounting Ethics (10 credits, semester 1)
AG310 Contemporary Management Accounting (10 credits, semester 2)
AG311 Advanced Financial Reporting (10 credits, semester 1)
AG314** Taxation (20 credits, full year)

** Students seeking professional accreditation in Accounting must take AG314.</td></tr>
<tr><td>Mathematics, Statistics and Economics</td><td>MM351, MM352, EC315, EC316</td><td>40 credits from: MM306, MM353, MM354, MM357, MM358, MM360</td></tr>
<tr><td colspan="3">EC315 Topics in Microeconomics with Cross Section Econometrics (20 credits, semester 1)
EC316 Topics in Macroeconomics with Time Series Econometrics (20 credits, semester 2)</td></tr>
<tr><td>Mathematics, Statistics and Finance</td><td>MM351, MM352, AG312, AG313</td><td>40 credits from: MM306, MM353, MM354, MM357, MM358, MM360</td></tr>
<tr><td colspan="3">AG312 Advanced Corporate Finance and Financial Markets (20 credits, semester 1)
AG313 Treasury Management and Derivatives (20 credits, semester 2)</td></tr>
<tr><td>Mathematics, Statistics and Business Analysis</td><td>MM351, MM352, MS311, MS361</td><td>40 credits from: MM306, MM353, MM354, MM357, MM358, MM360</td></tr>
<tr><td colspan="3">MS311 Knowledge and Innovation Management (20 credits, semester 2)
MS361 Understanding and Optimizing Business Systems (20 credits, semester 1)</td></tr>
<tr><td>Data Analytics</td><td>MM351, MM352, CS308</td><td>40 credits from:
CS310, CS312, CS316, CS317
(+ 20 credit elective)</td></tr>
<tr><td colspan="3">For the modules CS308, CS310, CS312, CS316, CS317 see previous page (Mathematics and Computer Science).</td></tr>
</table>

MATHEMATICS AND STATISTICS LEVEL 3 MODULES

Semester 1

MM351 **Applied Linear Algebra**
Credits: 20
Pre-requisites: MM201 or equivalent.
Students: Compulsory: all

MM352 **Regression Modelling**
Credits: 20
Pre-requisites: MM204 or equivalent
Students: Compulsory: M, MS, MWT, MP, MSA, MSE, MSBA, MSF, BA, DA

MM353 **Partial Differential Equations**
Credits: 20
Pre-requisites: MM201, MM202 (essential), MM225 (desirable)
Students: Compulsory: MWT
Optional: M, MS, MCS, MP, MSA, MSE, MSBA, MSF, BA

MM354 **Survey Design and Analysis**
Credits: 10
Pre-requisites: MM204 or equivalent
Students: Optional: M, MS, MSA, MSE, MSBA, MSF, BA

Semester 2

MM303	**Applicable Analysis 2**	
Credits:	20	
Pre-requisites:	MM201, MM203 or equivalent	
Students:	Optional:	M, MS, MCS
MM306	**Numerical Analysis**	
Credits:	20	
Pre-requisites:	MM201, ideally MM206 or equivalent.	
Students:	Optional:	M, MS, MCS, MP, MSA, MSE, MSBA, MSF, BA
MM355	**Mathematical Modelling: Dynamics and Applications**	
Credits:	20	
Pre-requisites:	MM201, MM202 or equivalent	
Co-requisites:	MM353 (desirable)	
Students:	Optional:	M, MS
MM356	**Game Theory and Applications**	
Credits:	10	
Pre-requisites:	MM201, MM204 or equivalent	
Students:	Optional:	M, MS, MCS, MP
MM357	**Experimental Design**	
Credits:	10	
Pre-requisites:	MM107, MM204 or equivalent	
Students:	Optional:	M, MS, MSA, MSE, MSBA, MSF, BA
MM358	**Statistical Inference**	
Credits:	10	
Pre-requisites:	MM202, MM204 or equivalent	
Students:	Optional:	M, MS, MSA, MSE, MSBA, MSF, BA
MM359	**Algebraic Structures**	
Credits:	10	
Pre-requisites:	MM143 (essential), MM145/8 (desirable)	
Students:	Optional:	M, MS, MCS, MP
MM360	**Stochastic Processes**	
Credits:	10	
Pre-requisites:	MM201, MM202, MM204 (essential), MM203 (desirable)	
Students:	Optional:	M, MS, MSA, MSE, MSBA, MSF, BA

Note: the Department reserves the right to alter the available modules at short notice; therefore the list of available modules and the semester in which they are provided may be subject to change.

MATHEMATICS AND STATISTICS MODULES — ADDITIONAL INFORMATION

The next pages contain the syllabuses of these modules.

MM303 Applicable Analysis 2

20 credits, Semester 2

Pre-requisite modules: MM201, MM203 or equivalent

Students: Optional for M, MS, MCS

Metric spaces: Definition of a metric; Examples to include d_1, d_2, and d_∞ on $\mathbb{R}^n$ ($\mathbb{C}^n$), infinite sequences, C[a,b], the discrete metric. Convergent and Cauchy sequences, uniqueness of limit, completeness. Closed sets and closures. Uniform convergence in C[a,b]. Continuous mappings, including criterion in terms of sequences. Derivation of the Contraction Mapping Principle and application to, e.g. existence and uniqueness of solutions of ODEs.

Normed vector spaces: Definition of a norm. Standard examples of normed vector spaces. Convergence of sequences and infinite series in a normed vector space. Continuity of the norm. Equivalent norms. Banach spaces, including standard examples of l^p, C[a,b] and finite-dimensional normed vector spaces; brief discussion of L^p spaces. Connection between complete subspaces and closed subspaces.

Inner product spaces and Hilbert spaces: Definitions and properties of inner product spaces and Hilbert spaces. Schwarz inequality, parallelogram law, orthogonality, orthogonal complements. Examples of Hilbert spaces: Euclidean space $\mathbb{R}^n$, unitary space $\mathbb{C}^n$, Hilbert sequence space l^2 and function space $L^2[a,b]$. The Projection Theorem and its application to approximation problems. Properties of orthonormal sequences. Fourier coefficients, Bessel inequality, Parseval relation. Gram-Schmidt process. Examples to include the usual complex Fourier expansion, and the Legendre and Hermite polynomials.

Continuous linear operators on normed vector spaces: Definition of a continuous linear operator, the range and kernel of an operator and standard properties of continuous linear operators. Definition of a bounded linear operator and connection with continuous linear operators. Examples of bounded linear operators including integral operators on C[a,b].

MM306 Numerical Analysis

20 credits, Semester 2

Pre-requisite modules: MM201, ideally MM206 or equivalent

Students: Optional for M, MS, MCS, MP, MSA, MSE, MSBA, MSF

Programming essentials: Introduction to Python with emphasis on improving skills to translate pseudocode into executable Python syntax through example codes for simple mathematical problems. Introduction to stability analysis of numerical methods.

Least-squares approximation: Exploration of discrete and continuous approximation techniques. Derivation of normal equations and review of direct methods. Iterative methods e.g. the Kaczmarz algorithm.

Interpolation: Polynomial data fitting. Lagrange interpolation. Error estimation and strategies for choosing optimal interpolation points. Introduction to polynomial approximation.

Numerical integration: Foundational integration techniques with error estimates. Connections between integration and interpolation. Degree of precision, Newton-Cotes formulas and associated error analysis. Advanced topics in quadrature and introduction to Montecarlo integration.

Solving nonlinear systems of equations: Fixed point methods including the fixed point theorem, algorithmic implementation, and convergence criteria. Root finding for one-dimensional functions with the secant and Newton’s method. Solution of systems of nonlinear equations using Newton's method with convergence analysis.

MM351 Applied Linear Algebra

20 credits, Semester 1

Pre-requisite modules: MM201 or equivalent

Students: Compulsory for all

Vector spaces: Revision of MM201 material. Subspaces. Linear independence. Bases. Ranks. Dimension.

Matrix algebra: Geometric interpretation of matrix-vector operations. Matrices and linear mappings, rotations, reflections, dilations. Solution of linear equations. The matrix inverse and conditioning. Matrix factorisations.

Eigenvalues and eigenvectors: Basic definitions. Algebraic and geometric multiplicity of eigenvalues. The spectral theorem. Jordan and Schur form. Gershgorin's theorem. Invariant subspaces.

Orthogonality: Orthogonal bases. Gram-Schmidt and alternatives. Projections.

Numerical linear algebra: Matrix decompositions such as the QR decomposition, iterative methods for computing eigenvalues and solving linear systems. Reliable computations. Applications.

MM352 Regression Modelling

20 credits, Semester 1

Pre-requisite modules: MM204 or equivalent

Students: Compulsory for M, MS, MWT, MP, MSA, MSE, MSBA, MSF, BA, DA

Multiple Regression: Review of simple linear regression; multiple regression; interaction terms; regression diagnostics; examples and interpretation of R output.

Generalised Linear Model: Introduction to principles; hypothesis testing; dummy/indicator variables; examples and interpretation of R output.

Transformations and Variable Selection: Ladder of power transformations; one-bend and two-bend relationships; non-constant error variance; non-normal errors; Box–Cox method; variable selection methods and criteria; all possible subsets regression; stepwise methods (forward, backward, and stepwise); model validation; examples and interpretation of R output.

Further Regression Techniques: Introduction to generalised linear models (GLMs), generalised additive models (GAMs), and penalised regression; examples and implementation in R; interpretation of R output.

MM353 Partial Differential Equations

20 credits, Semester 1

Pre-requisite modules: MM201, MM202 (essential), MM225 (desirable)

Students: Compulsory for MWT. Optional for M, MS, MCS, MP, MSA, MSE, MSBA, MSF, BA

Definitions of a PDE: degree, linearity, homogeneous and inhomogeneous equations, boundary and initial conditions, etc.

Fourier series and Sturm-Liouville eigenvalue problems: Fourier series, sine and cosine series; regular, singular and periodic Sturm-Liouville eigenvalue problems; eigenfunction expansions; generalised Fourier series.

Linear 1st order PDEs in two variables: Advection equation; method of characteristics

PDEs of 2nd order: Classification of 2nd order PDEs with constant coefficients; models for the wave and heat equations; solution techniques; steady-state solutions; Laplace's equation.

Method of separation of the variables: Wave, heat and Laplace equation in a rectangle; Laplace's equation in a circle; solution of PDEs using Bessel functions and Legendre polynomials.

Green's functions: Definition of Green's functions and their uses.

MM354 Survey Design and Analysis

10 credits, Semester 1

Pre-requisite modules: MM204 or equivalent

Students: Optional for M, MS, MSA, MSE, MSBA, MSF, BA

Survey Design: Methods of sampling from a population: probability and non-probability sampling. Types and sources of error. Questionnaire design. Survey administration methods. Sampling designs. Methods of estimation and standard errors. Calculating sample sizes. Estimating population sizes. Designing surveys using appropriate software (e.g. Qualtrics).

Survey Analysis: Survey data analysis using R. Cronbach's alpha. Missing data. Data imputation. LIKERT data. Ordinal regression. Interactions. Weighting survey data. Word clouds.

MM355 Mathematical Modelling: Dynamics and Applications

20 credits, Semester 2

Pre-requisite modules: MM201, MM202 or equivalent

Co-requisite modules: MM353 (desirable)

Students: Optional for M, MS

Constructing and simplifying models: Dimensional analysis and non-dimensionalisation; interpreting dimensionless parameters; linearisation and small-parameter approximations, as well as other ways to simplify a model.

Autonomous second-order dynamical systems: Phase portraits and trajectories; canonical linear systems; equilibria of nonlinear systems and their stability; limit cycles; bifurcations.

Linear partial differential equations: Diffusive processes and the heat equation; asymptotics; self-similar solutions and other solution techniques such as separation of variables; linear stability of steady states and analysis of perturbations.

These techniques will be demonstrated with applications to areas which may include physics, physiology, chemistry and economics.

MM356 Game Theory and Applications

10 credits, Semester 2

Pre-requisite modules: MM201, MM204 or equivalent

Students: Optional for M, MS, MCS, MP

Introduction history, application areas, classification of games

Zero-sum games: Key concepts: dominant strategies, pure/mixed strategies, expected payoff. Solution methods: Minimax theorem, algebraic and geometric methods, linear programming methods. Application areas: e.g. modelling conflict, distribution of resources

Non-zero-sum games: Key concepts: best response, dominant strategies, expected payoff. Solution methods: Nash equilibrium, algebraic and geometric methods, iterative elimination. Application areas: coordination with conflicting preferences, cooperation for higher rewards.

Extensive form games: Key concepts: game tree, actions, strategies, information sets. Solution methods: Backward induction, subgame perfection equilibrium. Application areas: Climate negotiations

MM357 Experimental Design

10 credits, Semester 2

Pre-requisite modules: MM107, MM204 or equivalent

Co-requisite modules: MM352

Students: Optional for M, MS, MSA, MSE, MSBA, MSF, BA

The module will cover principles of experimental design including how to analyse designs such as: Completely Randomised; Random Block; Factorial; Nested; Repeated Measures.

Analysis of variance and general linear models will be introduced with considerations to interactions and fixed and random effects. Differences will be explored using pairwise comparisons methods and linear contrasts.

MM358 Statistical Inference

10 credits, Semester 2

Pre-requisite modules: MM202, MM204 or equivalent

Students: Optional for M, MS, MSA, MSE, MSBA, MSF, BA

Introduction: Introduction to statistical inference. Discrete and continuous probability models. Multivariate distributions, marginal and conditional distributions. Independence of random variables. Expectation, variance, covariance, correlation. Generating functions. Transformations of random variables.

Estimators: Maximum Likelihood estimation. Sufficient statistics and factorisation theorem. Properties of estimators. Efficiency. Method of Moments estimation.

Confidence intervals.

Large sample results and properties of estimators: Asymptotic properties of estimators and large sample confidence intervals.

Tests: Hypothesis testing: classical framework, type I and II errors, power.

MM359 Algebraic Structures

10 credits, Semester 2

Pre-requisite modules: MM143 (essential), MM145/8 (desirable)

Students: Optional for M, MS, MCS, MP

The main aim will be to introduce groups, rings and fields. A selection of the types of topics covered is given below.

1. Sets and cardinality, countable and uncountable sets, Cantor's theorem.

2. Equivalence relations, equivalence classes, partitions.

3. Binary operations and semigroups.

4. The group axioms, symmetry and permutation groups.

5. Cyclic groups, subgroups and homomorphisms.

6. Cosets and Lagrange's theorem.

7. Groups actions on sets, orbits and stabilisers.

8. Rings and fields.

9. Ring homomorphisms, integral domains and the integers.

10. Finite fields and applications.

MM360 Stochastic Processes

10 credits, Semester 2

Pre-requisite modules: MM201, MM202, MM204 (essential), MM203 (desirable)

Students: Optional for M, MS, MSA, MSE, MSBA, MSF, BA

Markov chains: Markov property, n-step transition probabilities, classification of states, stationary distribution, 1st-step analysis, simple random walk.

Poisson processes: Independent and stationary increments, inter-arrival and waiting time distributions, thinning, superposition.

Renewal processes: Risk models, renewal sequence, renewal process, arrival times, inter-arrival times, renewal function and equation, renewal theorem.

Queueing theory: Poisson arrivals, exponential service times, probability distribution of queue size, stationary distribution. Different queue types

MM407 Applied Statistics in Society

Pre-requisite modules: MM204 (essential); MM206, MM352 (desirable).

Students: Compulsory for students in 4th year of BSc Honours or MMath in Mathematics and Statistics. Optional for 4th year students in other BSc Honours or MMath Mathematics-based degrees. Optional for 3rd year students, BSc Honours Mathematics with Teaching degrees.

This module is focussed on the application of statistics to real life problems. Several topics are covered each year and taught by staff with professional experience working in specific areas of applied statistics. Although some theory is necessary for a comprehensive understanding of the methodology, the emphasis of the module is on the applications of these statistical methods and students will have the opportunity to work on some real-world data sets using statistical software packages. Examples of topics included in this module are:

Survey Design and Analysis: Surveys are a tool to collect samples of observational data from a population and are used for various different purposes, e.g. market research, opinion polling and pre-election polling.

The lectures present basic concepts of survey sampling, practical issues such as minimising sources of error in survey results, several different approaches to selecting the sample from the population and the corresponding theory of estimation for each of these approaches. For estimation, the concepts of expected value, bias and unbiasedness, variance, covariance, precision and efficiency from MM304 are relevant. Although the derivation of the estimators and their properties is algebraic, the emphasis of the survey design and analysis material is applied and practical.

There will be several practical classes illustrating different aspects of the lecture material and using the SPSS software, students will have the opportunity to analyse some questionnaire data collected at Strathclyde from a series of surveys designed to investigate honey bee colony losses in Scotland. Aspects of these surveys will also be used to illustrate the lectures.

Quantitative Risk Analysis: Most people have an intuitive understanding of what risk is. In this module we aim to formalise this understanding and develop models to quantify risk. Quantification of risk relies on many statistical methods, some of which you will be familiar with. The emphasis in this course is the practical use of such methods, although some new methods will be introduced. In this course you will appreciate the difference between uncertainty and variability, quantify uncertainty using methods such as bootstrapping and Bayesian inference, fit appropriate probability distributions to data, build risk analysis models in R and finally communicate your results as written reports.

All theory will be implemented practically via computing sessions using the statistical software R. You will learn to create bespoke functions in R to implement your models and use summary statistics and plots to communicate your results. This topic builds on the statistical methods outlined in MM204 and the computing techniques covered in MM206.

Assessment: The format is continuous assessment and is a mixture of project work, lab based assessment and written class tests, with each contributing to the overall course mark.

MM408 Mathematical Biology and Marine Population Modelling

Pre-requisite modules: MM353.

Students: Optional for students in 4th year of BSc Honours or MMath Mathematics-based degrees (except Data Analytics).
Optional for 3rd year students, BSc Honours Mathematics with Teaching degrees.

Mathematical models have become an indispensible tool in understanding how biological systems work. In fact, in many cases the models provide scientists with the only means of making predictions about how biological systems will change or respond to human impacts. Will the population of an invasive non-native species grow or die out? Will a disease outbreak occur or not, and if it does can the disease become endemic? Under what situations can the immune system suppress a growing tumour? How did the leopard get its spots? Are there plenty more fish in the sea, and how do you know? How can marine populations be harvested sustainably? These are some of the biological questions to which you will encounter in this course, and which you can address using your mathematical skills.

The course is delivered in two 5-week parts. Part one will focus on the use of ordinary differential equations, difference equations, and delay differential equations in mathematical biology. You will be introduced to phase-line plots as a graphical means of analyzing systems with one state variable, and phase diagrams for two-dimensional systems. The use of linear stability analysis in understanding the dynamics near steady states will also be explained. You will learn how delay differential equations can be used to represent biological processes, such as breathing or population growth with reproductive delays, and learn how to calculate critical values of a delay required for system stability. Throughout, examples will be drawn from population ecology with particular emphasis on marine populations and ecosystems, including how to obtain maximum sustainable yields from fisheries, and how to analyze the stability of difference equation models for seasonally reproducing fish stocks. Other examples will include bacterial growth, the spread of infectious diseases, and enzyme kinetics.

Part two deals with biological systems which display, not only temporal variation, but also considerable spatial variation. Examples of such systems include the geographical spread of diseases, such as swine flu and foot and mouth disease, the growth and spread of a cancer, and the formation of a fully formed organism from an initial fertilized cell during embryonic development. The usual approach for representing processes of this type is to use partial differential equations. You will be introduced to a class of PDEs known as reaction-diffusion equations. These have been used in mathematical models that have been proposed as possible explanations of why specific spatial patterns occur in the coats of certain animals, such as leopards, zebras, giraffes and, closer to home, belted Galloway cattle. Reaction-diffusion equations also appear in mathematical models of wound healing, nerve signalling and the spatial spread of diseases. In connection with pattern formation, you will learn about a possible explanation that involves a mechanism called diffusion-driven instability. In the case of models of phenomena such as wound healing and cancer growth, you will discover the important role played by travelling wave solutions to reaction-diffusion equations.

The course runs over 10 weeks, with four hours of lectures and one tutorial each week. General feedback on your work will be provided in the tutorials. Additionally, you will have the option of working in small groups in order to submit answers to exam-style questions for grading and feedback. The assessment is in the form of a single three-hour final exam.

MM409 Mathematical Introduction to Networks

Pre-requisite modules: MM201.

Students: Optional for students in 4th year of BSc Honours or MMath Mathematics-based degrees.
Optional for 3rd year students, BSc Honours Mathematics with Teaching degrees.

One cannot ignore the networks we are part of and surrounded by in everyday life. There are our networks of family and friends; the transport networks; the telephone networks; the distribution network that shops use to bring us things to buy; the banking network; it doesn't take much effort to come up with dozens of examples. Analysis of networks, particularly the huge networks that drive the global economy (directly or indirectly) is a vital science; and mathematicians play an important role in the new science of networks.

Some of the mathematical tools we need to perform this analysis may be familiar to you and we start the course by collecting together the key ideas from graph theory and linear algebra that will be useful to us, such as node degree, network connectivity and the spectrum of a matrix. Some of the tools met before in linear algebra will need to be honed in order that they can be applied to networks: for example, you'll need to understand properties of nonnegative matrices and also what a function of a matrix means too. The first half of the module will equip you with the necessary armoury and starts to provide the context for their application.

The second part of the course introduces you to the modern concepts of networks, from the ‘small-world’ phenomenon to the characterisation of the importance of individuals in a network. We develop combinatorial and algebraic methods for quantifying small fragments in giant networks, to characterise the global structure of a network and to generate random models that emulate real-world networked systems. The course combines the theoretical development of these tools with the practical solution of mathematical problems and the computational methods needed to attack these problems in a real-world environment.

MM415 Medical Statistics

Pre-requisite modules: MM204 (essential); MM352 (desirable).

Students: Optional for 4th year students in BSc Honours or MMath Mathematics-based degrees.
Optional for 3rd year students, BSc Honours Mathematics with Teaching degrees.

Medical Statistics: **Medical statistics is the application of statistical methods to the field of medicine and medical practice.** It is the science of summarising, collecting, presenting, analysing and interpreting data in medical studies, and using this to answer research questions. It also has applications in the pharmaceutical industry which includes design of experiments, analysis of drug trials, and issues of manufacturing a medicine commercially (e.g. efficacy, safely, expiration dates and packaging).

The course is taught as a mix of lectures and computer labs using the statistical analysis packages Minitab and SPSS. Topics covered include survival analysis, experimental design (including clinical trials, cross-over designs and placebo controlled trials), sampling and observational studies (including cohort, cross-sectional and case/control studies), categorical data analysis, power and sample size computations, non-parametric hypothesis, tests, control charts and methods for analysing clinical measurements e.g. ROC curves for diagnostic testing and the construction of reference ranges. Many of the statistical methods build on ideas from MM204 but tailor the methods to suit medical type data which can be less robust than data generated from more controlled scientific studies.

Much of the course deals with the interpretation of statistical results in the context of the medical problem being investigated. This skill is necessary for the application of statistics to medical data which often differs from the traditional, standard interpretation of statistical textbook problems. Lectures will be used to explain the mathematical theory behind the statistical methods and to demonstrate the application of the statistical methods using real life medical examples. In the computer labs, students will apply the statistical methods taught in lectures to real life medical research studies using statistical software – mainly Minitab and SPSS.

The module is assessed by a group project and computer lab test. The computer lab test will be worth 70% of the final mark for the module with the remaining 30% coming from the group project.