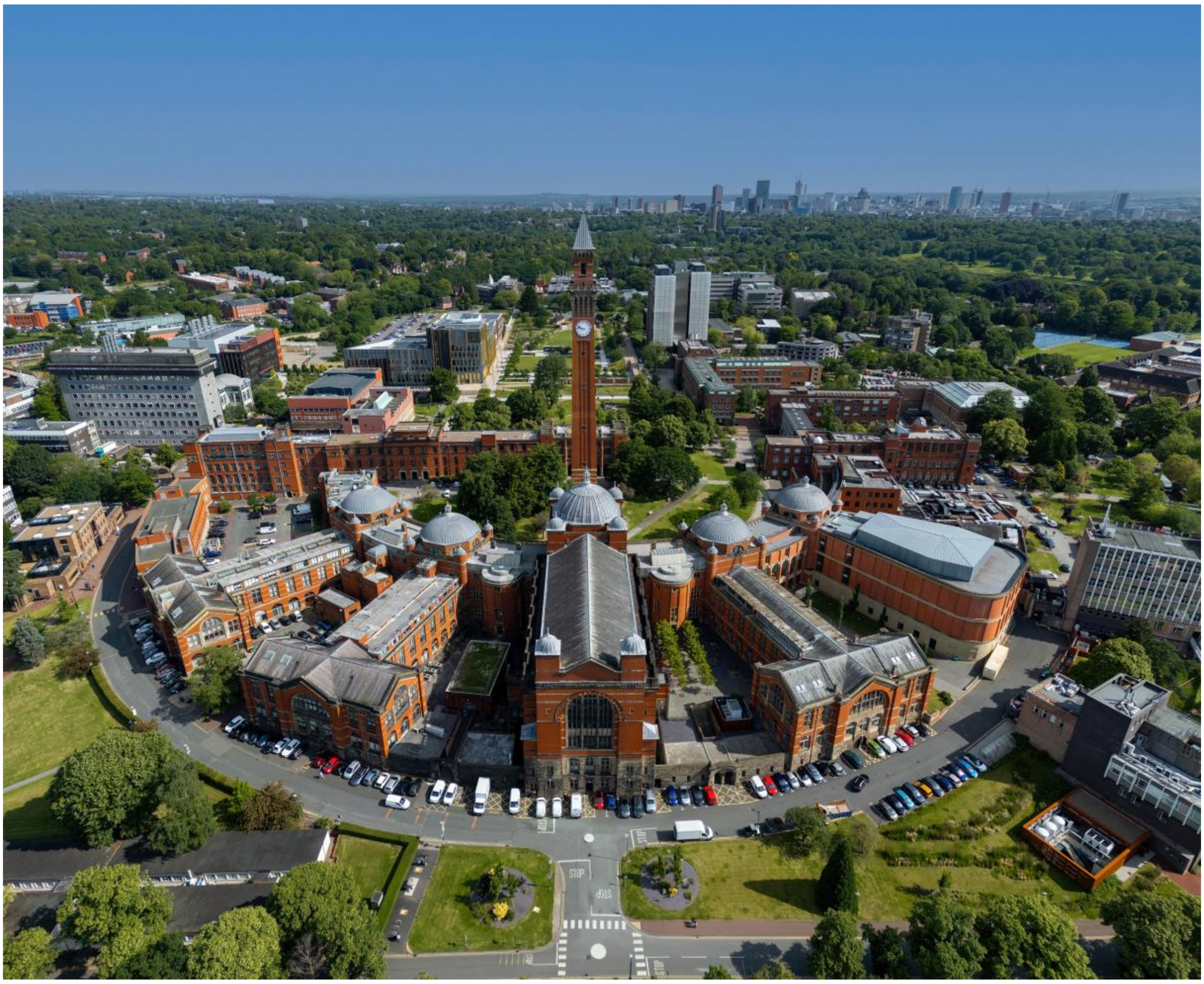
UNIVERSITY OF BIRMINGHAM

2024 / 2025 SCHOOL OF MATHEMATICS

STUDY ABROAD MODULE HANDBOOK



INTRODUCTION:

This booklet sets out the modules offered to exchange students visiting the School of Mathematics at the University of Birmingham in 2024-25.

Credits

If a student is here for one semester they should take 60 credits. If a student is here for a full year they should take 120 credits. Students who are here for both Semester 1 and 2 should ideally take 60 credits in each semester.

Selecting Appropriate Modules

Exchange students come to Birmingham from a wide variety of countries, and they will be at different stages of their degrees. Incoming students may take modules that are aimed at first year students, second year students and third year students.

Students must check that their home university is happy with their module selections. This responsibility is with the student.

Please note that, due to large demand for certain modules, you may not always get your first choice due to lecture room size restrictions.

Mathematics School Modules

At the School of Mathematics you can only select modules from a given set of options from the semester(s) you will be studying for:

Semester 2: January – June (spring term)

These options are designed to offer a coherent study while ensuring that there are no clashes in the timetable.

You need to communicate your choice with the education support office at the School of Mathematics. We have a strict deadline for changing modules, and modules cannot be changed under any circumstances after this deadline.

Non-Mathematics School Modules

Students may take modules from other schools if their home university permits this and if it is compatible with the student's timetable. However, it is the student's responsibility to find out whether the timetables are compatible, and to get in touch with different tutors and education support offices in each school to make such arrangements possible. The staff in the School of Mathematics will only deal with School of Mathematics modules.

Students affiliated with the School of Mathematics who are here for Semester 1 or 2 only may take up to 20 credits of non-mathematics school modules.

Students affiliated with the School of Mathematics who are here for both Semester 1 and 2 may take up to 40 credits of non-mathematics school modules.

Pre-requisites

Some modules will require students to have previously studied the subject or demonstrate study at a similar level.

Examinations

At the School of Mathematics, exams occur during the main summer exam period. For semester 1 and 2 only students, an alternative assessment will be put in place and will be contacted by the School of Mathematics Education Support team to confirm details.

Disclaimer

The contents of this booklet were accurate when it was compiled. Modules and exam formats change from year to year. Please note that the semester in which modules are taught may be subject to change.

For further information or guidance, please contact the Mathematics Exchange Tutor:

maths.ugexchanges@contacts.bham.ac.uk

For the maths education support office, please contact:

mat-phys-admin@contacts.bham.ac.uk

Semester 2 options

Option 1:

Module Code	Module Title	Credits	Year
25670	LI Differential Equations	20	2
22515	LH Applied Statistics	20	3
19590	LH Heuristic Optimisation	10	3
21624	LH Combinatorial Optimisation	10	3

You may take either all modules amounting to 60 credits or all Year 3 modules amounting to 40 credits.

Option 2:

Module Code	Module Title	Credits	Year
25765	LI Linear Programming	10	2
25671	LI Statistics	20	2
19590	LH Heuristic Optimisation	10	3
32281	LH Multicriteria Decision Making	10	3
21624	LH Combinatorial Optimisation	10	3

You may take either all modules amounting to 60 credits or all Year 3 modules together with LI Linear Programming amounting to 40 credits.

Option 3:

Module Code	Module Title	Credits	Year
25670	LI Differential Equations	20	2
25665	LI Algebra and Combinatorics	20	2
31131	LH Computation	10	3
33914	LH Numerical Linear Algebra	10	3

You may take both Year 3 modules amounting to 20 credits. You may combine these with up to two of the Year 2 modules amounting to 40 or 60 credits depending on whether you choose one or two Year 2 modules.

Option 4:

Module Code	Module Title	Credits	Year
25665	LI Algebra and Combinatorics	20	2
25671	LI Statistics	20	2
25670	LI Differential Equations	20	2
22515	LH Applied Statistics	20	3

You may take either all Year 2 modules amounting to 60 credits or LH Applied Statistics and LI Algebra and Combinatorics amounting to 40 credits (no other combination is possible due to timetable clashes). You may also take a single module amounting to 20 credits.

Year 2 modules

LI Algebra and Combinatorics

Module Code: 27142
Credits: 20
Level: LI
Taught: Semester 2
Assessment Method: Coursework (20%), Exam (80%)

Module Description: Algebra, or more accurately abstract algebra, extends the ideas of multiplication and addition in sets of matrices or real numbers to a more general setting. Abstraction allows us to view the results of specific calculations in a more generic setting. This is a core objective of pure mathematics. It means that a single theorem can be applied in many different mathematical situations. The primary algebraic objects are groups, rings and fields and these will be the main players in the algebra part of the module. This second module builds on the first year algebra course, extending results and producing new ideas which help us gain a deeper understanding of the algebraic structures which govern mathematics.

The fundamental notions which will be introduced are substructures, structure preserving functions and quotient structures and the course will introduce these ideas illustrating them with numerous examples. Combinatorics studies discrete mathematical structures. These structures are very simple themselves, but they often give rise to incredibly complex problems that are beyond the capacity of current computers to solve. Combinatorics is an essential component of many mathematical areas and also has important applications in Computer Science, Physics, Economics and Biology.

The Combinatorics part of the module consists of three topics. The first discusses advanced counting arguments, illustrating links to other areas of Mathematics. The second consists of topics in Graph Theory. There are many beautiful results in this area (e.g. the four colour theorem). These results are easily accessible but often require surprising ideas. The third topic builds on the previous two and deals with Combinatorial Algorithms and their efficiency, thus emphasizing links between Combinatorics and Computer Science.

LI Differential Equations

Module Code: 25670
Credits: 20
Level: LI
Taught: Semester 2
Assessment Method: Coursework (20%), Exam (80%)

Module Description

When mathematical modelling is used to describe physical, biological, chemical or other phenomena, one of the most common results is either a differential equation or a system of differential equations, which, together with appropriate boundary and/or initial conditions, describe the situation. These differential equations can be either ordinary (ODEs) or partial (PDEs) and finding and interpreting their solution lies at the heart of applied mathematics. This module develops the theory of differential equations with a particular focus on techniques of solving both linear and nonlinear ODEs. Fourier series, which arise in the representation of periodic functions, and special functions, which arise in the solution of PDEs such as Laplace's equation that models the flow of potential, are also introduced. A number of the classical equations of mathematical physics are solved.

LI Statistics

Module Code: 25671
Credits: 20
Level: LI
Taught: Semester 2
Assessment Method: Coursework (20%), Exam (80%)

Module Description: Statistics is the study of uncertainty, which arises in all aspects of life. How long will I live for? What is the probability that Birmingham City will win the FA Cup this season? Will it rain today? What is the probability that I will win the lottery this week? Statistical theory and methods are fundamental to our understanding of such uncertainty, and are an increasingly sought after skill. For example, Google uses statistics to improve their search algorithms; medical research uses statistics to design and analyse clinical trials evaluating whether a new cancer treatment is effective; and actuarial and economic teams use statistics to make accurate predictions about future risks and outcomes.

This module presents a parallel development of statistical theory and methods, building on the introductory material in Probability & Statistics. Topics covered include classical linear models, with an introduction to the analysis of variance; basic methods for handling discrete data; further work in the theory of probability distributions; and some aspects of the theory of estimation and hypothesis testing. In the computing sessions, a statistical package is used to illustrate the application of statistical methods to the analysis of some typical data sets.

LH Linear Programming

Module Code: 25765
Credits: 10
Level: LI
Taught: Semester 2
Assessment Method: Coursework (20%), Exam (80%)

Module Description: Linear programming grew out of attempts to solve systems of linear inequalities, allowing one to optimise linear functions subject to constraints expressed as inequalities. The theory was developed independently at the time of World War II by the Soviet mathematician Kantorovich, for production planning, and by Dantzig, to solve complex military planning problems. Koopmans applied it to shipping problems and the technique enjoyed rapid development in the postwar industrial boom. The first complete algorithm to solve linear programming problems, called the simplex method, was published by Dantzig in 1947 and in the same year von Neumann established the theory of duality. In 1975, Kantorovich and Koopmans shared the Nobel Prize in Economics for their work and Dantzig's simplex method has been voted the second most important algorithm of the 20th century after the Monte Carlo method.

Linear programming is a modern and immensely powerful technique that has numerous applications, not only in business and economics, but also in engineering, transportation, telecommunications, and planning.

Year 3 modules

LH Applied Statistics

Module Code: 22515
Credits: 20
Level: LH
Taught: Semester 2
Assessment Method: Coursework (20%), Exam (80%)

Module Description: This module provides an introduction to a wide range of applicable statistical techniques. A unifying theme is the transferability of statistical ideas. Common features shared by different fields of enquiry enable the development of statistical methodologies with applications throughout science, Industry and Medicine. Examples from such fields - including the rapidly developing area of Genomics - inform every aspect of the module. Topics covered which exhibit this transferability will include survival analysis, in which there are only lower bounds on some data values, muliti factor and other generalized linear models, of use when the influences of many factors must be unravelled, data mining techniques, applying when it is desired to search out relationships and, last but certainly not least, the principles and consequences of good statistically designed studies.

LH Computation

Module Code: 31131
Credits: 10
Level: LH
Taught: Semester 2
Assessment Method: Coursework (20%), Exam (80%)

Module Description: This part of the module introduces the foundations of the Theory of Computation covering topics such as (randomised) complexity classes, P vs. NP, Las Vegas and Monte Carlo algorithms and decidability. The goal of the module is to develop a detailed understanding of the design and analysis of several efficient randomised algorithms, which provide approximate solutions to computationally hard problems such as satisfiability and Max-cut. In each part of the module practical examples supplement and illustrate the theoretical concepts developed.

The module is aimed at students with interest in theoretical aspects of computing, graph theory, combinatorics, statistics or data science. Structures arising throughout the module also play important roles in other settings, for example, in stochastic models in finance.

LH Heuristic Optimisation

Module Code: 19590
Credits: 10
Level: LH
Taught: Semester 2
Assessment Method: Coursework (20%), Exam (80%)

Module Description: Many problems from management mathematics (discrete or continuous) are NP-hard. In other words, optimisation problems that arise in industry or in public sector could not be solved exactly in reasonable computing time, even with modern computers. Therefore, when traditional mathematics techniques fail to give fast answers, one should rely on near-optimal solution methods or heuristics. Ideas of classical heuristics (several from: greedy, constructive, A* search, relaxation, local search, divide and conquer, dynamic programming, Lagrangean etc) will be studied first. A modern heuristic (metaheuristics) or general frameworks for building heuristics, usually gives rules of escaping from the so-called "local optima trap". Some modern heuristics, such as Genetic algorithms, Tabu search, Simulated Annealing, Variable neighbourhood search, Neural Networks, Ant Colony etc. will be presented.

LH Combinatorial Optimisation

Module Code: 21624
Credits: 10
Level: LH
Taught: Semester 2
Assessment Method: Coursework (20%), Exam (80%)

Module Description: Many practical problems such as train and airline scheduling, vehicle routing, production planning, resource management, telecommunications and network design can be modelled as integer or mixed-integer programs.

This part of the module presents a systematic survey of methods of optimisation for problems with discrete features, and relates them to practical problems such as finding the cheapest route through a transportation network or efficiently assigning resources to objectives. The concept of computational complexity leads to a classification of problems into grades of hardness and to the concept of the efficiency of an algorithm.

LH Communication Theory

Module Code: 19601
Credits: 10
Level: LH
Taught: Semester 2
Assessment Method: Coursework (20%), Exam (80%)

Module Description: This part of the module consists of an introduction to information theory and coding theory. The aim here is to transmit information (i) efficiently and (ii) reliably over a noisy channel. For (i), the main result will be Shannon's noiseless coding theorem, which relates coding efficiency to the entropy of a source. For (ii) we will discuss error correcting codes, including several linear codes, such as Hamming codes. Both parts of the module are linked by the methods and ideas that are used.

LH Numerical Linear Algebra

Module Code: 33914
Credits: 10
Level: LH
Taught: Semester 2
Assessment Method: Coursework (100%)

Module Description: Numerical linear algebra is the language of all scientific computing, particularly for applications arising in mathematical and engineering modelling. This module is aimed at applied mathematicians with an interest in numerical methods and more generally scientific computation. After a review of linear algebra topics and an introduction to matrix theory and computation, the module will discuss in detail methods for linear systems of equations, both direct and iterative, methods for eigenvalue problems and an introduction to fast Fourier transforms. The module will include a programming component; in particular, standard algorithmic concepts will be introduced together with notions of computational complexity and good coding practice.

Applications drawn from applied mathematics (e.g., dynamical systems, ordinary and partial differential equations etc) will be used for illustration purposes. This module will use the computer package Matlab.

LH Multicriteria Decision Making

Module Code: 32281
Credits: 10
Level: LH
Taught: Semester 2
Assessment Method: Coursework (20%), Exam (80%)

Module Description: This part of this module explores multicriteria or multiobjective optimisation where several conflicting objectives have to be optimised simultaneously: stock portfolios have to be chosen such that the portfolio maximises the return and simultaneously minimises the risk; health care has to be managed such that the service is efficient yet not too costly; hazardous material has to be transported such that risk as well as costs incurred are minimal; bridges and buildings have to be designed such that they can be built cheap but still with maximum stability etc. As such, multicriteria problems are of prime importance for decision makers in the private as well as the public sector. This module brings together various ideas from geometry and analysis in studying solutions and solution methods for multicriteria problems in management and science.

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