The LTCC fosters the training of doctoral research students in the Mathematical Sciences. Its courses cover the areas of Statistics, Applied Mathematics and Pure Mathematics, with the aim of providing students with an overview of these areas, and of acquiring a working knowledge of classical results and recent developments in their own broad research fields but outside the specialised domains of their individual research projects. There is a wide range of expertise among the staff of the institutions currently in the LTCC consortium:

- Departments of Mathematics and Statistical Science, UCL
- The School of Mathematical Sciences, Queen Mary University of London
- Department of Mathematics, Imperial College London
- Department of Mathematics, King's College London
- Departments of Mathematics and Statistics, LSE
- Departments of Mathematics, City, University of London
- SMSAS, University of Kent
- Department of Mathematics, Brunel University London
- Department of Mathematics, Royal Holloway University of London
- School of Mathematics and Statistics, Open University

The LTCC programme emphasises direct teaching and personal contact rather than distance learning, and includes modular lecture courses and short intensive courses.

Note: A fee is payable by students from non-LTCC departments.

Lecture venue:

De Morgan House
57-58 Russell Square
London WC1B 4HS

Office address:
LTCC
Department of Mathematics
University College London
Room 610, 25 Gordon Street
London WC1H 0AY

Phone: 020 3108 1551
E-mail: office@ltcc.ac.uk
www.ltcc.ac.uk

This course list is subject to change. Further information, venue details, full text syllabi, the registration form and timetable are available online at **www.ltcc.ac.uk** or contact us at office@ltcc.ac.uk

Advanced Courses 2023 - 2024

LTCC

London Taught Course Centre

for PhD students in the mathematical sciences

9 October – 6 November 2023 (Block 1)

Gowers norms and the Mobius function
Dr Aled Walker, KCL
In this course, we will explain the use of Fourier analysis (and so-called 'higher order Fourier analysis') to study solutions to equations. We will begin by covering the classical circle method approach to three-term arithmetic progressions, before turning to a 21st century generalisation involving Gowers norms and nilsequences. Although at heart this is a course in analysis and number theory, some nilpotent algebra and combinatorics will also take a central role.

Topics in probabilistic number theory
Dr Steve Lester / Prof Igor Wigman, KCL
We will cover some foundational results in probabilistic number theory with an emphasis on the probabilistic viewpoint on the subject. First and foremost, we will cover the Erdos-Kac theorem, asserting the asymptotic distribution for the number of prime divisors of a "random" integer. Secondly, Selberg's central limit theorem for the Riemann zeta function on the critical line will be established. Finally, the asymptotic distribution of the residue classes of prime numbers pertaining to Chebyshev's bias will be examined.

13 November–11 December 2022 (Block 2)

Advanced computational methods in statistics
Dr Deniz Akyildiz, Imperial
This course will provide an overview of Monte Carlo methods when used for problems in Statistics. After an introduction to simulation, its purpose and challenges, we will cover in more detail Importance Sampling, Markov Chain Monte Carlo and Sequential Monte Carlo. Whilst the main focus will be on the methodology and its relevance to applications, we will often mention relevant theoretical results and their importance for problems in practice.

Birational geometry *Dr Calum Spicer, KCL*
We will begin with a tour of some classical aspects of the Minimal Model Program (for instance, what is covered in Kollar-Mori) before turning to some more modern techniques in the study of rational curves on varieties using foliations (for instance, Campana-Paun).

Beilinson's conjectures *Dr Oli Gregory, Imperial*
The aim of the course is to state and motivate Beilinson's conjectures relating the transcendental part of the leading coefficient of L-functions of algebraic varieties over number fields to algebraic cycles. We will introduce the necessary machinery (K-theory/motivic cohomology, Deligne cohomology, regulators), and then study some low-dimensional examples.

Probabilistic analysis of algorithms
Prof Alexander Marynych, Kyiv University and QMUL
Probabilistic analysis of algorithms is used to analyze delicate performance features of algorithms like estimating probability that its working time doesn't exceed a prescribed threshold. A student will become acquainted with probabilistic tools used to solve such problems and with various applications including analysis of sorting search and graph algorithms.

15 January – 12 February 2024 (Block 3)

Kernel methods in machine learning and statistics
Dr Nikolas Nusken / Dr Marina Riabiz, KCL
This course will cover the mathematical foundations of reproducing kernel Hilbert spaces (RKHSs) and Gaussian processes, emphasising the connections and equivalences between those and with a view towards applications in machine learning and statistics. Regression will serve as a running example and will be discussed from the RKHS, Gaussian process, kernel trick and deep learning perspective. The module will conclude with an overview of kernel based discrepancies between probability measures.

Mathematical topics in General Relativity
Dr Juan A. Valiente-Kroon, QMUL
This course will provide a general discussion of General Relativity as an initial value problem. In addition, it will serve as an introduction to applied methods of Differential Geometry and Partial Differential Equations.

Modular forms and representations of GL2
Dr Robert Rockwood, KCL
This course is an introduction to the automorphic representation theory of GL2 and can be considered as a second course in modular forms. The material contained in this course is a first look at some of the tools and methods underlying the Langlands programme, a far reaching web of theorems and conjectures comprising some of the most exciting number theory research today.

Introduction to Spectral Geometry *Dr Jean Lagacé, KCL*
Spectral Geometry is a broad domain of mathematics where we study the relationship between the geometry of objects and their 'vibration modes and frequencies', modeled by eigenvalues of some elliptic operators. In this course, we will explore deep relationships to geometric analysis through minimal surfaces, using modern variational methods.

19 February – 18 March 2023 (Block 4)

Black Holes *Prof. Rod Halburd, UCL*
This course will cover some mathematical aspects of black holes and it will be a good introduction to some key ideas in advanced general relativity such as the Newman-Penrose formalism and various approximation methods.

Numerical analysis of the Helmholtz equation
Prof. Jeffrey Galkowski, UCL
This course will give an introduction to the modern theory of numerical methods for the Helmholtz equation at high frequency. We will discuss error estimates and the pollution effect for both boundary based and interior based methods. Time permitting, we will also investigate errors coming from domain truncation methods such as the method of perfectly matched layers.

Introduction to random topology
Dr Omer Bobrowski, QMUL
Random graphs are rich mathematical objects with numerous applications. In this module we will review the fundamental properties of random graph, focusing on how they generalise to higher dimensional topological phenomena, using random simplicial complexes. We will cover key probabilistic theorems, including phase transitions, central limit theorems, and more.

Selective Inference
Dr Daniel Garcia Rasines, Imperial
Standard statistical procedures are unreliable when the parameter of interest is selected using the data. This is particularly relevant in high-dimensional settings, where inference is only provided for those aspects of the model that appear more relevant. This course covers the main methodological approaches to this problem.

Algebraic cycles with applications to motives
Dr Owen Patashnick, KCL
We will give an introduction to algebraic cycles, starting with basic definitions and properties of the classical Chow groups, and then moving on to do the same for the higher Chow groups. Time permitting we will discuss their application to motives (a theory that classifies cohomology theories) and relationships to special values of L-functions.