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 2265
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 2024 - 2025

LTCC

London Taught Course Centre

for PhD students in the mathematical sciences

7 October - 4 November 2024 (Block 1)

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 Monte Carlo methods for sampling and recent generative modelling techniques from a statistical perspective. Whilst the 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.

Topology and High-order Dynamics of Networks and Simplicial Complexes *Prof. Ginestra Bianconi, QMUL*
Higher-order networks are attracting large interest in network theory, machine learning and brain research.
This course will introduce fundamental topics in algebraic topology and discrete geometry and mathematical physics in order to discuss recent results on higher-order network dynamics including most relevantly topological synchronization

Birational Geometry *Dr Calum Spicer, KCL*
This course is a general introduction to birational geometry. We will cover some of the key results and ideas in birational geometry in arbitrary dimensions, before changing our focus to explain the main ideas of the proof of the abundance conjecture in dimensions 2 and 3.

11 November - 9 December 2024 (Block 2)

Mathematical Methods for Quantum Mechanics
Prof. Rod Halburd, UCL
After a quick overview of the postulates of quantum mechanics and an initial look at the hydrogen atom, we will discuss spin, addition of angular momentum and Clebsch-Gordan coefficients. We will go on to study a variety of approximation methods and an introduction to scattering theory.

Minimal and Constant Mean Curvature Surfaces
Dr Jean Lagacé and Dr Stephen Lynch, KCL
Minimal and constant mean curvature surfaces are ubiquitous in geometric analysis. Their rich structure comes from the fact that they can be described in many different ways. Nevertheless, they are notoriously elusive, and this course concentrates on recent approaches constructing them or proving their existence in various contexts.

13 January - 10 February 2025 (Block 3)

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.

Explicit Inertial Langlands Correspondence for GL(2)
Dr Lassina Dembélé, KCL
In this minicourse, we will describe an algorithmic approach to the inertial Langlands correspondence for GL(2). We will start with a review of the correspondence in the theoretical setting, then we will explain how one can rewrite it in a way that is suitable for computer implementation. We will illustrate our presentation with as many examples as possible. Our main reference will be the book by Bushnell and Henniart.

Design of Experiments
Prof. Steven Gilmour and Dr Vasiliki Koutra, KCL
This course describes the fundamental concepts of design of experiments, such as randomisation and the factorial treatment structure. It goes on to look at some modern practical applications, such as experiments on networks and experiments for functional data.

17 February - 17 March 2025 (Block 4)

Kernel Methods in Machine Learning and Statistics
Dr Nikolas Nusken, 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.

The Hardy-Littlewood Circle Method
Prof. Igor Wigman and Dr Steve Lester, KCL
The Hardy-Littlewood circle method is an important and general analytic technique, particularly useful for solving problems in number theory. This course provides an introduction to the Hardy-Littlewood circle method, its theoretical foundations, and a number of applications to problems in number theory will be discussed.

Arithmetic Statistics *Dr Christopher Keyes, KCL*
This course is an introduction to arithmetic statistics via the problem of counting number fields. We will study the results of Davenport and Heilbronn for S3-cubic extensions and explore its connection to the Cohen-Lenstra heuristics. Time permitting, we will touch on recent innovations due to Bhargava and other related problems.

High-Dimensional Statistics Dr Yanbo Tang, Imperial
A brief introduction to high-dimensional statistics, focusing on sparse linear regression, covariance estimation, and principal component analysis. This course will also introduce some concentration inequalities and basic random matrix theory, which are commonly used in theoretical statistics and probability outside of high-dimensional statistics.

Numerical Methods for Elliptic Partial Differential Equations *Prof. Stephen Langdon, Brunel*
Partial differential equations can be used to model many physical systems. Construction of analytical solutions is impractical for all but the most basic scenarios, hence numerical methods are often required. In this course we derive, implement and analyse some numerical methods for the solution of model elliptic partial differential equations.

Non-Linear Free Surfaces
Prof. Jean-Marc Vanden-Broeck, UCL
This course is concerned with the computation of nonlinear free surface flows. Both the effects of surface tension and gravity are included in the dynamic boundary condition. Special attention is devoted to the singular behaviour at the points where free surfaces intersect rigid walls. Applications to bubbles rising in a fluid, flows emerging from a nozzle and cavitating flows are presented. It is shown how physical solutions are selected in the limit as the surface tension tends to zero.

Numerical Relativity *Dr Katy Clough, QMUL*
In this course we use a python code called engrenage (https://github.com/GRTLCollaboration/engrenage) to illustrate the concepts of numerical relativity - the solution of Einstein's equations of general relativity on a computer as a Cauchy problem - and techniques for the numerical solution of coupled non-linear hyperbolic PDEs. The course will consist mainly of hands-on exercises.