The LTCC

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
- Department of Economics, Mathematics and Statistics, Birkbeck

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
Gower Street
London WC1E 6BT

Phone: 020 7679 4309
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 2022 - 2023

LTCC

London Taught Course Centre

for PhD students in the mathematical sciences

3 October- 31 October 2022 (Block 1)

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).

Nonlinear Free Surface Flows with Gravity and Surface Tension *Prof. Jean-Marc Vanden-Broeck, UCL*
The course is concerned with analytical and numerical methods to solve nonlinear free surface flows. Surface tension and gravity are taken into account. We will start with a brief derivation of the basic equations and proceed with problems of increasing difficulty. Applications to bubbles and jets will be presented.

Topics in the Design of Experiments *Dr Steve Coad, QMUL*
This course covers some of the topics which are essential background for much of the current research in design of experiments. It is in two parts: optimal design theory and sequential design.

Gowers norms and the Mobius function
Dr Aled Walker, KCL
In this course, we use Fourier analysis and so-called 'higher order Fourier analysis' to study solutions to equations. In particular we will study objects called 'nilsequences', and use them to establish a property of k-term arithmetic progressions. Although at heart this is a course in analysis and number theory, some nilpotent algebra and combinatorics will also take a central role.

7 November– 5 December 2022 (Block 2)

Advanced Computational Methods in Statistics
Dr Nikolas Kantas, 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.

Foliations and 3-dimensional manifolds
Dr Mehdi Yazdi, KCL
This course is an introduction to foliations on 3-dimensional manifolds, which have been very fruitful in low-dimensional topology. After discussing the basics, we cover classical theorems such as Reeb stability and Novikov’s compact leaf theorem. We will then study taut foliations and a related important invariant of 3-dimensional manifolds, namely Thurston norm.

Adeles and L-functions *Dr Jesse Jääsaari, QMUL*
We will start by introducing adeles and their basic properties. We then study Hecke L-functions from an adelic point of view following Tate's thesis. Time permitting, we will also talk a little bit about generalizations for L-functions attached to automorphic forms.

9 January – 6 February 2023 (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.

Toric varieties *Dr Tim Magee, KCL*
In this course we will study toric geometry. Toric varieties are among the best-understood objects in algebraic geometry, and many algebraic geometry concepts have intuitive convex polyhedral geometry descriptions in the toric world. In light of this, we will treat toric geometry as a gateway to broader fields in algebraic geometry.

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.

Combinatorial optimisation: packing, partitioning, and covering *Dr Ahmad Abdi, LSE*
Packing, partitioning, and covering are basic problems that lie at the heart of almost every problem in Combinatorial Optimisation. In this course, we study important examples of such problems in Graph Theory, namely, vertex colouring, maximum matching, and multicommodity flows. This leads us to the theories of perfect and weakly bipartite graphs. We also cover the structural, polyhedral, and algorithmic aspects of such graphs.

Calibrated submanifolds *Dr Lorenzo Foscolo, UCL*
Calibrated submanifolds are a class of volume minimizing submanifolds in Riemannian manifolds endowed with special closed differential forms called calibrations. The prototypical examples of calibrated submanifolds are holomorphic submanifolds of Kähler manifolds. Aspects of the theory we will discuss include examples in Euclidean space, singularities and moduli spaces.

13 February – 13 March 2023 (Block 4)

Introduction to Random Matrix Theory
Dr Igor Smolyarenko, Brunel
This course aims to provide a practical introduction to the foundations of random matrix theory, and give a survey of the key concepts, methods and results. Topics will include Gaussian and Wigner ensembles, universality of spectral distributions, and a selection of modern applications.

Introduction to the Modern Theory of Scattering
Prof. Jeffrey Galkowski, UCL
This course will give an introduction to the modern theory of scattering; the theory of how waves interact with perturbations of free space. We will cover meromorphic continuation of resolvents, resonance expansions, and the scattering matrix.

Higher-order networks
Prof. Ginestra Bianconi, QMUL
Higher-order networks capture the interactions among two or more nodes and they are ubiquitous complex systems, including brain networks and social networks. Here we show how to model higher-order networks and we reveal that higher -order interactions are responsible for new dynamical processes that cannot be observed in pairwise networks.

Asymptotic Methods and Statistical Applications
Dr Heather Battey, Imperial
Many problems in statistics do not possess an exact analytic solution. While numerical evaluation is possible, greater insight is obtained through approximate analytic solutions. These, for instance, allow one to quantify the performance of statistical procedures in terms of intrinsic features or key tuning parameters.

Painlevé equations and the Painlevé property
Prof. Rod Halburd, UCL
We will see how the singularity structure of the solutions of an ODE in the complex domain can be used to detect integrable equations. The six Painlevé (differential) equations arise in many applications in a remarkable number of fields, including random matrix theory and water waves. We will study the special properties of these equations as well as their integrable discrete analogues.

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.