

About the Department of Mathematics

1. Overview

1.1 Introduction

The LSE Department of Mathematics has been on a growth trajectory for a number of years now, since it was first established as a separate department in 1995.

The Department currently (as of November 2015) has 9 Professors, 10 Associate Professors, 5 Assistant Professors, 1 Centennial Professor, 3 (part-time) Course Tutors, 2 LSE Fellows and 4 professional services staff. It also has a team of long-standing Guest Teachers, in addition to GTAs.

1.2 Research

The Department's current research activity can, broadly speaking, be grouped into four areas (with corresponding staff indicated):

- **Discrete Mathematics and Algorithms** [Allen, Anthony, Batu, Biggs (Emeritus), Böttcher, Brightwell, van den Heuvel, Skokan, Swanepoel].
- **Mathematical Game Theory and related areas** [Gossner, Lewis-Pye, Liddbetter, Simon, von Stengel, Young (Centennial Professor)].
- **Financial and related Mathematics** [Czichowsky, Danilova, Gapeev, Lokka, Ostaszewski, Sasane, Veraart, Zervos].
- **Operational Research** [Lu, Papadaki, Sorkin, Végh, Zambelli].

These areas overlap, with some staff active in more than one area. For instance, some recent work in financial mathematics connects with mathematical game theory and addresses problems related to operational research. They are also approximate descriptors: for example, some work in discrete mathematics and algorithms, as well as in game theory, has strong links with operational research and theoretical computer science.

Our areas of research have evolved over time to be relevant to our particular position within an institution that specialises in the social sciences, and they link with work in other departments. For example, operational research has connections with Management and there are likely future connections between discrete mathematics and algorithms and OR with several departments through initiatives such as 'data science' and 'analytics'. Also, mathematical game theory has

connections with Economics; and financial mathematics with Accounting, Finance and Statistics.

1.3 Teaching

The Department is responsible for the following programmes (with admissions targets indicated):

- BSc in Mathematics and Economics and BSc in Mathematics with Economics (97 new students each year, combined).
- MSc in Applicable Mathematics (30).
- MSc in Financial Mathematics (25).
- MSc in Operational Research (40) (from 2017/18).

All these programmes are in high demand and attract very well-qualified students.

We have a thriving PhD programme: the number of PhD students has grown in recent years. The PhD programme now includes taught courses delivered through the London Taught Course Centre for PhD Students in the Mathematical Sciences and the London Graduate School in Mathematical Finance, to both of which we contribute teaching. Additionally, PhD students are active participants in the Department's various seminar series and specialised reading groups.

We also teach many students from other departments of the School and host a regular cohort of General Course (one-year visiting) students in the Department.

Of taught students registered on programmes in the Department, roughly around 75% are undergraduate, 20% are MSc students and 5% are General Course students

The Department is also active in the University of London International Programmes, having introduced the successful BSc in Mathematics and Economics, delivered by flexible distance learning through UoLIP. It has also recently become involved in the LSE Methodology Summer School.

The Department of Mathematics plays a vital role in teaching at LSE. Even some of our specialist courses (by which we mean those taken by students on one of our own programmes) are taken in significant numbers by students on a range of programmes in other departments. We also provide 'service' courses such as for students not on our programmes.

2. Department structure and academic staff

2.1 Governance, organisation and decision-making

The Department has a Head and a Deputy Head (Teaching). The main committee in the Department is the Departmental Meeting. Other committees are: Teaching Committee, Research Committee, and the Committee of Professors (the membership of which is all Full Professors). Important office-holders in the Department (other than the Head and Deputy Head) include: Chair of Teaching Committee (who need not be the Deputy Head Teaching), Research Director, Departmental Tutors (one for 1st years and one for

2nd and 3rd years), MSc Programme Directors, and Doctoral Programme Director.

Governance in the Department is open and transparent. Discussions relating to promotion and review are confidential items for the Committee of Professors, but all other matters are discussed in the Departmental Meetings, which all staff attend

2.2 Current academic staff

Current staff are listed in the following table.

Name	Rank	M/F	PhD Institution	Country of PhD
Prof Martin Anthony	Professor	M	Royal Holloway/LSE	UK
Prof Graham Brightwell	Professor	M	Cambridge	UK
Prof Olivier Gossner	Professor	M	Paris 6	France
Prof Adam Ostaszewski	Professor	M	UCL	UK
Prof Amol Sasane	Professor	M	Groningen	Netherlands
Prof Gregory Sorkin	Professor	M	Berkeley	USA
Prof Jan van den Heuvel	Professor	M	Twente	Netherlands
Prof Bernhard von Stengel	Professor	M	Passau	Germany
Prof Mihail Zervos	Professor	M	Imperial	UK
Dr Albina Danilova	Associate Professor	F	Princeton	USA
Dr Pavel Gapeev	Associate Professor	M	Lomonosov Moscow State	Russia
Dr Andy Lewis-Pye	Associate Professor	M	Leeds	UK
Dr Arne Lokka	Associate Professor	M	Oslo	Norway
Dr Katerina Papadaki	Associate Professor	F	Princeton	USA
Dr Robert Simon	Associate Professor	M	Bielefeld	Germany
Dr Jozef Skokan	Associate Professor	M	Emory	USA
Dr Konrad Swanepoel	Associate Professor	M	Pretoria	South Africa
Dr Luitgard Veraart	Associate Professor	F	Cambridge	UK
Dr Giacomo Zambelli	Associate Professor	M	Carnegie Mellon	USA
Dr Peter Allen	Assistant Professor	M	LSE	UK
Dr Tugkan Batu	Assistant Professor	M	Cornell	USA
Dr Julia Böttcher	Assistant Professor	F	TU, München	Germany
Dr Christoph Czichowsky	Assistant Professor	M	ETH, Zürich	Switzerland
Dr László Végh	Assistant Professor	M	Eötvös, Budapest	Hungary
Dr Eleni Katirtzoglou	Course Tutor	F	Memphis	USA
Dr Ioannis Kouletsis	Course Tutor	M	Imperial	UK
Dr James Ward	Course Tutor	M	Imperial	UK
Dr Tom Lidbetter	LSE Fellow	M	LSE	UK
Dr Xue Lu	LSE Fellow	F	LBS	UK
Prof Peyton Young	Centennial Professor	M	Michigan	USA

2.3 Academic staff: mentoring and review

Mentoring

The School encourages academic staff, in particular those in the early stages of their career, for whom it is a requirement, to be assigned a (senior) colleague as a mentor, and to have regular meetings. The Department of Mathematics complies with this, but there is also broader, more informal, networking and mentoring that takes place within and between the different research groups. In the Department of Mathematics, the formal arrangement is that every Assistant Professor has two mentors (one Associate and one Full Professor), while Associate Professors have one mentor assigned to them.

Peer observation of teaching

The Department has a system of peer observation of teaching for all teaching staff (including permanent faculty). The objectives are: to identify strengths and weaknesses, in order to help improve the quality of teaching and learning; to provide advice and support for less experienced teachers in the Department; to obtain extra information on the quality of teaching, which may be used when deciding on re-appointment of class teachers; and, for the observer, to take away some possible ideas to improve their own teaching.

Those who are new to the Department are observed in their first term of teaching, and, additionally, during the next academic year. Thereafter, class teachers are observed at least once every two years; permanent faculty at least once every three years. Student survey results can trigger more regular observations.

Review

As is now standard LSE practice, there is an annual Academic Career Development Review (ACDR) meeting for academic staff who are not yet Associate Professors, and a tri-annual ACDR for Associate Professors. These meetings are with the Head of Department.

2.4 Equality and diversity

The Department has a dedicated Equality Officer, whose role is to oversee all aspects of organisation regarding equality and diversity. One of the specific duties of the role is to make sure that, as far as possible, departmental activities (seminars, meetings, social events) are scheduled during core hours, so that staff with caring responsibilities can participate fully. The Department also supports School-wide initiatives in this area, such as Unconscious Bias training for members of staff.

The Department has signed up to the London Mathematical Society Good Practice Scheme. Developed by the LMS Women in Mathematics Committee, this has the aim of supporting mathematics departments interested in embedding equal opportunities for women within their working practices. The Scheme provides specific support for departments working towards Athena Swan Award status. This Athena Swan programme is now much more relevant for LSE as a whole, as it is being extended from science disciplines to include humanities, social science and other disciplines. The Department is represented in the School's Gender Equality Steering Group, which is in charge of preparation for a future submission for an Athena SWAN Charter award.

In general, LSE has excellent provisions for staff with caring roles, including generous paternity, maternity and adoption leave, with additional research leave for staff following long-term absence from the School.

3. Teaching and learning

3.1 Undergraduate programmes

The Department currently has two undergraduate programmes. The Mathematics and Economics degree is approximately 50% mathematics and the Mathematics with Economics degree is approximately 75% mathematics. Both programmes receive the top rating on the School's programme health indicators. The Mathematics with Economics programme, introduced in 2010/11, has been significantly more popular than anticipated when it was started.

Our two 3-year undergraduate degree programmes provide courses in pure mathematics and mathematical methods to the national standard in these areas, complemented by courses mainly from the Departments of Economics, Finance and Statistics. These programmes enable students to learn logical argument, problem solving and mathematical modelling, appropriate to applications in social sciences. The learning of a logical framework also requires a facility with abstraction and rigorous formal developments, as well as an examination of the validity of assumptions and the validity of conclusions. As to applications, these include primarily economics, finance, operational research, and optionally some actuarial science. The teaching programme is designed so that the mathematics and the areas of its application both support each other, the latter providing a firm context for the former.

The Department, working with colleagues on the University of London International Programmes, also runs a BSc in Mathematics and Economics through distance and flexible learning via UoLIP. This programme closely mirrors the corresponding internal degree programme of the same name.

3.2 MSc programmes

The Department is currently responsible for two MSc programmes, both of which score highly in the School's health indicators.

The MSc in Applicable Mathematics (12 months, full-time) draws together traditional and modern mathematical techniques in a variety of social science contexts. It is designed both for mathematics graduates who wish to make themselves more marketable by adding social science aspects to their knowledge and skills base, and for non-mathematics graduates with strong quantitative backgrounds who wish to add to and improve their understanding of the mathematics behind much of social science. Reflecting the increasing importance of computation, the programme has a compulsory algorithms and

computer programming element. The MSc in Applicable Mathematics is probably one of the largest Mathematics MSc programmes in the country, other than programmes in financial mathematics.

The MSc in Financial Mathematics (10 months, full-time) combines the Department's strength in financial mathematics with that of LSE in finance and related areas. It aims to develop students' understanding of the foundations of financial mathematics, and to equip them with the knowledge of a range of mathematical and computational techniques that are required for a variety of quantitative positions in the financial sector. The programme starts with a compulsory pre-session course (MA400), which introduces some key concepts and techniques. The programme provides high-level instruction in the mathematical theory underlying finance, and training in appropriate computational methods, including a compulsory computer programming element. Students take courses from the Departments of Finance and Statistics.

3.3 PhD programme

In recent years, the Department has had a steady influx of talented PhD students. Completion rates have been excellent.

Funding for PhD students comes from a variety of sources, including LSE's PhD scholarship scheme.

The Department (along with Statistics) is a founding member of the LTCC (London Taught Courses Centre for PhD Students in the Mathematical Sciences), which began in 2006/07. This consortium provides a programme of courses for PhD students at various stages of their study. The scheme is a valuable opportunity for PhD students to have both advanced specialist teaching in their chosen field and to acquire insight into new developments across mathematics. The Department (again along with Statistics) was also among the founding members of the LGSMF (London Graduate School in Mathematical Finance), a consortium of the mathematical finance groups in Birkbeck College, Brunel University, Cass Business School, Imperial College, King's College, LSE and UCL. Its main purpose has been to provide a programme of advanced courses in mathematical finance, primarily but not exclusively for first-year PhD students. In recent years, every PhD student in the Department has attended several courses in the LTCC and/or the LGSMF.

PhD students are active participants in the established departmental seminar series. There is also an informal

weekly lunchtime Friday seminar series, in which PhD students regularly present their work, followed by an informal networking lunch discussion. Additionally, there are Reading Groups in Discrete Mathematics and in Financial Mathematics.

Doctoral students are encouraged (and financially supported) to attend and participate in conferences, workshops and other research meetings, both nationally and internationally.

3.4 Individual courses

The Department provides a wide variety of courses, some very large and some small and highly specialised.

Undergraduate level	
MA100 Mathematical Methods	651
MA103 Intro to Abstract Mathematics	245
MA107 Quantitative Methods (Maths) (H)	398
MA110 Basic Quantitative Methods	18
MA203 Real Analysis (H)	137
MA207 Further Quantitative Methods (H)	58
MA208 Optimisation Theory (H)	57
MA209 Differential Equations (H)	99
MA210 Discrete Mathematics (H)	42
MA211 Algebra & Number Theory (H)	36
MA212 Further Mathematical Methods	282
MA300 Game Theory	15
MA301 Game Theory I (H)	107
MA303 Chaos in Dynamical Systems (H)	11
MA305 Optimisation in Functions Spaces (H)	12
MA310 Mathematics of Finance & Valuation (H)	9
MA313 Probability for Finance (H)	17
MA314 Algorithms in Java (H)	35
MA315 Algebra and its Applications (H)	17
MA316 Graph Theory (H)	30
MA317 Complex Analysis (H)	14
MA318 History of Mathematics (H)	14
MA319 Partial Differential Equations (H)	new

Masters level	
MA402 Game Theory (H)	27
MA407 Algorithms & Computation (H)	22
MA408 Discrete Maths & Graph Theory (H)	13
MA409 Continuous-time Optimisation (H)	10
MA410 Information, Communication & Cryptography (H)	10
MA411 Probability & Measure (H)	9
MA412 Functional Analysis & Applications (H)	11
MA413 Games of Incomplete Information (H)	9
MA414 Stochastic Analysis (H)	7
MA415 Maths of Black-Scholes Theory (H)	31
MA416 Foundations of Interest Rate & Credit Risk Theory (H)	27
MA417 Computational Methods in Finance (H)	24
MA418 Preferences, Optimal Portfolio Choice & Equilibrium (H)	1
MA419 Search Games (H)	susp.
MA420 Quantifying Risk Modelling & Alternative Markets (H)	6
MA421 Advanced Algorithms (H)	10
MA498 Dissertation in Mathematics	24

Numbers of students on Mathematics courses, 2014/15. (Table excludes pre-sessional and PhD courses. (H) denotes half-unit course.)

In 2015, together with the Department of Statistics, we launched a Maths & Stats Support Centre. This centre provides additional support to students through a drop-in clinic model.

4. Research

4.1 Research areas

The research work of the Department can, broadly speaking, be split into four (overlapping) areas.

Discrete Mathematics and Algorithms

The research areas covered by this group vary from pure mathematical ones (including extremal and structural properties of graphs and hypergraphs, random structures, probabilistic methods, and combinatorial geometry) to more applicable ones (including machine learning, sublinear algorithms for massive data sets, and algorithmic aspects of discrete mathematics in general). Increasing collaboration with operational research has encouraged the expansion of research in discrete algorithms as well as the development of new approaches to approximation, heuristic and randomised algorithms. The group plans to strengthen these connections further, together with growing connections with the mathematical game theory group. There will also be interest in working on 'big data' and 'analytics' as part of School-wide initiatives in these areas.

Established international collaborations include Emory University, Australian National University, Dartmouth College, Georgia Institute of Technology, Hungarian Academy of Sciences, IMPA Rio de Janeiro, ENS Lyon, TU Hamburg-Harburg, Goethe-Universität Frankfurt, Liège, University of Melbourne, Adam Mickiewicz University Poznan, Charles University Prague, Rutgers, University of Sao Paulo, ETH Zürich.

Mathematical Game Theory

Game theory is a major tool and paradigm for economic theory. As a result, most game theory scholars now work in economics departments. Along with Paris and Jerusalem/Tel Aviv, LSE has one of the few mathematics departments with a concentration of game theorists. The mathematical aspects of game theory are the main focus of the group. Research topics include the economics and the strategic use of information, entropy methods, models of bounded rationality, games of incomplete information, stochastic games, and the computational and geometric structures of equilibria in games.

Central themes for future research include the understanding of strategic behaviour with bounded information, memory, and computational power; the diffusion of behaviour and information in networks of strategic agents; the existence of equilibria in stochastic and Bayesian games; the computational complexity of game-theoretic solution concepts.

Established international collaborations include Universities in Paris (École Polytechnique, Paris 6, Paris-Dauphine, Paris School of Economics), Pisa, ETH Zürich, Warsaw, Göttingen, Barcelona, Valencia, Tel Aviv, Jerusalem, Princeton, Stanford, Yale.

Financial and related Mathematics

This group has strong links with the Risk and Stochastics group in the Department of Statistics. Taken together, they form one of the biggest concentrations of researchers in the area internationally. Within LSE, the group also has strong links with the Financial Markets Group. The research of the group covers a wide range of topics in mathematical finance and optimal control.

The group's ambition is to make theoretical advances that will be instrumental in the development of a mathematical finance theory that will enhance the stability of financial markets. Ground-breaking research activity in these directions will inevitably involve the development of genuinely new theory in the fields of stochastic processes and stochastic analysis.

Established international collaborations include UC Berkeley, Columbia University, Humboldt University Berlin, Karlsruhe Institute of Technology, University of Duisburg-Essen, Universities in Paris (Evrly Val d'Essonne, Paris Est, Sciences Po), Steklov Institute Moscow, University of Sydney, University of Vienna, ETH Zürich.

Operational Research

The operational research group has a wide range of interests, from the highly theoretical to the applied, many of which connect with those of other groups in the Department. Theoretical research areas include methods for solving linear and integer programs and network flows; polyhedral combinatorics; combinatorial optimization; network reliability; average-case analysis of algorithms for graph problems, formula satisfiability and constraint satisfaction problems; phase transitions in the same contexts; and exact algorithms for NP-complete problems. Applications, at levels from theoretical research motivated by practical problems to commercial development, include mobile network efficiency, car and truck fleet scheduling, search games and patrolling games, manufacturing optimisation, computer virus detection and recovery, and DNA sequencing. The operational research group is also keen to be involved in any 'big data' and 'analytics' work.

Established international collaborations include Georgia Institute of Technology, Carnegie Mellon, MIT, Princeton, Rutgers, Waterloo, EPFL Lausanne, CWI Amsterdam, Eötvös University (Budapest), CORE Belgium, Padova, Uppsala, New South Wales, NICTA, Ohio State, Notre Dame, University of Cyprus.

4.2 Research seminars, workshops and public engagement

The Department hosts a number of series of seminars and workshops. Weekly during term-time, it has a Discrete Mathematics and Game Theory seminar, a Joint Risk and Stochastics and Financial Mathematics seminar, an Operations Research seminar, and an informal Friday lunchtime seminar. In addition to these seminars it co-hosts the bi-weekly London Mathematical Finance seminar with several other London-based universities.

In collaboration with QMUL, the Department runs a two-day Combinatorics Colloquium each year (with one day at LSE and one at QMUL), financially supported by the London Mathematical Society and the British Combinatorial Committee. This has attracted some very high-profile speakers. In recent

years, the Department has also organised a number of workshops in search games, in algorithmic game theory, and in infinite combinatorics.

We recently organised a public lecture by Nobel Prize-winning physicist Frank Wilczek, and coordinated an EPSRC-supported Game Theory Workshop which attracted speakers including Alvin Roth, winner of the 2012 Nobel Prize in Economic Sciences. Additionally, Andy Lewis-Pye (with colleagues) won the Infographics photograph award of the Royal Society's Picturing Science Competition and Paul Dütting, who was an LSE Fellow in the Department 2014/15, presented a poster at SET for Britain 2015, at the Houses of Parliament.

The Department has set up a research blog (supported by a departmental Twitter account), which will be formally launched in October 2015. The goal of the blog is to inform an interested lay audience about our research activities.