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NEWSLETTER

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GRAPHS ON GROUPS: AN INDIAN ADVENTURE

AI TOOLS — RESULTS FROM A SURVEY

NOTES OF A NUMERICAL ANALYST

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Eravikulam National Park, Kerala. Photo credit: Peter J. Cameron

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LMS NEWS

Susan Oakes and the LMS

This year Susan Oakes retired from her 43 years with the LMS. She was the first full-time employee of the Society and senior members may fondly recall toiling up to her half-an-office on the top floor of the Royal Astronomical Society's premises in Burlington House, Piccadilly, then rented out to the Society. Before long, with two part-time colleagues, she negotiated a move to their own office. In 1999, she was a member of the small group tasked with finding new premises to be owned by the Society, and the acquisition of De Morgan House, conveniently located for the LMS Library held in University College, was the outcome.

Over her time with the LMS, Susan was involved in most administrative activities of the Society, including preparing Council papers as well as dealing with membership and grants. She was involved from the very start of the *LMS Newsletter*, which began life as a postcard to members! Susan was actively engaged in numerous other activities, including for example supporting and promoting the Society on its travels to the *British Mathematical Colloquium*, the *International Congress of Mathematicians* and the *European Congress of Mathematics*, as well as various events such as the *LMS Popular Lectures*. In 2019, she helped to coordinate the celebration of 21 years in DMH. Most recently, she has fielded for the *Newsletter* incoming contributions, put them into appropriate format, run them past the Editor and submitted them to the Office for final production, as well as handling the commercial advertising.

Susan has known the Society and its workings better than almost anyone else and, to echo the words of the then Treasurer Alun Owen Morris in 2001, her constant dedication to the well-being of the Society has been inspirational.

Thank you, Susan.

David Chillingworth
LMS News Editor

New Managing Editors for the *Bulletin of the LMS*

The LMS is pleased to welcome Julia Wolf (University of Cambridge) and Minhyong Kim (University of Edinburgh) as the new Managing Editors of the *Bulletin of the London Mathematical Society*.

Julia Wolf Minhyong Kim

Julia and Minhyong succeed Professors Andrey Lazarev (Lancaster University) and Sibylle Schroll (University of Cologne), who have led the *Bulletin* since 2019. During that time, the *Bulletin* Editors have achieved great success with attracting innovative research and articles that stimulate new interest and activity, raising the prestige of the *Bulletin*. The Society expresses its deepest gratitude to Andrey and Sibylle for their excellent service to the *Bulletin* and to the Society at large.

Anna Agathopoulou
Publishing Coordinator

Forthcoming LMS Events

The following event will take place soon:

LMS Computer Science Colloquium 2024:
10 December, London and online
(https://tinyurl.com/mr3b5vak)

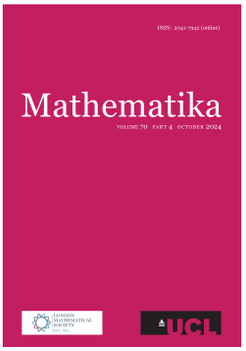
A full listing of upcoming LMS events can be found on page 36.

Journal Anniversaries

Two journals published by the LMS have been celebrating anniversaries in 2024.

Mathematika: 70 Years

The journal *Mathematika* was founded by legendary English mathematician Harold Davenport in the early 1950s and published its first volume in 1954.



An amusing story is told about the origins of *Mathematika*. Davenport's handwriting was beautiful and elegant, and he used to prepare many of his manuscripts solely by hand. Many journals at the time required submissions to be typewritten, and legend has it that a few of Davenport's handwritten papers had been returned to him without consideration. *Mathematika* was founded on the principle that it would welcome neatly handwritten manuscripts, a practice that continued throughout Davenport's editorship.

As Editor-in-Chief, Davenport took a great interest in the journal, and it has been told that he acted personally as referee for many submissions to the extent that he would not merely suggest improvements but would send junior colleagues carefully rewritten versions for their approval.

Over the years, *Mathematika* has published many highly influential papers. These include Klaus Roth's pioneering work on irregularities of distribution and his resolution of the Siegel conjecture in Diophantine approximation, for which he won the Fields Medal. Other important results, such as Alan Baker's investigations into linear forms in the logarithm of algebraic numbers and the 'large sieve' by Roth and Enrico Bombieri, have had far-reaching implications for the development of modern analytic number theory.

Today, *Mathematika* is a well-established international journal with a broad coverage of mathematics and traditional strengths in combinatorics, geometry, analysis and number theory. It is published by the London Mathematical Society on behalf of its owner, University College London.

Transactions of the LMS: 10 Years

With a 2-year impact factor of 1.1, a 5-year impact factor of 1.0 and a Mathematical Citation Quotient (MCQ) of 1.09, the *Transactions of the London Mathematical Society* is holding its head high amongst the LMS portfolio of journals.

The *Transactions* was launched by the LMS as a fully Open Access journal in 2013 in anticipation that some research funders might require publication specifically in such a journal. As it has turned out, Open Access has taken many forms and about 54% of the articles published in the Society's other journals are also Open Access.

The *Transactions* is, therefore, now principally one of the five journals owned by the LMS. It is privileged to have an eminent editorial board of leading international mathematicians, including three Fields medallists, to oversee the peer review. The scope of the journal particularly welcomes articles that provide an "excellent exposition of research which explores the interconnectedness of pure mathematics or extends the boundaries of its applicability".

The *Transactions* is free to readers and free of charge to individual authors. It is included in wide-reaching publishing agreements whereby many authors are automatically eligible to publish Open Access free of charge. Under all circumstances, the *Transactions* is committed to publishing all papers that meet the journal's high standards of peer review, and the LMS has a range of measures in place to guarantee this.

Journal of the LMS

It is early days, but preparations are already underway to celebrate the 100th anniversary of the *Journal of the London Mathematical Society*, founded in 1926.

Ola Törnkvist
LMS Publisher

National Academy Focused on the Mathematical Sciences

The UK government has reversed the pledge of the previous administration to fund the setting up of a proposed national academy focused on the mathematical sciences. The Department for Science, Innovation and Technology (DSIT) announced in September that the £6 million grant commitment would be withdrawn.

While the government acknowledged the critical role of mathematics in UK science, engineering and innovation, it stated that it would explore alternative strategies to support and promote the field without establishing a new academy.

The LMS and member societies of the Council for Mathematical Sciences expressed their disappointment at this decision in a joint statement (tinyurl.com/5354efzw). LMS President, Professor Jens Marklof, emphasised the potential economic benefits of the academy, stating:

> Funding for the Academy could be a huge driver of economic growth by improving the flow of mathematical analysis, cutting-edge research, and technological innovation into policymaking. The government's announcement pledges to explore other ways to promote and support mathematics, so we hope to engage with them on this as soon as possible.

The Academy for the Mathematical Sciences (AcadMathSci; www.acadmathsci.org.uk) remains committed to its mission. In October, it released a new report, *Quantifying the UK Economic Contribution of the Mathematical Sciences in 2023*. This study, an update to the 2013 Deloitte report, underscores the significant economic value that the mathematical sciences bring to the UK: an extraordinary £495 billion a year in 2023, representing 20% of total UK gross value added. The report estimates that in 2023, 4.2 million individuals were directly employed in mathematical science occupations, ranging from engineers and computer programmers to financial analysts, statisticians and actuaries: 13% of all employment in the UK. This is indicative of growing demand for mathematical skills in the modern economy. A summary and link to the full report can be found at www.acadmathsci.org.uk/publications/mathsci-supercharges-uk-econ-growth.

The Academy has also announced a partnership with XTX Markets to conduct a scoping project aimed at better understanding how both organisations can support UK mathematical science departments. The project will focus on widening access to undergraduate study and providing support for early career researchers.

To gather information about current outreach and widening access activities, as well as support for early career researchers, the Academy invited mathematical sciences departments to complete a survey, which closed in November. The insights gained from this survey will help inform the development of future initiatives.

Maths for the Future: Royal Society Calls for Curriculum and Assessment Reform

Calling for a 'radical reform' of the education system, the Royal Society has published a new report, *A New Approach to Mathematical and Data Education*. The report argues for a complete overhaul of the maths curriculum, proposing a new one that:

- Blends traditional mathematics with data, computing and artificial intelligence (AI)
- Places greater emphasis on applying maths to real-world contexts

This report is the culmination of the Mathematical Futures programme launched in 2020. The programme sought answers to three key questions:

(1) What mathematical skills will citizens and society need to succeed in the future?

(2) How can education systems develop these essential skills?

(3) What changes are necessary to achieve this future vision?

By emphasising data, computing and AI alongside core mathematical concepts, the Royal Society believes this new approach will equip students with the tools they need to thrive in an increasingly data-driven world.

Read the full report and learn more about the Mathematical Futures programme: royalsociety.org/news-resources/projects/mathematical-futures.

Shaping the Future: Government to Review the National Curriculum

The government is undertaking a comprehensive review of the national curriculum and assessment system in England, including mathematics. Led by education expert Professor Becky Francis CBE, the review aims to create a curriculum that equips students with the knowledge and skills they will need throughout their lives, fosters a love of learning, and prepares them for the evolving world they will navigate.

Professor Francis emphasises a data-driven approach, building upon existing successes while recognising potential pitfalls. Her goal is to ensure a smooth and effective update, focusing on evolution rather than revolution.

The newly formed Maths Horizons Project (www.mathshorizons.uk), supported by XTX Markets, is a collaborative initiative dedicated to examining potential reforms of mathematics curricula and assessments. The project brings together experienced educators and experts to provide an evidence-based response to the government review, focusing specifically on the needs and challenges of mathematics education. The aim of this project is to feed in to the Francis Review specifically on mathematics.

Read more about the government review at www.gov.uk/government/groups/curriculum-and-assessment-review.

UK Position Paper on EU Research and Innovation Framework Programme

The DSIT has released a position paper outlining the UK's stance on the successor programme to Horizon Europe, the EU's current research and innovation framework. The new initiative, Framework Programme 10 (FP10), is set to launch in 2028.

FP10 aims to leverage top-notch research and innovation to bolster European security, sustainable prosperity and competitiveness. The government, according to the position paper, is keen on maintaining close collaboration with its European partners and hopes FP10's development will reflect this goal.

Guidance on who can bid for Horizon Europe funding and what support is available can be found at www.gov.uk/business-finance-support/horizon-europe-funding.

Read the position paper at tinyurl.com/4d8td6y5.

Digest prepared by Katherine Wright
LMS Communications and Policy Manager

Note: items included in the Mathematics Policy Digest are not necessarily endorsed by the Editorial Board or the LMS.

OTHER NEWS

LMS at the Joint Mathematics Meeting, Seattle, USA, 8 to 11 January 2025

The London Mathematical Society (LMS) is excited to announce its participation in the *Joint Mathematics Meeting (JMM)* in Seattle, USA. You can find us at stand 621, where we look forward to meeting LMS members and friends.

To celebrate our presence at *JMM 2025*, we will be raffling a signed copy of Marcus du Sautoy's *Around the World in 80 Games* at the opening event. Don't miss this fantastic opportunity to take home a unique prize.

If you'd like to learn more about meeting up with the LMS at *JMM 2025* or have any questions, please don't hesitate to email us at lmsmeetings@lms.ac.uk. We can't wait to catch up with you in Seattle!

Jennifer Gunn
Head of Society Business

Funding Opportunities for Mathematicians Available Through ARIA

ARIA, the Advanced Research + Invention Agency, is a UK government agency established to drive innovation and support breakthrough research. Its mission is to invest in high-risk, high-reward projects that could have a significant impact on society.

ARIA provides a range of funding opportunities that are specifically designed to support ambitious and cutting-edge mathematical research. These opportunities include:

- Research grants for a wide range of mathematical research projects. ARIA is particularly interested in projects that have the potential to address real-world challenges.
- Fellowships to talented mathematicians who are at an early stage of their careers. These fellowships provide funding for independent research and professional development.
- Awards that support collaborative research projects between mathematicians and researchers from other disciplines. ARIA is particularly interested in projects that have the potential to lead to new and innovative applications of mathematics.

ARIA offers a flexible approach to funding, which allows mathematicians to tailor their research projects to their specific needs. There are no fixed deadlines, allowing researchers to submit proposals at their own pace. ARIA may also provide funding in stages, allowing researchers to adapt their projects based on early findings and progress. In some cases, it may provide open-ended funding, giving researchers more flexibility to explore new avenues and unexpected discoveries.

Applicants should submit a proposal through the ARIA website. Current funding opportunities can be found at www.aria.org.uk. Current programmes seeking input include Safeguarding for AI (www.aria.org.uk/programme-safeguarded-ai), which has a central mathematical component.

Professor Iain Gordon
LMS Vice-President and Chair of Research Policy Committee

OPPORTUNITIES

Mathematics Degrees for the Future Grants

The Campaign for Mathematical Sciences (CaMS) is inviting applications from UK higher education institutions to design and implement new, innovative degree programmes in the mathematical sciences. These can range from interventions in existing programmes to major collaborations between several institutions or subject areas.

Maths Degrees for the Future Grants will be administered by the London Mathematical Society, which is partnering with CaMS to deliver the grants. The criteria are broad, but successful applications will be expected to demonstrate the following:

- A clear vision for the mathematical knowledge and skills that the programme will develop for students over the next 10 years, and how this relates to the needs of academia, industry or teaching.
- That the programme will retain a core focus in foundational mathematics and equip graduates with the flexibility to move into a wide range of future careers.
- How the programme will attract a wider pool of students into the mathematical sciences, including from related fields and diverse backgrounds.
- How success will be measured and tracked, and how best practice will be shared with other universities and the wider mathematical sciences community.
- That there is a clear justification for how the funds will be used to develop the current provision and ensure its long-term sustainability.

Any applications up to £500,000 will be considered. Applications do not have to request the maximum funding available. Applications must comply with the

rules on eligible expenditure, including that the funding is used within three years. For more information see: tinyurl.com/5v78eep7.

Simon Edwards
Executive Secretary (CEO)

LMS Grant Schemes

The next closing date for Research Grant applications (Schemes 1 to 5 and Mathematics in Africa) is 22 January 2025. Applications are invited for the following grants to be considered by the Research Grants Committee at its February 2025 meeting. Applicants for LMS grants should be mathematicians based in the UK, the Isle of Man or the Channel Islands. For grants that support conferences or workshops, the event must be held in the UK, the Isle of Man or the Channel Islands. For more information on how to apply, please visit the following link: www.lms.ac.uk/grants.

Conferences and Workshops (Scheme 1)

Please note that as of 1 August 2024, the LMS Scheme 6 Workshop Grant has been merged with the Scheme 1 Conference Grant to become the Scheme 1 Conference and Workshop Grant.

Grants of up to £5,500 are available to provide partial support for conferences and workshops. This includes travel, accommodation and subsistence expenses for principal speakers, UK-based research students, participants from Scheme 5 countries and caring costs for attendees who have dependants.

Visits to the UK (Scheme 2)

Grants of up to £1,500 are available to provide partial support for a visitor who will give lectures in at least three separate institutions. Awards are made to the host towards the travel, accommodation and subsistence costs of the visitor. Potential applicants should note that it is expected that the host institutions will contribute to the costs of the visitor. In addition, the Society can offer a further amount of up to £200 to cover the caring costs for those who have dependants.

Research in Pairs (Scheme 4)

These grants are available to mathematicians inviting a collaborator to their home base or who are visiting a collaborator at another institution. Grants of up to £1,200 are available to support a visit for collaborative research, either by the grant holder to another institution abroad or by a named mathematician from abroad to the home base of the grant holder. For mathematicians collaborating with another UK-based mathematician, grants of up to £600 are available to support a visit for collaborative research, either by the grant holder to another institution or by a named mathematician to the home base of the grant holder. In addition, the Society can offer a further amount of up to £200 to cover the caring costs for those who have dependants.

Research Reboot (Scheme 4)

Grants of up to £500 for accommodation, subsistence or travel plus an additional £500 for caring costs are available to assist UK mathematicians who may have found themselves with very little time for research due to illness, caring responsibilities, increased teaching or administrative loads, or other factors. The aim of this scheme is to allow the researcher to leave their usual environment so that they can focus entirely on their research for a period from two days to a week.

Collaborations with Developing Countries (Scheme 5)

For mathematicians inviting a collaborator to the UK, grants of up to £3,000 are available to support a visit for collaborative research by a named mathematician from a country in which mathematics could be considered to be in a disadvantaged position to the home base of the grant holder. For mathematicians going to their collaborator's institution, grants of up to £2,000 are available to support a visit for collaborative research by the grant holder to a country in which mathematics could be considered to be in a disadvantaged position. Applicants will be expected to explain in their application why the proposed country fits the circumstances considered eligible for Scheme 5 funding. In addition, the Society can offer a further amount of up to £200 to cover the caring costs for those who have dependants. Contact the Grants team if you are unsure whether the proposed country is eligible or check the definition of a developing country adopted by the IMU's Commission for Developing Countries (tinyurl.com/y9dw364o).

Mathematics in Africa Grants

Grants of up to £2,000 are available to provide partial support for mathematical activities based in Africa, including attendance at conferences or workshops,

organising conferences or workshops, or mathematical research collaborations.

Early Career Research Grant

The next closing date for early career research grant applications (Schemes 8 and 9 and ECR Travel Grants) is 22 February 2025. Applications are invited for the following grants to be considered by the Early Career Research Committee at its March 2025 meeting.

Postgraduate Research Conferences (Scheme 8)

Grants of up to £2,500 are available to provide partial support for conferences organised by and are for postgraduate research students. The grant award is to be used to cover the costs of the participants. In addition, the Society allows the use of the grant to cover the caring costs for those who have dependants.

Celebrating New Appointments (Scheme 9)

Grants of up to £400 or £500 are available to provide partial support for meetings to celebrate the new appointment of a lecturer at a university. Potential applicants should note that it is expected that the grant holder will be one of the speakers at the conference. In addition, the Society allows the use of the grant to cover the caring costs for those who have dependants.

ECR Travel Grants

Grants of up £500 are available to provide partial support for travel or accommodation to allow UK-based early career researchers to attend conferences or undertake research visits, either in the UK or overseas.

LMS Research Schools and Research Schools on Knowledge Exchange 2026

Call for Proposals

Grants of up to £15,000 are available for LMS Research Schools and LMS Research Schools on Knowledge Exchange, which provide training for research students in all contemporary areas of mathematics. Normally, the Society supports up to three Research Schools or Research School on Knowledge Exchange. The LMS Research Schools and LMS Research Schools on Knowledge Exchange support the participation of research students from both the UK and abroad. The lecturers are expected to be international leaders in their field. The LMS Research Schools and LMS Research Schools on Knowledge Exchange are often partially funded by the Heilbronn Institute for Mathematical Research (heilbronn.ac.uk).

Information about how to submit an application can be found on the LMS website:

Research Schools:
www.lms.ac.uk/events/lms-research-schools

Research Schools on Knowledge Exchange:
www.lms.ac.uk/events/lms-research-schools-ke

Applicants are strongly encouraged to discuss their ideas for Research Schools with the Chair of the Early Career Research Committee, Professor Jelena Grbic (research.schools@lms.ac.uk), before submitting an application.

Applications should be submitted by 1 March 2025 to research.schools@lms.ac.uk.

LMS Undergraduate Summer School 2026

The call for expressions of interest to host the LMS Undergraduate Summer School in 2026 is now open. Expression of interest deadline: 1 March 2025

A grant of up £25,000 plus income from registration fees (£250 per registered student attending in person and £25 per registered student attending remotely) is available to support the costs of the LMS Undergraduate Summer School 2016. The school should be able to accommodate at least 50 undergraduate students attending in person and up to 200 undergraduates attending remotely.

The London Mathematical Society has held an annual LMS Undergraduate Summer School, aimed at introducing enthusiastic undergraduate students to modern mathematical research, since 2015. The LMS Undergraduate Summer Schools take place for up to two weeks in July each year and have proved very popular.

For more information or to submit an expression of interest, please visit: www.lms.ac.uk/events/lms-summer-schools.

LMS Undergraduate Research Bursaries in Mathematics 2025

Applications now open

The Undergraduate Research Bursary scheme provides an opportunity for students in their intermediate years to explore the potential of becoming a

researcher. The award provides £300 per week to support a student undertaking a 6–8-week or 12–16-week (part-time) research project over the summer of 2025 and under the direction of a project supervisor.

Students must be registered at a UK institution for the majority of their undergraduate degree and may take up the award only during the summer vacation between the intermediate years of their course. Students in the final year of their degree intending to undertake a taught master's degree immediately following their undergraduate degree may also apply. Applications must be made by the project supervisor on behalf of the student.

For further information and to download the application form, visit www.lms.ac.uk/grants/undergraduate-research-bursaries/applications.

Queries may also be addressed to Lucy Covington (urb@lms.ac.uk). The closing date for receipt of applications is 5pm on 1 February 2025.

Lucy Covington
Grants Administrator

LMS Prizes 2025: Call for Nominations

Deadline: 12 January 2025 (11.59pm)

Nominations are now open for the following LMS prizes in 2025:

- The De Morgan Medal: The Society's premier award for which the only grounds are the candidate's contributions to mathematics.
- The Senior Whitehead Prize: For work in, influence on or service to mathematics or recognition of lecturing gifts in the field of mathematics.
- The Naylor Prize and Lectureship in Applied Mathematics: For work in, influence on and contributions to applied mathematics or the applications of mathematics or for lecturing gifts.
- The Berwick Prize: Awarded to the author(s) of an outstanding piece of mathematical research published by the Society in the past 8 years. The awardee should have fewer than 15 years' full-time involvement in mathematics.
- The Whitehead Prizes: For work in and influence on mathematics to mathematicians with fewer than 15 years' experience at postdoctoral level (up to six may be awarded).
- The Anne Bennett Prize: For work in and influence on mathematics, particularly for acting as an inspiration for women mathematicians. The awardee should have fewer than 10 years' full time involvement in mathematics.

We strongly encourage nominations for women and other under-represented groups in the mathematical community for all LMS prizes. The Prizes Committee interprets the criteria for all prizes broadly, so if in doubt, please submit a nomination.

Nominations should be submitted via the Society's website; see nomination forms and the regulations for each prize at www.lms.ac.uk/prizes/lms-prizes. Any queries should be sent to prizes@lms.ac.uk.

Prizes nominations are considered for two rounds, so any nomination that was submitted in the last round and is still eligible will be considered.

Katherine Wright
Communications & Policy Manager

Hirst Prize and Lectureship 2025: Call for Nominations

Nominations are invited for the Hirst Prize and Lectureship in 2025. Jointly awarded by the LMS and the British Society for the History of Mathematics (BSHM), the Hirst Prize recognises contributions to the study of the history of mathematics. The prize is awarded in recognition of original and innovative work in the history of mathematics, which may be in any medium.

The prize is open to any mathematician or historian of mathematics. Members of the Hirst Prize panel and members of the LMS and BSHM councils are ineligible for the prize. There is no requirement for the winner to be based in the UK.

The award will be considered by the councils of the LMS and BSHM in spring 2025, and the winner will be announced in summer 2025. The winner will be invited to give a lecture on the history of mathematics at a meeting of the LMS in the year following the award.

Read more about the Hirst Prize and Lectureship and download a nomination form at www.lms.ac.uk/prizes/hirstprize.

The completed nomination form should be sent to prizes@lms.ac.uk by 31 January 2025, 23:59 GMT.

Please send any queries to Katherine Wright at prizes@lms.ac.uk.

Katherine Wright
Communications & Policy Manager

David Crighton Medal 2025: Call for Nominations

Nominations are invited for the LMS/IMA David Crighton Medal in 2025. The medal is awarded to an eminent mathematician for services both to mathematics and to the mathematical community.

The David Crighton Medal was established by the councils of the London Mathematical Society (LMS) and the Institute for Mathematics and its Applications (IMA) to pay tribute to the memory of Professor David George Crighton FRS. The prize-winner must be resident in the UK on 1 January of the year of the award.

The prize-winner will receive a silver gilt medal, which will be presented at a joint meeting of the LMS and the IMA, and will be invited to give a lecture.

Previous winners of the David Crighton Medal are Professor Alison Etheridge (2023), Professor Caroline Series (2021), Professor Ken Brown (2019), Professor I. David Abrahams (2017), Professor Frank Kelly (2015), Professor Arieh Iserles and Dr Peter Neumann (2012), Professor Keith Moffatt (2009), Professor Sir Christopher Zeeman (2006) and Professor Sir John Ball (2003).

Read more about the David Crighton Medal and download a nomination form at www.lms.ac.uk/prizes/david-crighton-medal.

The completed nomination form should be sent to prizes@lms.ac.uk by 28 February 2025.

Please send any queries to Katherine Wright, Secretary to the David Crighton Medal Panel via prizes@lms.ac.uk.

Katherine Wright
Communications & Policy Manager

VISITS

Visit of Husnu Ata Erbay

Professor Husnu Ata Erbay will be visiting the School of Mathematics in Cardiff University between 18 and 25 January 2025. Professor Erbay is the head of the Department of Mathematical Engineering in Özyeğin University in Istanbul, Turkey. He was awarded the TUBITAK Incentive Award in 1994 and the Sedat Simavi Science Award in 1996 for his research in applied mathematics. He was elected a member of the Science Academy of Turkey in April 2013. His research interests cover a large spectrum of applied mathematics. In particular, he is interested in numerical methods for nonlinear differential equations, nonlinear dispersive waves, continuum mechanics and nonlinear elasticity. During his visit, Professor Erbay will give a seminar at

- Cardiff University, 21 January (contact Yasemin Sengul Tezel: sengultezely@cardiff.ac.uk)

For further details contact Yasemin Sengul Tezel (sengultezely@cardiff.ac.uk).

The visit is supported by an LMS Scheme 5 grant.

Solidarity Programme: A Mathematician's Experience in the UK

On 1 October 2024, my tenure as an academic visitor at the Department of Mathematics Education at Loughborough University ended. This opportunity, which spanned 20 months, was made possible through the Solidarity for Mathematicians programme, which was initiated by the Isaac Newton Institute for Mathematical Sciences and the London Mathematical Society.

My family and I have been residing in the UK since August 2022. We were forced to flee the war in Ukraine, where our home remains. Regrettably, this was the second time we had to leave our place of residence, as we had previously lost our home in Donbas, which was occupied by Russia in 2014.

I have a strong desire to continue my scientific and educational career in the UK, as I have dedicated my life to university education. My most recent position in Ukraine was as a professor at the Department of Mathematics and Physics at Borys Grinchenko Kyiv Metropolitan University.

My way to the Solidarity Programme began in October 2022. Through my participation in another Science for Ukraine programme, I had the opportunity to meet Colin Foster, a renowned mathematics education researcher from Loughborough University. With his support, I was later awarded a Solidarity Programme grant, and Colin Foster became my host professor at Loughborough University.

We researched the challenges Ukrainian refugee students face in secondary schools in the UK. We deliberately chose this research topic not only to address the didactic aspects of mathematics but also to study the critical social and pedagogical issues related to the adaptation of Ukrainian refugees to UK schools. The findings of this research may contribute to the development of effective teaching practices for mathematics education for migrants and refugees in the UK.

Thanks to the Solidarity Programme, I could actively engage with scientific developments in the UK. I attended conferences and seminars at Loughborough University and other institutions, including regular participation in the *British Society for Research into Learning Mathematics Conference* and events hosted by the London Mathematical Society. I also had the opportunity to present the results of my scientific research at conferences in Germany, Italy and Poland.

One of the most memorable events in my life was when I had the chance to sign the LMS Members' Book, which dates back to 1865.

Additionally, I was thrilled to participate twice in the Induction Course for New Lecturers in the Mathematical Sciences at the Isaac Newton Institute for Mathematical Sciences in Cambridge. Despite not being a young lecturer by age, I am new to the British education system. Therefore, I consider the knowledge gained from the esteemed lecturers in the UK to be extremely valuable and beneficial.

A webinar on job searches, organised by the Isaac Newton Institute specifically for the participants of the Solidarity Programme, was very helpful. In general, my time in the Solidarity Programme flew by quickly. It was filled with exciting activities, meetings with new people and getting to know the education and science system in the UK.

Thanks to the Solidarity Programme, I have been able to distract myself from thoughts about losing my native home and fill my life with new ideas and plans for the future.

Today, I would like to thank the friendly staff of the Department of Mathematics Education at Loughborough University for their excellent support and positive attitude towards me. I give special thanks to the host professor, Colin Foster, who accompanied me at all stages of the implementation of the Solidarity Programme, and thanks to whom it was possible to implement our research on mathematics education.

Thanks also to the Isaac Newton Institute for Mathematical Sciences and the London Mathematical Society, which have introduced an excellent programme to support Ukrainian mathematicians and provide refugees from Ukraine with a unique chance for a professional future in the UK!

Sincerely,
Volodymyr Proshkin

Visit of George Yin

Professor Yin from the University of Connecticut USA is a thinker and a scholar. He was elected as an IEEE Fellow in 2002, an IFAC fellow in 2014 and a SIAM Fellow in 2015 for his outstanding contributions to stochastic systems theory, control and applications.

- University of Edinburgh, 4 February (contact Jiawei Li: jiawei.li@ed.ac.uk)
- University of Strathclyde, 6 February (contact Xuerong Mao: x.mao@strath.ac.uk)
- University of Glasgow, 7 February (contact Lawrence Bull: Lawrence.Bull@glasgow.ac.uk)

For further details, contact Xuerong Mao (x.mao@strath.ac.uk).

The visit is supported by an LMS Scheme 2 grant.

Heilbronn Institute for Mathematical Research

UKRI Engineering and Physical Sciences Research Council

2025 HEILBRONN FOCUSED RESEARCH GRANTS - Call for proposals

The Heilbronn Institute for Mathematical Research is offering a number of grants of up to £8K to fund focused research groups to work on adventurous and challenging mathematical problems, or to discuss important new developments in mathematics. Grants under this scheme will be funded either through the UKRI/EPSRC 'Additional Funding Programme for Mathematical Sciences' (part of the £300M government investment announced in 2020) or by the Heilbronn Institute directly.

Open to all mathematicians and to any department in the UK, these grants will support travel and local expenses for groups (typically of up to 8 people) to come together to focus intensively on a problem or to discuss a significant new development in mathematics, normally for up to a week. Groups are encouraged to include a range of career stages and involve a substantial UK-based component. The funded activity is expected to take place in the UK.

Proposals from these areas of research, interpreted broadly, will be given priority: Pure Mathematics, Probability and Statistics, and Quantum Information.

Two A4 page proposals should be sent by **9am, Monday, 3rd February 2025** to: heilbronn-administrator@bristol.ac.uk For further particulars and additional information, please visit our website: https://heilbronn.ac.uk/frg/

LMS Council Diary — A Personal View (June)

The Society's General Meeting held at De Morgan House in June coincided with the Celebration of Kelvin's 200th Anniversary (in partnership with the British Society for the History of Mathematics and the University of Glasgow). As is usual, Council met before the General Meeting. This was a mostly in-person meeting, though unfortunately two Council members experienced severe travel disruption en route to London but at least they were able to participate via Zoom.

Council received an oral report from President Jens Marklof on his wide-ranging activity including exciting progress in the Society's strategic goal of engaging with the international community with the identification of three regions for particular focus and the aim to host meetings in these regions and fund visits. The President attended and gave enthusiastic feedback on the *75th British Mathematical Colloquium* in Manchester, making special mention of Corinna Ulcigrai's LMS Lecture *Flows on Surfaces: Dynamics and Rigidity*. The President also reported to Council the recommendation of the Presidential Search Panel that Professor Mark Chaplain FRSE (University of St Andrews) be nominated as the President-Elect. Council gave its full endorsement, and the nomination was subsequently announced at the Society's General Meeting later in the afternoon.

Among the many other items of business considered by Council were matters related to the Academy for the Mathematical Sciences, progress and presentations on the Society's fundraising review, and an update on the bid, joint with the Institute of Mathematics and its Applications (IMA), to host the *10th European Congress of Mathematics* at ExCeL London in 2028. Consideration of the Society's third quarter financial review and budget planning also occupied Council at length. Other highlights included discussion and approval of the Society's Hardy Lectureship for 2025, the next Chair of the Nominating Committee and the recipient of the 2024 Christopher Zeeman Medal (awarded jointly with the IMA).

After conclusion of its business, Council members enjoyed lunch before attending the General Meeting followed by the excellent afternoon lectures of the Celebration of Kelvin's 200th Anniversary meeting.

Robb McDonald
General Secretary

LMS Council Diary — A Personal View (October)

The Council met via videoconference on Friday, 18 October. The meeting began with the President's business, which included updates on the rebranding of the Protect Pure Maths Campaign as the Campaign for the Mathematical Sciences, the launch of the Maths Degrees for the Future funding call, which aims to help attract a bigger, more diverse group of students to study for mathematics degrees at university, and the activities of the LMS Global Engagement Working Group, which is developing plans for several LMS Global Meetings in 2025 that will be presented in more detail at the November Council Meeting. The President also reported on the very engaging *LMS Representatives Day* that had taken place in September and a trilateral meeting of the Royal Society, the Polish Academy of Sciences and the Ukrainian Academy of Sciences, which incorporated a mathematical meeting that he attended along with Professor Jon Keating, former LMS President and current Treasurer of the Royal Society.

After hearing from the Academy for the Mathematical Sciences Working Group that planning for the new Academy was continuing with a view to replacing the withdrawn government funding by private investment, the Treasurer gave a summary of the year-end position and reported that the Auditors' Management Letter had given the Society a clean bill of health. Council then approved the Trustees' Annual Report 2023/24, including the Annual Accounts for the year 1 August 2023 to 31 July 2024, and agreed an update to the operational procedure for allocating funding from the Strategic Development Fund, which supports activities that develop the strategic goals 'LMS in the Global Community', 'Engaging Our Community' and 'Pathways in Mathematics'.

Other business included various aspects of committee membership, an update on LMS membership and a discussion regarding the challenges with the diversity of nominations received for LMS Prizes, both in terms of gender and geographical spread, which had been highlighted in the Prizes Committee Annual Report.

The meeting concluded with the President thanking everyone for their contributions.

Elaine Crooks
Member-At-Large

REPORTS OF THE LMS

Report: LMS Reps Day

On 25 September, 23 LMS reps attended the *LMS Reps Day* at De Morgan house with three more joining online. The President, Jens Markof, led the day and outlined how important and valued the work of the LMS reps is to the Society. The President was joined by Anne Taormina, Member-at-Large for Membership, and Jason Lotay, Chair of the Society Lecture and Meetings (SLAM) Committee and Member-at-Large.

All three Council members led workshops with the reps including

- How can the LMS support the LMS reps?
- How to engage with younger members (graduate, postgraduate and ECRS) and increase LMS membership?
- How to enhance regional meetings?

Council members Rachel Newton, Member-at-Large, and Simon Salamon, Treasurer, popped in during the day to listen to the discussion and meet the reps. Also in attendance were key members of the Society Business Team, who gave updates on LMS strategic priorities, fellowships and grants, society meetings, and communications including newsletters and social media content.

The reps provided the Council members and staff with lots of ideas for future engagement with the LMS membership in universities. Feedback from the day has highlighted the benefits of bringing this key group of LMS volunteers together to network and work in partnership with the LMS staff team.

Jennifer Gunn
Head of Society Business

Report: LMS Bookshop Event Series

The LMS recently trialled a series of events with mathematical authors at Waterstones Trafalgar Square in London, celebrating new books that are transforming the way we see and speak about mathematics.

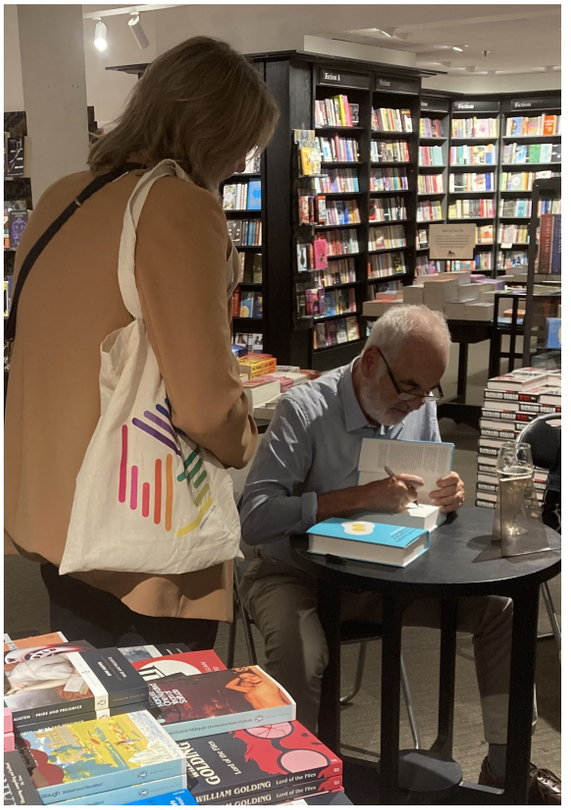
The events were centred around a recently published book by an author known through their mathematics and who has the ability to communicate their research and ideas in interesting and accessible ways. The author was engaged in conversation with an interlocutor, also from a mathematics background, in an exploration of the mathematics contained in the work.

Sarah Hart (left) in conversation with Rob Eastaway (right)

The events ended with an audience Q&A and there was a chance for attendees to meet the authors and get a copy of their book signed.

On Wednesday, 17 July, Sarah Hart was in conversation with Rob Eastaway regarding her book *Once Upon a Prime: The Wondrous Connections Between Mathematics and Literature* (Mudlark, 2024).

Next, on Wednesday, 18 September, David Spiegelhalter discussed *The Art of Uncertainty: Living with Chance, Ignorance, Risk and Luck* (2024, Pelican) with Timandra Harkness.



David Spiegelhalter (right) signing a book

Finally, on Wednesday, 16 October, Marcus du Sautoy talked about his book *Around the World in 80 Games: A Mathematician Unlocks the Secrets of the Greatest Games* (Fourth Estate, 2024) with Sophie Maclean.

The series was influenced by our own popular lectures, which bring mathematical research and its applications to a non-specialist audience, including A-level students and beyond, who have an interest in high-level mathematics but do not necessarily have high-level training.

The series was also informed by my own background working in the book trade and seeing first-hand how popular in-person events are and the power they have in sharing and communicating big ideas, something that online retailers just aren't able to do.

Waterstones Trafalgar Square was chosen for its proximity to the LMS office to minimise costs. Moreover, the branch is known for its events programme covering 'big ideas', especially books on the sciences, so it felt like a natural fit. The branch is also centrally located in London and very easy to access by people living both inside and outside London.

Of benefit to the LMS, our branding was visible on all event marketing, from posters in the store to the Waterstones website. As well, there was extensive promotion on social media. We also had a table in the event space displaying LMS promotional materials, where I was stationed most of the time to talk to attendees about the Society. Mary McAlinden, LMS Education Secretary, began each talk with an introduction to the Society. LMS members also benefitted from free entry to each event, compared to the standard ticket price of £6.

Each of the three events had strong attendance, from 35 people in the first event with Sarah Hart, 56 people for David Spiegelhalter and 47 for Marcus du Sautoy. It was clear from the conversations I had, as well as the Q&A section from each event, how varied the audience was in terms of age, background and engagement with maths. One of our goals was to reach beyond our usual audience and membership, and I believe this has been achieved.

My thanks go to Kevin Houston and to Mary McAlinden, previous and current education secretaries, respectively, for giving the green light to this event series, to Thuvaja and Anna from Waterstones Trafalgar Square for being such faultless hosts, and to each speaker and chair for three wonderful evenings. For further information on future events, please contact education@lms.ac.uk.

Kieran O'Connor
Events Coordinator



London Mathematical Society Prizes 2025

Celebrating Mathematical Excellence: Nominate Today!

Nominations are invited for London Mathematical Society prizes in 2025. The prizes celebrate outstanding achievements in UK mathematics and contributions to the field, including lecturing gifts and services to the community.

- Anne Bennett Prize
  For work in and influence on mathematics, particularly acting as an inspiration for women mathematicians. The awardee should have fewer than 10 years' full time involvement in mathematics.
- Berwick Prize
  Awarded to the author(s) of an outstanding piece of mathematical research published by the Society in the past 8 years. The awardee should have fewer than 15 years' full-time involvement in mathematics.
- De Morgan Medal
  The Society's premier award, for which the only grounds are the candidate's contributions to mathematics.
- Naylor Prize and Lectureship in Applied Mathematics
  For work in, influence on, and contributions to applied mathematics and/or the applications of mathematics, and lecturing gifts.
- Senior Whitehead Prize
  For work in, influence on, or service to mathematics, or recognition of lecturing gifts in the field of mathematics.
- Whitehead Prizes
  For work in and influence on mathematics to mathematicians with fewer than 15 years' experience at post-doctoral level (up to six may be awarded).

Read more and submit a nomination at lms.ac.uk/news/prizes2025

LONDON MATHEMATICAL SOCIETY
EST. 1865

Records of Proceedings at LMS meetings
LMS/IMA Joint Meeting: Mathematics for the Environment

The joint meeting was held on Friday, 20 September 2024, at De Morgan House, London, and online via Zoom. Altogether 27 members and guests were present in person and 83 online for all or part of the meeting.

The meeting began at 11am with Professor Catherine Hobbs, Vice President of the London Mathematical Society and Chair for the Joint Meeting, giving a warm welcome to everyone present.

No members were elected to Membership at this Society Meeting. No members signed the Members' Book and were admitted to the Society.

Dr Emiko Dupont (University of Bath) introduced the first lecture, which was given by Professor Rebecca Killick (Lancaster University) on *Change and the Environment: A Journey of Statisticians and Environmental Scientists*.

Dr Francisco de Melo Viríssimo (London School of Economics) introduced the second lecture by Dr Vera Melinda Galfi (Vrije Universiteit Amsterdam) on *Mathematical Insights into Climate Extremes*.

After lunch, Dr Dupont introduced the third lecture by Professor Christina Cobbold (University of Glasgow) on *The Role of Individuals and Their Traits in Determining the Impacts of Environmental Change: From Blowflies to Mosquitoes*.

Dr de Melo Viríssimo introduced the fourth lecture given by Professor Onno Bokhove (University of Leeds) on *Visualising Return Periods of Extreme Flooding Events and Visualising Cost-effectiveness of Flood-mitigation Measures*.

After a break, the final session was a panel discussion chaired by Professor Valerio Lucarini (University of Leicester) and panellists Dr Jochen Broecker (University of Reading), Professor Chris Budd (University of Bath), Dr Mohamad Elmasri (Alan Turing Institute), Dr Dawn Geatches (Innovate UK Business Connect) and Professor Rebecca Killick (Lancaster University).

Dr de Melo Viríssimo and Dr Dupont thanked the speakers for their excellent lectures and then thanked all the guests on behalf of the Scientific Committee and the LMS and IMA for a wonderful meeting. Afterwards, a wine reception was held at De Morgan House. The Society dinner was held at Sophie's Italian Restaurant on Southampton Row.

Kieran O'Connor
Events Coordinator

Records of Proceedings of the Black Heroes of Mathematics Conference 2024

This meeting took place at De Morgan House, London, and online via Zoom. Over 100 members and guests were present for all or part of the conference.

No members were elected to membership at this Society Meeting.

Day one of the conference took place on Wednesday, 2 October 2024, and was opened by LMS Vice-President Professor Catherine Hobbs, who welcomed everyone in attendance to the conference. Lectures were given by:

- Kim Sellers: (online) *Dispersed Regression Models for Dispersed Count Data*
- Justice Aheto: (online) *Spatiotemporal modelling and Interactive Web-based Spatial Mapping of Malaria Risk under Integrated Nested Laplace Approximation to Support Preventive and Control Efforts in Ghana*
- Angela Tabiri: (online) *Becoming the World's Most Interesting Mathematician*
- Flavia H. Santos: (in person) *Scoping Maths Anxiety in our Community*

The first day of the conference was then concluded with a panel session of guest speakers including: Mark Richards, Flavia Santos, Sylvester Jude, Stephen Edwards, Jordan Marajh, Kabiru Abubakari, Paulette Watson MBE, Deborah Harris FCA and Herbert Daly.

Members and guests enjoyed a drinks reception to conclude the first day of the conference.

Day two of the conference took place on Thursday, 3 October 2024, and was opened by Professor Nira Chamberlain OBE. Lectures were given by:

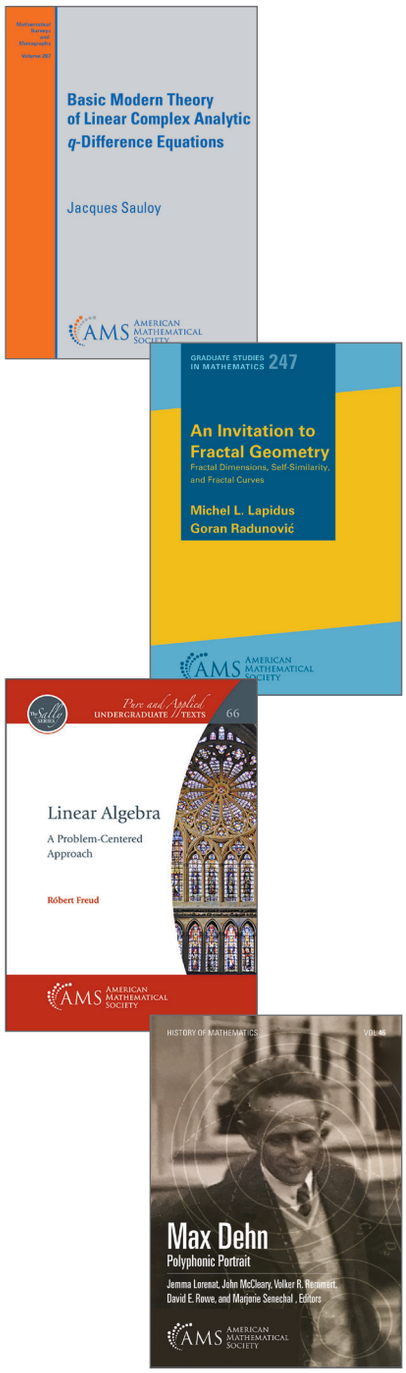
- Teresa Senyah: (online) *Representation in Mathematics Education*
- Imoleayomide Ajayi: (online) *Modelling Low Energy Electron Emission with a Truncated Normal-Generalised Linear Model (TN-GLM)*
- Nathalie Ayi: (online) *Shaping Collective Opinions: Mathematical Insights into Social Dynamics in Large Populations*
- Robin T. Wilson: (online) *Bob Moses and the Movement for Math Literacy as a Civil Right*

The conference was then concluded with a panel session of guest speakers including: Rashada Harry, Donald Palmer, Jason Gottfried, Dr Iretioluwa Akerele, Herbert Daly, Ayodeji Akiwowo and Charlene Hunter MBE.

Professor Nira Chamberlain thanked everyone for their attendance and officially closed the conference.

Nicola Goldie
Committee, Grants & Membership Manager

AMS AMERICAN MATHEMATICAL SOCIETY



BASIC MODERN THEORY OF LINEAR COMPLEX ANALYTIC q-DIFFERENCE EQUATIONS

Jacques Sauloy

Mathematical Surveys and Monographs, Vol. 287

The roots of the modern theories of differential and q-difference equations go back in part to an article by George D. Birkhoff, published in 1913, dealing with the three "sister theories" of differential, difference and q-difference equations. This book is about q-difference equations and focuses on techniques inspired by differential equations, in line with Birkhoff's work, as revived over the last three decades.

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Graduate Studies in Mathematics, Vol. 247

Offers a comprehensive exploration of fractal dimensions, self-similarity, and fractal curves. Aimed at undergraduate and graduate students, postdocs, mathematicians, and scientists across disciplines, this text requires minimal prerequisites beyond a solid foundation in undergraduate mathematics. While fractal geometry may seem esoteric, this book demystifies it by providing a thorough introduction to its mathematical underpinnings and applications.

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Pure and Applied Undergraduate Texts, Vol. 66

Invites readers to dive into the mathematical ideas of linear algebra. Offering a gradual yet rigorous introduction, the author illuminates the structure, order, symmetry, and beauty of the topic. Opportunities to explore, master, and extend the theory abound, with generous exercise sets embodying the Hungarian tradition of active problem-solving.

Dec 2024 305pp 9781470477363 Paperback £74.00

MAX DEHN

Polyphonic Portrait

Edited by Jemma Lorenat, Pitzer College et al

History of Mathematics, Vol. 46

Max Dehn (1878–1952) is known to mathematicians today for his seminal contributions to geometry and topology - Dehn surgery, Dehn twists, the Dehn invariant, etc. He is also remembered as the first mathematician to solve one of Hilbert's famous problems. However, Dehn's influence as a scholar and teacher extended far beyond his mathematics. This book is a collection of essays written by mathematicians and historians of art and science. It treats Dehn's mathematics and its influence, his journeys, and his remarkable engagement in history and the arts.

Oct 2024 290pp 9781470461065 Paperback £104.00

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Graphs on Groups: An Indian Adventure

PETER J. CAMERON

During the pandemic, a complicated set of circumstances led to my leading an online research discussion in India, on the subject of graphs on groups; the classic example is the commuting graph, where two elements of the group are joined if they commute. The research area has flourished since then. Here I discuss some of the ways in which the theories of graphs and groups interact, to the benefit of both.

Background

The year 2021 was not a happy one. Many of us were in lockdown for much of the time, while friends and colleagues were taken out by the coronavirus; for me, there was added pressure from my partner's life-changing accident (she was in hospital for two months, and for the first few weeks, visiting was not allowed). At the same time, it was the start of a major adventure.

The mathematical topic is *graphs on groups*; this refers not to Cayley graphs but to graphs whose definition reflects some local aspect of the group structure. The original and best example is the *commuting graph* of a group G, in which two elements x and y are joined by an edge if $xy = yx$. This graph was used by Brauer and Fowler [7] in 1955 when they showed that there are only finitely many finite simple groups of even order with a prescribed involution centraliser. (Their paper predates the odd order theorem of Feit and Thompson, and so they required the even order hypothesis.) With hindsight, this was perhaps the first step towards the classification of finite simple groups, probably the major achievement of 20th century mathematics; much of the work towards the classification involved determining the simple groups with some specific centraliser.

In a group G, the centraliser of x (the set of all elements that commute with x) is precisely the closed neighbourhood of x in the commuting graph. But the word 'graph' does not occur in the paper of Brauer and Fowler; graph theory was not mainstream mathematics then. Instead, they state that the *distance* between two elements x and y is the length of the shortest chain of non-identity elements from x to y in which each element commutes with the next. We would now call this the distance in the commuting graph with the identity removed. They proved that the distance is bounded and used arguments that would now probably be called graph-theoretic to bound the number of vertices.

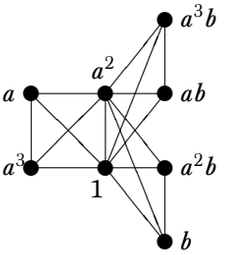

Figure 1. Commuting graphs of dihedral and quaternion groups of order 8

In recent years, the study of this and related graphs on finite groups has grown enormously. The *power graph* of G has x and y adjacent if one is a power of the other. At the *British Combinatorial Conference* in 2009, Shamik Ghosh asked a question about the power graph, which I was able to answer [8]. Later, I worked intermittently on these graphs, until someone asked me another question about them. I no longer recall what the question was or who asked it, but I started thinking about the topic again and realised that there was a great deal that I had to say about it. So I opened a file and filled it with my observations.

When the file reached 80 pages, I decided that enough was enough, so I put it on the arXiv, with no intention of publishing it elsewhere. But two things happened. First, Alireza Abdollahi, the editor-in-chief of the *International Journal of Group Theory*, a diamond open-access journal, invited me to submit it to his journal. It appeared in 2022 and is already the most highly cited paper in the journal [9].

The next was even more significant. I had met Ambat Vijayakumar, from Kochi in Kerala, India, at a conference he organised in 2010 (a satellite of the

Hyderabad ICM). He saw the arXiv paper and invited me to run an online research discussion on the topic. We had no idea how long this would last; but in fact, it met once a week for the entire summer of 2021, and by the end I was in contact with mathematicians all over India who had participated and were either working on these topics or keen to get started.

Figure 2. Ambat Vijayakumar, Cochin University of Science and Technology

As a result, I have about 25 publications arising directly from this initiative (and several more on the arXiv), with about the same number of new co-authors, mostly Indian but a few from other countries including China, Germany, Russia, Slovenia and Vietnam.

Some graphs on groups

Here is a brief summary of some of the graphs that have been considered. First, there is a hierarchy of 'local' graphs, starting with the power graph. Next is the *enhanced power graph*, in which x and y are joined if there exists an element z such that x and y are both powers of z. This is equivalent to saying that the group $\langle x,y\rangle$ generated by x and y is cyclic. This description shows us how to extend the sequence: the commuting graph joins x to y if $\langle x,y\rangle$ is abelian, and we can go on to the nilpotency and solubility graphs by requiring these properties for $\langle x,y\rangle$. Each graph is a *spanning subgraph* of the next; this means that the edge set of each graph is contained in that of the next.

Another sequence involves generation properties. The *generating graph* joins x to y if x and y generate G; the *rank graph* joins them if $\{x,y\}$ is contained in a generating set of least cardinality; and the *independence graph*, introduced by Andrea Lucchini, joins them if $\{x,y\}$ is contained in a minimal (under inclusion) generating set. These also form a hierarchy but with inclusions reversed.

Simple arguments show that the independence graph is contained in the complement of the power graph, the rank graph in the complement of the enhanced power graph and (if G is non-abelian) the generating graph in the complement of the commuting graph. (For example, if x and y are both powers of z, then a generating set containing x and y can be reduced in size by replacing x and y by z.)

Another graph has also been considered. It lies between the enhanced power graph and the commuting graph and is called the *deep commuting graph*. In this graph, x and y are joined if and only if their inverse images in every central extension of G commute. Its study involves rather different ideas, such as the Schur and Bogomolov multipliers and the notion of isoclinism [10].

Another type of graph involves an equivalence relation $\sim$ on the group G as well as a graph Γ from the above list. (Apart from equality, the equivalence relations that have been considered are conjugacy and the relation 'same order'.) These graphs have expanded and compressed forms. In the expanded form, x and y are joined if there exist $x' \sim x$ and $y' \sim y$ such that $\{x',y'\}$ is an edge of Γ. (These are called B superA graphs, where A and B are names of the graph and the equivalence relation.) In the compressed form, the vertices are the equivalence classes. Two vertices are joined if there is an edge of Γ between elements of the corresponding classes.

Defining classes of groups

Using these graphs, we can define classes of groups in two ways: either the class of groups for which two of the graphs coincide or the class of groups for which the graphs belong to a specified graph class,

such as perfect graphs. Of many results of this type, here are three.

The groups for which the power graph and enhanced power graph coincide are the so-called *EPPO groups*, those in which every element has prime power order [1]. The soluble EPPO groups were classified by Higman in the 1950s and the simple ones by Suzuki in the 1960s; the complete classification is in a little-known paper by Brandl in 1981 [6].

The groups for which the commuting graph and the conjugacy supercommuting graph coincide are the 2-*Engel groups*, those satisfying the identity $[[x,y],y] = 1$, where $[x,y] = x^{-1}y^{-1}xy$ [3].

A graph is *split* if its vertex set is the disjoint union of two subsets, one containing all possible edges and the other no edges. These form a class of graphs with good algorithmic properties. The commuting graph of G is split if and only if either G is abelian or it is generalised dihedral of twice odd order (these are groups with an abelian subgroup A of odd order with index 2, such that elements outside A conjugate elements of A to their inverses) [14].

Figure 3. Eravikulam National Park, Kerala

Results about groups

The most famous result about groups proved using graphs is the theorem of Brauer and Fowler. Here is a new result improving an old theorem of Landau.

Landau showed that the order of a finite group is bounded by a function of the number of conjugacy classes. This was improved using the *soluble conjugacy class graph*, the compressed graph in which the vertices are the conjugacy classes. Two vertices are joined if the classes contain elements generating a soluble group. We were able to show that the order of G is bounded by a function of the *clique number* of this graph, the number of vertices in the largest complete subgraph [4]. Unlike Landau's, our proof uses the classification of finite simple groups but only in a light-touch way; we conjecture that this can be avoided.

Beautiful graphs

The alternating group A_5 has order 60; it is the smallest non-abelian finite simple group. We were rather shocked to discover that the automorphism group of its generating graph has order $23{,}482{,}733{,}690{,}880$. The commuting graph is even more extreme: it has $477{,}090{,}132{,}393{,}463{,}570{,}759{,}680{,}000$ automorphisms. Usually, a large automorphism group indicates a beautiful graph, but here these large groups are mostly rubbish, which has to be stripped away.

One method of doing this is *twin reduction*. Two vertices of a graph are *twins* if they have the same neighbours, possibly excepting one another. (This means that there are two types of twins, but the difference will not concern us.) Now being equal or twin is an equivalence relation, and an arbitrary permutation of an equivalence class (fixing everything else) is an automorphism. These automorphisms are of no great interest.

Figure 4. Twin reduction can create new twins

Twin reduction is the process of identifying a pair of twins (or, equivalently, deleting one) and repeating that until no twins remain. (One identification may create new twins, so this involves more than just shrinking each equivalence class to a point.) It is not hard to show that the graph obtained by twin reduction, up to isomorphism, is independent of the way in which the reduction is carried out.

A *cograph* is a graph that does not contain the 4-vertex path as an induced subgraph. This class of graphs has been rediscovered (and given different names) a number of times. The most relevant property here is that twin reduction shrinks a graph to a single vertex if and only if the graph is a cograph. So,

there is added incentive to decide for which groups a certain type of graph is a cograph. There are many partial results for this, for example [12].

So our question is this. For which graph types, and which groups, does twin reduction give an interesting graph?

So far this is mostly 'experimental mathematics'. To select just one result from many [5], we take the graph to be the difference between the enhanced power graph and the power graph (so that its edges are the edges belonging to the enhanced power graph but not the power graph). This was chosen because the power graph and enhanced graph are usually close together (for example, they have the same matching number [13]), so the graph is relatively sparse.

Applied to the sporadic Mathieu simple group M_{11} of order $7{,}920$, we obtain a graph with 385 vertices, which is bipartite with blocks of size 165 and 220. Vertices of the first block have valency 4 and those of the second, valency 3. The graph has diameter 10, girth 10 and automorphism group M_{11}; so, we have indeed stripped away the rubbish and left only the interesting part.

Further developments

A large area of activity about which I have not said much is the investigation of the graph-theoretic properties of some of these graphs.

Another area involves graphs defined on other algebraic structures, such as rings; see [2], for example.

Finally, the investigation has been extended to hypergraphs and simplicial complexes; see, for example, [11].

A selection of papers from the project is listed below.

FURTHER READING

[1] G. Aalipour, S. Akbari, P.J. Cameron, R. Nikandish, F. Shaveisi, On the structure of the power graph and the enhanced power graph of a group, *Electron. J. Comb.* 24(3) (2017) P3.16.
[2] G. Arunkumar, P.J. Cameron, T. Kavaskar, T.T. Chelvam, Induced subgraphs of zero-divisor graphs, *Discrete Math.* 346 (2023) 113580.
[3] G. Arunkumar, P.J. Cameron, R.K. Nath, L, Selvaganesh, Super graphs on groups, I, *Graphs Comb.* 38 (2022) 100.
[4] P. Bhowal, P.J. Cameron, R.K. Nath, B. Sambale, Solvable conjugacy class graph of groups, *Discrete Math.* 346 (2023) 113467.
[5] S. Biswas, P.J. Cameron, A. Das, H.K. Dey, On the difference of the enhanced power graph and the power graph of a finite group, *J. Comb. Theory Ser. A* 208 (2024) 105932.
[6] R. Brandl, Finite groups all of whose elements are of prime power order, *Boll. Unione Mat. Ital., V. Ser. A* 18 (1981) 491–493.
[7] R. Brauer, K.A. Fowler, On groups of even order, *Ann. Math.* 62 (1955) 565–583.
[8] P.J. Cameron, The power graph of a finite group, II, *J. Group Theory* 13 (2010) 779–783.
[9] P.J. Cameron, Graphs defined on groups, *Int. J. Group Theory* 11 (2022) 43–124.
[10] P.J. Cameron, B. Kuzma, Between the enhanced power graph and the commuting graph, *J. Graph Theory* 102 (2023) 295–303.
[11] P.J. Cameron, A. Lakshmanan S., M.V. Ajith, Hypergraphs defined on algebraic structures, *Commun. Comb. Optimiz.*, in press.
[12] P.J. Cameron, P. Manna, R. Mehatari, On finite groups whose power graph is a cograph, *J. Algebra* 591 (2022) 59–74.
[13] P.J. Cameron, V.V. Swathi, M.S. Sunitha, Matching in power graphs of finite groups, *Ann. Comb.* 26 (2022) 379–391.
[14] X. Ma, P.J. Cameron, Finite groups whose commuting graph is split, *Trudy Instituta Mat. i Mekh. UrO RAN* 30 (2024) 280–283.

Peter Cameron
After more than 50 years of university teaching in Oxford, London and St Andrews, Peter Cameron expects to be put out to grass next year. But he does not intend to stop plying his trade as a mathematician.

Mathematics Students' Adoption and Perceptions of Generative AI tools — Results from a Survey

ANIA DOMAGALA, OZAN EVKAYA, PAOLA IANNONE AND STEVEN O'HAGAN

We report on a survey gathering university mathematics students' experiences and perceptions of generative artificial intelligence. We found that students were making widespread use of generative AI tools and believed proficiency with these will be crucial in the workplace. Students were aware of the limitations of generative AI tools and thought human instructors were more effective teachers.

Introduction

Recent advances in generative artificial intelligence (GenAI) have prompted higher education institutions to adapt their policies and practice. Much energy has gone into addressing the issue of academic misconduct. However, little has been written specifically about mathematics students' own practice, experiences and views. How are mathematics students using GenAI tools, and how do they perceive the strengths and weaknesses of these tools for supporting their learning?

Technology-enhanced mathematical sciences education

The School of Mathematics at the University of Edinburgh has a group dedicated to technology-enhanced mathematical sciences education (TEMSE). This group consists of teaching-focused lecturers and researchers of mathematics education. The group develops and implements research-informed teaching and influences practice across the school. The TEMSE group is one of the largest such groups in the UK, with 20 members.

At the University of Edinburgh, central policies recognise that the use of GenAI will vary by academic discipline. This allows schools to act according to their and their students' requirements. We, as members of TEMSE within the School of Mathematics, aim to inform our department's use of GenAI by:

- identifying and mitigating challenges, particularly regarding teaching and assessment;
- researching possible applications of GenAI to the learning and teaching of mathematics;
- stimulating and contributing to discussion across higher education in mathematics.

Degree structure at the University of Edinburgh

Like other universities in Scotland, full-time undergraduates typically study with us for four years. A small number of students study for an integrated masters (MMath) over five years. In year 1, students aiming for an honours degree in mathematics will typically fill around half of their timetable with courses in mathematics and half with other subjects. These could be in any discipline across the university. The School of Mathematics also offers taught master's programmes (MSc) in Computational Applied Mathematics, Financial Mathematics, Operational Research and Statistics. These typically last one year.

Alongside discussing how they might adapt their own practice, we think lecturers should be aware of, and be informed by, their students' experiences and attitudes towards these tools. With this aim, and in collaboration with colleagues from Turkey, we developed and administered the Generative AI Student Perception and Experience Index (GEN-AI SPEX) to all students taking a mathematics course.

Here, we describe the design and administration of the survey, highlight key results and relate these to other work on students' views of GenAI. We conclude by summarising what we believe are important points for mathematics lecturers to consider as they adapt their teaching to the arrival of GenAI.

Survey design and administration

The GEN-AI SPEX survey aims to understand how students use and perceive GenAI tools, such as ChatGPT, Microsoft Copilot and Google Gemini. It was developed by Ozan Evkaya in collaboration with Selçuk Kılınç (Middle East Technical University, Ankara) and Sezer Kızılates (Sheng Kung Hui Tsoi Kung Po Secondary School, Hong Kong).

The survey questions were inspired by recent literature [1, 3] and were arranged into three parts: (i) student demographics, (ii) general familiarity with technology and experience of using GenAI, and (iii) perceptions and perspectives on the use of GenAI, including beliefs about the future of the tools. Each part had a mixture of five-point Likert scale questions and some open-ended questions.

The survey was administered using Jisc Online Surveys in February and March 2024. It was advertised on posters, in-class announcements and by email to all 3,247 students enrolled on a course offered by the School of Mathematics. We received 295 responses, 9% of the population. The survey questions, anonymised data and supplementary files are available at github.com/oevkaya/GenAI-Edi-Survey.

Our sample covered all years of undergraduate (262) and postgraduate (33) study, as summarised in Figure 1. Around half of the undergraduates and one-third of the postgraduates were studying for a degree awarded by the School of Mathematics; others were studying at least one mathematics course as an outside subject. An exploratory data analysis on subgroups of participants revealed no clear differences in experiences or attitudes based on year or programme of study.

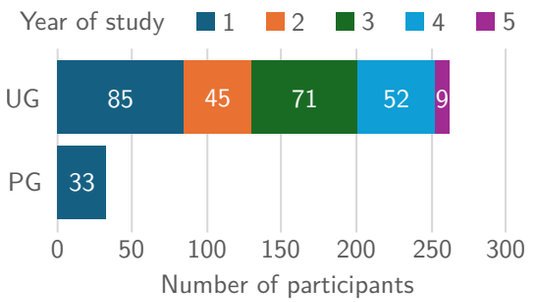

Figure 1. The number of undergraduate (UG) and postgraduate (PG) participants in the survey and their year of programme.

How are students using GenAI?

Overall, the majority of participants in the survey self-identified as being very (40%) or extremely familiar (31%) with technology in general. Around 93% of participants indicated that they had used GenAI, higher than suggested by a recent survey carried out by the Higher Education Policy Institute [11] of students across different subjects. This may be due to mathematics students having a higher than average familiarity with technology compared with students in general or simply that students who had used GenAI may have been more likely to complete our survey. The small number who had not used GenAI tools said either that they did not know what these tools were or that they had consciously chosen not to engage with them.

Almost all participants who were somewhat familiar with GenAI had used ChatGPT (from OpenAI). This was, by far, the most widely used tool. Others mentioned were Claude (from Anthropic), Gemini (from Google), Perplexity (from Perplexity AI) and Copilot (from Microsoft).

Participants were asked to select from a list the ways in which they had used GenAI. The uses chosen by more than half of the respondents were as follows:

- asking technical questions (64%)
- asking quick questions when stuck on a problem (60%)
- explaining concepts (58%)
- asking general knowledge questions/advice (54%)
- carrying on a conversation out of curiosity (50%)

Less commonly reported uses included solving homework (28%) and writing essays (17%).

When asked to specify in what other ways they had used GenAI, participants listed coding, summarising, generating artwork, proofreading or simply "messing around with them for fun".

What do mathematics students think of GenAI?

Accuracy of GenAI output

The majority of participants (85%) agreed that "GenAI tools often lack reliability and contextual appropriateness"; only 5% disagreed with the statement. A

recent report by Jisc [2] concluded that mathematics students felt GenAI output could still help their learning, even when they believed the output to be inaccurate. This conclusion is supported by the work of Das and Madhusudan [7], who found that students tended to agree that ChatGPT helped them to learn difficult concepts despite also believing that it could be unreliable and may not understand the nuances of certain topics or assignments.

The extent to which mathematics students are able to judge the accuracy of GenAI output requires more research. However, there has been some work in this area in other STEM fields. Dahlkemper et al. [6] asked physics students to rate the scientific accuracy of ChatGPT and expert-generated explanations of physics concepts. They found that students rated the expert-generated explanations more highly than ChatGPT's. However, students with less (self-assessed) knowledge of a particular concept rated the ChatGPT answers more highly than did more knowledgeable students.

In another study involving physics students, Ding et al. [8] found that around half of the students taking a multiple-choice test with the aid of ChatGPT trusted the AI even when its answers were incorrect. These findings suggest, unsurprisingly, that novices may not be well equipped to judge the accuracy of GenAI output.

Note that we made no attempt in this study to determine the mathematical accuracy of GenAI output, only students' perceptions of it. However, several benchmarking studies have measured the technical accuracy of GenAI tools, with varied results. Research by OpenAI [12] found that ChatGPT-4 scored more highly than 89% of students in the multiple-choice SAT Math examination but performed less well (43rd–49th percentiles) in the Advanced Placement Calculus BC test, which covers content like that in a first course in calculus offered at Edinburgh.

Work by Frieder et al. [9] assessed ChatGPT-4's responses to a wide range of textbook and Olympiad problems. They found that ChatGPT-4 performed reasonably well at retrieving definitions and completing gaps in named theorems but quite poorly at solving more novel Olympiad problems.

The mathematical capabilities of GenAI tools may well improve as large language models are paired with formal logic systems, though it remains to be seen how such tools will affect the fundamental skills we aim to teach mathematics students.

Beliefs about teaching and assessment

Majorities of students in our sample believed that GenAI tools should be allowed in academic settings (65%), felt confident in their ability to use these tools effectively (57%) and believed that GenAI tools can help students save time (84%). Over half (54%) agreed that they can provide personalised and immediate feedback, and almost half of the students surveyed (48%) felt that these tools can help them write more efficiently.

Moreover, the majority of students also indicated that GenAI tools were not essential to their learning (57%) and that they preferred traditional search engines for finding information (63%). A narrow majority (51%) indicated that they believe that GenAI tools provide little assistance with numerical and quantitative subjects. Views on whether using GenAI for homework diminishes its educational value were mixed: 46% of participants felt that it did; 35% felt that it did not.

These results may reflect that we do not properly understand the ways in which GenAI tools can enhance learning, and therefore, students are not aware of its potential benefits. It is also worth mentioning that the students in our sample all had some experience of education before GenAI became widespread, and so may have been less enthusiastic about these tools than students will in the future.

While many potential uses of GenAI in education have been suggested (see, e.g., [2, 13]), there is little published evidence of their effectiveness. On the contrary, there is some early evidence that they may be counterproductive. Thompson et al. [14] compared Japanese students' interest in learning English with a human conversation partner versus with a chatbot. Students with a human partner reported increased interest in learning English over a 15-week period, while the interest of those with a chatbot partner declined. Similarly, work by Weber [16] found that only 3.94% of students using a goal-setting digital study assistant persisted with the tool to the end of the intervention period. Furthermore, recent work by Bastani et al. [4] studied the impact of a GenAI tutor on the performance of high school mathematics students. They found that students with access to a GenAI tutor outperformed those without. However, when all students were later tested without access to GenAI, those who had previously used the tool did not perform as well as those who had never used it. These studies call into question the ability of GenAI

to help with some aspects of learning and teaching. There is no doubt that further research is needed, but given this emerging evidence, we should be careful when introducing these tools, as they may bring unintended consequences.

A majority of students in our sample (75%) believed that GenAI tools are not as effective as human instructors in guiding coursework, while 34% felt that GenAI could potentially carry out some functions of human teachers and tutors. It has been suggested that GenAI could play the role of a personalised tutor (see, e.g., [2, 13]), and there is evidence from our survey that students are already using GenAI in this way (see the previous section). However, our survey also suggests that the students in our sample believe human guidance is preferable.

Students' apparent preference for human teachers may come down to trust; if students are (as our survey suggests) aware that GenAI output can contain errors, then they may simply trust human teachers more. There is some supporting evidence for this in the literature. Tossell et al. [15] asked students to rate their trust in the marking of an essay assignment. The study found that students were significantly more trusting of a human marker than they were of a human assisted by ChatGPT. Students trusted human-only marking most of all.

Beliefs about life outside higher education

The majority of students in our sample (84%) felt that artificial intelligence will dramatically influence work, society and daily life in the next five years. They also believed that the use of GenAI assistants will become widespread (63%) and that proficiency with these tools will be crucial to their competitiveness in future job markets (67%).

These findings support the findings by Jisc [2] and the Cengage Group [5] that students believe being skilled in the use of GenAI will be valuable to their future careers. There appears to be support for this view from employers too: a recent report by Microsoft and LinkedIn [10] found that 66% of leaders say they would not hire someone without AI skills. (Though, of course, Microsoft is heavily invested in the technology.)

Concluding remarks

The mathematics students in our sample overwhelmingly believed that GenAI tools are here to stay and will play an increasingly important role in education and the workplace. Indeed, students reported that they had used GenAI tools in their studies to answer technical questions, explain concepts and to get help when stuck on a problem. We found that students believed that GenAI tools could help them save time and write more efficiently.

Most students knew that GenAI output is not always accurate and felt that the output must be read critically, but they still felt that these tools had a role to play in their learning. We found some evidence that students believed that using GenAI for homework could diminish its educational value. Indeed, more work is needed to understand how GenAI tools might genuinely help with the learning and teaching of mathematics.

The students in our sample felt strongly that GenAI tools are not as effective as human teachers in guiding coursework but did feel that these tools should be allowed in educational settings.

The students in our sample were much more aware of the limitations of GenAI than we had expected. A small proportion reported that they had used these tools to solve homework, but our impression is that most were using these tools critically in an attempt to help their own understanding. Rather than worrying too much about students using GenAI to circumvent assessment, perhaps we should reflect critically on the tasks we set students and the standards we expect of them.

As GenAI tools become ubiquitous, the experiences and views of university mathematics students are bound to change. Therefore, our survey findings should be treated as a snapshot of a particular context at a particular time.

Acknowledgements

We thank Selçuk Kılınç (Middle East Technical University, Ankara) and Sezer Kızılates (Sheng Kung Hui Tsoi Kung Po Secondary School, Hong Kong) for developing the survey questions. We are grateful to the School of Mathematics for providing a budget to print materials publicising the survey to our students and to offer a prize draw to participants.

FURTHER READING

[1] S. Amani et al., Generative AI perceptions: A survey to measure the perceptions of faculty, staff, and students on generative AI Tools in academia. Preprint 2023, arxiv.org/abs/2304.14415.
[2] S. Attewell, *Student perceptions of generative AI*. Jisc report, 2024, https://edin.ac/3Y8Y2Cd.
[3] C.K.Y. Chan, W. Hu, Students' voices on generative AI: Perceptions, benefits, and challenges in higher education, *Int. J. Educ. Technol. High Educ.* 20(1) (2023) 43.
[4] H. Bastani, O. Bastani, A. Sungu, H. Ge, Ö. Kabakcı, R. Mariman, *Generative AI Can Harm Learning*. Report, 2024, https://hamsabastani.github.io/education_llm.pdf.
[5] Cengage Group, *2024 Graduate Employability Report: Preparing Students for the Gen-AI-driven Workplace*. Press release, 2024, https://edin.ac/3A068mJ.
[6] M.N. Dahlkemper, S.Z. Lahme, P. Klein, How do physics students evaluate artificial intelligence responses on comprehension questions? A study on the perceived scientific accuracy and linguistic quality of ChatGPT, *Phys. Rev. Phys. Educ. Res.* 19(1) (2023) 010142.
[7] S.R. Das, J.V. Madhusudan, Perceptions of higher education students towards ChatGPT usage, *Int. J. Technol. Educ.* 7(1) (2024) 86–106.
[8] L. Ding, T. Li, S. Jiang, A. Gapud, Students' perceptions of using ChatGPT in a physics class as a virtual tutor, *Int. J. Educ. Technol. High. Educ.* 20(1) (2023) 63.
[9] S. Frieder et al., Mathematical capabilities of ChatGPT, in: *Proc. 36th Conference on Neural Information Processing Systems* (eds. A. Oh, T. Naumann, A. Globerson, K. Saenko, M. Hardt, S. Levine) Curran Associates, 2023, pp. 27699–27744.
[10] Microsoft and LinkedIn, *AI at Work Is Here. Now Comes the Hard Part.* Report, 2024, https://edin.ac/3WwUrfR.
[11] J. Neves, J. Freeman, R. Stephenson, P. Sotiropoulou, *Student Academic Experience Survey*. AdvanceHE Report, 2024, https://edin.ac/4bVEFzC.
[12] OpenAI, GPT-4 technical report. Preprint, 2024, arxiv.org/abs/2303.08774.
[13] M. Sharples, Towards social generative AI for education: Theory, practices and ethics, *Learn.: Res. Pract.* 9(2) (2023) 159–167.
[14] A. Thompson, A. Gallacher, M. Howarth, Stimulating task interest: Human partners or chatbots?, in: *Proc. Future-proof CALL: Language Learning as Exploration and Encounters*, Research-publishing.net, 2018, pp. 302–306.
[15] C.C. Tossell, N.L. Tenhundfeld, A. Momen, K. Cooley, E.J. De Visser, Student perceptions of ChatGPT use in a college essay assignment: Implications for learning, grading, and trust in artificial intelligence, *IEEE Trans. Learn. Technol.* 17 (2024) 1069–1081.
[16] F. Weber, A digital study assistant for hierarchical goal setting companion faces the first real users, in: *Proc. 19th International Conference on Cognition and Exploratory Learning in the Digital Age (CELDA 2022)*, IADIS Press, 2022.

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Ania is a learning technologist in the School of Mathematics. She holds a postgraduate diploma in digital education.

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Ozan is a university teacher in statistics at the School of Mathematics and teaches mathematics students in higher education across different subjects.

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Steven is a learning designer in the School of Mathematics at the University of Edinburgh in the Technology Enhanced Mathematical Sciences Education group.

Notes of a Numerical Analyst

Silly digits

NICK TREFETHEN FRS

Web searches just now have told me:

The current world population is 8,182,491,355.

In 2021, Nature *had an impact factor of 69.504.*

The average body mass index (BMI) in the United States is 29.23.

In 2023, its GDP per capita was $81,695.20.

What should we make of statements with such preposterous precision?

It's interesting how the flavours of nonsense vary. The world population, say, is a reasonably well-defined number at a given instant; what's absurd is the hint that we might know it to 10 digits of accuracy. (Indeed it may be only 1, for Nick Eberstadt of the American Enterprise Institute tells me "I am not certain we can be confident about that second digit. . . .") In the other cases the absurdity goes deeper, for even if the calculations were exactly correct in terms of the relevant definitions, the numbers still wouldn't have much meaning. An impact factor, for example, is computed from a sample of n papers spread over two years, and n might be in the hundreds if you're lucky. For 5 digits to be meaningful, it would have to be closer to 10^{10}.

$$3.14159265358979323846264338327950288\ldots$$

Figure 1. All the digits of π as displayed by Don Knuth

Spurious digits don't appear only in online statistics possibly garbled by AI. Flesh and blood students and colleagues record them regularly in homework assignments and published papers:

The computation times grow at the rate $n^{2.1104}$.

E = 1.7386e-8 [one entry in a table of errors depending on various parameters].

I tell my students to keep their brains in gear when they write down a number. In my course this autumn I tried to convey the message lightly:

To look foolish,
State results with too many digits.

Some associated emails around this time led to unexpected developments. Tim Cole of UCL told me that Gauss had apparently said the same thing, if more ponderously:

> Lack of mathematical culture is revealed nowhere so conspicuously as in meaningless precision in numerical computations.

Seeing this quote gave me a boost, for it seemed to confirm that in the good old days, even the very top mathematicians cared about numbers. I asked for help in tracking down Gauss's original German from Folkmar Bornemann of TU Munich, who proceeded to unearth a tangled history [1]. According to Bornemann, it seems likely that Gauss never said this. Maybe Wilhelm Weber or Franz Neumann said it, early in the 19th century. In the handbook of chemical analytics by Küster and Thiel, it was printed with the name of Gotthilf Hagen for generations, then re-attributed to Gauss starting with the 41st edition in 1935. The attribution to Gauss spread further with Morgenstern's book *On the Accuracy of Economic Observations* (2nd ed., 1963).

Happily, we know some numbers with unarguable precision, such as π (Figure 1). And the speed of light is 299,792,458 m/s *exactly*! — for the meter has been defined that way since 1983.

FURTHER READING

[1] F. Bornemann, Tracing a 'quote' of Gauss the numerical calculator, unpublished note, September 2024.

[2] T.J. Cole, Too many digits: the presentation of numerical data, *Arch. Dis. Child.*, 100 (2015) 608–709.

Nick Trefethen
Trefethen is Professor of Applied Mathematics in Residence at Harvard University.

Mathematics News Flash

Jonathan Fraser reports on some recent breakthroughs in mathematics.

Small volume bodies of constant width

AUTHORS: Andrii Arman, Andriy Bondarenko, Fedor Nazarov, Andriy Prymak, Danylo Radchenko
ACCESS: arxiv.org/abs/2405.18501

A non-empty compact convex set in $\mathbb{R}^d$ is said to have *constant width* if the projection of the set onto any line has the same length. It doesn't take long to come up with a closed ball as an example of a set of constant width, but it is rather harder to come up with further examples. In the plane, a *Reuleaux triangle* is the next simplest example, but there are many others in the plane and in higher dimensions. In fact, the Reuleaux triangle and the ball are extremal examples in the sense that the former has the smallest possible area of a set of constant width and the latter has the largest. Oded Schramm posed an interesting problem back in 1988, which asks if one can beat the ball by a uniform constant as the ambient spatial dimension d grows. That is, does there exist $c \in (0,1)$ such that, for all $d \geq 2$, there exists a set of constant width 2 in $\mathbb{R}^d$ with volume less than c^d times that of the unit ball? This remarkable paper, which appeared on arXiv in May 2024, answers this question in the affirmative. For sufficiently large d, they construct explicit examples with $c = 0.9$; all in just 7 pages!

The local–global conjecture for Apollonian circle packings is false

AUTHORS: Summer Haag, Clyde Kertzer, James Rickards, Katherine Stange
ACCESS: arxiv.org/abs/2307.02749

Apollonian circle packings are beautiful and simple geometric constructions that have been studied since at least Apollonius of Perga (c. 240–190 BCE) and in modern mathematics have relevance in many fields including hyperbolic geometry and number theory. To construct one for yourself, begin by drawing three circles in the plane, each tangential to the other two and having a pairwise disjoint interior. Apollonius proved that there are precisely two circles that are tangential to your initial three circles. One of these will be large and contain the three circles and the other will be small, lying in the gap in the middle. Draw them both and then proceed iteratively by drawing the largest circle you can at each step that is tangential to three circles already on the page. This can be repeated infinitely often, and the result is the Apollonian circle packing. (Incidentally, a Reuleaux triangle can also be constructed by drawing three circles in the plane.)

When you constructed your Apollonian circle packing, you might (not) have noticed that there are certain restrictions on the curvatures that appear. For a primitive integral Apollonian circle packing, the curvatures must fall into one of six or eight residue classes modulo 24. The celebrated *local–global conjecture* states that every sufficiently large integer in one of these residue classes must appear as a curvature. In 2014, Bourgain and Kontorovich famously proved that a set of curvatures of density 1 must appear within the admissible collection. However, this paper, published in *Annals of Mathematics* in 2024, proves that the local–global conjecture is false!

Radical bound for Zaremba's conjecture

AUTHORS: Nikita Shulga
ACCESS: arxiv.org/abs/2310.09801

Zaremba's conjecture states that for each integer $q \geq 2$, there exists an integer $1 \leq a < q$ coprime to q such that the continued fraction expansion of a/q has the property that all of its coefficients are bounded by a uniform constant not depending on q. The conjecture is known to hold in certain families, e.g., for $q = 2^n$ or $q = 3^n$. This paper, published in the *Bulletin of the London Mathematical Society* in 2024, shows that for all other q, the coefficients can be bounded by $\mathrm{rad}(q) - 1$, where the radical $\mathrm{rad}(q)$ is the product of all prime factors of q. This establishes Zaremba's conjecture for many new families.

Jonathan Fraser is a pure mathematician based in St Andrews. He likes fractals and analysis. He is pictured here during a visit to the pumpkin patch at Cairnie Fruit Farm.

Obituaries of Members

Seán J. Tobin: 1930 – 2023

Seán J. Tobin, LMS member and expert on group theory, has died at the age of 93. A full obituary of Professor Tobin has been published in the Summer 2024 edition of the *Irish Mathematical Society Bulletin* (doi.org/10.33232/BIMS.0093.31.33).

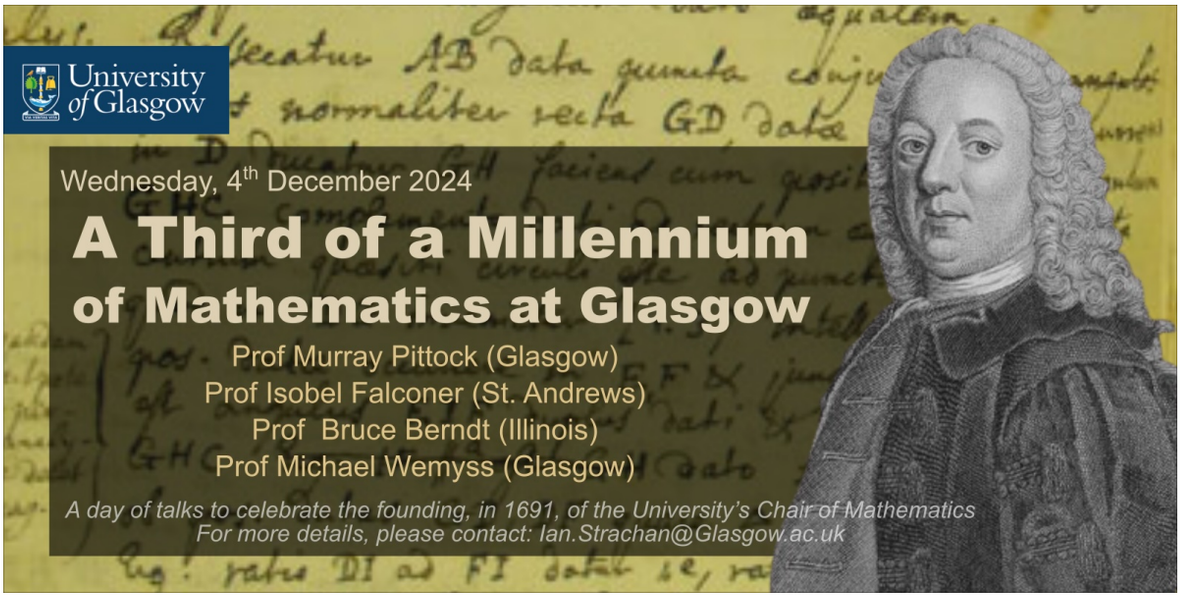
John Frederick Barrett

John Frederick Barrett, LMS member and expert in the mathematics of control engineering, has died at the age of 93. A full obituary of Dr Barrett by Professor J.M. Maciejowski will be published in the 2024 edition of the *Pembroke College Gazette* (www.pem.cam.ac.uk/alumni-development/connect-pembroke/publications/pembroke-gazette).

Death Notices

We regret to announce the following deaths:

- Professor Emeritus David Tall, who was elected an LMS member on 21 December 1967, died on 15 July, aged 83.
- Professor Emeritus Peter E. Newstead, who was elected an LMS member on 19 October 1972, died on 27 July 2024, aged 82.
- Dr Aldric L. Brown, who was elected an LMS member on 13 June 1957, died on 10 October, aged 90.
- Dr Ian M.S. Dey, who was elected an LMS member on 15 June 1961, died on 4 February, aged 85.
- Professor Munibur R. Chowdhury, who was elected an LMS member on 20 April 1967, died on 27 July 2024, aged 83.
- Professor Richard Hall, who was elected an LMS member on 16 November 1984, died on 25 October 2024, aged 84.



LTCC Intensive Course — Introduction to the K-stability of Log Fano Pairs

Location: Room 706, UCL Mathematics Department
Date: 7–8 November 2024
Website: ltcc.ac.uk/intensives/

The Leverhulme Visiting Professor Kento Fujita will deliver an intensive course *Introduction to the K-stability of Log Fano Pairs* for the London Taught Course Centre for students in mathematical sciences.

To register please send an email to office@ltcc.ac.uk.

Dynamics of Random Systems (UK Easter Probability Meeting)

Location: Durham University
Date: 31 March – 4 April 2025
Website: tinyurl.com/UKEaster25

We are pleased to announce the *2025 UK Easter Probability Meeting* on the theme of random dynamics arising from physical and biological systems.

There will be a range of invited talks, as well as mini-courses from Nina Gantert (*Exclusion Processes: Some Recent Results and Open Questions*), Ron Peled (*Disordered Spin Systems, First-passage Percolation and Minimal Surfaces in a Random Environment*) and Augusto Teixeira (*Probability on Hierarchical Lattices*).

The meeting is supported by ICMS and LMS.

Society Meetings and Events

This calendar lists forthcoming Society meetings. A fuller list is given on the Society's website (www.lms.ac.uk/events/calendar).

December

10 LMS Computer Science Colloquium, De Morgan House London and online via Zoom

July 2025

4 LMS General Meeting, London

Calendar of Events

This calendar lists other mathematical events. To promote your event in this calendar, send updates or make corrections, please contact calendar@lms.ac.uk.

December

1–3 International Conference on Applied Mathematics and Computer Simulation, Chamonix, France

4 A Third of a Millennium of Mathematics at Glasgow

January 2025

8–11 Joint Mathematics Meeting, Seattle, WA, USA

March

31–4 Apr Dynamics of Random Systems (UK Easter Probability Meeting)

June

23–26 4th IMA Conference on Dense Granular Flows, Cambridge

24–26 IMA Mathematics Anxiety International Conference, Cambridge