MANCHESTER 1824
The University of Manchester

MIMUC
By students. For students.

MANCHESTER 2024 INTERDISCIPLINARY MATHEMATICS UNDERGRADUATE CONFERENCE

Programme of events

Thurs 11th & Fri 12th April

Alan Turing Building
& University Place

Scan me

mimuc_manchester

Look out for

- **plenary speakers, including author and film-maker Simon Singh,**
- **academic and industry panels,**
- **student talks,**
- **networking opportunities.**

Email: MIMUC.organisers@manchester.ac.uk

Institute of mathematics & its applications

LONDON MATHEMATICAL SOCIETY EST. 1865

MANCHESTER 2024 INTERDISCIPLINARY MATHEMATICS UNDERGRADUATE CONFERENCE

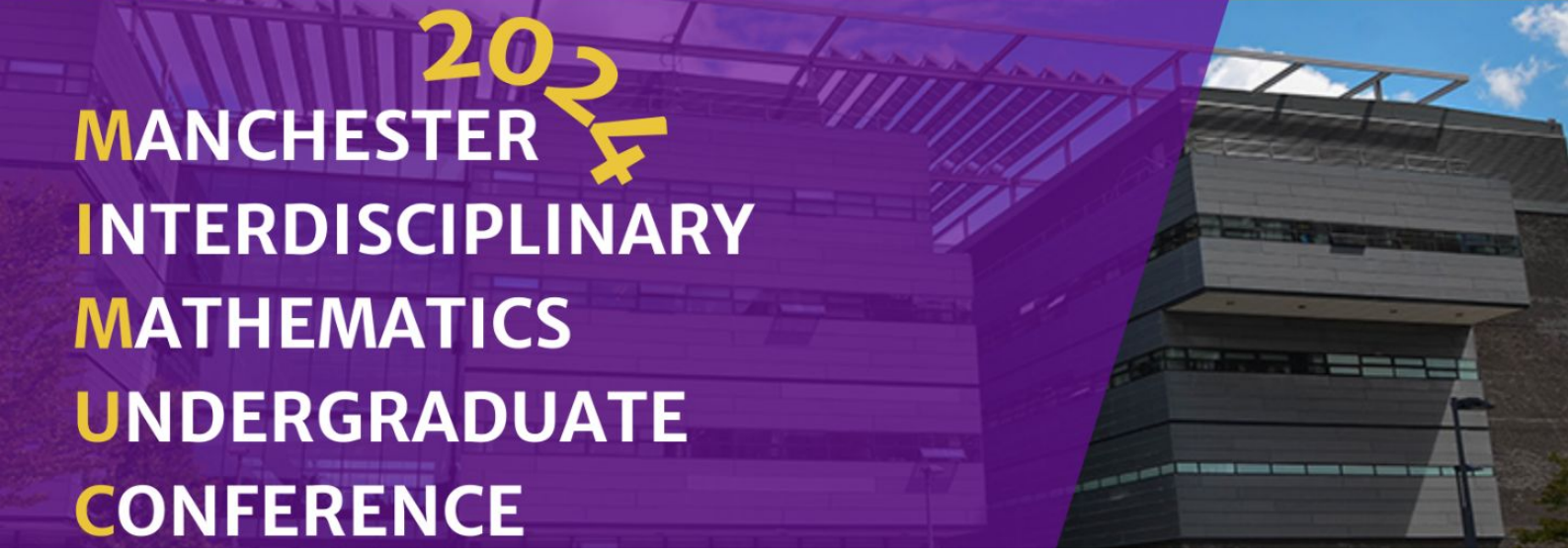
Thursday 11th April

11:00-11:40	**Registration & Welcome**	*ATB Frank Adams 1&2*
11:40-12:20	**Nichola Roberts** Data Scientist at Connex One	*ATB Frank Adams 1&2*
12:20-13:00	**Lunch**	*ATB Kitchen and Bridge Area*
13:00-14:00	**Student Talks**	*ATB Frank Adams 1&2*
	Sébastien André-Sloan — The Mathematics behind the Finite Element Method	
	Sonia Bălan — The Butterfly's Choice: navigating the reflection of chaos theory and deterministic systems on free will	
	Aneurin Quinn — Slim chances	
14:00-14:40	**Kate O'Brien** Postdoctoral Researcher in Mathematics Education at the University of Manchester	*ATB Frank Adams 1&2*
14:45-15:30	**Academic Panel**	*ATB Frank Adams 1&2*
15:30-16:00	**Networking Session**	*ATB Frank Adams 1&2*
16:00-18:00	**Student Talks**	*ATB Frank Adams 1&2*
	Emma Phelps — Utilising elliptic curves in cryptography	
	Luke Dowling — Beheading the Hydra: On generalising the notion of winnability in Hydra games	
	Jakub Šťavina — Introduction to the Lattice Boltzmann Method	
	Jess Watson — The mathematics of architecture	
	Leo Henderson — How group theory can solve the Rubik's cube	
	Rebecca Maver — The Witches of Mathematics: Representing Female Mathematicians of History	

MANCHESTER 2024 INTERDISCIPLINARY MATHEMATICS UNDERGRADUATE CONFERENCE

Friday 12th April

11:00-11:10	**Registration**		*ATB G.107*
11:10-11:50	**Stamo Georgiev** Quant at Man Group		*ATB G.107*
11:50-12:50	**Student Talks**		*ATB G.107*
	Aqib Faruqui	Linear algebra in neural networks	
	Lluís Salvat Niell	Reinforcement Learning and Applications to Mobile Health	
	Will Woolfenden	Positivity-preserving numerical methods	
12:50-14:00	**Lunch**		*ATB Kitchen and Bridge Area*
14:00-14:45	**Industry Panel**		*University Place Theatre A*
14:45-15:00	**Networking Session**		*University Place 5.205*
15:00-16:00	**Student Talks**		*University Place 5.205*
	Daniel Jackson	The Twin Prime Conjecture	
	Jiayin Wang	ARIMA: How can it reduce cost for an entrenched medical equipment company?	
	Ansar Adibay	How Physics Theories Are Built	
16:00-16:45	**Simon Singh** Author and film-maker	*Remember to book a ticket!*	*University Place Theatre A*
16:45-17:00	**Prize-giving Ceremony**		*University Place Theatre A*



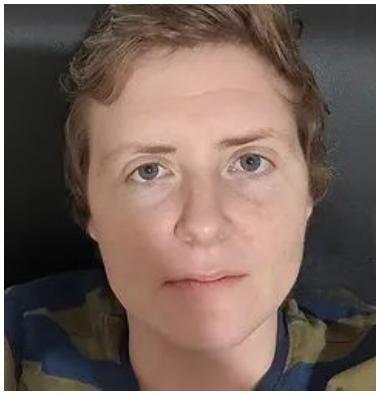
Plenary Speaker: Nichola Roberts

The realities of working with LLMs such as ChatGPT

Insights from a mathematician turned data scientist

As the emergence of ChatGPT has thrust data science into the mainstream, the potential of Language Models (LLMs) has captured the imagination of the average person. However, transitioning these powerful models from novelties to real-world applications poses significant challenges for data scientists. This presentation will explore the practical hurdles encountered when operationalizing LLMs and strategies to overcome them.

Drawing from a background in mathematics and a passion for problem-solving, the speaker will provide insights into the realities of working with LLMs in data science. From grappling with the theoretical complexities underpinning these models to navigating their real-world implementation, attendees will gain a candid understanding of the skills and mindset required to harness the full potential of LLMs effectively.



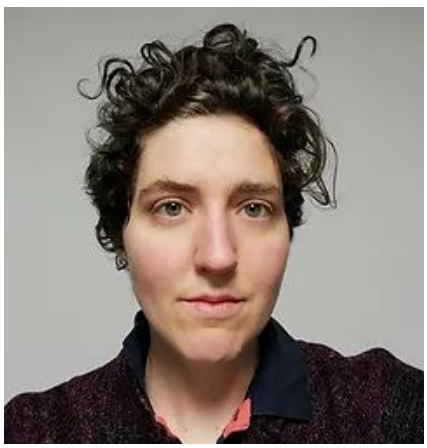
Nichola works as a data scientist for Connex One in NLP. Currently Nichola is working on LLMs, and how to use them to deliver value to clients.

MANCHESTER 2024 INTERDISCIPLINARY MATHEMATICS UNDERGRADUATE CONFERENCE

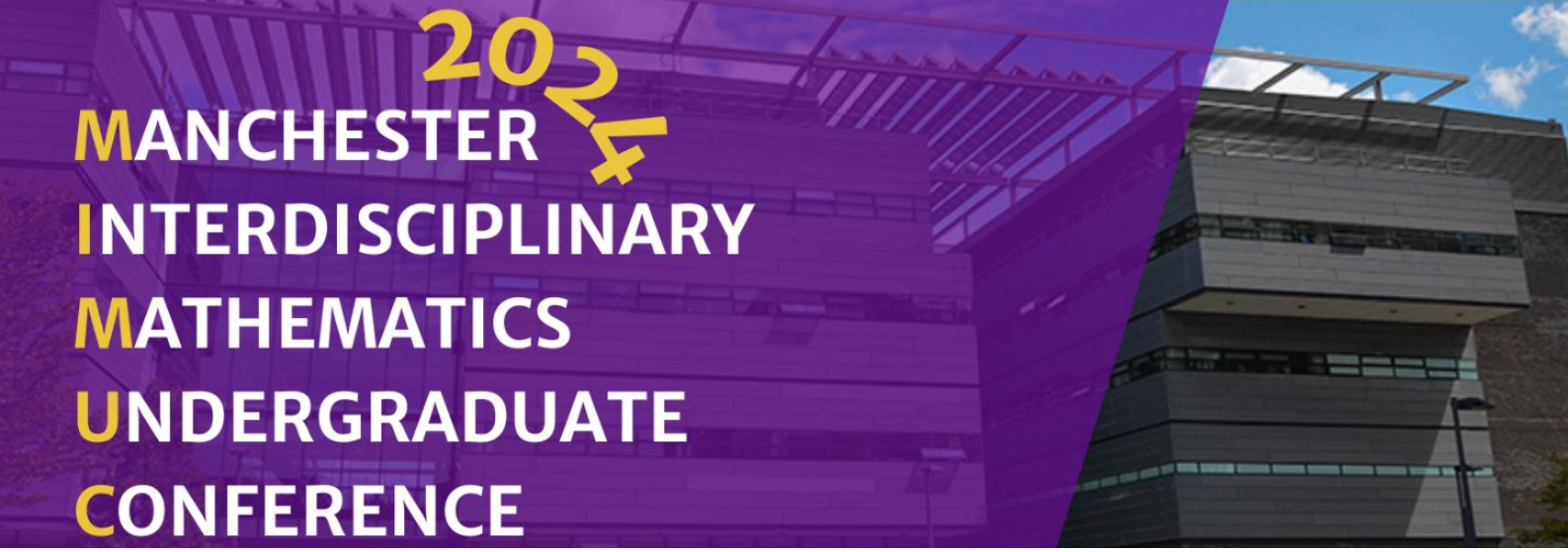
Plenary Speaker: Kate O'Brien

Following lines: Strings, looms, and weaving diagrams as sources of mathematical invention

How do artists participate in mathematical invention? This talk explores the mathematical practices of makers who use weaving technologies in the production of their work. Drawing on a wide range of contemporary and historical examples, it will examine two important but often overlooked aspects of mathematical invention: 1) thinking with materials and 2) engaging with diagrams and models. Looking at the important role of string and paper, looms and computers in creative activity, the talk will celebrate the rich symbiotic relationship between making art and making mathematics.



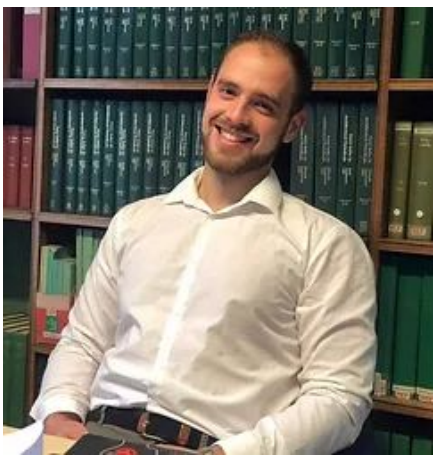
Kate is an artist, educator, researcher, and minor mathematician. She holds a BA in mathematics and philosophy from Yale University and a BFA from the Maryland Institute College of Art. Having recently finished a PhD exploring the mathematical practices of textile artists, she currently works as a postdoctoral researcher in mathematics education at the University of Manchester.



Plenary Speaker: Stamo Georgiev

A Practical Guide to the Job Market in 2024

Exactly 3 years ago, I was like you - a jobless student, attending hundreds of interviews and watching countless hours of interview prep videos. I will tell you the most practical advice for your career to apply today and see results tomorrow! I still vividly remember and feel your pain - bring a notebook and listen carefully! See you on the 12th of April!



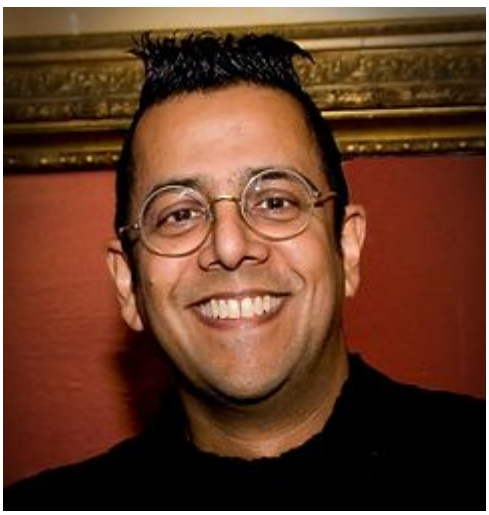
Stamo is a Quant at Man Group where he develops and improves high-performant alpha models. Stamo has a BSc Mathematics from the University of Manchester and is a Gold Medalist from Math Competitions like Harvard-MIT Math Tournament, European Cup and more.

MANCHESTER 2024 INTERDISCIPLINARY MATHEMATICS UNDERGRADUATE CONFERENCE

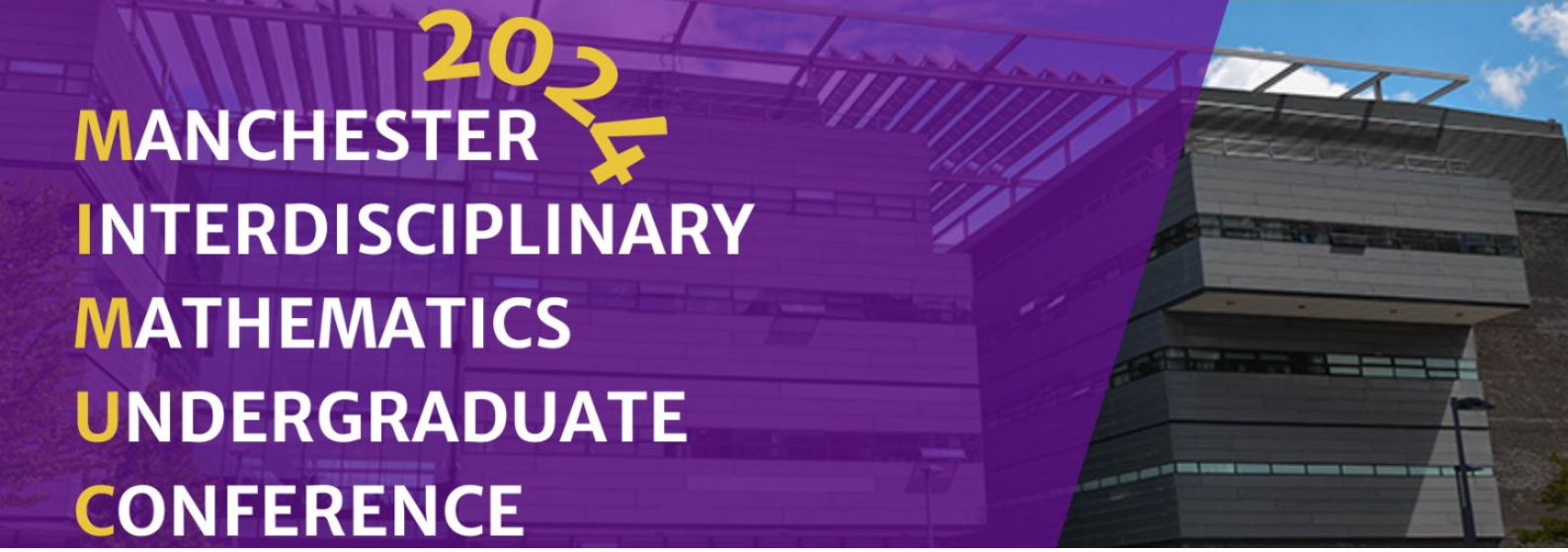
Plenary Speaker: Simon Singh

Fermat's Last Theorem, turning maths into an adventure

As well as being the author of the No.1 bestseller "Fermat's Last Theorem," Simon Singh also directed the BBC TV documentary on the same subject. Simon will explain how he turned the story of the world's most notorious maths problem into an award-winning film.



Please make sure you have registered for a ticket to Simon's talk.



Ask questions and gain insight into life as an academic…

Michael O'Donoghue
Lecturer in the Manchester Institute of Education
PGCert in Higher Education Programme Director

Radha Kessar
Professor in Pure Mathematics

Jenny Sexton
Teaching Fellow in Mathematics

Vahagn Aslanyan
Dame Kathleen Ollerenshaw Fellow

Charlotte Charlton
PhD Student

Calum Hughes
PhD Student

Academic Panel

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Ask questions and gain insight into the careers of our industry panellists…

Rachel Beattie
Co-founder, Careaux

Suvineet Singh
Software Engineer

Zöe Fassam TEP CTA
Assistant Tax Manager

Adam Jorgensen
Senior Data Engineer

Sarah Polland
Deputy Head of Department at North Halifax Grammar School

Industry Panel

MANCHESTER 2024 INTERDISCIPLINARY MATHEMATICS UNDERGRADUATE CONFERENCE

Student Abstracts

Sébastien André-Sloan BSc Computer Science and Mathematics (Third Year)

The Mathematics behind the Finite Element Method

The Finite Element Method (FEM) stands as a cornerstone in the realm of numerical analysis, offering a powerful framework for solving complex engineering and scientific problems. This presentation will be a gentle and motivated introduction to the fundamental concepts that make FEM.

FEM contains many important techniques, including discretization of continuous systems into finite elements, formulation of governing equations using variational principles, and solution techniques such as the Galerkin method. The concept of interpolation functions, pivotal in approximating the behaviour of physical phenomena within finite elements, is explored.

Furthermore, the presentation will explain at a high level the process of assembling the global system of equations, followed by the implementation of boundary conditions and solution methods like direct and iterative solvers. Real-world examples and case studies illustrate the versatility of FEM in diverse fields such as heat transfer, fluid dynamics, and electromagnetics.

In essence, this presentation serves as a primer for students seeking to comprehend the theoretical underpinnings of FEM, thus empowering them to tackle complex engineering or scientific challenges with a better toolbox of PDE solving methods.

Sonia Bălan MMath Mathematics (First Year)

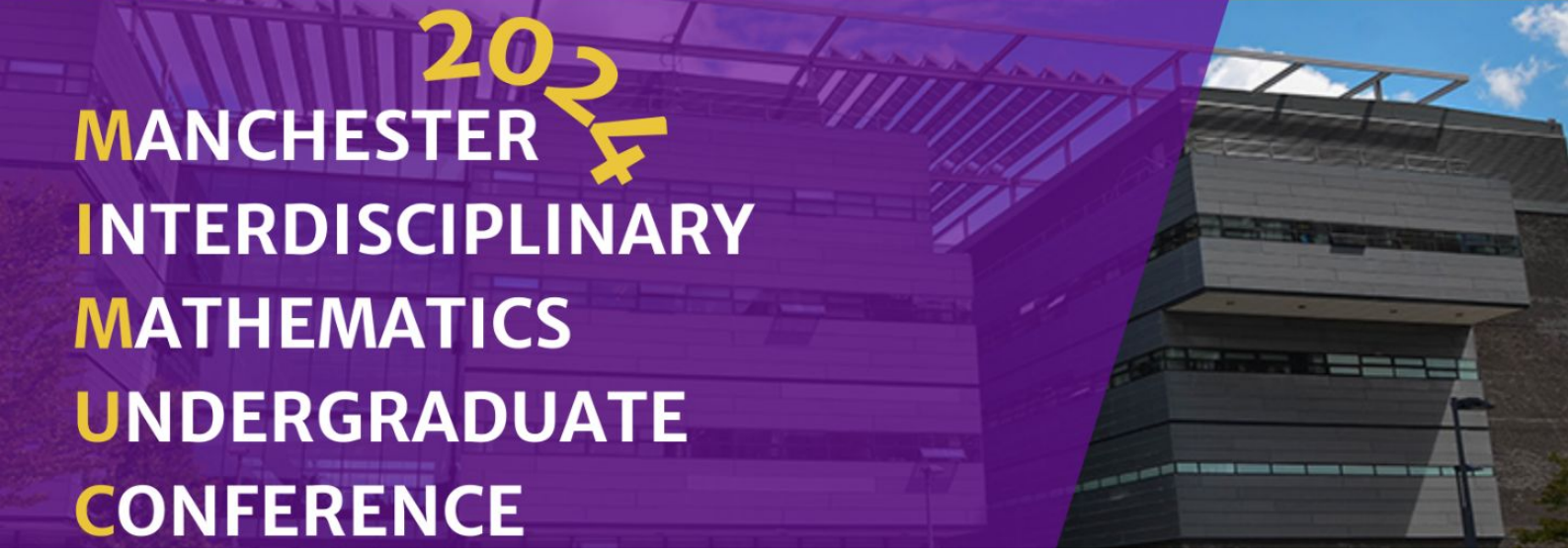
The Butterfly's Choice: navigating the reflection of chaos theory and deterministic systems on free will

The debate between free will and determinism has long captivated philosophers, scientists, and thinkers across disciplines. Chaos theory, renowned for its exploration of seemingly random and unpredictable systems, provides an unique framework to reevaluate the nature of choice and determinism, while giving a new perspective on choice and agency.

Aneurin Quinn MMath Mathematics (Second Year)

Slim chances

“Compound interest is the eighth wonder of the world. He who understands it, earns it … he who doesn't … pays it.” - Albert Einstein. Small changes, no matter how small, create advantages and disadvantages discriminately to those who abuse them, and those who ignore them. Trying to double £50 at a casino (50.4% lose and 49.6% win), results in losing all your money 70% of the time assuming you can only bet £1 at a time. Both these numbers round to 50%, and have less then 1% difference, yet they have a huge difference in actual results; this problem is famously known as the gambler's ruin. The power of compound interest can be applied to everything, even itself. In this talk, I will go over the absolute power of statistical testing and the necessity of it in the real world, as well as how we can improve the testing and the real world applications of this improvement. I will touch upon confidence intervals, parameters, and full and reduced model F-testing.



Student Abstracts

Emma Phelps MMath Mathematics (Second Year)

Utilising elliptic curves in cryptography

We live in a digital age, where we constantly share sensitive data that require robust security measures. Whether it's your private messages or major financial transactions, cryptography is the method behind keeping all that information safe. Elliptic curve cryptography stands out as one of the most secure cryptographic techniques we can use, with the likes of Bitcoin using it to keep their data secure. We will examine the intricacies of elliptic curves, by leveraging principles from group theory, to unravel what makes these curves so secure and useful. Additionally, we will investigate the Koblitz curve, the specific curve that Bitcoin has adopted for its data encryption and explore the properties that make this curve special.

Luke Dowling MSc Pure Mathematics and Mathematical Logic

Beheading the Hydra: On generalising the notion of winnability in Hydra games.

We can consider a Hydra game played on a starting tree as follows. For a given tree and turn, we select a head to behead, and we conjoin new trees, branching out of each vertex in the direct path between the root and the vertex immediately below the beheaded head, according to some pre-determined function, whose inputs include the tree at the start of the turn, the turn number, and the height of the vertex from the root. The game is called always winnable, for a given starting tree, if the player eventually beheads all heads except the root in a finite number of turns, regardless of which heads are cut in each turn. A popular example of a Hydra game is one given by Kirby and Paris, which is shown (in ZFC) to be always winnable for any given starting tree, as the tree at the start of each turn can be said to be larger before the head is cut and the sub-trees are added. The goal of this project is then to generalise on this intuition to devise a condition which if met by the game and starting tree, ensures the game is always winnable.

Jakub Šťavina MMath&Phys Mathematics and Physics (Third Year)

Introduction to the Lattice Boltzmann Method

In this talk, we will introduce the Lattice Boltzmann method as a powerful tool for solving partial differential equations involving transport of momentum or a substance. The Boltzmann transport equation will be used to motivate the method. We will discuss the fundamentals of this computational technique in a step-by-step breakdown. Considering the lattice structure and the collision rules that govern particle interactions, we illustrate how they mimic macroscopic fluid behaviour. Moreover, we will highlight the method's versatility in handling complex situations such as the thermal flows resulting from Navier-Stokes equations coupled to advection-diffusion equation. By the end of this talk, attendees will gain an appreciation of the method's capabilities and its potential applications in various fields, from engineering to biophysics.

MANCHESTER 2024 INTERDISCIPLINARY MATHEMATICS UNDERGRADUATE CONFERENCE

Student Abstracts

Jess Watson BA Architecture (Third Year)

The mathematics of architecture

Both mathematics and architecture have roots embedded in geometry. However, whilst mathematics is concerned with the description and definition of space, architecture is concerned with its creation. This talk will look at how architecture and mathematics intersect and overlap, in particular looking at multiple case studies that would not have been possible even 20 years ago. I will look at areas such as topology; surfaces and seriality; optimization; and chaos, complexity, and emergence, and how these mathematical concepts are utilised in the creation of physical space.

Leo Henderson MMath Mathematics (Second Year)

How group theory can solve the Rubik's cube

A popular toy and challenge that most people have tried to solve in their lives, the Rubik's cube and its solution is known to many. However, who can say that they didn't just look up the result or learn from a friend? Even those who did find it by trial and error would struggle trying to explain why it is that the algorithms they used work. This is where a branch of maths called group theory comes in. One of its major themes is symmetry and permutations and it turns out that it is exactly what is needed to describe how to move parts of the cube but keep the rest invariant, using the idea of conjugacy.

Rebecca Maver MMath Mathematics (Second Year)

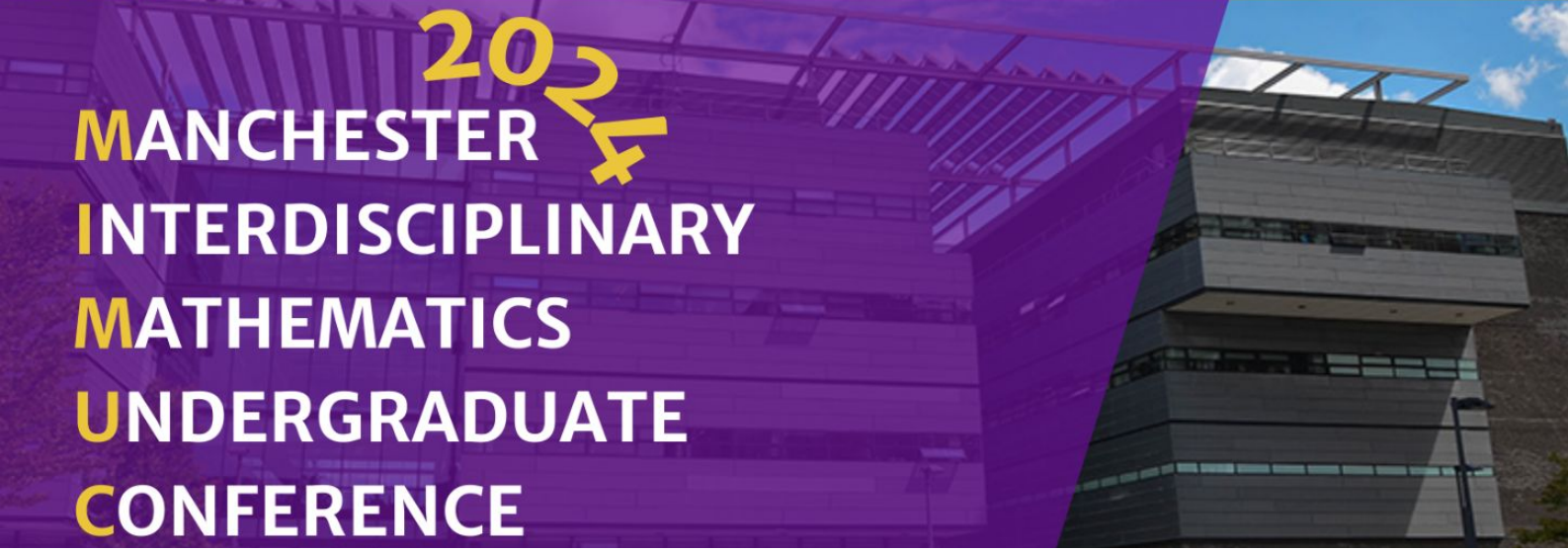
The Witches of Mathematics: Representing Female Mathematicians of History

In this talk I explore a few historical female mathematicians, from the ancient Greek Hypatia to the 20th century 'Rocket Girls,' delving into their mathematical contributions and how their legacies were shaped - or neglected. Asking, in particular, who is the Witch of Agnesi? The portrayal of female mathematicians in art and text give us powerful tools to understand the shifting attitudes towards women in maths throughout history. Can we find the answers to the still prevalent gender gaps in mathematics in this history?

Will Woolfenden MMath Mathematics (Fourth Year)

Positivity-preserving numerical methods

We can construct dynamical systems to describe processes where the quantities involved are always positive, such as chemical reaction models. However, popular numerical methods for solving these systems often fail to preserve positivity unconditionally. In this talk, we will explore how we can formulate a problem and a numerical method to guarantee positivity, and discuss some of the challenges that arise.



Student Abstracts

Aqib Faruqui BSc Computer Science (First Year)

Linear algebra in neural networks

I aim to explore the implementation of one of the most influential areas of mathematics in an ever-evolving part of machine learning and data science. As undergraduate students, a lot of our studies focus on somewhat disjoint modules and subjects - and so it is particularly exciting when we can take such important, yet distinct, areas of two disciplines and combine them. I plan on taking the audience through a step-by-step process of the design of a simple neural network model, highlighting the application of linear algebra throughout.

Most listeners will be more familiar with linear algebra than neural networks and machine learning. So, after a brief overview of the use of vectors and matrices in representing weights, biases and inputs and the opportunity to represent operations in neural networks as matrix operations, I will walk through core principles in machine learning in the context of a feedforward neural network model and training using backpropagation - more specifically using matrix operations to update biases and weights using error values.

Finally, I'd like to discuss the real-life uses of neural networks, such as:

- Natural language processing (NLP);
- Recommendation systems and image recognition;
- Diagnosis in medicine.

Lluís Salvat Niell MMathPhys Mathematics and Physics (Third Year)

Reinforcement Learning and Applications to Mobile Health

In this talk we outline the foundations and principles of reinforcement learning (RL), a branch of artificial intelligence (AI) that involves sequential decision-making under uncertainty. In particular, it sets up problems under the framework of an agent interacting with an environment, and it seeks to find a behaviour that maximises the agent's reward. We cover the main model of an environment, a Markov decision process (MDP), as well as value functions and policies, which guide the agent in solving the problem, and also explain the main challenges. We briefly discuss the main applications, such as large language models (LLMs) and recommendation systems. Finally, we present a novel algorithm, Dyadic RL, to be deployed in a mobile health study to enhance medication adherence in cancer patients, designed using findings from domain science. It is based on establishing a hierarchy of states and actions to accelerate learning and reduce variance, and it exhibits superior empirical performance compared to existing baselines. This work was conducted during a research internship in the Statistical Reinforcement Learning Laboratory at Harvard University and can be accessed at https://arxiv.org/abs/2308.07843.

MANCHESTER INTERDISCIPLINARY MATHEMATICS UNDERGRADUATE CONFERENCE 2024

Student Abstracts

Daniel Jackson BSc Mathematics and Physics (First Year)

The Twin Prime Conjecture

The Twin Prime Conjecture is a famously unsolved problem in mathematics and one of the Millennium Prize Problems, a list of seven important unsolved problems in mathematics that were selected in 2000. With the first statement of it given in 1846 by Polignac, the problem has evaded proof for nearly 200 years of extensive attempts from mathematicians despite its simplicity. Proving the statement would have major significance in a range of fields, including analytic number theory and cryptography. With the conjecture stating that there exist infinitely primes p such that both p and $p+2$ are prime, it looks at how the distribution of twin primes prognose as numbers become larger. But why has this simple conjecture remained unsolved for so long, how can we better understand the distribution of twin primes, and how can we work towards proving what has troubled so many mathematicians for so long? In this talk, we will be exploring the Twin Prime Conjecture and its related properties, explore some recent developments made by mathematicians, and some applications related to the conjecture.

Jiayin Wang BSc Mathematics (First Year)

ARIMA: How can it reduce cost for an entrenched medical equipment company?

Previously, a medical instrument company relied on experiential judgement for sales promotion to hospitals due to the undeclared purchase period of a hospital. After speaking with experienced staff, I found that the purchase period might be seasonal and predictable, and it can be analyzed on the macro or micro level. Unlocking the potential of ARIMA analysis enables the company to streamline its sales efforts and significantly reduce costs. This talk will present the process of data collection, modeling, and evaluation.

Ansar Adibay BSc Mathematics and Physics (Second Year)

How Physics Theories Are Built

In this presentation, as a particular example, I would like to give a historical overview of how the theory of Quantum Mechanics was developed. I would like to show a strong causal connection between the phenomena observed and the corresponding attempts for mathematical description. Schrödinger's and Heisenberg's formulations will be presented first. Then, John von Neumann's mathematical breakthrough, and finishing the most modern approach to Quantum Mechanics - the algebraic approach. I would like to show the development of functional analysis as a particular case of a symbiosis between mathematics and physics. If time was left, I would also speak about potential mathematical developments that can be obtained in the attempts of a canonical approach to Quantum Gravity.

MANCHESTER INTERDISCIPLINARY MATHEMATICS UNDERGRADUATE CONFERENCE 2024

Thank you to our organisers…

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