Tomorrow's Mathematicians Today - Abstracts

Saturday 15 February 2014 - University of Surrey

Talks

- **Fermat Problem in Geometry - talk**

  Nadezhda Aplakova and Aleksandar Kolev (University of Glasgow)

  This project is based on application of the isogonal conjugation for generalizing the Fermat problem in Geometry. It was initially stated as follows: In a given acute triangle ABC, locate a point whose distances from A, B and C have the smallest possible sum. The solution is the point from which each side subtends an angle of 120 degree. This problem is limited to specific type of geometric construction, which is represented by $F(Y) = \lambda.AY + \mu.BY + \nu.CY$. We aim to find its minimum for different points i.e. computing the weights λ, μ and ν (which in the original problem are all equal to 1) and recognizing the triangle centre Y in which this minimum can be reached. This paper consists of detailed description of the knowledge required for understanding the Fermat problems generalisation as well as many examples of solved Fermat problems for particular triangle centres. Based on this problem we developed an original method for generating geometric inequalities, whose number depends on the number of the triangle centres. They are based on the $F(Y') \geq F(Y)$ where the equality holds true for $Y' \equiv Y$. Among the inequalities generated so far there are some well-known, such as Finsler - Hadwigers and Newtons inequalities. Approximately 90 of the generated problems are original to the best of our knowledge.

- **L^p Convergence Problems in Fourier Analysis - talk**

  George Simpson (University of Sussex)

  Harmonic analysis is a branch of pure maths that studies functions in their function spaces. It possesses deep connections with other fundamental areas of maths including partial differential equations, number theory and geometric measure theory.

  Norm and restriction estimates are directly linked to the study of the convergence of functions, and we need information such as this on any function to be able to analyse and manipulate it further.

  I shall give an introduction to advanced harmonic analysis, important tools, techniques, including multipliers and various notation. I shall proceed to talk about general problems and solutions to these such as the Bochner-Riesz means, and the introduction of the g-function to stabilize L^p norm estimates. I will then talk about solved problems and results by leading people in the field (such as Charles Fefferman), and then I will explain open problems and approaches to them.

  I shall finish with showing connections with other areas of both pure and applied maths.

- **Bernoulli Factory via Markov Chains**

  Alex Wendland (University of Warwick)

  The project links the following two problems.

- 1. Consider a discrete state space Markov chain X_n on $\chi = f\{1, ..., k\}$ with a transition matrix P and stationary distribution π. From basic Markov chain theory we know that given appropriate assumptions on P, the distribution of X_n converges to π for every starting point $X_0 = x_0$.

  On the other hand there exist (simple) algorithms that take P as an input and output a random variable, say X_{inf} distributed as π exactly. These are called perfect sampling algorithms.
- 2. Consider a black box that generates p-coins, i.e. iid coin tosses with probability of heads being p. Assume p is unknown. For a given and known function $f : [0, 1] \to [0, 1]$, consider the problem of generating an $f(p)$-coin using the black box generating p-coins.

  There exist algorithms that take the black box generating p-coins as an input and generate a single $f(p)$-coin as an output. These are called Bernoulli Factory algorithms.

Now, given the two above problems, we used the Markov chain perfect sampling algorithms to generalise the Bernoulli Factory problem towards taking a p-coin generating black box as an input and (given appropriate conditions are met) outputting a random variable on $\chi = f\{1, ..., k\}$ distributed as π where π is now allowed to be a rational function of p.

- **Non-Monotonic Logic**

  Kristijonas Cyras (University of Leeds)

  Common-sense reasoning is defeasible: everyday we make decisions based on incomplete information about the world and on default assumptions about various phenomena. Whereas human mind is the main source of such reasoning, given our increasing reliance on technology, we want computers to exhibit common-sense reasoning as well: to make certain decisions for us and to communicate with us in a humane fashion. However, in order to implement common-sense reasoning with computers, it must first be formalised mathematically. The study of such formalisation is technically termed Non-monotonic Reasoning. Based on mathematical logic, the field captures various techniques to rigorously describe common-sense reasoning. Due to very recent intense development in computer technologies, this area of research is very novel. A modern and very promising approach to non-monotonic reasoning is Argumentation Theory. Generally a very abstract method treating logical reasoning as a form of arguing, it captures, generates and investigates various formalisms for common-sense reasoning, stretches to different disciplines - from mathematics to politics - and exerts influence on computer science, law, medicine etc. Argumentation may help us to examine human behaviour, political events, legal reasoning, as well as to develop tools for improving medical care, customer service and many other everyday experiences.

- **Reconstruction of Attractors for Blood Pressure Data**

  Ying Hao Huang (University of Surrey)

  Septic shock is a condition with a very high death rate. However death can be prevented through early diagnosis. Physiologists from KCL have collected blood pressure data (1000 Hz) from healthy and sick mice. We use these datasets to develop software that analyses the blood pressure data over continuous time windows.

  It is difficult to detect subtle changes from the graph of blood pressure against time when dealing with an enormous amount of data. Hence we split the data into smaller windows. By

using the 3D version of Takens Embedding Theorem that uses time delay coordinates with a fixed delay we can visualise the trajectory generated by the data in a 3D phase space. We observe that there is a triangular attractor on the plane orthogonal to the line $x = y = z$ where x is the blood pressure and y, z are the time delay coordinates. We also obtain a density diagram for this attractor. The whole dataset can be visualised as a moving window animation.

We have extracted many useful measures of the original data such as the pulse pressure, cycle length, variability and waveform in each window from analysing this attractor.

- **Cryptographic Hash Functions**

  Heather Callaghan (University of Greenwich)

  Cryptography is something that affects peoples daily lives but most don't understand it or know what it is, but theyd certainly notice if it no longer worked. After an overview of what Cryptography is, in which I will explain the difference between codes and ciphers and will give a brief history. Starting with the first codes and ciphers used, I will go on to cover how cryptography has evolved, particularly in recent years, up until how cryptography is used in our modern society today, giving examples.

  I will then talk about the role cryptographic hash functions play in our daily lives, for example in passwords, including an explanation of what they are and an overview of the mathematics behind it. A short discussion will follow on how secure they are and the different levels of security offered by the various available hash functions. To conclude, I will speak about the possibility of ultimate security, for example, an unhackable function.

- **Rational Tangles and the Euclidean Algorithm**

  Muhammad Syafiq Johar (Imperial College London)

  We are going to look at Conway's rational tangles, which are tangles constructible via a finite sequence of operations called "reflections" and "twists". To enable us to work with such tangles in a physical setting, we may reformulate the operation "reflection" as "rotation" and still retain all the original properties, particularly the tangle numbers and the useful Conway's Theorem attached to it. The theory of integral colouring will also be touched briefly as a tool to classify these tangles easily. Using Conway's theorem, we are going to investigate algorithms to untangle rational tangles and explore their relationship with the Euclidean algorithm. Finally, using this connection, we can optimise the number of steps required to untangle any given rational tangle.

- **Moduli Problems**

  Ben Wormleighton (University of Warwick)

  Moduli problems are fundamentally problems of parameterisation: given a class of geometric objects and some relation between them, we can naively form a space of representatives of equivalence classes, but it is often fruitful to enquire whether or not we can impose a geometrical structure on this space that is consistent with the geometry of the objects considered. In order to do so, we often need to refine our class of objects to exclude some exceptional cases, and so one is led to consider universal ways of achieving this. I will introduce the formal notions of a moduli problem and moduli space, and discuss a specific moduli problem related to the McKay correspondence to which I contributed during last

summer with work based at the University of Warwick. There is sparse literature on moduli problems in general, since it is often the case that different problems are approached by relatively diverse methods strongly tied to the individual context of the problem, making the examples the focus of this talk. Moduli spaces are widely studied in algebraic and differential geometry and number theory; both intrinsically and with a view towards studying the objects they parameterise.

- **A study on the calibration of rainfall forecasts generated from Numerical Weather Prediction Models**

  Ga Log Andy Chan (University of Surrey)

  There are many different models that help Meteorological Offices around the globe to predict weather forecasts in their respective areas; these can range from Global Models to Regional Models. However the global models are not very accurate at predicting heavy rainfall (more than 20mm of rainfall) and over-predicts light rainfall (less than 5mm of rainfall). The methodology used was an adaptation of JMAs Frequency Bias Correction where it maps the forecast predictions close to the observation data. The result shows the verification results increase for heavy rainfall and decrease generally for light rainfall. These findings prove that JMAs Frequency Bias Correction does give an experimental method in removing bias.

- **Applying Graph Theory to Sudoku**

  Conchita Mliswa (University of Greenwich)

  Sudoku, also known as Number Place, is a $n^2 \times n^2$ grid puzzle based on Latin Squares and Gerachte Designs, probably invented by Howard Garns in 1979. Over the last ten years Sudoku has become extremely popular worldwide and puzzles are published each day in British newspapers. Mathematics has been used to gain insight into the complexities of creating and solving the puzzle. In this talk, I will explain mathematical principles which can be applied to derive the final solution of a Sudoku puzzle.

  Broadly speaking, the identification of the combinations and patterns hidden in the puzzle is the key to solving a Sudoku puzzle. I will focus on the subject of graph theory - presenting the Sudoku puzzle as a graph colouring problem. Initially, I will consider simple and multi-colouring techniques to deduce the position of a candidate solution in a puzzle based on logical chains. Looking at the research work presented by Agnes M. Herzbeg and M. Ram Murty in their paper Sudoku Squares and Chromatic Polynomials, I will then expand these ideas to deduce the minimum number of colours required for a Sudoku puzzle to have a unique solution.

- **In search of the Stradivarius-like solutions in classical wave mechanics - talk**

  Maurese Gargan (Trinity College Dublin) and Anna Lawless (Trinity College Dublin)

  In this project, solutions of the one dimensional wave equation in a material containing short-range scatterers are studied, and the effect of these scatterers on the acoustic response of the material is investigated. This is done using Greens function methods, and by demonstrating that the problem can essentially be reduced to solving the Schrödinger Equation of Quantum Mechanics for a "potential" composed of delta functions. Thus well-known results from Quantum Mechanics, such as Dysons equation, may be exploited. The ultimate goal is to solve the inverse problem, i.e. to determine how the mass of a

material should be spatially distributed to generate a specific wave response. The motivation for this comes from acoustic engineering and the construction of musical instruments. The normal modes of vibration of a material are generally dependent on how its mass is distributed, so we address the question of whether it is possible to reproduce the response of Stradivarius instruments with ordinary pieces of wood. By considering a more simplified one dimensional case, this project aims to capture the essential mathematics and physics of the problem.

- **Tales of modularity**

  Andrea Dotto (Imperial College London)

  The complex plane has a huge amount of symmetry; some of it has to do with number theory. The objects providing this connection are called modular forms.

  To illustrate the idea, well look at the problem of solving a quadratic equation - except we'll be interested in the solutions you get modulo a prime number. We will see how a deep classical theorem, the quadratic reciprocity law, allows us to rephrase this in terms of a family of linear operators acting on a certain space of functions. The fact that eigenvalues of linear operators encode arithmetical information generalizes to a class of important objects in number theory, the elliptic curves. I will define modular forms as functions respecting certain symmetries of the complex plane, and talk about how they provide a way of doing this.

- **On Pseudodifferential Operators and Applications to Spectral Geometry**

  Jean Lagacé (Trinity College Dublin)

  In this presentation, I will make an exposition of pseudodifferential operators, a generalisation of differential operators through the symbols of their Fourier integral representation, and give an application. I will start by talking about their representation, properties of symbolic calculus and how they can be used to solve some specific PDEs.

  In the second part of this talk, I will present some results by Polterovich and Sher about geometric invariants that can be found by studying the trace of a specific pseudodifferential operator, the Dirichlet-to-Neumann map, as it acts on the boundary of a manifold. Specifically, we will be able to see how that trace will give us information about the n-dimensional volume and surface area of the manifold, as well as its curvature.

- **Counter-intuitive properties on infinite sets : Hilbert's investment strategies**

  Karl Hallgren (London School of Economics)

  As an introduction, I would present the Hilbert's paradox of the Grand Hotel. Considering a hotel with a countable infinite number of single rooms (all occupied), I would show that finitely many new guests and infinitely many new guests can be welcomed in the Hotel.

  Let us then build a metro which can contain a countable infinite number of passengers. It runs from the airport (station 0) to the terminus (station w). On the lign between station 0 and the terminus there are the stations $1, 2, ..., x, x+1...$ and the Grand Hotel's station called h. The metro stops at each station.

  Consider that at each station one passenger leaves the metro and 10 ones get in. We would ask ourselves how many passengers are in the metro when it reaches the Grand Hotel. I would show that it can be any natural number, 0 or a countable infinity (and I would give an example in each case).

Consider now that one passenger leaves the metro at each station and a countable infinity of new passengers gets in. I would show that it is still possible that 0 passenger arrive at the Grand Hotel and most surprisingly that the metro is necessary empty when it reaches the terminus.

Finally, a conclusion on basic topology showing that the journey of the metro is the Long Line would allow us to point out the lack of realism of the situation.

- **The Dynamical Behaviour of Quasiregular maps near a Superattracting Fixed Point**

  Timothy Westwood (Imperial College London)

  There is a rich theory of holomorphic dynamics originating from the early 20th century, in particular there is a well established theory for the behaviour of holomorphic maps near fixed points. Many such results are based on simplifying coordinate transformations, one of which is known as "Böttcher Coordinates", where in a local neighbourhood of infinity holomorphic maps behave like z^n. But can such dynamical results about holomorphic maps be extended to a more general class of maps known as "quasiregular maps"? Quasiregular maps are maps that can be factored as $f \circ q$, where f is holomorphic and q is a quasiconformal map. That is, informally, q sends infinitesimal circles to infinitesimal ellipses. These quasiregular maps are almost holomorphic, this gives us our intuition that some results from holomorphic dynamics can be extended to this class of maps.

  I aim discuss a geometric definition of both quasiconformal and quasiregular maps, expand on the relationship between holomorphic maps and quasiregular maps in particular outline a generalisation of the "Böttcher Coordinates" theorem for quasiregular maps.

- **How to walk on water (and other lessons from fluid mechanics)**

  Daniel Meeson (University of York)

  We live and breathe in a fluid. Our planet is surrounded by fluids (the atmosphere) and the majority of its surface is covered by another (water). Cosmologists even treat the evolution of the universe as a fluid. So what are fluids, and why, as mathematicians, should we care?

  In this talk I will give a brief introduction to Fluid Mechanics, exploring its main tools and a few exciting applications. From the initial insights of vector calculus developing our language of such concepts as pressure, viscosity and vorticity, to the formulation of the powerful (and difficult) Navier-Stokes equations, the surprisingly elegant mathematical methods developed to analyse fluids have proved highly successful. When applying these equations and concepts to the explanation of natural phenomena we once again further the unreasonable effectiveness of mathematics in our understanding of the world. Consider the motion of the fluids that compose the atmosphere: clearly chaotic (turbulent), yet still highly ordered structures like hurricanes can form, underpinned by the relatively basic mechanics of vortices. The study of fluids can even offer satisfying answers to two questions that have mystified mankind for generations: what is the Loch Ness monster? and how can I walk on water?

- **Mathematics in gambling**

  Edyta Dziedzic (Kingston University London)

  The aim of this research is to produce good estimates for the "true probabilities of winning 3 types of games: Games of Skill (e.g. Tennis, Volleyball), Partly Random Games (e.g. Poker,

Blackjack) and Games of Chance (e.g. Slot Machines). The results determine how these probabilities compare to those offered on the market. Firstly, an assessment of games of skills uses previous and current world rankings. This work also constructs an alternative method using the Page Rank algorithm. The required data was obtained and further analyzed using statistical techniques. The obtained results along with past results formed bases to 2 logistic models predicting the future outcome. Partly Random Games depend on random values. Nonetheless, the human skill element involved significantly influences the final outcome of the game. The research focuses on the identification and assessment of the most favorable betting strategy for the player (e.g. Kelly Odds Overlay). Finally, for calculating the true odds in the Games of Chance a uniform distribution of outcomes was assumed. In this type of games no measurable skills are involved and past results are not available to the public.

- **The Art Gallery Problem**

  Aimilia Kosyva (University College London) and Andrei Stoica (University College London)

  This project will target one of the most fascinating visibility problems with real-world applications, the Art Gallery Problem:

  "What is the minimum number of stationary CCTV cameras required to cover all points of the gallery, assuming they each have a 360 degree view?"

  In order to solve this problem, we will consider a simply-connected n-sided polygonal gallery, meaning that the walls of the gallery are straight and that the gallery has no holes. Then, a set of cameras is said to be guarding the gallery if every point in the gallery can be joined to one of the cameras by a straight line, lying entirely inside the polygon. Having no idea of the shape of the gallery, but knowing how many sides the polygon has, Chvátal found the exact number of cameras required to guard the gallery. We will examine his solution and then extend it to more general cases, where the gallery has polygonal holes inside it. This will slightly change Chvátals result and reveal the beauty of the Art Gallery Problem. With the aid of visual representations and mathematical arguments we will solve the problem, find a way around an obstacle and attain an aim which was not immediately attainable.

- **The Half-Product Problem: Submodularity and Differential Approximability**

  Rebecca Sarto Basso (University of Greenwich)

  Combinatorial Optimization is an exciting and rapidly developing field of Applied Mathematics, closely related to Theoretical Computer Science and Operational Research. The main focus in this area is on the study of effective algorithms for solving optimization problems over discrete structures. The presentation will focus on one particular problem of Boolean quadratic programming, the Half-Product Problem (HPP). This problem is particularly relevant because of its vast range of scheduling applications, which will be briefly outlined. This presentation will then introduce an original link between this problem and submodular optimization. It will be proved that the Half-Product problem can be reduced to the problem of maximizing a submodular set function. It follows that HPP can be solved by any algorithm for submodular maximization, in particular an interesting variant of the greedy algorithm will be presented. To conclude the presenter will examine how the inclusion of an additive constant influences the behaviour of the approximation algorithm for HPP. More generally the results from this project can establish a novel framework for solving a class of quadratic Boolean programming problems and consequently a class of relevant scheduling problems.

- **Linear Regression & Bayesian Inference Models Underlying Anti-Doping Techniques**

  Aoibheann Brady (Trinity College Dublin)

  This talk will discuss anti-doping methods within sport. Various statistical methods, both previous and current, will be considered. A brief introduction to linear regression and Bayesian inference models will be provided. The probability of an athlete doping will be modelled via Bayesian networks - both population-based and hierarchical approaches for between-subject variability. These networks will be implemented using JAGS and R, including the simulation of training data and the use of existing athlete biological passport data available publicly. Performance of the models will be assessed and compared via precision, recall, Bayes factors and other common statistical tools.

- **On the admissions to the University of Greenwich Computing and Mathematical Sciences Department (CMS)**

  Francesca Ravenhill (University of Greenwich)

  This project aims to assess the admissions to the University of Greenwich Computing and Mathematical Sciences Department (CMS). The aim is to find potential correlations, which can then be implemented to predict future admissions. I will compare predicted grades of students and the obtained UCAS points from last year. In the process I will look at the schools that students apply from in relation to the success of their application. Developing this I will also analyse the decision made by students, depending on the offer made by the university. I will compare the predictions made for A-levels and for BTEC examinations, and also look at links to the degree course that they are applying to study. My aim is to use the analysis of the 2013 intake to forecast the average UCAS tariff for the 2014 intake using simulation. This will involve aiming to predict the number of students expected, based on the predicted A-level and BTEC grades, to maximise UCAS tariff.

- **Representation Theory**

  Eamon Quinlan (University of Glasgow)

  Representation Theory is easy to define: it's the study of group actions on vector spaces. As arbitrary and specific this might seem, the breadth and depth of Representation Theory, a branch of mathematics of now more than 100 years, is immense. This is not surprising: the study of group actions was one of the main areas of study in the 20th century. Therefore by combining this with the power of linear algebra we can only expect a very rich theory.

  In this short talk, I will describe some of the basic results of Representation Theory as well as some of its applications, which range from Molecular Orbital Theory to Number Theory. I will show that not only is Representation Theory very versatile and useful, but also incredibly beautiful and elegant.

- **Knots, Links and Braids**

  James Goodwin (University of Surrey)

  In this talk we look at the mathematical theory of Knots in the framework of low-dimensional topology, their connection with group theory and the wider context of their appearance in the real world and application in the sciences. We begin with a brief historical introduction, looking at examples of knots in ancient and medieval art such as the Trefoil

knot and the "Endless knot", knots used in sailing, knot theory's initial debut in the world of physics and subsequent developments. We start the mathematical description with a summary of the important topological concepts involved, and how they can be used to classify knots. We then look at the concepts of knot groups and knot polynomials. We finish with an introduction to the related structures of Links and Braids (including the concept of a braid group) and their interrelation with knots, and conclude with a brief look at one of the ways they feature in modern mathematical physics. The talk should be accessible to anyone with experience in group theory and basic mathematics (sets and mappings).

- **On Rubik's Cube**

  Piotr Kalarus (University of Glasgow)

  Erno Rubik invented a cube, which has been given name after him, in 1974. Since then Rubiks Cube became a 'toy' that is known all over the world. But 'the toy' is far more than meets the eye. It is one of the most useful tools for mathematicians dealing with group theory. It allows explaining what the group theory is and demonstrating a wide range of related concepts. Even though it was his invention, Erno Rubik spent a month on solving the problem of the cube. A lot of algorithms allowing 'fixing' the cube have been developed since then. By using them some players are able to solve it in less than 10 seconds. Lately developed algorithm shows that the cube can be solved in 22 (or even less) moves. The great popularity of the cube and increasing number of ways how to solve it caused a need for more sophisticated variations. Thus Rubik's Cube can be now found in original version $3 \times 3 \times 3$ (cube) through $4 \times 4 \times 4$ to a dodecahedron shape. Despite this there is one more version which has never been produced - a tesseract. Rubik's Tesseract is a four-dimensional version of the cube which would be a great challenge even for those who call themselves 'professionals' in solving ordinary cube.

- **Maths and Law**

  Sonia Chowdhury (University of Greenwich)

  Mathematics is applied in every aspect of our lives, but what about when it is applied to determine whether a person is innocent or not? Criminal Law cases deal with evidence, but the difficult question for Solicitors/judges is whether the evidence found is viable to use against a defendent. This is since the historic R Vs Adams case (1996), where statistics was first used in the court room to discuss whether evidence found had a link to the overall case, showing mathematical measures can be put in place when deciding a crucial decision of someone's life. Many cases since then have used different mathematical theories to investigate evidence.

  Statistical theorems such as Bayes theorem is used to analyse the validity of evidence, however these tests are not carried out by mathematicians, and therefore have resulted in errors being made in high profile cases such as the Amanda Knox case. 'Math on Trial' by Leila Schneps and Coralie Colmez highlighted the misuse of maths in criminal law cases, which is what i will briefly present in my talk.

  My talk aims to express to mathematicians how maths is used in the legal field in order to open their eyes to a potential career path, as I myself intend to go Into Law with my Maths degree.

- **A parallel implementation of Strongly Connected Divide and Conquer**

  Iva Babukova (University of Glasgow), Huw Evans (SAS Institute Inc) and Adam Kurkiewicz (University of Glasgow)

  This work presents a parallel Java implementation of the Strongly Connected Divide and Conquer (SCDC) algorithm [1], which is used to identify strongly connected components of a directed graph. Our main goal is to achieve a good level of performance and scalability. Both stages of the algorithm - the search of random vertex descendants and predecessors, and subsequent recursive invocation - are parallelised.

  Descendants and predecessors are explored using reachability analysis. The algorithm used is a parallel non-deterministic search, optimised to use a custom stack of vertices as opposed to a stack of recursive calls, which reduces its space complexity. The algorithm accepts as a parameter a granularity level, which is set experimentally to provide different scalability characteristics for multi-core machines.

  Recursive invocation is optimised to allow recursion only on sufficiently large subgraphs. For small subgraphs we are using Tarjan's [3] algorithm, which we show gives performance gain. The size we consider sufficiently large is tuned experimentally.

  Performance of such optimised SCDC is compared with our implementations of single-threaded Tarjan's [3] and Kosaraju-Sharir's [2] algorithms, and unoptimised multi-threaded SCDC [1] on various classes of random and real world graphs. We discuss the impact of our optimisations and show the direction for further improvements.

  References

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  [2] M. Sharir. "A strong-connectivity algorithm and its applications in data flow analysis". In: Computers & Mathematics with Applications 7.1 (1981), pp. 67 -72. issn: 0898-1221. doi: http://dx.doi.org/10.1016/0898-1221(81)90008-0. url: http://www.sciencedirect.com/science/article/pii/0898122181900080.

  [3] Robert Endre Tarjan. "Depth-First Search and Linear Graph Algorithms". In: SIAM J. Comput. 1.2 (1972), pp. 146-160.

- **Isolating isomorphisms: making abstract algebra less abstract**

  Max Brozynski (London School of Economics)

  Usually the first introduction to mathematical abstraction, abstract (or, modern) algebra is a fascinating and revealing tool that generalizes the solving of equations. Unfortunately, this often means struggling with the inability to draw pictures, sketch graphs, or run through examples.

  In this poster presentation, we take a detailed look at the three official and one unofficial isomorphism theorems for the two algebraic structures seen in introductory abstract algebra courses: groups and rings. With an eye to specific examples, we show that some isomorphisms are intuitive and simply our understanding of certain quotients, while others seem to complicate it. Moreover, we show interesting and well-known results in linear algebra and number theory that are concluded from the Theorems.

  This treatment presents a great opportunity to mention the history of the Theorems and the several mathematicians to whom we owe our modern study of abstract algebras: Noether, Dedekind, and van der Waerden.

Posters

- **Working Towards a Solution to the $\widehat{A}_n$ Standard Form Problem**

  Thomas Robinson (University College London)

  In the attempt to classify 2-fusion systems of component type, it is necessary to prove an analogue of the component theorem for finite groups. We consider some problems on alternating and symmetric groups needed to solve the standard form problems for 2-fusion systems with components which are 2-fusion systems of the covering group of an alternating group. In particular, we fill in details of a proof by Solomon and relate his theorem to fusion systems.

- **Fermat Problem in Geometry - poster**

  Nadezhda Aplakova and Aleksandar Kolev (University of Glasgow)

  This project is based on application of the isogonal conjugation for generalizing the Fermat problem in Geometry. It was initially stated as follows: In a given acute triangle ABC, locate a point whose distances from A, B and C have the smallest possible sum. The solution is the point from which each side subtends an angle of 120 degree. This problem is limited to specific type of geometric construction, which is represented by $F(Y) = \lambda.AY + \mu.BY + \nu.CY$. We aim to find its minimum for different points i.e. computing the weights λ, μ and ν (which in the original problem are all equal to 1) and recognizing the triangle centre Y in which this minimum can be reached. This paper consists of detailed description of the knowledge required for understanding the Fermat problems generalisation as well as many examples of solved Fermat problems for particular triangle centres. Based on this problem we developed an original method for generating geometric inequalities, whose number depends on the number of the triangle centres. They are based on the $F(Y') \geq F(Y)$ where the equality holds true for $Y' \equiv Y$. Among the inequalities generated so far there are some well-known, such as Finsler - Hadwigers and Newtons inequalities. Approximately 90 of the generated problems are original to the best of our knowledge.

- **In search of the Stradivarius-like solutions in classical wave mechanics - poster**

  Maurese Gargan (Trinity College Dublin) and Anna Lawless (Trinity College Dublin)

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