UCL DEPARTMENT OF MATHEMATICS

NEWSLETTER 2013

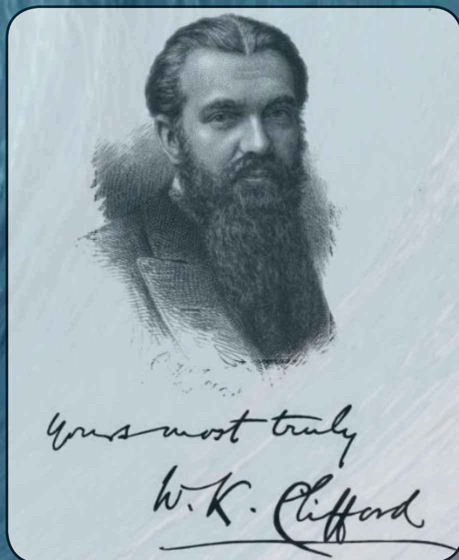
De Morgan Association NEWSLETTER

Introduction

William Kingdom Clifford (1845-1879) held a Chair in Applied Mathematics at UCL from 1871 and died of TB at the age of 33. Appointed Fellow of the Royal Society in 1874, he was an influential mathematician both then and now, with his major contributions being in geometry, especially non-Euclidean geometry. Clifford algebras continue to be studied today and find application in, for example, physics and image processing. An early pioneer of ‘knowledge transfer’, WK Clifford was an outstanding communicator of mathematics and his general lectures were genuinely popular and attracted large audiences.

We are delighted to associate the name of Clifford with our inaugural Fellowship scheme. The first Clifford Fellow will join the department in 2014 with each successive Fellow being appointed for a three year term. The Fellowship will bring talented early-career mathematical researchers to UCL, enabling them to concentrate on research, while contributing to teaching. This will not only benefit their own careers but enhance the department’s research and research-led teaching environment. Should future funds permit, we are keen to grow the scheme.

The department continues to grow with further hiring of excellent new staff. Since the last newsletter we welcome Dr Lauri Oksanen who does research in the mathematics of inverse problems and Dr Lars Louder who researches in geometric group theory and low dimensional topology. Recent successes in obtaining grants have led to the highest ever number of post-doctoral researchers in the department: 15 at the time of writing, all of whom contribute to the department’s dynamic research and teaching environment.



Further staff appointments are ongoing in Financial Mathematics following a successful beginning for our new research group in this area and the launch in 2012-13 of a popular MSc programme in Financial Mathematics.

We are proud of the results of the 2013 National Student Survey: 96% of UCL mathematics students were satisfied overall with their courses. This places us 4th among all departments at UCL, and makes us the leading mathematics department in the Russell group of universities. This is an excellent achievement and we are grateful to the students who completed the survey and their positive views. Our challenge now is to maintain and improve on this performance in the years to come.

- **Robb McDonald**
  Head of Department

Issue - 21

December 2013

Editor **Ted Johnson**

Associate Editor **Bonita Carboo**

Contents

From the Editor

The Annual Dinner of the De Morgan Association was held on Wednesday 7 June 2013 in the Old Refectory Room at UCL, preceded by sherry in the Haldane Room. This year the Guest of Honour was Dr Hannah Fry, from the Centre for Advanced Spatial Analysis here at UCL. Many of us have known Hannah from her early career in the Mathematics Department, first as an undergraduate and then through her PhD with Frank Smith. Hannah addressed the serious question of the perception of mathematics in the wider academic community and the outside world in a highly entertaining and informative presentation (as expected of an alumnus of the Bright Club, described in Newsletter Issue number 20).

This is my first year as Editor on the Newsletter. Under Patricia Rothman and Michael O'Neill the Newsletter evolved into its current form with its balance of news from undergraduates, graduate students, staff and alumnus together with mathematical articles of general interest.

Continuing this tradition would have been impossible without the continuity and expertise provided by Bonita Carboo as Associate Editor who efficiently guided the whole process. We hope you enjoy this edition and encourage you to send us articles and photographs for future editions.

- **Ted Johnson**
  Professor of Mathematics

De Morgan Association Dinner 2013

Dr Hannah Fry speaking at the De Morgan Association Dinner

It was just a little over 11 years ago that I first joined the UCL Mathematics Department as a fresh-faced undergraduate studying mathematics with theoretical physics. Since then, I have completed my masters, finished a PhD in fluid dynamics and taken up a lecturing post within UCL's Centre for Advanced Spatial Analysis, working alongside physicists, computer scientists and geographers, with a remit to study complex social and economic systems.

As someone fully aware of the magnitude of the request, it was a tremendous honour to be asked to speak at the De Morgan dinner this year by Robb McDonald and especially to have the chance to talk within a department where I have such a long history. This came with its own pressures however, and speaking as a very junior academic in front of the professors who taught me as an undergraduate meant I wanted to choose a topic with which I have a particular personal interest – something which would allow me to offer my own perspective. So, having found myself increasingly involved in public engagement of mathematics over the years, I thought this would be a good opportunity to reflect on my experience of promoting mathematics within science communication.

I have always been a fan of mathematics (even before I became a practitioner) and spent a great deal of my youth reading popular books on mathematics by Ian Stewart and Simon Singh, amongst others. But, as much as I enjoyed the rich history and intriguing insights that mathematics has to offer, I always felt disappointed with the way the subject is viewed by the outside world.

This disappointment has only been magnified as I advanced through my academic career and realised just how much mathematics has to offer - and how much the general perception of the subject is at odds with the reality. Since leaving UCL mathematics and going to work in an interdisciplinary department, the starkness of this contrast has been highlighted to me even more than ever: because it is not just the outside world which struggles to see the value of mathematics – even other academics have no concept of the importance of our work.

It strikes me that mathematics is alone in this regard. Physicists, economists – even historians - don't seem to have this problem. As Edward Frenkel, Professor of Mathematics at the University of California, Berkeley, points out, the Higgs Boson, general relativity and quantum theory are regularly trotted out by the media and lapped up by the public giving a strong sense of the role of the subject in our modern world, but there are no equivalently high-level mathematical concepts in the public consciousness. And it does lead me to wonder – how have we failed to promote our subject so badly that no one has any idea what we do?

To some extent, I suppose the public's perspective is understandable. From spending time with school children through the Mathematics in Education and Industry (MEI) and the Princes Teaching Institute, I have seen first-hand how many students see mathematics as pointless and uncreative. The topics are uninspiring, the ideas have not changed in hundreds of years and the answers are all written in the back of the textbook. No wonder they think "maths" was wrapped up and finished long ago.

I also appreciate that on leaving school there is little to demonstrate the fundamental importance of mathematics in today's modern and technology-driven world to the public. As Ian Stewart quite rightly points out - for mathematics to be useful in today's society, it has to be invisible. If you had to have a PhD in mathematics to be able to use a mobile phone or a computer, they never would have become commercially successful.

The hidden role of advanced mathematics has not been helped by public engagement of the subject, most of which offers nothing more interesting or relevant than the mathematics that most people hated at school. On the one hand, the public are told that mathematics is beautiful, elegant and important and yet, on the other, the only examples they are given to illustrate this are quirks of prime numbers and polygons. There is certainly a place for these examples and there are a number of excellent communicators promoting this perspective, but I believe that mathematics has so much more to offer.

In my experience at least, people who are not already engaged with mathematics do not want to hear science communicators pretend to be excited by irrational numbers or to hear that they are not capable of understanding anything more advanced. But they are interested to hear the surprising and counter-intuitive insights into our world that mathematics can offer and see how these ideas are directly relevant to them and their everyday lives.

I know that some mathematicians are frustrated by any attention to practical application and prefer to focus on the intellectual interest and idiosyncratic beauty of the subject, but it would be foolish to ignore the wealth of answers that mathematics offers to the question that interests people: after all, it is the foundation stone upon which every major scientific and technological achievement of the modern era has been made. And aside from anything else, a greater public understanding of the relevance of our subject could only lead to improvements in research funding. I can see only positive outcomes in telling the public about Hilbert spaces in image recognition, or asymptotics in burglary prevention, or graph theory in stopping the spread of infectious diseases, and countless other tangible examples.

Perhaps this is one area where the physicists have overtaken us, in being motivated to find and communicate the examples that make their subject come alive to the uninitiated. But perhaps this too is where another of our problems lie, because if non-mathematicians can be said to take pride in being ignorant of our subject, some mathematicians also take pride in our being closed off from the outside world. To repeat a phrase I have heard, mainly in jest, but many times across the years:

"The world fears mathematicians. Let's keep it that way".

It would not be fair to take this too seriously, but – public perception to one side - I think it is worth noting that mathematicians could do more to collaborate with academics from other disciplines. Just from my own experience, I have seen population experts use the logistic map to model

Guests at the De Morgan Association Dinner

migration patterns and wonder why they were getting weird results, or government departments, with a fundamental lack of understanding of combinatorics, use excel spreadsheets to devise emergency response systems and wonder why the model was not scalable. And with more serious consequences, the world witnessed Sally Clark be wrongly convicted of murdering her two sons after a tragic misunderstanding of frighteningly basic probability and statistics, and 2008 saw the global financial crash, largely created due to a lack of understanding of the limitations in mathematical models.

Seeing these mistakes from the perspective of a mathematician does make them rather surprising, but I think it is important to ask ourselves – how is the world supposed to know these are the kind of problems a mathematician could tackle in their sleep if they have no idea what it is that we do?

And so, I leave you with a plea. Please promote our subject. It's beautiful, it's powerful and it's important. And there is no reason why we should keep it to ourselves.

- **Hannah Fry**
  Lecturer, The Bartlett Centre for Spatial Analysis, UCL

Guests at the De Morgan Association Dinner

De Morgan Association Dinner 2014

Friday 13 June

Sherry in the Haldane Room at 6.45pm and Dinner in the Jeremy Bentham Room at 7.30pm

Guest of Honour and After Dinner Speaker:

Professor Keith Ball FRS, FRSE

All those on the UCL Alumni database will be sent an invitation to the next De Morgan Association Dinner. Make sure you send us addresses of anyone else who may want to receive an invitation and remember to keep the Department and Alumni Relations Office of UCL informed of any changes of your address.

Provost’s Spirit of Enterprise Award 2013

Frank Smith FRS, Goldsmid Professor of Mathematics, is a world-leading applied mathematician who has engaged enthusiastically and effectively with many industrial partners during his career. The range and depth of activity has been remarkable in recent years involving a variety of partners (e.g. Buhler-Sortex, QinetiQ, UK Sport, Unilever, AeroTex, TotalSim, EOARD) covering a wide range of applications (e.g. food-sorting machines, aircraft safety, Olympic sports performance, shopping). Funding for research has come in many forms e.g. CASE awards, Faraday and Knowledge Transfer Network (KTN) partnerships. This has provided a welcome boost in PhD numbers in the department, as well as forming a major part of UCL’s UoA10 Research Excellence Framework (REF) impact case studies.

A glittering, red-carpet ceremony was held on Tuesday 14 May 2013 at the Bloomsbury Theatre to celebrate UCL’s Enterprise Awards. Frank Smith won the UCL Provost’s Spirit of Enterprise Award. This is a great achievement and recognises Frank’s many research collaborations with a remarkable range of industrial and medical organisations.

Videos and citations can be found at

www.ucl.ac.uk/enterprise/about/awards/2013

Professor Stephen Caddick, Vice-Provost (Enterprise) and Frank Smith

Geometry and Undecidability

1. Geometry

The word geometry usually conjures up images of the Ancient Greeks drawing triangles in the sand or doing unspeakable things with circles. But this is flat geometry, Euclidean geometry, and really we're interested in doing geometry on curved spaces. Of course, the Ancient Greeks knew this because they knew that the surface of the Earth is a sphere, and as the word "geometry" translates literally as "Earth-measurement" we will start our discussion by contemplating the geometry of the sphere.

1.1. **Geodesics.** The fundamental question, for geometers and airline pilots alike, is what is the shortest path between two points? The answer is a segment of a great circle: a circle on the surface of the sphere which divides it into two equal hemispheres. These curves are called geodesics (from the Greek meaning "Earth-dividing"). As long ago as the first century, the geometer Menelaus realised that you could use these geodesic segments instead of straight lines to do geometry and invented the subject of spherical geometry. This was radically different from Euclidean geometry: for example, in spherical geometry, the sum of angles in a triangle is always bigger than 180 degrees (Figure 1).

Of course, geodesics are not always length-minimising. If a pilot in Heathrow wanted to get to Heathrow, she wouldn't fly all the way around a geodesic till she landed back where she began. Similarly, if she wanted to fly to Lisbon she would go around the geodesic segment that passes over the English Channel, not the one passing over the Arctic circle. However, they are always locally length minimising: each short segment minimises distance between its endpoints.

We use the same name, geodesic, for a locally length minimising path in any curved space. A fundamental problem of geometry is to determine the geodesics in a given space. For example, in general relativity, the geodesics in spacetime are the trajectories of particles in free-fall in a gravitational field. For example, the geometry of our solar system is, to some approximation, the so-called Schwarzschild geometry: analysing geodesics in Schwarzschild geometry tells you about the trajectories of planets under the influence of the sun's gravity and allows you to predict the perihelion shift of Mercury. Indeed, when science documentaries tell you about what happens when you fall into a black hole they are paraphrasing statements about the behaviour of geodesics in Schwarzschild geometry.

Writing explicit equations for geodesics (as we can on the sphere) is usually not possible and it is actually remarkable we can say anything about them. But sometimes one can make nontrivial statements about the qualitative behaviour without solving the geodesic equations explicitly. For example, it is sometimes possible to guarantee the existence of a closed geodesic loop, like a great circle on the sphere. This is

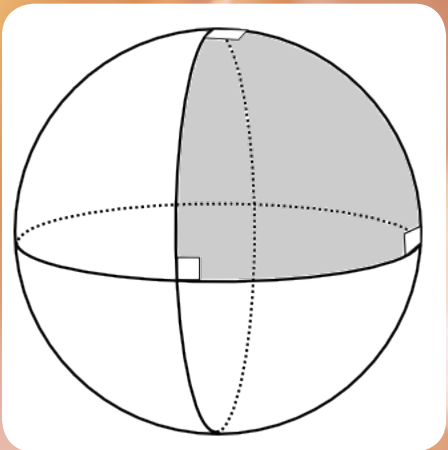


FIGURE 1. A sperical triangle with three right angles, formed from three geodesics.

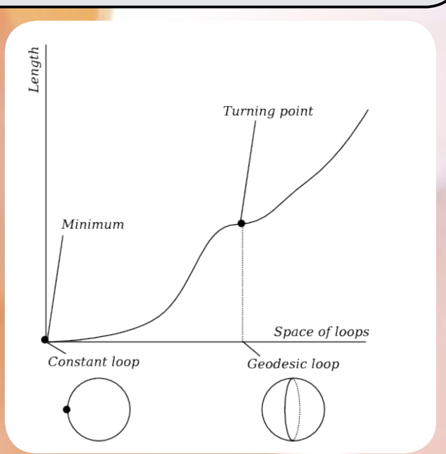


FIGURE 2. The length function on the space of all loops has a global minimum at each constant loop and a turning pint at each geodesic

the question I want to focus on today: when is there a closed geodesic loop in a given curved space?

On the sphere we have actually seen two different types. There is the great circle, and there is the constant loop (staying at the same point). Obviously the constant loop minimises length, while the great circle is geodesic but not length-minimising. You should think of this by analogy with critical points of functions, where the derivative vanishes: there are maxima or minima and there are turning points. Indeed, there is a function on the space of loops which assigns to each loop its length (Figure 2). The constant loop sits at a minimum of this function. The great circle sits at a turning point. Of course the space of all loops is infinite-dimensional and finding turning points of functions on infinite-dimensional spaces is harder than the usual problem in single-variable calculus. The condition for being a turning point is that the loop solves the Euler-Lagrange equation.

You can convince yourself that this picture makes sense by thinking about elastic bands. An elastic band tries to minimise its tension, which is proportional to its length, so it will always seek out a geodesic. You can wrap an elastic band around a sphere, with difficulty, and make it sit precisely on a great circle. But if you perturb it slightly it will shrink and shrink until it pings off and hits someone in the audience. If it were bound, magnetically, to the surface of the sphere then it would just go on shrinking down to a single point. In our picture of the length function, we have pushed the elastic band off the turning point and it has fallen down the graph of the length function until it hit the constant loop at the bottom (Figure 3). It always travels down the direction of steepest descent, that is it contracts as efficiently as possible. This means that evolves according to a partial differential equation called the harmonic map flow: just as the heat flow equation describes how a temperature distribution evolves in time, the harmonic map flow governs the contraction of loops to geodesics. These equations are very similar in nature: they are so-called parabolic equations, which tend to smooth out irregularities and converge exponentially fast towards an eventual steady state.

One of the major themes of modern geometry and physics is the study of critical points and gradient flows of functions on infinite-dimensional spaces.

1.2 **Geodesics from topology.** Now what happens if I use a more interesting space? The surface of a doughnut, for example? This is called a torus and what makes it most interesting is its nontrivial topology. It has a hole in it. We can find loops which wrap around this hole, like the loop α in Figure 4. It is not possible to shrink α to a single point whilst staying on the surface of the torus. So suppose I concentrate on those loops which can be obtained by deforming α and I restrict the length function to those loops. This new function has an interesting minimum at the point α in fact it has a circle's worth of minima like α' and α'' in Figure 4 obtained by rotating α around the torus. If I perturb an elastic band wrapped around α it contracts back to one of these minima via harmonic map flow.

We obtain interesting closed geodesics whenever there is a loop which cannot be contracted to a point: just flow along the harmonic map flow and you end up with a noncontractible geodesic. Of course you need some hard analysis to

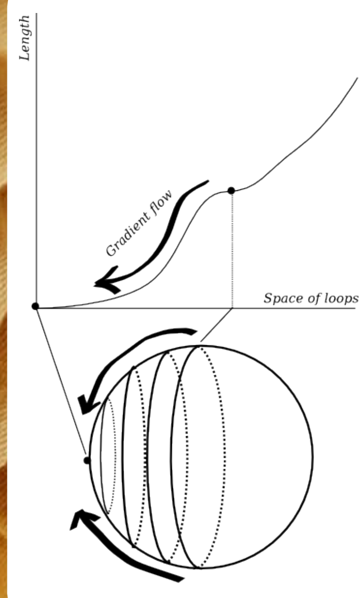


FIGURE 3. An elastic band moves along the gradient flow in the space of loops, also known as the *harmonic map flow.*

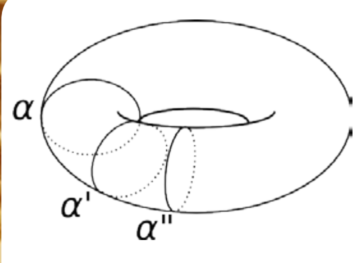


FIGURE 4. A torus with some topologically nontrivial geodescis.

prove that properly but, modulo that analysis, we now have a theorem guaranteeing us the existence of closed geodesics: if there is a noncontractible loop then there is a noncontractible geodesic. Of course, there can be different kinds of noncontractible loops in a space, so let us study noncontractible loops more carefully.

1.3. **The fundamental group.** Fix a point x in your space X. Consider the set of all deformation classes of loops starting and ending at x. This set is called the fundamental group $\pi_1(X)$. It is called a group because you can multiply loops: to multiply loops a and b starting and ending at x you just concatenate them (Figure 5). The "inverse" of a loop a^{-1} is just the loop a run in reverse.

For example, let X be the unit circle in the plane: loops in the circle are determined up to deformation by the number of times they wind around. Concatenating a loop with winding number a and one with winding number b gives you a loop with winding number $a + b$. A loop with winding number zero can be contracted to a point. So the fundamental group of the circle is the group of integers: concatenation corresponds to addition.

For the torus it is more interesting: there are two circles to wind around. Let us call one loop α and one loop β. We have the interesting phenomenon that $\alpha\beta = \beta\alpha$ best illustrated with a picture (Figure 6). So the fundamental group is $\mathbb{Z}^1$: a loop is completely determined by two winding numbers.

Our theorem now says: for every element of the fundamental group there is a noncontractible geodesic loop representing that element[1].

1.4. **Contractible geodesics.** We started our discussion with geodesics on the sphere, which were contractible. Indeed these were more subtle and interesting because they were turning points and not minima for the length function. So let me ask:

Question. *When can we find (nonconstant) contractible geodesics?*

Theorem. *If $\pi_1(X)$ has undecidable word problem then there are infinitely many contractible geodesics.*

Some remarks are in order:
(1) Having "undecidable word problem" means "being extremely complicated" in a way I shall shortly make precise.
(2) This theorem is strange: it assumes there are lots of noncontractible loops and outputs lots of contractible geodesics!

So what does undecidability mean?

2. Undecidability

Some problems are undecidable. That is we cannot write a computer program to solve them. This is not just a lack of computing power or ingenuity - we can't write a program to solve them because such a program does not exist in the universe of all computer programs.

2.1. **The halting problem.** What is a computer program? It is a string of 0s and 1s which act as instructions to a computer. Given an input string of 0s and 1s, the program operates on the input and produces output. Two possibilities arise: either the computer program terminates after finite time and returns a string of 0s and 1s or the program goes on for ever and ever and never stops churning. Anyone who has tried computer programming will probably have experienced this and will have banged their

[1] CAVEAT: Not quite! As harmonic map flow doesn't preserve the basepoint x we are only guaranteed a geodesic in each *conjugacy* class.

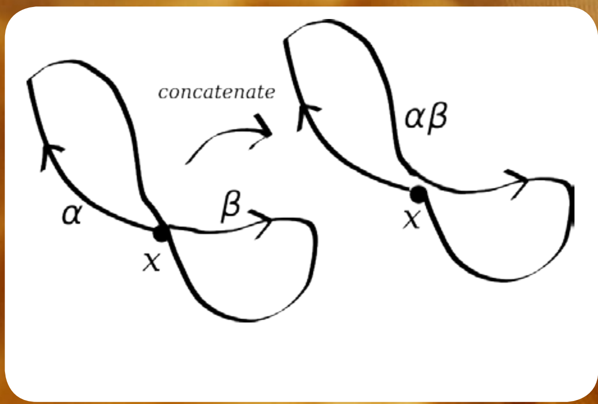


FIGURE 5. Multiplication in the group $\pi_1(X)$ comes from concatenating loops.

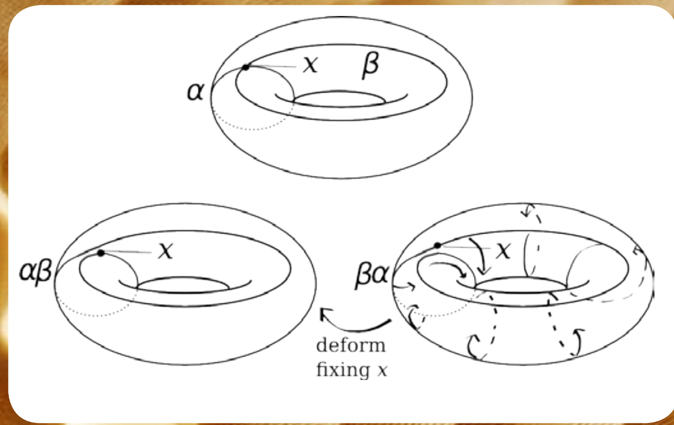


FIGURE 6. Above: Two loops α and β generating the fundamental group of the torus. Below: An illustration of how to deform $\alpha\beta$ to $\beta\alpha$ to whilst fixing the point x.

heads on the desk trying to work out what went wrong with their code.

It would be nice if we could write a computer program A which stops this from happening. Maybe we tell A what program we are running (P) and what we're going to input (I) and A tells us either $A(P, I) = 0$ or $A(P, I) = 1$. The output 0 means "don't try this or you will be sitting there banging your head on the desk forever" (i.e. program P will not terminate on input I; output 1 means "yes that's fine" (i.e. program P will eventually terminate on input I). It may take a long time, but at least if $A(P, I) = 1$ we can be assured that we will see a result (or maybe our grandchildren's grandchildren will see a result if the computer has to churn for that long).

Unfortunately we don't have such a program, because the halting problem (as it is called) is undecidable. Program A could never be written. Let's see why. Assume that some clever people have written this amazing program A. Of course their work is patented and closed source, so we don't know how A works, all we know is what A does: eats P and I and tells us if P will terminate given input I.

We are naturally suspicious when we hear this, so we decide to write out own program B. B takes program P and asks A "If I fed program P its own code as input, would it terminate?". If A says yes (i.e. $A(P, P) = 1$) then B goes into an infinite loop; if B says no (i.e. $A(P, P) = 0$) then B finishes and outputs 1. Schematically:

```
program B(P){
 if {A(P,P)==1} then
  label C; goto C;   # this causes an infinite loop
 else
  return 1;
}
```

Now we would like to demonstrate that program A violates the laws of logic, so we run $B(B)$. I invite you to contemplate what happens. If your brain remains unfried by this contemplation, you will realise that we must have made a false assumption, and the only assumption we made was the existence of the program A. So A cannot exist.

This seems like an abstract problem in logic, but there are "real-world problems" in mathematics which are undecidable. For example, for certain groups, the *word problem* is undecidable...

2.2. **Word problem.** Remember that our fundamental group had a couple of loops which generated it: any loop in the circle can be obtained by iterating the basic loop which wraps around once; any loop on the torus can be obtained by combining the two basic loops α and β in some way. For example, $\alpha\beta\alpha^{-1}\beta^{-1}$ is a loop on the torus obtained by concatenating this "word" of loops (going once around α, once around β, once backwards around α and once backwards around β). Now we can simplify this word using the relation we established: that $\alpha\beta = \beta\alpha$. Take all the αs to the left and the βs to the right and cancel $\alpha\alpha^{-1}$ to the "empty word" and $\beta\beta^{-1}$ to the empty word so we get the empty word overall. This corresponds to not going anywhere at all, i.e. the constant loop.

Problem. (The word problem). *Given a word in the basic loops, can it be reduced to the empty word using the given relations?*

Geometrically, can the concatenated loop corresponding to the word be contracted to a point?

Some groups G (see [1] for an explicit example) are sufficiently complicated that you can use multiplication in them to simulate the behaviour of a computer (a "Turing machine"). Then you can translate the halting problem into the word problem for G. So these groups have undecidable word problem: there is no computer program which can determine if the given word can be reduced to the empty word. I won't show you how to build a Turing machine using a group: there is a nice survey paper by John Stilwell [4] where he discusses such constructions. Instead I'll come back to our theorem:

Theorem. *If $\pi_1(X)$ has undecidable word problem then there are infinitely many contractible geodesics.*

Proof.
(1) If there are finitely many geodesics then there exists a list of them. Maybe we're not good enough geometers to actually solve the equations and write the geodesics explicitly, but we can assume that somehow we obtained this list from an oracle who is good enough. Remember, undecidability means that the program we're trying to write cannot be written, not matter how ingenious we are or how many resources we have. Let's assume we have this resource.
(2) Now given a word, form the corresponding loop.
(3) Flow this loop down the harmonic map flow until it becomes a geodesic.
(4) Compare this geodesic with the geodesics on our list. This involves finitely many steps as there are finitely many geodesics. If it appears, we know the geodesic is contractible and hence the word can be reduced to the empty word. If it does not appear then we know the geodesic is not contractible and hence the word cannot be reduced to the empty word.

So if there are finitely many contractible geodesics then we can write a computer program to solve the word problem for $\pi_1(X)$. This is a contradiction so there must be infinitely many contractible geodesics.

Bizarre! Having a really complicated fundamental group means that you get infinitely many *contractible* geodesic loops.

Some more remarks are in order. First, step 3 of the proof is not so easy to fill in because solving partial differential equations is something nondiscrete: it uses the real numbers instead of integers and computers can only cope with 0s and 1s. So we really need to replace loops and harmonic map flow with some kind of approximations: take a triangulation of our space and approximate the loop with edges of triangles; flowing now means making moves on edges to reduce the length of the loop. It turns out that this step is possible to achieve (in theory) on a computer and this follows from work of Alexander Nabutovsky [2] (as part of a much deeper, more far-reaching paper).

Second, the fundamental group used loops passing through the basepoint x. Harmonic map flow (or its combinatorial replacement) might not force loops to pass through x, so really we should be working with conjugacy classes of loops in $\pi_1(X)$. This is OK because undecidable word problem implies undecidable conjugacy problem: deciding if an element is trivial is the same as deciding if it is conjugate to the identity.

3. Morals

- In geometry we study functions on infinite-dimensional spaces; their critical points and gradient flows. Critical points correspond to geometric objects which are taut or energy-minimising in some sense (like elastic bands) and gradient flows correspond to the evolution of unstable configurations to stable configurations.
- Some problems in mathematics and logic cannot be solved algorithmically.
- Loops in spaces form interesting algebraic structures (like the fundamental group).
- Undecidability of problems in group theory can then be applied to deduce existence theorems for critical points of functions on infinite-dimensional spaces. This has been explored in depth in the work of Nabutovsky and Weinberger, for example see [3,5].

References

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[5] Shmuel Weinberger. *Computers, rigidity, and moduli.* M. B. Porter Lectures. Princeton University Press, Princeton, NJ, 2005. The large-scale fractal geometry of Riemannian moduli space.

- **Jonny Evans**
  Lecturer, Department of Mathematics

Adam Townsend and Professor Malcolm Grant

Provost's Teaching Award

Three academics from the Faculty of Mathematical and Physical Sciences have been recognised for their outstanding teaching in the annual Provost's Teaching Awards.

Andrew Fisher (UCL Physics and Astronomy)
Adam Townsend (UCL Mathematics)
Andrew Wills (UCL Chemistry)

Adam Townsend, a PhD student in the Department of Mathematics was given the award for being the best postgraduate teaching assistant in all of UCL this year. Adam taught the Mathematical Methods for Arts and Sciences course, part of UCL's new degree in arts and sciences.

The interdisciplinary Bachelor of Arts and Sciences (BASc) course, similar to liberal arts degrees in the US, is very different from traditional British university teaching, and it presents a number of challenges for academics. Students come from a variety of backgrounds, and with varied interests and future plans, so crafting a course which meets all their expectations needs a lot of skill.

"In teaching a mathematical methods course for UCL's new BASc, I faced a challenge: how do you bring a traditional mathematics education to such an innovative programme?" Adam says. "Engagement using social media has been a wonderful answer, providing lively forums throughout the year as well as allowing some interesting micromanaging.

Setting up peer-learning sessions over breakfast worked out fantastically for both understanding and communication skills. I was keen to exploit the wealth of online learning material as well, complementing my lectures and preparing students for an international world. And in following education trends, I was able to trial new classroom techniques and get immediate feedback. As ever, thanks go to both the mathematics and BASc departments for their endless support, and of course my students, who are truly stars and a pleasure to teach."

Adam is working on a PhD in the area of non-Newtonian fluids, part of a long tradition of research into the mathematical properties of fluids at UCL.

Non-Newtonian fluids are fluids whose viscosities behave in strange ways. But despite their exotic properties, they are actually quite common, even in everyday life. For instance, ketchup (which becomes more liquid as it is agitated) and cornflour and water (which thickens when stirred) are both non-Newtonian fluids.

Professor Robb McDonald, Head of the Department of Mathematics, noted that:
“This is an outstanding achievement and, to my knowledge, is the first Provost’s Teaching Award won by someone from this department. Well done Adam!”

MAPS Faculty Postgraduate Prize

Many congratulations to Olga Chervova, winner of the 2012 Faculty Postgraduate Research Prize, and to Chris Banerji, (MRes in Modelling Biological Complexity, CoMPLEX) winner of the 2012 Faculty Postgraduate Taught Prize.

The 2012 Postgraduate Research Prize was awarded to Olga Chervova for her outstanding achievements in her PhD in Mathematics.

Olga’s Supervisor Professor Dmitri Vassiliev noted that:
“The most striking result of the thesis is the one contained in our joint paper which is due to appear in Journal of Spectral Theory. We show in this paper that ALL publications on two-term asymptotics for first order systems, spanning the period from 1980 to date, are either incorrect or incomplete, and provide the correct formula for the second asymptotic coefficient. Olga made a major contribution to our paper. The analysis involved is very complicated and it would have been difficult for me to arrive at the correct formula for the second asymptotic coefficient on my own”.

Professor Robb McDonald, Head of Department for Mathematics, noted that:
“Olga’s publication with Professor Vassiliev is truly outstanding having solved a long-standing important problem – there is little doubt it will be rated 4* by the REF. It is worth noting that Olga has a further 4 published papers resulting from


Olga Chervova

her doctoral research, and another one has recently been submitted. Such output of high quality work is excellent and rare”.

In her response to being awarded the prize, Olga Chervova stated:
“I feel extremely proud and happy to win this prize. I would like to thank my supervisor Professor Dmitri Vassiliev and Head of Department Professor Robb McDonald for supporting my nomination. The aim of my PhD research was to have a fresh look at the massless Dirac equation (the accepted mathematical model in theoretical physics for a massless neutrino field) and to identify mathematical problems in other subject areas which generate this equation. Together with my supervisor Professor Dmitri Vassiliev we found two new perspectives on the massless Dirac equation: a continuum mechanics interpretation and a microlocal analysis interpretation. I hope to stay in academia, so now I am looking for a research (and/or teaching) position at university.”

Inaugural Lecture 2012 - 2013

Rod Halburd

Rod Halburd gave his Inaugural Lecture **'Detecting Integrability: singularities, sovability and solitons'** on Wednesday 13 March 2013.

Abstract:

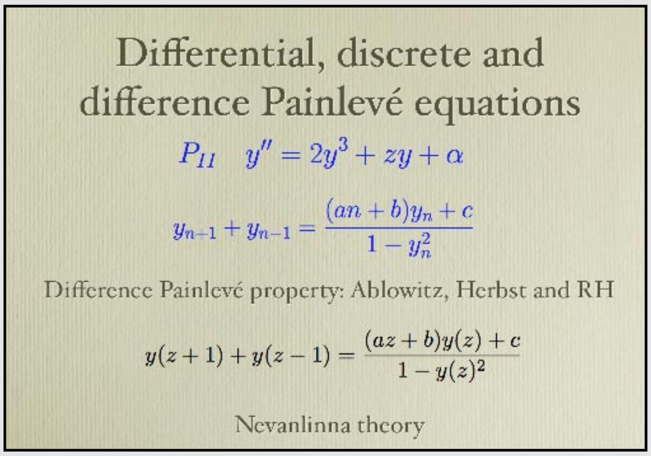
Roughly speaking, an equation (e.g., a differential or discrete equation or a cellular automaton) is said to be integrable if it is in some sense solvable or at least if its solutions can be characterized in a particularly nice way. The integrability of an equation is not always obvious. In this talk I will describe various properties that can be used as integrability detectors. In particular, I will describe the behaviour of solutions of some differential and difference equations in the complex plane and some number-theoretic properties of solutions of discrete equations. There will also be a quick look at "tropical" mathematics.

Guests at the Inaugural Lecture of Professor Rod Halburd

Rod Halburd presenting his Inaugural Lecture

Professor Richard Catlow, Executive Dean, Faculty of Mathematical and Physical Sciences (MAPS), UCL. Chair of Rod Halburd's Inaugural Lecture

Rod Halburd and Robb McDonald, Head of the Department of Mathematics



On 13 March 2013 the department hosted Professor Halburd's inaugural lecture.

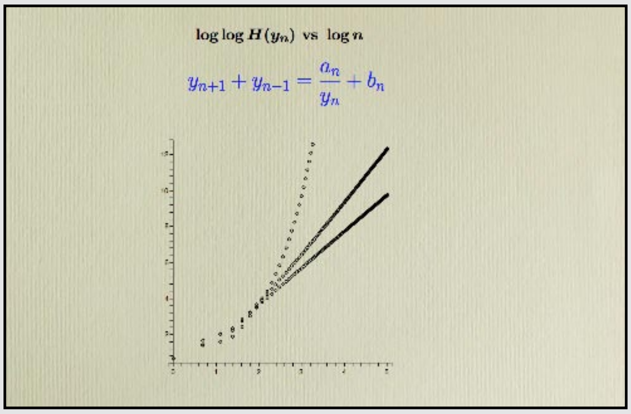
Rod Halburd was awarded his BSc in 1990 from the Australian National University and his PhD in 1996 from the University of New South Wales. From 1996 until 1999 Rod held a temporary position at the University of Colorado at Boulder in the USA. In 2000 Rod moved to the UK: he was appointed to a permanent Lectureship at Loughborough University and later, in 2006, promoted to a Readership. Rod came to UCL in 2007 as a Reader and was promoted to Professor in 2010.

A major achievement in Rod's research career was the award of an EPSRC Advanced Research Fellowship. This Fellowship freed up Rod from everyday duties and allowed him to concentrate on his research. The Fellowship covered the period 2005-2010, which meant that Rod brought his Fellowship with him when he moved to UCL in 2007.

Rod's inaugural lecture was entitled "Detecting Integrability: singularities, solvability and solitons". "Integrability" is a mathematical concept which loosely describes the fact that certain nonlinear differential or difference equations admit solutions which are solitary waves, or solitons. Such solutions are of permanent form, are localised within a region and can interact with other solitons.

The soliton phenomenon was first described in 1834 by the Scottish civil engineer John Scott Russell (1808–1882) who observed a solitary wave in the Union Canal in Scotland. Solitons have fascinated mathematicians ever since. Apart from purely mathematical interest, the study of solitons may also have far reaching consequences for mathematical physics. Say, it would not be unreasonable to expect that one day we will be able to describe elementary particles as solitons.

In the first half of his lecture Rod gave a most entertaining and informative introduction to integrability, elaborating on the life and work of Paul Painleve - a leading figure in the subject. Paul Painleve was a remarkable man who

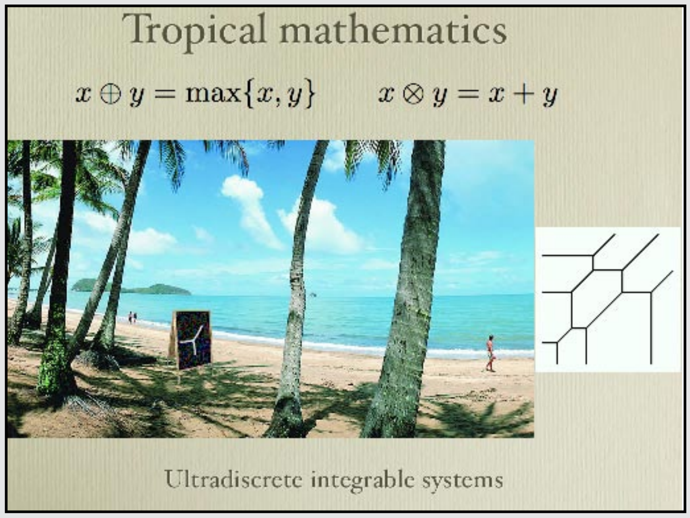


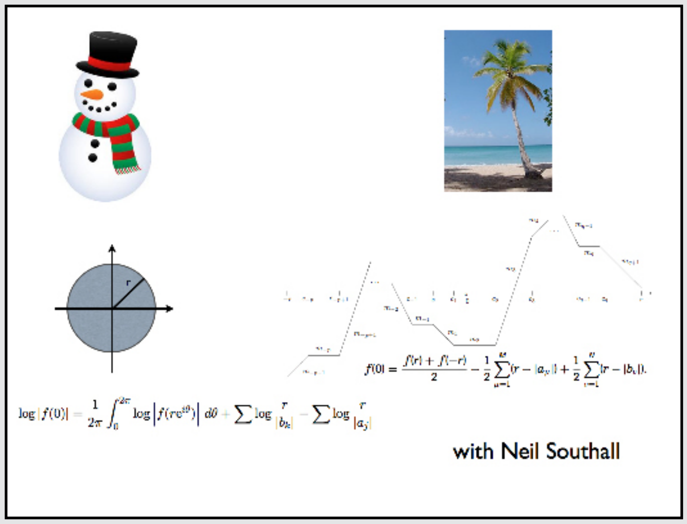
successfully combined mathematical research with politics. He was Prime Minister of France in 1917 and in 1925, and after his death in 1933 was interred in the Pantheon. In the end of the 19th- beginning of 20th-century Painleve identified classes of ordinary differential equations which possess integrability properties. These equations are now known as Painleve equations and they have been the subject of extensive mathematical research by numerous authors.

In the second half of his lecture Rod gave an overview of his own work, which is mostly centred around Painleve equations. Painleve equations come in various forms - differential, difference and discrete - and Rod contributed to the study of all three types. A characteristic feature of Rod's research is that he often uses complex theoretic methods in his analysis. Here it is worth recalling a quote from the famous French mathematician Jacques Hadamard: "The shortest path between two truths in the real domain passes through the complex domain".

Rod Halburd has been at UCL a relatively short time, only six years, but his presence has greatly influenced the life of the department. He brought with him a culture of research on the borderline between pure mathematics, applied mathematics and theoretical physics which is so rare in modern academia. Rod's inaugural lecture celebrated his research achievements and provided a road map of exciting future research.

- **Dima Vassiliev**
  Professor of Mathematics





Guests at the Inaugural Lecture of Professor Rod Halburd

What to do on the most miserable day of the year?

What will you be doing on the most miserable day of the year (BBC News 19th January 2005)? Will you be trying again to make that perfect cheese on toast (Huffington Post 17th August 2013) or will you go out and see if that new patisserie on the high street serves the perfect cream tea (Daily Mail 27th May 2013)? Alternatively, and perhaps more depressingly, you can wonder if this is all that the majority of the general public thinks mathematical formulae have to offer society. It is sad how some of the mainstream UK media appear to love a useless equation, which to some degree subtly reinforces the stereotype of eccentric academics huddled in their ivory towers dreaming up magic equations governing the minutiae of everyday life.

I am certain that most mathematics and science graduates would agree that mathematics needs to engage more with the media and society as a whole. However, instead of seeing articles on how amazing equations are used to power internet search engines, to encrypt our personal information, for medical imaging, for designing heart valves and to reduce drag and noise generated by aircraft, the public are subjected to ridiculous equations that I, along with many others, think do a considerable disservice to the subject. In my opinion, many of these equations provide no useful value and, worse still, adversely distort perceptions of what proper mathematical research can really achieve.

I have learnt from my own experience on this matter when I was asked by a PR company to come up with an equation (during Wimbledon of course) for the “perfect tennis serve”. Unlike previous requests I said “yes” to this one because (i) I knew I could come up with an equation based on the actual physics and (ii) I thought I could pitch it at A-level maths students which may, in turn, encourage some to consider studying mathematics at university. Over a weekend I developed a nice simple equation for a targeted spin serve possessing the basic physics of lift and drag. Unfortunately, when the mainstream media picked up the story, not one newspaper published the equation or indeed much of the science behind it. Indeed the outcome left me with the sense that had I instead simply hashed together in a few minutes a completely nonsensical expression like:

$$\textbf{Andy Murray wearing his favourite shirt} + \textbf{The roar of the Wimbledon crowd} - \textbf{The number of break points not converted} = \textbf{How good the serve is ,}$$

it would have bizarrely received higher recognition from the media. We can only hope the day will come when editors and journalist finally turn more of their attention towards the challenges mathematicians and scientists face in their day-to-day research and away from these pointless schemes generated for PR purposes.

- **Nick Ovenden**
  Senior Lecturer, Department of Mathematics

Student Choice Teaching Awards, UCLU

A new category of awards this year were the UCLU Student Choice Teaching Awards which was entirely student-led in setting the award categories and criteria, and in making the nominations and decisions as to who wins the awards. Isidoros Strouthos has won awards in 2 such categories: 'Outstanding Teaching' and 'Outstanding Personal Support'.

The overarching principle of these awards are to recognise and reward those who have made an outstanding contribution to the improvement of students' lives at UCL. They celebrate those individuals who have gone above and beyond to support teaching and learning.

Students were invited to submit nominations for these awards. The full list of nominations can be found at

http://uclu.org/scta-nominees-2012-13

The winners for 2012-13 are:

Outstanding Teaching
Mr James Frederick Daniel Hales, Institute of Archaeology
Mr Daniel Rogger, Department of Economics
Mr Mike Rowson, Institute for Global Health
Dr Isidoros Strouthos, Department of Mathematics

Outstanding Personal Support
Ms Judy Medrington, Institute of Archaeology
Dr Isidoros Strouthos, Department of Mathematics

Outstanding Support for Teaching
Dr Alastair McClelland, Division of Psychology and Language Sciences
Ms Judy Medrington, Institute of Archaeology
Dr Julie Pitcher, Laboratory for Molecular Cell Biology.

Edwin Clifford-Coupe (l); Edwin was the UCLU Education and Campaigns Officer for the 2012-13 academic year, Isidoros Strouthos (c) and Professor Malcolm Grant (r)

The Recent Advances in Algorithmic and High Frequency Trading Conference 3-5 April 2013

Since the flash crash of 2010, Algorithmic and High Frequency Trading have constantly been in the headlines and it is now a hot topic in Financial Mathematics. The Department of Mathematics at University College London and the Department of Statistical Sciences at the University of Toronto, in partnership with the SIAM activity group on Financial Mathematics and Engineering, recently held a three-day conference on “Recent Advances in Algorithmic and High Frequency Trading” to present state-of-the-art research in this area of Applied Mathematics.

The event took place at University College London in April where around one hundred delegates had the opportunity to listen to leading academics and practitioners who are developing cutting edge research in their fields. Days were long and rewarding. Three days and thirty-four talks later everybody had the chance to learn about: high frequency market making, flash crashes, self-excitation, optimal liquidation and acquisition, market impact, foreign exchange, interest rates, market quality, market microstructure, volume/time weighted average price, limit order books, etc. The event wrapped up with a round table discussion on the role that Algorithmic and High Frequency trading are playing in modern electronic markets.

The conference was a success thanks to the quality and timing of the material and the mix of presentations. A key aspect of the conference’s success was to bring together mathematicians, economists and industry practitioners under one roof. Topics were interspersed to allow participants to see problems from another viewpoint and attendees found the format to be refreshing and engaging.

In all, the conference shows that Algorithmic and High Frequency Trading is a fresh source of problems ranging from modelling issues, to mathematical challenges, to statistical estimation and Economics. At a policy level, the jury is still out on some of the effects that Algorithmic and High Frequency Trading have on electronic trading and whether the end consumer is getting a fair deal. We certainly look forward to the next meeting and to where the markets and regulators will take us by then.

- Álvaro Cartea (UCL Mathematics)
- Sebastian Jaimungal (University of Toronto)
- Andrea Macrina (UCL Mathematics)

Speakers included:

Robert Almgren, Courant Institute, NYU and Quantitative Brokers
René Carmona, ORFE, Princeton University
Álvaro Cartea, Department of Mathematics, University College London
Rama Cont, Department of Mathematics, Imperial College London
Sebastian Jaimungal, Department of Statistics, University of Toronto
Michael Ludkovski, Department of Statistics and Applied Probability, University of California Santa Barbara
Huyên Pham, LPMA, University Paris 7
Alexander Schied, Department of Mathematics, University of Mannheim
Philip Treleaven, Department of Computer Science, University College London
Jamie Walton, Morgan Stanley

Our Former Colleague Wins Nobel Prize

Our former colleague Peter Higgs has been awarded the 2013 Nobel Prize for Physics, for his work in the 1960s that led to the concept of a mass-giving particle now known as the Higgs Boson.

Peter Higgs was a temporary lecturer in the UCL Department of Mathematics from 1958 until 1960. In 1960 he accepted a permanent appointment at the University of Edinburgh and has stayed at Edinburgh ever since.

In 2010 UCL awarded Peter Higgs an honorary doctorate of science. The photo was taken in 2010 at the dinner following the conferment of the honorary doctorate. Sitting left to right: Peter Higgs, Roger Penrose and Dima Vassiliev.

The poor quality of the photo is due to a number of reasons: a) I forgot to bring a camera so I had to use somebody's mobile phone; b) the lighting in the Jeremy Bentham Room was poor and c) in the absence of a professional photographer I had to call upon the photographic skills of the UCL Provost Malcolm Grant.

- **Dima Vassiliev**
  Professor of Mathematics

Professor Peter Higgs, Professor Sir Roger Penrose, OM, FRS and Dima Vassiliev (left to right seated) at UCL's Honorary Degree Ceremony on 6 September 2010

Departmental Colloquium

The Departmental Colloquium resumed its work in the academic year 2013-2014. The first speaker was Richard Melrose from MIT. On 15 October 2013 he delivered a talk entitled "Loops, spin and stringstructures".

Previous Departmental Colloquia featured talks by Frank Smith (UCL), John Toland (University of Bath), John Ball (Oxford), Brian Davies (King's College London), Jeremy Gray (UCL and Open University), Nick Trefethen (Oxford), John Ockendon (Oxford) and Artur Avila (Institut de Mathématiques de Jussieu and IMPA).

Marcello Seri, Jason Lotay (background), Richard Melrose, Jacqui Espina, Richard Pymar and Phil Haines.

Doctoral Training in Geometry and Number Theory

We are delighted to have been awarded EPSRC funding for a new Centre for Doctoral Training in Geometry and Number Theory. This is a partnership between Imperial College, King's College London, and University College London.

The Centre will offer a 4-year PhD programme for students wanting to undertake research in a broad range of topics across geometry and number theory. There is a pool of around 40 potential supervisors across the three institutions who will offer a wide range of research projects as well as graduate-level taught courses. We expect to admit 14–15 students per year over a 5-year period, with the first intake in September 2014.

A new website is currently under construction.

Professor Michael Singer (UCL Mathematics), director of the new Centre for Doctoral Training in Geometry and Number Theory at the Interface, said:
"This CDT, which has been set up in partnership with Imperial and King's, will help train the next generation of pure mathematicians in the core areas of geometry and number theory. Students will have the opportunity to gain a broad foundation in these fields before undertaking a cutting-edge research project. Additionally communication and coding skills will be incorporated with teamwork as an integral part of the training. Our graduates will contribute to the sustainability of the mathematical sciences as well as the UK economy more widely. Our centre will also find innovative ways to advance women in mathematics."

Professor Singer's CDT will be the first in the country in the field of pure mathematics, and will play a key role in maintaining the competitivity of mathematical research in the UK.

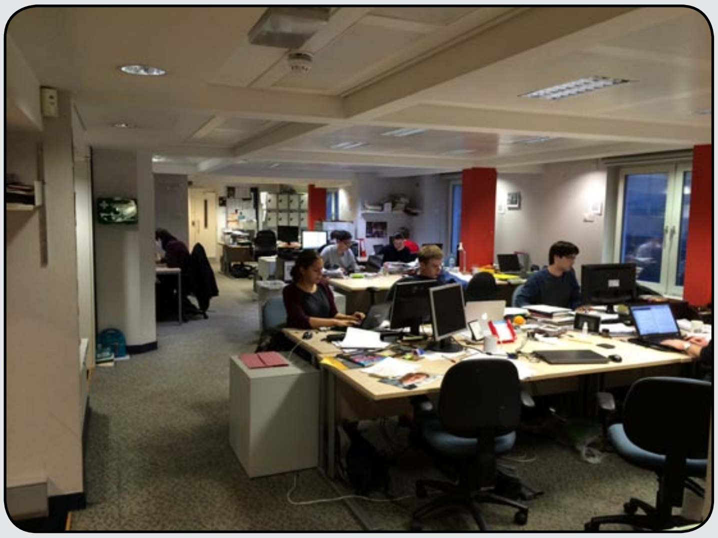
Professor Robb McDonald, Head of Department for Mathematics, noted that:

"This is a great development for the department which will bring many positive benefits not only to our geometers and number theorists, but to the department as a whole. Many thanks to all those involved for their hard-work in preparing this successful bid including, in particular, Michael Singer. Michael is to become the inaugural Director of the CDT. Well done Michael and many congratulations!"

Postgraduate Research

It has been a bumper term for the UCL mathematics postgraduates. The run of second year talks at the weekly postgraduate seminar has concluded after 17 triumphant performances. As a rite of passage, every second-year PhD student is expected to give a talk of varying length at these regular meetings to their fellow postgraduates, filling everyone in on what has kept them so busy. The programme for the second term looks to be full of developments from our older colleagues as they share their discoveries and results.

The subsequent, traditional tea and biscuits has been a continued success (apart from the ghastly Penguin Wafers, but the less said about those pretenders to the chocolatey-biscuit throne the better). The tea has been hot and Yorkshire (following a notable campaign by Ali last year) and the chatter engaging and intelligent. The postgrad pub quiz team has attempted to defend its title as second-place champions in Phineas on a number of occasions, with varying success following the migration of our stalwarts into the real world. If there is anyone who has *any* sporting knowledge, let us know.



Postgraduate Researchers

Postgraduate seminar

We are very pleased that the department has kindly offered once again to fund a night out on the tiles, or more specifically a pleasant dinner out, following the last talk and so this year we are pleased to be having a well-attended Christmas dinner at some suitably upscale establishment. The Christmas dinner also features the culmination of the office Secret Santa, where we test whether we do actually like each other and whether we know each other's names. As there are at least four Toms in the office, this is not quite as tricky a task as one might think.

The summer saw lunchtimes out in the quad, when we emerged from the shadows of our north-facing offices to sit in the sunshine while eating our sandwiches. Tom Ashbee was joined rather abruptly by a rather juicy caterpillar on one occasion which resulted in mass paranoia about sitting under trees which only resided once said caterpillar was picked up by a blackbird and then thrashed to death during an interesting but probably excruciating three-minute ordeal. Now in the winter, we have retreated to more sensible haunts like the Refectory, ULU and the Cruciform building for our communal lunch breaks.

Productivity has been boosted this term with the introduction of Fancy Fridays, when the postgraduates sample the culinary offerings of the wider Bloomsbury area. The boost to productivity comes from the need to condense

Postgraduate Christmas Dinner

a day's work into a slightly shorter day because of the two-hour lunch break. Nonetheless, this forced socialising has afforded some of UCL's mathematical minds the time to crack relatively easy puzzles and bask in the consequent glory. Also complicit in this effort is the afternoon tea break, which offers its presence when we can wrench the library next door from the Chemists who like to colonise it. An opportunity to discuss our individual work with each other over a cuppa and a biscuit, these have proved useful oases to solve each other's dilemmas with Matlab or perhaps just to help conceptualise an abstract problem.

A mammoth effort took place in November as the KLB fridge was cleaned for the first time in probably six years. Unearthed treasures include a jar of Sainsbury's Basics mayonnaise which was positively glowing green, a Tupperware box containing lunch (circa 2008), and a flat bottle of Kopparberg. With thanks to Huda, Sam and Gin for their efforts in bringing in heavy-duty gloves and bin bags to bear the brunt of the highly suspicious green/brown sludge that had materialised at the bottom of the fridge over recent months.

Meanwhile, we are pleased to hear that the department has officially recognised our motion to rename the nearby Origins Seminar Room in the KLB the "X-Men Origins Seminar Room". We are yet to see whether we can claim some framed photographs of Wolverine and Professor Xavier on expenses.

The news in the recent Provost's View that the interior of the KLB will indeed meet its maker was greeted with denial in the KLB office. If plans do go ahead, we are in talks to arrange an occupation (#OccupyKLB), which will be all the more comfortable with the newly improved heating. Meanwhile, the tragic temporary demise of the Almighty Coffee Machine in the staff room caused great disturbance for many weeks as postgraduates were forced to buy their lattes from the union again in order to get through the monstrous piles of undergraduate marking that are kindly thrown our way.

On the whole, all is well. We are pleased that some of our ranks who are working out in the "real world" are progressing happily, that we have only accidentally clogged up the departmental servers with terabyte files a couple of times, and that there have been successful vivas over the last few months. May it continue for 2014.

- **Postgraduate Researchers**

Freshers' barbeque

Augustus De Morgan (ADM) Mathematics Society

The UCL ADM Mathematics society, named after the first Mathematics Professor at UCL, Augustus De Morgan, is one of the oldest running societies at the university, boasting a membership of approximately 600 mathematics students. The current committee consists of seven very keen and able students who are enthusiastic about increasing the number and significance of the events the ADM runs. As such, we have been working on bringing a variety of careers talks and seminars and social events to our members. We have also created a new, improved website for the society, which you can find here: http://www.ucl.ac.uk/~ucahadm/

It is important for us that our graduates have the opportunity to get exposed to a wide range of career options, which they may not consider otherwise. Therefore, we have endeavoured to attract speakers from different sectors of industry and academia and have worked on making our events tailor-made to the students from the Mathematics Department, rather than overlapping with other University-wide events.

This term, we have organised several careers talks – a general careers talk for mathematicians by a representative from the Institute of Mathematics and its Applications (IMA) and a talk on catastrophe modelling and investing for a hedge fund by two UCL Mathematics alumni. We are also planning another seminar with an alumnus and an academic talk by a member of staff. In addition, we have been in contact with the founder of a successful technology company and other employees of financial and technology firms who have expressed an interest to get involved in the activities of the society in the second term. The alumni talks we have had so far have been received very well and therefore we would be delighted to hear from any alumnus who wishes to give a talk about their career or research, life after UCL, or any other topic of interest.

In addition to careers events, we will also run social events throughout the year, as we are hoping to bring students from different year groups together and provide them with memorable events which they will relate to the department later on. At the beginning of the year, we had a Mathematics BBQ and a pub crawl which were both very successful. We are also currently looking into the possibility of holding a chess and poker tournament for students and members of staff in the second term. At the end of the first term, we also had our traditional Departmental Christmas Quiz, hosted by Professor McDonald, and a Christmas Dinner, subsided partially by our IMA grant.

We aim to take part in inter-university events, such as the IMA Maths Competition, which will give students the opportunity to get involved in a challenging extracurricular mathematics activity. If you would like to get in touch with us, please feel free to contact us via our email: adm.maths@gmail.com

- **Desislava Bankova**
  President of ADM Maths Society

'Getting paid for going back to the School'

I still remember receiving the email from the UCL Mathematics Department advertising the opportunity to be a student on Series Two of 'Dara O' Briain: School of Hard Sums'. I applied on a whim, thinking that it was about time I started applying for opportunities to boost my confidence. Somehow, applying for the show was a way of easing myself into the unforgiving process of job applications; after all I was a third year – it was about time I applied for something!

The interview process was incredibly informal, more of an audition which of course made sense! I auditioned with four other students, two of whom were from UCL. I did not feel I had done particularly well and was surprised to be called back for a meeting with one of the two executive producers of the show, Katherine Parsons (a former UCL student). It was then that I was informed that it was almost certain I would make the show. I can still remember the strange concoction of shock, excitement and dread that filled me. All of a sudden, it dawned on me that I would actually be on the show. On television. Doing mathematics.

I vividly remember arriving at the Studios in Shepherds Bush on Friday 18th January 2013 for rehearsals. After a rather roundabout unplanned trip around the studios, I arrived at the 'green room', where we would be based throughout the week of filming. There were 12 students, 4 of which were from UCL: Rasini Ranawake, Ben Smith, Graham Benham and of course me. The rehearsal day allowed us to adjust to the surprisingly gruelling schedule that filming would bring and enabled us to get to know one another.

When the first morning of filming arrived, there was a buzz in the air. Everyone was a little apprehensive. I remember feeling self-conscious walking into 'hair and make-up', wondering what they would do to me! Thankfully, I got a dusting of powder and was sent on my way, 'into studio'. The studio was hot and extremely bright with hundreds of lights, but it felt much more spacious than I had imagined. We were 'mic-ed up', given pads of paper and permanent markers. There were lots of people running around the studio floor whilst we looked on, ensuring everything was perfectly placed before the cameras started rolling.

Initially I felt that we were all quite jittery, trying to get the answer to the questions right and then make them look as pretty on our pads of paper as was possible. In the battle of 'Brain versus Brawn', fighting Dara's corner against the two guest comedians, we wanted to triumph. The amazing thing was that we all had different approaches. In our groups of three, sitting at our desks and discussing the possible routes we could take to decipher the problem, we were suggesting very different things. Half the time we had over complicated the problem and sometimes our methods were not very mathematical at all! Strangely, without being told which area of mathematics a question used, we were often stumped. Once you spot a tool you can use to solve a problem, using the mathematical machinery comes second nature. The real difficulty was breaking down the problems into a language which poised the question mathematically rather than a less direct, hypothetical 'scenario'. Of course, the experience was not all about mathematics. It was surreal meeting both Dara O' Briain and Marcus du Sautoy, as well as the guest comedians who appeared on the show. Some of the most classic comedy lines were delivered off camera, and I was totally and utterly star struck. I could not believe how down to earth and approachable they were.

On the final day of filming, there was a strange sense of relief, excitement and exhaustion. There was also an eerie sense of finality. One of the 'runners' informed me that the series was one of the last ever series to be recorded in Studio 4 of the BBC Television Centre, where shows such as 'Parkinson', 'Blackadder' and 'Only Fools and Horses', were transmitted (if not recorded). This made it even stranger for me, thinking that we had just 'made' history.

This was not the end of my experience with the show. This summer I was lucky enough to be successful in my application for the position of 'Junior Questions Researcher' for Series Three. I worked mainly with the show's producer, as well as liaising with Marcus du Sautoy and two Oxford PhD students. I was lucky enough to attend two VT shoots, filming the comedians' practical attempts at the questions, as well as attending the recording of one of the shows - this time off camera. It was during this time, working for the show on the content creation side, that I realised how difficult it is to maintain the balance between making mathematics accessible and keeping it interesting. The problem is that non-mathematicians do not understand what mathematics fundamentally is. Somehow there is an intrinsic understanding of what every other subject 'is', even if one cannot understand the technicalities. But with mathematics, there is none.

Often, I have been asked 'So, what do you actually study?' and I have found it difficult to communicate the mathematics I have studied at university to anyone else in a succinct, digestible way. I often feel that the problem is the mathematical framework itself. Mathematical context takes such a long time to set up before one reaches any interesting ideas and there is no real opportunity to allow others to appreciate mathematical beauty without this framework.

However I believe this show, in trying to communicate real mathematical ideas in a light hearted comedy way, is making headway in an area which has not been popularised on mainstream media before. I am proud to have played a small part in its role of providing the general public with a glimpse into the depth of mathematics - and to have earned my first ever monthly pay packet by going back to the 'School of Hard Sums'.

- **Laura Guthrie**
  Fourth Year MSci Student

Dara O' Briain, Laura Gutherie and Marcus du Sautoy

DEPARTMENT NEWS

Keith Ball

Keth Ball, formerly Astor Professor and Head of Pure Mathematics, who left for Warwick in December 2011, was made FRSE in March and more recently FRS.
http://royalsociety.org/people/keith-ball/

This is a great personal achievement for Keith but also one that this department can be very proud of.

Imre Bárány

Imre Bárány has been appointed Astor Professor of Mathematics.

Steven Bishop

Congratulations to Steven Bishop who has been elected Foreign Member of the Estonian Academy of Sciences.
http://www.akadeemia.ee/en/membership/_foreign/bishop/

Hannah Fry

Hannah Fry, a former PhD student in the department and now lecturer in UCL's CASA, has recently been awarded a Provost's Award for Public Engagement.
http://www.ucl.ac.uk/public-engagement/opportunities/awards2012

Leonid Parnovski

Leonid Parnovski has been appointed Head of Pure Mathematics.

Michael Singer

Congratulations to Michael Singer to his recent election as a Council Member of the London Mathematical Society.

APPOINTMENTS

The following have recently joined the Department of Mathematics:

Professor G Barsegian, Marie Curie Senior Fellow

Professor Erik Burman, Chair of Computational Mathematics

Dr Nicolas Chaulet, Research Associate

Dr Susanne Claus, Research Associate

Dr Fabrizio Coiai, Teaching Fellow in Financial Mathematics

Mr Robert Downes, Research Associate

Ms Kim Duffy, Administration Team

Dr Jacqui Espina, Research Associate

Mr Pablo Fernandez Medina, Administration Team

Dr Pilar Guerrero Contreras, Research Associate

Dr Philip Haines, Research Associate

Dr Larsen Louder, Lecturer in Pure Mathematics

Dr Lauri Oksanen, Lecturer in Mathematics

Dr Martin Orr, Research Associate

Dr Ruben Peréz Carrasco, Research Associate

Dr Richard Pymar, Research Associate

Dr Nicolas Salles, Research Associate

Dr Felix Schulze, Reader in Mathematics

Professor Michael Singer, Chair of Pure Mathematics

Dr Oldrich Spacil, Research Associate

Ms Nicola Townsend, Administration Team

Promotion to Professor

Gavin Esler
Professor of Applied Mathematics

Research areas of interest include:
- Methods of statistical physics applied to fluid dynamics
- Atmospheric transport modelling, particularly stochastic trajectory modelling
- Nonlinear waves in fluids and their generation by topography
- Instabilities and turbulence in geophysical fluid dynamics
- Vortex dynamics and stratospheric sudden warmings

Promotion to Reader

Christian Böhmer
Reader in Mathematics

Research areas of interest include:
- Modified gravity
- Cosmology
- Continuum mechanics
- Spinors

Promotion to Reader

Ilia Kamotski
Reader in Mathematics

Research areas of interest include:
Partial differential equations and applications to continuum mechanics and waves.
- Elliptic problems: regularity of the solutions in irregular domains, homogenisation, spectral problems, scattering, surface waves
- Parabolic problems: regularisation of singular problems, solutions' asymptoticsetc
- Hyperbolic problems: propagation of singularities, microlocal analysis, multiple characteristics

Promotion to Reader

Nadia Sidorova
Reader in Mathematics

Research areas of interest include:
- Parabolic Anderson model
- Random processes in random environment
- Small deviations and conditioning principles
- Probabilistic models of statistical mechanics
- Stochastic processes on Riemannian manifolds

Prizes Awarded to Undergraduate Students July 2013

The following students were awarded prizes:

Jianzhi Cheng – Bosanquet Prize

Huiyi Ma – Kestelman First Year Prize

Congrong Fu; Ignatius Pinto – Kestelman Second Year Prize - shared

Michal Porvaznik – Andrew Rosen Second Year Prize

Matthew Frost – Andrew Rosen Final Year Prize

Michael Duong – Nazir Ahmad Third Year Prize

Nikoleta Kalaydzhieva – Stevenson Prize

Anusheel Sharma – The Ellen Watson Memorial Scholarship in Applied Mathematics

Lara Du – Mathematika Prize

Udhav Fowdar – Filon Prize

Torezhan Amanzholov – Hill Prize

Andrei Stoica – Jeffrey Prize

Patrick Hough – Sessional Prize

Noami Kraushar – Sessional Prize

Christopher Tay – Sessional Prize

Hang An – Sessional Prize

Efstathios Christodoulakos – Sessional Prize

Ilya Tolchenov – Sessional Prize

Xinze Zhu – Sessional Prize

Joint honours prizes:

Bingqian Huang – Bartlett Prize (Mathematics/Statistics)

Lu Heng (Sunny) Hu – Castillejo Prize (Mathematics/Physics)

Additional one-off prize:

Atiqa Sheikh

The Institute of Mathematics and its Applications (IMA) Prizes – 1 year membership of the IMA

Lara Du – Finalist

Atiqa Sheikh – Fourth Year

The following students were awarded Dean's List Commendations:

Lara Du, BSc Mathematics; Atiqa Sheikh, MSci Mathematics; Anusheel Sharma, BSc Mathematics; Ekta Shah, BSc Mathematics; George Leadbetter, MSci Mathematics; Kamaal Basran, BSc Mathematics with Modern Languages.

Jackson Lewis Scholarship 2012-2013:

Jianzhi Cheng, MSci Mathematics, Year 2 to Year 3

Students who have recently obtained PhDs from the Department include:

Jonathan Remez - Diagonal resolutions for the metacyclic groups G (pq)

Luisa Pruessner - Waves on flexible surfaces

Louise Jottrand - Shadow boundaries of convex bodies

Seamus O'shea - Stably free modules over virtually free groups

Asad Munir - Series representations and approximation of some quantile functions appearing in finance

Rubi Bilal - Dynamics of gene regulatory networks in the immune system

Edgardo Roldán Pensado - Problems in convex geometry

Nenna Campbell-Platt - Metaplectic cusp forms on the Group SL2(Qi)

Peter Kowalski - Models of interannual mid-latitude sea surface temperature variability

Jean-Pierre O'Brien - Improved characterisation and modelling of microbubbles in biomedical applications

Pablo Soberon Bravo - Partition problems in discrete geometry

Daniel Ellam - An approach to the congruence subgroup problem via fractional weight modular forms

Matthew Hunt - Linear and nonlinear free surface flows in electrohydrodynamics

Prizes awarded to MSc and PhD Students – November 2013

Caroline Flux and Thomas Deschatre

Frank T Smith Prize
Awarded in the MSc Mathematical Modelling programme for the best overall performance.

Meng Lu

MSc Financial Mathematics award

Yan Long Fang

John Hawkes Scholarship

Supervisor: Professor Dmitri Vassiliev
Provisional title of thesis: **'Microlocal analysis on mathematical fermions'**
To understand the concept of mathematical fermions, one needs to mention about spinors. The mathematical concept of spinors has been introduced by E. Cartan since 1913 and then developed by many other mathematicians and theoretical physicists. More precisely, the language of Clifford algebra, Lie algebra, representation theory and physical description of fermions are intimately related by the concept of spinors. Moreover, the idea of spinors was encoded within the Dirac field, which was later generalised to the concept of ferminoic fields. However, the recent research developed by Professor Dmitri Vassiliev has shown that by employing microlocal analysis to PDEs, one can naturally obtain geometric concepts such as metric, connection, torsion and spinor. The striking part of the research is that it unveils a new idea of mathematical fermions by means of microlocal analysis. Therefore, my role in the research is to apply further microlocal techniques together with spectral theory to furnish the new approach of mathematical fermions, which is supposed to be a generalisation of the old one. Apart from such a generalisation, our research also aims at deriving geometry contents by performing microlocal analysis and spectral theory.

Hui Gong

Wren Fund; Monica Hulse Scholarship, Mayor de Rothschild

Dr Álvaro Cartea is my personal advisor and the current research supervisor. Dr Sebastian del Baño Rollin supervised my completion of MSc degree dissertation, which has the titile of: **Analysis of Stochastic Volatility and Local Volatility distribution using Copulae methods**
Abstract: This paper aims at better understanding of the difference between stochastic volatility and local volatility. The instrument we introduced for comparison is the copulae. Our use of copulae is different from the traditional application where one synthesizes a multi-dim pdf out of its marginals. We use copulae for comparison of pdfs with same marginals.

We use the Heston Model as the objective of study in stochastic volatility model. The reason for using Heston here is that this model can provide us a closed form vanilla option. After comparing the PDE approach and Monte Carlo simulation approach, we calibrate the Heston model and obtain the vanilla option price. The option price can help us obtain the cumulative distribution function and the probability density function of the spot process. The most important thing is obtaining the bivariate distribution from the joint characteristic function, and the shape of the copula can be obtained from this.

In the chapter of local volatility, Gyöngy's Theorem proved that there exists a weak solution having the same one-dimensional probability distribution as the one in the Itō's differential for any time $t > 0$. So we can use the Dupire formula to calibrate the local volatility model to stochastic volatility model in the previous chapter. Then we generate the stock price again by using local volatility. The joint probability distribution is obtained via kernel estimation in two dimensions and also for the copula function.

Finally, we compared the copulae under stochastic volatility and local volatility via Kullback-Leibler divergence. From this we can find the significant difference between these two copulae and conclude that the local volatility models will underestimate cliquets price.

My PhD research is under the supervision of Álvaro Cartea and my interest area will focus on **Algorithmic Trading and High Frequency Trading**. Optimal Stochastic Control techniques will be used to model the arrival of limit and market orders and how traders with superior computing power are able to make markets as well as take directional bets on short-term price derivatives. Moreover, different stochastic models will be proposed to model the micro-structure dynamics of prices where adverse selection is explicitly modelled and how this affects optimal market making and speculative decisions.

Lorenzo Toricelli

Edwin Power Fund; Corte Studentship

Supervisor: Professor William Shaw

John Evans

Archibald Richardson

Supervisor: Professor Frank Johnson (below is a provisional title and abstract).
Title of thesis: **'Projective and Stably Free Modules over Binary Polyhedral Groups'**
Abstract: Thus far, my research has dealt the lower K-groups of algebraic K-Theory, as well as investigating non-trivial projectives over a finite group rings. In particular, this has involved an in-depth look at the smallest such example, the case where the group is the quaternion group of order 8. I am currently investigating the case where G=Q(24).

Tao Gao

Sir George Jessel Studentship

Supervisor: Professor Jean-Marc Vanden-Broeck
Title: **Flexural-Gravity waves**
The research is concerned with a study of linear and non-linear waves propagating in a fluid bounded above by an elastic sheet. Such waves

can be generated by a load moving on the ice sheet. The research is motivated by applications to transport systems in cold regions, where bodies of water are transformed into roads and runways and where air-cushioned vehicles are used to break the ice.

Sergei Siyanko

David Warren Fund

My supervisor is Professor William Shaw.
My research interest is as follows: Pricing in incomplete markets with jumps and, in particular, when jumps are directed towards fundamental value of the stock; asymptotic methods for pricing Asian Derivatives.

J J Sylvester Scholarship Fund 2013-2014 (To be confirmed)

The J J Sylvester Scholarship Fund was set up in 1997, on the centenary of the death of J J Sylvester, one of the most gifted scholars of his generation. The Fund aims to award a scholarship to help support a gifted graduate mathematician.

You can make your gift to UCL online, by telephone or by post. Donations may be made by cheque, charity voucher or GiftAid. Cheques should be made out to the UCL Development Fund and sent to the Department Manager, Helen Higgins. Any donation, large or small will be gratefully acknowledged by the College. If you are interested in knowing more about the Fund or other tax-efficient ways of supporting the Fund please do not hesitate to contact Hamish Stewart at makeyourmark@ucl.ac.uk or on
+44 (0)20 3108 9127.

Giving Online:
http://www.ucl.ac.uk/makeyourmark/giving
Giving By Post: To make a gift by credit or debit card, or set up a direct debit (if you have a UK bank account) by post, please download our UK/overseas gift form:
https://www.ucl.ac.uk/makeyourmark/how-to-give/give-accordion/post.pdf
and return it to UCL Development & Alumni Relations Office, University College London, Gower Street, London, WC1E 6BT, UK.
Giving over the phone: To make a gift over the phone, using a credit or debit card, please contact the Regular Giving team on
+44 (0)20 3108 9127.
Giving for US and Canadian alumni and friends:
US: http://www.ucl.ac.uk/makeyourmark/how-to-give/give-accordion/uclfaa.pdf
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Sylvester was one of the greatest mathematicians to be associated with UCL and it is hoped that, through contributions made to the Scholarship Fund, we shall be able to assist in progressing the education of other mathematicians so as to realise their full potential for the benefit of us all.

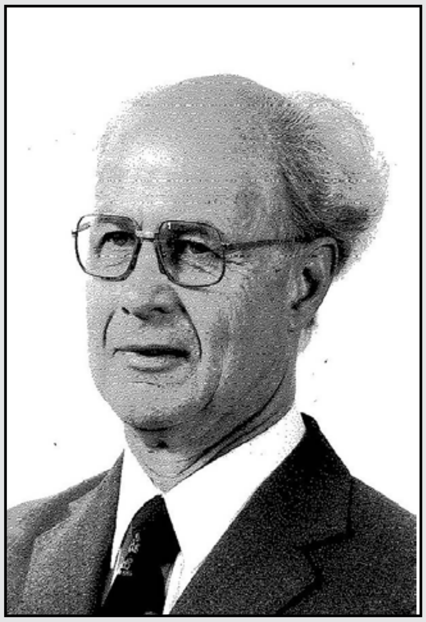
Inaugural Lecture 2013-2014

Michael Singer
Michael Singer will present his Inaugural Lecture 'The aesthetics of shape' on Wednesday, 5 March 2014, 4.30pm in Room 505, followed by refreshments in Room 502.

Abstract: There has been a close relation between aesthetics and geometry since the time of the Ancient Greeks. The golden ratio, the platonic solids and the geometry of perspective are classical examples of the intimate links between the mathematical subject of geometry and the human sense of aesthetics and beauty. At the beginning of the twenty-first century, the mathematics is more abstract, but a sense of beauty still guides us in our research. I shall try to give a sense of the aesthetics of shape from a modern standpoint.

In Memoriam: Howard Davies

27 August 1931 - 30 March 2013



Howard was a long serving member and, for a time, Treasurer of the UCL Old Students' Association, a position also occupied by colleagues Len Few and Hugh Michael from the Department. He took part in the general life of the College, especially the Rowing Club for which he lobbied successfully for grants for boats, oars and other equipment from the UCL Friends. His life-long interest in rowing dated from his days as an undergraduate at FitzWilliam College, Cambridge, where he graduated with first class honours in the Natural Sciences Tripos, which included Botany. After graduation, he was then required to serve two years' National Service in the Army before a brief period working in industry prior to returning to the life of an undergraduate student when he enrolled for the BSc degree in Mathematics at Birmingham University. There, he met his friend and mentor Ambrose Rogers with whom he later worked as a research student. Rogers was appointed to the Astor Chair in Mathematics at UCL in 1958 and Howard came to London at that time to continue his work with Rogers. Howard joined the staff at UCL in 1961.

Howard had a great many interests apart from mathematics, and was a keen cyclist, long before cycling became fashionable in Britain. He disliked cars although he owned one – his "polluting machine" – for a few years, preferring to ride his bike or use public transport. His studies in Botany at Cambridge led to his life-long interest in wildlife and natural history. He served on committees at the London Natural History Society and the South London Botanical Institute. Howard is remembered there as "that eccentric, interesting, helpful, ever-questing, ever (valuably) difficult and awkward, but constant presence who will be sadly missed".

Colleagues from the Mathematics Department write:

Michael E O'Neill: I suppose that Howard Lloyd Davies was the first member of staff I met after I took up my appointment in the Department of Mathematics in 1963. I had just settled into my allocated office – Room 814 – when there was a knock on the door one day and Howard, or HL as he became to be affectionately known, introduced himself to me. He had not been an undergraduate student at UCL and had worked as a research student on problems in Packing and Covering under the supervision of Professor Ambrose Rogers, first at Birmingham and then at UCL when Rogers succeeded Harold Davenport as Astor Professor of Mathematics in 1958.

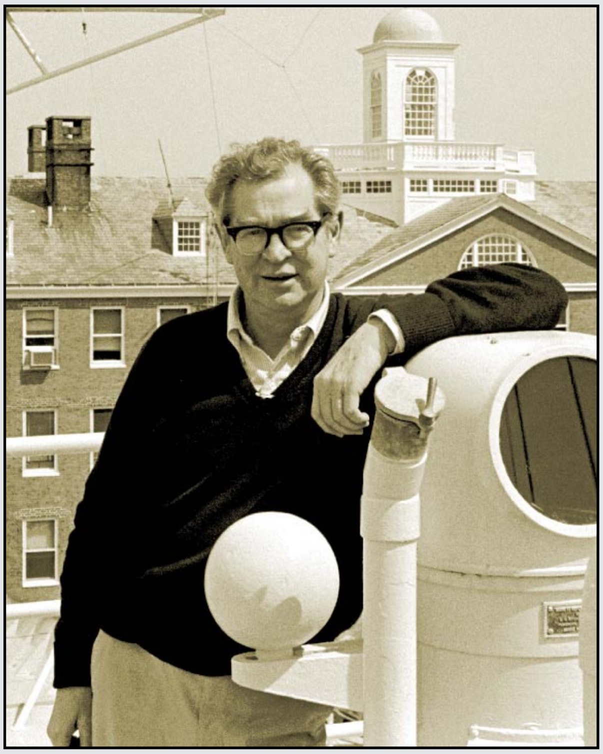
HL and I were to work together teaching mathematics to the first year students of Engineering – all of them, divided alphabetically into A-M and the N-Z group. I think that I taught the N-Z group. We had to set joint examination papers, both the terminal paper at Christmas and the University of London papers in the Summer. I always remember HL being very meticulous, both with regard to the grammar and punctuation and the style of questions that he set which would have been a test for first year mathematicians let alone engineers! Howard’s attention to detail and methodology became very useful in his role over many years as Examinations Secretary, and many an examiner was surprised to find his draft paper returned for grammar or punctuation to be corrected! He was Examinations Secretary during the five years I served as Chairman of the Board of Examiners. This was before we had the use of the computing facilities that we take for granted today. There were numerous sheets of tables of results that had to be assembled by hand, and Howard was determined that we always had the sets of examination results data ready for the examiners’ meetings even if it meant his staying overnight and sleeping in his office!

I think that I can echo the words of the London Natural History Society and the South London Botanical Institute “that eccentric, interesting, helpful, ever-questing, ever (valuably) difficult and awkward, but constant presence who will be sadly missed” in remembering my association with Howard Davies at UCL. Although he could drive us up the wall at times, I think that those members of staff and students who knew him will always remember HL with affection as one of that group of “characters” who have inhabited our department over its long history.

David Larman: My memories of Howard stem from when he marked my Analysis homework in the first year. He was very kind and was always willing to give us a hint on problems when he realised we had tried really hard, without success. I then followed Howard as a PhD student of Ambrose Rogers where he did some nice work on the packing of tetrahedra on the surface of a sphere. The situation was reversed when I became a member of staff. He attended my lectures on Convex sets and on Measure Theory; would borrow my books on the subject and then would, on occasion, make significant contributions to unsolved problems in the area. I will miss our conversations and his constant good humour.

In Memoriam: John H. Steele

15 November 1926 - 4 November 2013



John Steele began his studies in the Mathematics Department, UCL during the war, at the early age of 16. He would comment that the professors had to compete with incoming German rockets for the attention of their students. Upon graduation in 1946, he served in the RAF research establishment, researching aeronautical mechanics. After his discharge, in 1951, he found a position at the Marine Laboratory in Aberdeen, Scotland. This institution was charged with fisheries management, but Dr Steele recognized that doing this properly required an understanding of the broader ocean environment. During his years at Aberdeen, Dr Steele became involved with the idea of studying small systems that might embrace the processes of the broader ocean, but that were small enough to allow a complete characterisation of the ecosystem. One approach to this involved measurements in Loch Ewe, on the Scottish west coast; a second, bolder approach involved the use of large, two-meter-opening, plastic bags called mesocosms floating in the ocean.

About this same time, Dr Steele's interests broadened to embrace the entire marine ecosystem. Of Dr Steele's numerous and diverse accomplishments, he was most proud of his role in the broadening of biological oceanography from being essentially a descriptive science to a quantitative, mathematically based discipline. The defining moment in his career came with the publication, in 1974, of his book, The Structure of Marine Ecosystems, that spelled out his mathematical approach and demonstrated its use with actual data. He was awarded a Doctor of Science degree from UCL in 1963, elected to the Royal Society of Edinburgh in 1968, received the Alexander Agassiz Medal from the U.S. National Academy of Sciences in 1973 and was elected as a Fellow of the Royal Society of London in 1978. During the 1950s, Dr Steele began his long-term relation with the Woods Hole Oceanographic Institution in Massachusetts. His ties with WHOI strengthened over the years until, in 1977, he became the Institution's director, a position he held until 1989. He used this platform not only to enhance the Institution's international leadership, but to serve the interests of the broader oceanographic community. Thus, he played a central role in the development of several international oceanographic projects that ultimately dealt with the ocean's role in defining Earth's climate.

These projects incorporated ocean circulation, chemistry and biological activity.

Further details of Dr Steele's life and work can be found on the WHOI website (http://www.whoi.edu/main/obituaries?tid=3622&cid=180989).

The photograph taken in the Mathematics Department staff library from the left shows:
Les Ferry, Roger Pymar, Roy Drage, Nigel Cowan, Ian Clarkson, Zena Howell (nee Gordon), Graham Pointer, Jenny Scholey (nee Wray), Bob Scholey and Graham Lyons.

Mathematics Department - Class of 1963 Reunion

The Mathematics class of 1963 held a 50th anniversary reunion on 11th October 2013. The group which included a few friends from other departments were shown around by Zoe Wright and Bonita Carboo, thanks to the help of Briony McArdle, Manager of Alumni Relations.

The group met in the Print Cafe at 2pm and had a light lunch in a bustling (and to our old ears noisy) atmosphere. Zoe then guided us to the Mathematics Department which we were glad to discover was still in the same building. There we were met by Bonita who was most helpful in showing us the reading and lecture rooms. Much had changed since our day, not least because the intake is almost 5 times what it was in the 60's. We were also given a good insight into the highly successful (and profitable) mathematics department of today by former head of department Dima Vassiliev....

We also had a look downstairs where the main Union bar used to be, and where social events used to be held. This now looked very different, so we reverted to type and trooped off to the pub. After a pleasant hour or two in the Bricklayers Arms, we had an excellent meal in Elena's Etoile in Charlotte Street. All agreed we should repeat the reunion before too many of us dropped off the perch.

Sadly I did not have contact details for most of those who were in our year, so anyone interested in joining the next reunion should contact Briony McArdle who will put you into contact with us.

- **Roy Drage**
  Mathematics 1963

People

Name: Mr Gregory Forsythe
Year of Graduation: 1982
My wife Julie (nee Cummins - graduated in 1984) and I have lived in Pittsburgh for 24 years. Our eldest daughter Verity - attending the De Morgan Society Dinner with me - will be studying Mathematics and Physics at Case Western Reserve University starting in August.
I recently became Chair of the Professional Board of the International Valuation Standards Council.
www.ivsc.org

We would welcome news and contributions for the next newsletter which should be sent to:

Professor Ted Johnson, The De Morgan Association, Department of Mathematics,
University College London, Gower Street, London WC1E 6BT.

Email:
editor_newsletter@math.ucl.ac.uk. or administrator_newsletter@math.ucl.ac.uk