# Paradox

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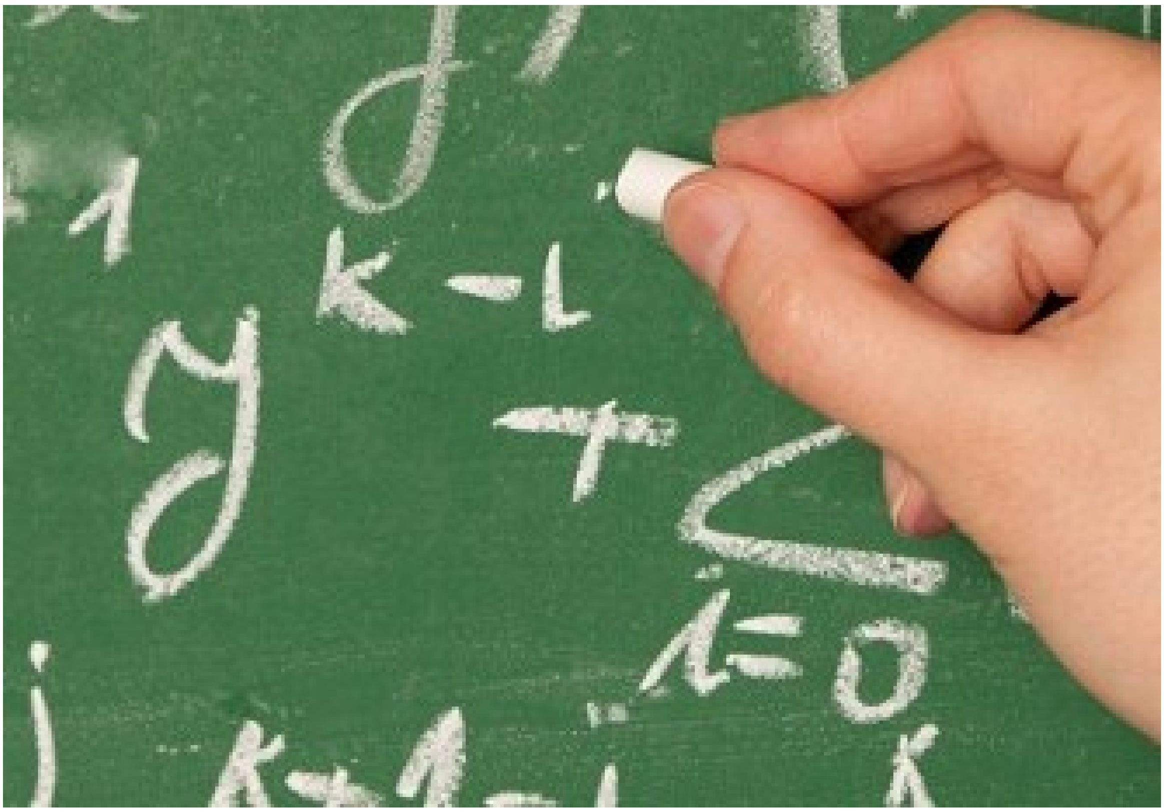
The Magazine of the Melbourne University Mathematics and Statistics Society



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# In This Edition of Paradox

## Regulars



## Articles & Special Features



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# Words from the Editor

Welcome to a new year, and with it the first issue of Paradox, the magazine produced by the Melbourne University Mathematics and Statistics Society (MUMS). Over the years, Paradox has had many different focuses, yet it has managed to keep largely the same format and the same penchant for bad maths jokes. Part of the fun with Paradox is precisely that there are regulars over the long run which are often not as regular as they seem, yet there are always delights within the next issue.

Among the regulars that have returned in this issue include biographies, interviews, and most missed of all: puzzles! Expect to see them for many more issues to come now that Paradox has a team dedicated to keeping these types of submissions coming. Nonetheless, there are still many potential positions listed on the second-last page of this issue, so make sure you apply! Helping put Paradox together is a fun and memorable experience, and we have even more new and exciting things planned for 2014. We eagerly await a new hero to grace the pages of Paradox, while all of the episodes of Rubik's Turtle are now available on the MUMS website.

In this issue of Paradox, find out what university maths is like from a student's perspective, what postgraduate research workshops are like, and how a certain famous French mathematician had many more claims to fame than just his mathematics. We also have an interview with a recent visitor to the University of Melbourne together with a review of his latest book! Also, make sure to try your hand at the first of our knots for this year—the solution will be provided as part of the knot in the next issue. While you enjoy procrastining by reading Paradox, check out the many events we'll be running this semester on the final page or think of an interesting question to 'Ask a Maths Student' by putting it in an envelope on the MUMS Room door.

Although the next issue of Paradox shall be my last as Editor and I have already received some submissions that couldn't make it into this issue, I'm very keen to finish my long time as Editor in style. To contribute to the next issue, feel free to contact me at `paradox.editor@gmail.com` and I wish you all a great start to the semester!

— Kristijan Jovanoski

# Words from the President

Hello, and welcome to a new year of MUMS. This particular year is very special for us, as we will be celebrating 10 years since a certain former Vice-President released the very first MUMS Puzzlehunt puzzle, Surströmming. Since then the Puzzle Hunt has grown into an event attracting around 800 participants each year, while the aforementioned former Vice-President has fallen into obscurity, apparently he's now stuck in some foreign embassy in some other foreign country…

To mark the anniversary, we'll be releasing 20 puzzles (plus a meta puzzle) over 5 days on our website, which will lead you to the location of a final object hidden somewhere around the university. Oh wait, we do that every year…whatever, we'll just have to make the Puzzle Hunt extra awesome this year.

But the Puzzle Hunt isn't until May (and strictly speaking, the 10 year anniversary is in September). There are plenty of MUMS things for you to do before that. We've got weekly seminars (Fridays at 1:00pm in Old Geology Theatre 1), Games Nights and much, much more! And you don't even have to wait for those to do MUMS stuff, you can come to our room and play a board game or if you're there around lunchtime, do the daily Super Quiz and Target with us.

If you can't quite make it all the way *into* the MUMS room, we've got a new thing on the door just for you! We bring you *Ask a Maths Student*. Ask us any question from "Who's your favourite Pokémon?"[1] to "How many dominoes does it take to cover a chessboard?"[2] and we'll answer it in the next issue of Paradox. If you want an answer more quickly, just leave your email address and we'll send you the answer.

Finally, in the second last week of the semester we've got our AGM, and I WANT YOU FOR MUMS COMMITTEE (insert picture of Uncle Sam wearing an orange MUMS t-shirt). Alternatively, just turn up, eat free pizza, and vote for the funniest speaker.

— Andrew Elvey Price

[1] Metapod. So meta. Also, it's one of the only Pokémon who plays nice with the others.

[2] One. It just has to be a really big domino or a really small chessboard.

# An Undergraduate's Guide to Maths

So, you're reading this, which means that you're a very curious undergrad, an extremely bored individual, or a seasoned postgrad who is hoping that I'm not making an absolute mockery of their specialization. Nevertheless, my aim is to provide a little insight into the various mathematics majors offered.

The reality of mathematics is that it's a giant toolbox in which you can only keep adding more tools to. With a little bit of experimenting and logic, you'll discover how some of these tools work with each other to produce new and interesting results. Just like every other general field of study, mathematics has a number of diverse branches which may seem somewhat boggling to those who have only experienced at least one of: 'Specialist Mathematics', 'Mathematical Methods', and 'Further Mathematics'.

## I'm a first year! What subjects do I take?

First year is similar to high school mathematics in that you'll learn a bunch of basic toolbox techniques that are required for further study in mathematics. The subjects you take in first year is dependent on your study score for Specialist Mathematics:

**$<$ 27 or haven't studied Specialist Mathematics:**
MAST10005 Calculus 1, MAST10006 Calculus 2, MAST10007 Linear Algebra

**$\geq$ 27 in Specialist Mathematics:**
MAST10006 Calculus 2, MAST10007 Linear Algebra

**$\geq$ 38 in Specialist Mathematics:**
MAST10008 Accelerated Mathematics 1, MAST10009 Acc. Mathematics 2

## Woo! I'm no longer a JAFFY!

Second year is when you can start branching out into different areas of mathematics. In general, you can't go wrong in taking MAST20009 Vector Calculus and MAST20026 Real Analysis as they can be taken in either semester and are prerequisites for several 3rd year subjects. Nonetheless, the best way to choose your 2nd year subjects is to take a look at the 3rd year subjects you want to take, and check out their prerequisites. That said, some areas don't get interesting/juicy until 3rd year or Masters level, so it's completely okay if you still haven't figured out what major you want to do right now.

## Pure Mathematics

The theoretical stuff. The stuff that makes mathematics an art. And art is subjective: you either like it or you don't. To me, it's like a giant rabbit hole with forever-expanding tunnels that eventually connect with each other in the strangest of places, and for others it's a trove of indescribable beauty that can only be discovered through logic.

Mathematics and its branches are built on axioms, definitions, the 'ground rules' so to speak. Whether it is from established principles, or entirely new concepts, pure mathematicians enjoy linking these concepts together, or discovering entirely new consequences. Part of it is finding the perfect proof, building up a picture of the truth with logic.

Another thing pure mathematicians love is generalising concepts. So we can measure things in three dimensions, great! What about $n$ dimensions? Is there a general way we can do this? Three dimensions is simply not enough! Pure mathematics is not for the faint of heart, but it is definitely the most popular branch of mathematics studied at this university.

## Applied Mathematics

Applied mathematics is like the more serious and less adventurous brother to physics, but still comes with its merits. If you want something a little more hands-on, designing experiments and the like, physics or engineering might be more up your alley.

**Differential equations** can be used to model a wide variety of situations such as traffic flow, transportation of blood cells, and movement of particles across a field. Some of these equations cannot be easily solved by sitting down with a pencil and paper—that's when you get the computer to produce an approximate solution!

**Mathematical physics** looks at physics concepts from a more rigourous point of view. Statistical mechanics is one branch that looks at interactions of particles, as well as a number of theoretical models that, whilst not necessarily a perfect representation of their counterparts in the real world, is more mathematically rigourous and pays attention to the details.

Personally I think the highlight of this major would be the fact that our University offers a subject on string theory! Unfortunately you can't do that until Masters. Boo.

## Probability, Statistics and Stochastic Processes

**Probability** is pretty much as you can imagine it: What is the chance of a given event occurring? How long until it happens again? You'll start by being introduced to various distributions that cover a range of possible scenarios and then use them in different combinations.

**Statistics** is also fairly straightforward in concept. What trends are the data showing? Do the results show a significant change? How can we use these data to better inform future decisions? We look at techniques that allow us to interpret and manipulate data, as well as ways to help the less mathematically-inclined figure out how many people they need to experiment on.

**Stochastic processes** are generally models with some element of randomness. One such topic in this area is queueing theory where we analyse how a queue is affected by varying factors, e.g., the time it takes for the next person in the queue to be served. Does the queue eventually become too big and crowded, or does it remain empty most of the time? On average, how many people are served over a given period of time? Other examples of stochastic processes in action also include financial models, hospital waiting room times, and charting the evolutionary process of birds!

All in all, it's a practical branch of mathematics with plenty of attractive opportunities in the industry. Statisticians are typically in huge demand, and knowing stochastic processes allows you to branch out into further areas of study such as bioinformatics.

## Discrete Mathematics and Operations Research

**Discrete mathematics** studies discrete objects. That means objects that can be 'counted' by the natural numbers (i.e. 1, 2, 3, 4, 5...) instead of real numbers. For example, lattices instead of planes, as a given point on a lattice has a set coordinate, whereas a point on a plane may have a coordinate that has an infinite decimal expansion.

Applied discrete mathematics is generally covered within the applied mathematics and operations research majors, whereas from third year onwards discrete mathematics will focus on topics that complement the pure mathematics specialization. Combinatorics is one such topic, where past the usual "How many different ways can I put four rabbits/potatoes/students into eight sacks/boxes?" questions, you realize how several different objects can be counted similarly. For example, Fibonacci numbers can 'count' the number of rabbits in a specific breeding pattern, as well as the branching of trees.

**Operations research** attempts to use mathematics for informed decision making. You'll produce models that aim to answer questions such as "What's the most efficient way for Santa to travel around the globe to deliver his presents all around the world?" and "Which items should I steal from this exhibit such that I get the best value, but still be able to carry them in my knapsack?"

In the industry, problems like these become very complex and you'll learn techniques that may not deliver the best solution, but a 'good enough' solution in a smaller frame of time, whilst a computer may take weeks!

## I'm worried about getting a job.

Keep these points in mind:

- One studies maths to learn how to think; how to break down concepts; how to develop ideas from basic principles. All of these skills are flexible and applicable, and highly valued by employers. You don't need to major in statistics or operations research to work in either of these areas in the industry since learning it along the way is a straightforward process.
- You can't go wrong with knowing a bit of programming and computer science. Computer science has a lot of mathematics in it, and you can approach programming in the same way as you approach mathematics: learn the syntax/language and how each and every function operates, then figure out how to put them all together.
- The basic advice of 'It's not what you know, but who you know' heavily applies here. Go to your lecturers' consultation hours, do some research on the companies that you'd like to work for, and attend careers fairs!
- You hear more from employers hoping for mathematicians once you start studying maths. Apparently everyone needs a mathematician to look pretty in the corner...

— Matthew Mack

"This is a one line proof... if we start sufficiently far to the left."

# Interview with Simon Singh: Author, Presenter, and Science Advocate

British author Simon Singh is perhaps best known for his work in promoting science to the public. Simon recently presented a talk at the University of Melbourne on his latest book, *The Simpsons and Their Mathematical Secrets*, and he graciously set aside some time to talk with me.

**You completed a PhD in particle physics at Cambridge University and at CERN, Geneva. What inspired you to study this particular field?**

I've just always loved physics. I guess it's the fundamental questions in science. Where does life come from? How did humans evolve? What are the forces that hold the universe together? For me it's not a case of "How did you get interested in it?", but rather a case of "How could you not be interested in it?". Physics is just so amazing and baffling. I've always wanted to be a physicist and make some great discovery, but when I was finishing my PhD, I could just see that the person on the other side of the office was much brighter and quicker than me, and they were going to be the person that would make great discoveries, and they have gone on to do just that. So I thought that if they're going to go and do those great things, what should I do? I still love science and I still love physics, and I love teaching those subjects, as well as writing and talking about them too. So, journalism seemed to be the most obvious place to go with that.

**Some of our readers are entering their final year of their undergraduate study. Is there any advice you would give to them about choosing their next move?**

I think it's purely about looking at what your skill set is. When it comes to getting a job, there are three key things that somebody once taught me: what will somebody pay you to do, what do you enjoy doing, and what are you good at? You might be good at lying at the beach, and you might enjoy lying at the beach, but no one will pay you to lie at the beach. Somebody might pay you to be a tree surgeon, you might be good at being a tree surgeon, but you might not want to be a tree surgeon. That's one thing I would look at. The second thing is to look at what makes you unique, what is it in your skill set that means that you could be ahead of everyone else? What makes you special? So for me it turned out to be that I was good at physics, but lots of people are good at physics, but I also had an ability to write and communicate, so that's what made me a bit different. It could be an ability with languages, or an ability with leadership; all sorts of different things. Look at what makes you special and a bit different and then find out what you can do with that.

**Particle physics would have its fair share of mathematics, but what is it about mathematics that fascinates you the most?**

As a physicist, I always saw mathematics as a tool, something that you use in order to do physics. Or if you're an engineer, mathematics is something you use to do engineering. It was only when I made a film about Fermat's Last Theorem that I really appreciated the inherent beauty within mathematics and why mathematicians fall in love with mathematics. One of the things I will always remember is that the number 26 is the only number between a perfect square and a perfect cube. Firstly, it's surprising there's only one such number. Secondly, you can prove that fact without any doubt; there's a logical step-by-step proof that ensures that no other number exists with that quality. And thirdly, this proof involves infinity, since you have to prove that none of the numbers after 26 amongst the infinity of numbers has this property. And so, you're dealing with infinity, you're dealing with absolute proofs and you're dealing with something that is unique and special. So that sort of thing really made me realize that mathematics is jaw-dropping stuff; it's as interesting as dark matter or the fundamental forces of the universe.

**You directed the BAFTA-winning film *Fermat's Last Theorem*, and you later wrote a book of the same name. What made you choose this particular conundrum as your subject matter?**

It was just a fantastic story; it's just a privilege to write about a story like that. John Lynch, a director at the BBC, originally wanted to make the film. He was a very experienced producer who then got promoted within the BBC and couldn't really make the film just by himself. So he asked whether I'd make it with him, and I said absolutely yes. There's the Riemann Hypothesis, which is probably an even more important problem in mathematics but it's unresolved, so that's a story that doesn't have an ending yet. In contrast, Fermat's Last Theorem *does* have an ending. It's a story about a problem that we all can kind of understand at some level. It's a problem where the answer exists, but the guy never told us what the answer was. So there are lots of beautiful things about that story, and once you're offered the story or you discover the story, then you just have to write about it.

**As I was reading up on Fermat's Last Theorem, I only recently found out that Andrew Wiles' initial proof had a slight error in it.**

Yeah! And from a writer's point of view that's an even better story. Just like a Hollywood film where the monster comes back to life, it makes the story much better and more dramatic. It's just like *The Simpsons* book: when you discover that there is mathematics in *The Simpsons*, and you realise that very few other people know this, that again is an incredibly attractive story because people who love *The Simpsons* and are interested in mathematics are able to combine the two in a shocking and surprising way. It is an irresistible story, and that's what I'm looking for. When I write a book it has to be something that makes me very excited and which will hopefully make others very excited.

**What inspired you to investigate and explain the mathematical secrets hidden in *The Simpsons* and *Futurama*?**

I noticed one particular episode called *The Wizard of Evergreen Terrace*. Homer is working in his basement trying to be an inventor and he writes on the blackboard various bits of gobbledegook—or what looks like gobbledegook—but one of the equations turns out to be related to Fermat's Last Theorem. And when I saw that I knew immediately: "Wow, there must be something there; the writers must love mathematics!" The writer turned out to be a chap called David S. Cohen who had written mathematical research papers, and sure enough, he put bits of maths into *The Simpsons*. But he's not the only one: there are others who have degrees in math, one of them was even a Yale professor before he became a comedy writer at *The Simpsons*, and they have all been putting maths into *The Simpsons*. And at that point, it was just irresistible.

**And this would have been from the very early days of the series, right?**

Yes, from the very first episode of the first series, there were two mathematicians, two people who really had an enthusiasm for maths. One was Mike Reiss, who had been in the maths team at school; and the other chap named Al Jean, who also had been at the maths team at school, and was so brilliant in mathematics he went to Harvard to study in the field when he was only 16.

**How was it working with the writers?**

They were fantastically helpful and generous. I spent about a week there and I interviewed them one by one. Afterwards, if I had any follow-up questions, they were always willing to reply. When the book was published, they were very generous and kind about the book. They gave interviews when I gave a lecture with Mike Reiss at the Museum of Mathematics in New York. The book is called *The Simpsons and their Mathematical Secrets*, but it was never really a secret; it was just maths that they hid away so that non-mathematicians wouldn't be confused or put off. But they're overjoyed when people do spot these references and appreciate what they are doing. They're very keen on that, and so they have been very supportive.

**Do you think this links to your ethos of getting science and maths out there?**

Yes, there are people who won't pick up *Fermat's Last Theorem* because it sounds a bit scary; a lot of people have read it and that's fantastic, but it's focused on a certain kind of readership. This book, I feel, will appeal to more people because it is about The Simpsons and Futurama with more familiar characters. At the same time it's not trivial; some maths in The Simpsons goes beyond what is covered in Fermat's Last Theorem. So it's not a trivial book, but I hope it's also very accessible and engaging.

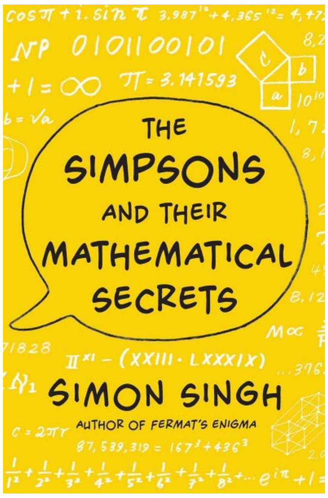
**So... if you happened to be cryogenically frozen for 1000 years, Fry-style, what scientific or mathematical discoveries would you hope to have been made by the time of your awakening?**

I suppose we all want to know where our Universe came from. Was our Universe the result of another universe that somehow gave birth to ours? Is our universe some kind of everlasting, rebounding universe? I think that kind of ultimate question, what came before the Big Bang, is something I'd like to have a more satisfying answer to, and maybe in another 1000 years we'll have that answer or at least be closer to it. I'd also be curious to know how this whole global warming debate has played out. There is a strong consensus: we don't have all the answers, we don't have all of the perfect predictions, but there is a very strong consensus that the Earth is warming, $CO_2$ levels are increasing, and that if we don't take action in the future, these temperatures will increase even more significantly. I'm not a climate change expert or scientist, but by deferring to those experienced in the field, it behoves us to really take action as individuals, states, and nations to solve this problem.

— Ruwan Devasurendra

Old maths professors never die, they just become irrational and can no longer differentiate.

# Book Review: *The Simpsons and Their Mathematical Secrets* by Simon Singh (Bloomsbury, 2013)




On 21 January 2014, I attended an AMSI Public Lecture given by Simon Singh at the University of Melbourne. Singh was talking about his new book, *The Simpsons and Their Mathematical Secrets*, and it was clearly a popular topic—it was a full house at the Elisabeth Murdoch Theatre, with some latecomers being turned away due to the lack of seats.

Singh was an engaging speaker and was warmly received by the audience. He took the audience through a number of interesting (and sometimes amusing) examples of maths in *The Simpsons*, and also gave us a snapshot of the show's maths-loving writers. At the conclusion of the talk, he fielded questions on a variety of topics, ranging from defamation law[1] to the importance of encouraging maths-minded children to continue with maths.

Like Singh's talk, *The Simpsons and Their Mathematical Secrets* is an accessible book aimed at a general audience. The maths is for the most part quite simple, and Singh provides explanations for what many Paradox readers will regard as very basic mathematical concepts, such as prime numbers and $\pi$. That being said, Singh doesn't shy away from the more complex mathematical ideas that do occasionally crop up in *The Simpsons*, and the appendices to the book provide some more in-depth mathematical exploration for interested readers.

Furthermore, you don't have to be a *Simpsons* devotee to enjoy the book. Having only watched a handful of episodes in my lifetime,[2] I didn't encounter any difficulties in following the book. Singh provides succinct and clear explanations of the scenes he discusses, and occasionally uses screenshots of scenes (although a couple more screenshots would have made things even easier for the reader).

[1] In 2008, Singh was sued in libel by the British Chiropractic Association over comments Singh made in an article in *The Guardian* about the effectiveness of chiropractic treatments. The libel suit was eventually dropped by the BCA in 2010: Pallab Ghosh, 'Chiropractors' Libel Case Dropped against Simon Singh', *BBC News* (online), 15 April 2010 `http://news.bbc.co.uk/2/hi/science/nature/8621880.stm`.

[2] I can already hear the gasps of horror and the exclamation, "But. . . what were you *doing* in your childhood?"

The book is grouped loosely into mathematical themes, including $\pi$ (chapters 2 and 12), Fermat's last theorem (chapter 3), Erdős-Bacon numbers (chapter 5), women in mathematics (chapter 7), and infinity (chapter 9). Each chapter gives examples of scenes from *The Simpsons* related to the chapter's particular theme(s), and uses these as a springboard to explore the history of the mathematical concepts in question.

This approach makes the book a worthwhile read for maths novices and experts alike: maths novices can absorb the interesting maths on offer, while those who are already familiar with the maths will discover some fascinating anecdotes that they may not have been aware of previously. One of my favourite anecdotes from the book is an attempt by the legislature of Indiana (US) to pass a Bill fixing the value of $\pi$ as 3.2 (chapter 2). As a trainee lawyer, I found this greatly amusing, though sadly not all that surprising.

The book also explores the writers behind *The Simpsons*, many of whom have backgrounds in maths or physics—the list of degrees they hold (including BS, MS and PhD degrees from Harvard, UC Berkeley and Princeton) is very impressive indeed! Singh delves into the evident correlation between maths and comedy in *The Simpsons* team, and presents some interesting explanations for why mathematicians might make good comedians. All this strongly suggests that a Paradox comedy column or a MUMS revue is in order.

The final chapters of the book are actually devoted to the mathematical secrets of *Futurama*, the sister show to *The Simpsons*. Despite not having watched any *Futurama* episodes before, this was a delightful surprise and the final chapter arguably offers the most interesting piece of maths in the book: the Futurama Theorem (or Keeler's Theorem), the first theorem specifically devised for the purposes of a TV show. The book is also littered with references to other series that are dear to nerd/geek hearts, such as *Star Trek* and *Doctor Who*.

In sum, *The Simpsons and Their Mathematical Secrets* is a fun and easy-to-read book. Singh is very good at communicating mathematical ideas simply and clearly, and his enthusiasm for his subject shows. The book is a must for *Simpsons* fans, but is also worthwhile for the uninitiated or the casual watcher.

⋆⋆⋆⋆ (out of 5)

— Julia Wang

# Joseph Fourier (1768–1830)

> *Yesterday was my 21st birthday; at that age Newton and Pascal had [already] acquired many claims to immortality.*
>
> — Joseph Fourier[1] to Bonard, 22 March 1789[2]

This article will examine Fourier's life up to the time of his claim to immortality: the publication of *The Analytical Theory of Heat* in 1822. Specifically, it will study his involvement in the revolutionary and Napoleonic governments, his place in Napoleon's expedition to Egypt, and will end with the predecessor of *The Analytical Theory of Heat*, *The Propagation of Heat in Solid Bodies*.

## The French Revolution[3]

Fourier's involvement in the French Revolution began in 1793, when he joined the Committee of Surveillance in his home town of Auxerre. Instituted during the Revolutionary war, the role of these Committees was initially to monitor strangers and travellers, but they also monitored French citizens after the Law of Suspects was introduced on 17 September 1793, with vague conditions under which one could be arrested as an enemy of the Revolution.

In October 1793, while on a mission to collect horses for the war, Fourier defended the leaders of three families of radical sans-culottes against the representative on mission in Orléans, which led to his arrest on 4 July 1794, on the charge of Hébertism[4]; 9th Thermidor[5] and the fall of Robespierre saved his life.[6] However, he was arrested once more on the night of 7–8 June 1795, for the part he played in the Terror, during the reactionary period which fol-

[1] For an excellent and highly detailed biography on Fourier's life, see John Herivel, *Joseph Fourier: The Man and the Physicist*. Oxford: Clarendon Press, 1975, 5–147.

[2] Ibid., 124.

[3] To fully understand Fourier's experience of the French Revolution, the reader needs a good understanding of the French Revolution itself, particularly the Terror. An excellent introductory text is Peter McPhee, *The French Revolution 1789–1799*. New York: Oxford University Press, 2002.

[4] The Hébertists were a particularly radical group in the Revolution who were at this point becoming quite dangerous and so were being executed on Robespierre's orders

[5] An explanation of the Revolutionary calendar has been excluded for brevity; see the appendix to McPhee, 2002.

[6] Lefevbre in Herivel, *Joseph Fourier: The Man and the Physicist*., 43.

lowed Robespierre's demise. After he was released, he presumably returned to teaching at the École Polytechnique, although he did not teach for long.

## The French expedition to Egypt

Napoleon selected Fourier to be part of the scientific and literary commission, in turn a part of the expedition to Egypt, which sailed from Toulon on 19 May 1798. After being elected Permanent Secretary of the newly established Cairo Institute on 25 August, Fourier performed predominantly administrative duties. However, just after Napoleon left for France on 18 August 1799, Fourier and Costaz led a scientific and literary expedition to Upper Egypt; this expedition gave rise to a publication series known as *Description of Egypt*.

After Napoleon's successor Kléber was assassinated on 14 June 1800, his successor, General Menou, appointed Fourier to many administrative roles, including negotiations with Murad Bey, the leader of the Mamelukes, whom Napoleon defeated when beginning his occupation of Egypt. Fourier persuaded Murad to ally with the French, which was very important since the French were not very strong at this time. After the French surrendered to the British on 30 August 1801, Fourier returned to the École Polytechnique as Professor of Analysis. Once again, however, he did not teach for long.

## Prefect of Isére

After witnessing Fourier's great administrative abilities in Egypt, Napoleon made him the Prefect of Isére in February 1802. The department of Isére[7] was in south-eastern France, bordering Italy, and centred at Grenoble. The Prefect represented the executive arm of government in a department. The first of Fourier's greatest achievements as Prefect was draining the marshes around Bourgoin, between Grenoble and Lyon. He visited almost every landowner whose land bordered the marshes and convinced them to relinquish their rights briefly, to allow draining to take place; a treaty was signed in 1807 and the draining completed by 1812. Immediately, the annual fever epidemics caused by these marshes ceased, and the value of the reclaimed land increased by almost four times the cost of the drainage.[8]

[7]France was divided into 83 administrative regions—departments—in 1790.

[8]Herivel, *Joseph Fourier: The Man and the Physicist.*, 81.

The second of Fourier's great achievements as Prefect was opening the road between Grenoble and Turin on the French side. He overcame the opposition of the Minister of the Interior—Fourier's direct superior—by applying directly to Napoleon. Knowing the man well, Fourier sent a one-page document outlining the benefits—especially the military ones—of building such a road. Permission was granted two days later, and the road had been opened as far as the Italian border by 1814. While Fourier kept his job during the First Restoration of the monarchy after Napoleon's abdication in 1814, he was eventually suspended from his position as Prefect on 9 March 1815 (after Napoleon returned from Elba) for siding with the monarchy. Nonetheless, Napoleon installed Fourier as Prefect of the Rhône (the department bordering Isére) three days later. Fourier resigned a few months later and returned to Paris.

## *The Propagation of Heat in Solid Bodies*

Perhaps Fourier's greatest achievement while Prefect was scientific: in 1807 he completed *The Propagation of Heat in Solid Bodies*. His motivation seems to be the differing climates of Egypt and the cold Grenoble, to which it is said that Fourier never fully adjusted. This, combined with his chronic rheumatism, prompted him to always go out wearing an overcoat, and to keep his rooms very warm. To report on Fourier's memoir, the Institut de France established a commission consisting of Lagrange, Laplace, Monge, and Lacroix. This commission made two major criticisms: Lagrange in particular criticized the lack of rigour and generality in Fourier's maths and his trigonometric series (now called Fourier series), while Fourier's derivation of the equations for the movement of heat in a continuous solid was also criticized.[9]

The ensuing controversy took a curious turn when the Institut announced that its grand prize in mathematics for 1811 would be on the subject of the propagation of heat in solid bodies. Fourier won this prize after modifying his 1807 paper a little, although the lack of rigour and generality was still criticized. This controversy meant that Fourier's paper was never published, nor would Fourier's battle for his work progress much further for the following few years, due to Napoleon's return from Elba. It was only in 1822, after adding a treatment of infinite solids, that Fourier published his work, with the new name *The Analytical Theory of Heat*.

— Sam Lyons

[9] Unfortunately the conflict concerning Fourier's paper is too long and complex to articulate here; for an in-depth treatment, see ibid., 100–3, 126–7.

# Days of Our Lives: Attending a Postgraduate Mathematics Workshop in Montreal

It was around November 2013 when I realised that I needed to travel. Amongst other things, I was interested in the recent proof of Soergel's categorification theorem (which I discussed in Issue 3 of Paradox last year under the title 'The Kazhdan-Lusztig Conjectures') and I needed to learn about the theory of Kac-Moody algebras. At some point, my supervisor sent out a departmental email advertising a two-week workshop at the University of Montreal, on 'Categorification and Kac-Moody Algebras'. Going to Montreal would kill two mathematical birds with one stone, so I booked by flights.

The workshop was marketed towards postgraduates or anyone within five years of completing their PhD, so the attendies were between 23 and 35 years old, with a few exceptions. They came from distant countries such as Japan, Korea, Spain, France, Belgium; and some came from closer countries such as the USA and Canada. I was the only Australian.

One of the pleasures of attending international meetings is interacting with people from other cultures. This extends to differences in mathematical culture as well: students from different institutions differ in they way they do, think and speak mathematics. For example, in some European countries, postgraduate students are much more formal in their relations with their supervisors, and the Australian way of addressing your supervisors by first name would perhaps be met with awkwardness or amusement. As well, European mathematics feels to me more 'highbrow' or 'austere' ; they casually use words such as 'scheme', 'homology' and 'BBD decomposition' as if they've mastered these concepts. I've been told, and constantly remind myself, not to be afraid of these big words.

Another result of going to these meetings is being reminded that there's enough interesting mathematics out there to last a thousand lifetimes. Depending on how one looks at it, this can be a beautiful or tragic thing. Beautiful because it makes one treasure life, and tragic because one is always scratching at the surface, only to find yet more surfaces to scratch beneath.

The main part of the workshops were the lectures. The style was like a typical undergraduate maths lecture, except with less chit-chat and fewer phones going off.

Afterwards, we'd discuss the lectures over lunch or dinner, or talk about our thesis work, or some other work we've done, or we'd talk about the terrible weather in Montreal, or how great it was that you can get from one building to another while staying underground, where it was nice and warm. A few of the attendees, who really hit it off, skipped lectures so that they could work together on things of mutual interest.

I went into the conference with the goal of getting a nontrivial example of categorification in my head.[1] At night, I transcribed the day's lectures. I used to think that this was a poor way to learn, but I've since learned that one can pick up the flow of the theory this way. Often it's better to transcribe than to write nothing at all, else one could end up in a 'loopy' headspace. While transcribing, I would circle terms that I needed to understand, and anything that sounded interesting enough to chase up.

Although I won't go into technical details of categorification here, my supervisor describes the philosophy behind categorification as similar to proving combinatorial identities by counting combinatorial objects. For example, the Vandermonde identity

$$\binom{m+n}{r} = \sum_{k=0}^{r} \binom{m}{k}\binom{n}{r-k},$$

can be proved by algebraic manipulation, showing that the left hand side is equal to the right side by expanding and cancelling terms, etc., or it can be proved by showing that the numbers on the left hand side and the right hand side are just two different ways of counting the same set of objects. Categorification is really just a beefed up version of the latter.

— Jon Xu

Q. Why was the identity $\sin(2r) = 2\sin(r)$ refused a loan?
A. He didn't have a $\cos(r)$.

[1]The outcome can be found at `http://www.ms.unimelb.edu.au/~jyxu/Notes/Acategorificationofthepolynomialrepresentationofthe Weylalgebra(ver2).pdf`. This is based on the course notes found at `http://mysite.science.uottawa.ca/asavag2/categorification/index.html`.

# Knot 1 (with apologies to Lewis Carroll)

Ten tired gnomes trudged on through the darkening woods. The day had begun so promisingly, when one fat gnome had discovered an especially attractive fishing spot by a pretty little stream, complete with a copse of large toadstools to shade them from the sun. This had delighted the gnomes, and they had spent the morning and the best part of the middle of the day casting their lines into the stream, lounging around underneath the toadstools and whistling peculiar little gnomish tunes.

Then it had all started to go wrong when one gnome had been dragged into the stream by an especially large and willful fish. The little gnome had quickly bobbed along down the stream, calling for help when he could in between mouthfuls of water, and his friends had had to run after him before he was taken completely out of sight by the current. One of the better swimmers had tried jumping into the stream in the hope of rescuing his friend, but was soon just as powerless to get out in the surprisingly strong current. To make matters worse, the gnomes still on dry land had soon found themselves running down a steeper and steeper slope, until they were simply rolling and bouncing downhill with no more control over their destination than their friends in the water.

Finally the stream had gushed into a still pool at the bottom of a deep gully, and the two soaked gnomes had managed to get out of the water to join their bruised and battered friends. Not being especially athletic, the gnomes had been unable to climb out of the gully to go back the way they had came, so they were forced to follow the path of the stream as it flowed out of the pool until they reached a spot where the gully was shallow enough to get out of.

So now here they were: cold, bruised, exhausted and lost as the sun was drifting below the horizon, and the day that had started so well gave way to what promised to be a miserable night.

Suddenly, the fat gnome who had found the fishing spot earlier in the day gave a cry of relief.

“Look! I can see a light over there,” he said, jumping up and down with renewed vigour. “Maybe it’s a house where we can stay the night!”

The rest of the gnomes were all quite happy at the thought of putting up their feet, so they hurried towards the light. When they arrived, they found a quaint little cottage with a lamp burning brightly over the door. One of the gnomes gave the door a loud knock, and they all waited nervously, hoping that whoever lived inside would not turn them away and make them spend the night out in the cold.

After some time, it became apparent that no one was home. Unwilling to wait all night for the owner of the house to turn up, one of the gnomes made a circuit of the cottage to inspect all of the windows. To his delight, he found one that was ajar and he and his friends spent the next ten minutes awkwardly climbing onto the window ledge and squeezing through the gap into the house.

The cottage was as cozy and warm inside as it appeared outside. There was a low fire burning in the fireplace, a couple of soft armchairs and a cold but delocious-looking pie sitting on a table. The gnomes quickly gravitated towards the pie, deciding that they had probably had a tougher day than whoever lived here, and were therefore more deserving of it.

Now this pie, as it happened, had been baked in a square dish, which presented the gnomes with something of a problem when dividing it fairly between them. Every gnome learns how to divide up a round pie into equal parts so that every piece had the same amount of crust almost as young as he learns to fish, but they were less sure how to divide a square pie. One gnome volunteered a measuring tape which he had been using to measure out his fishing lines that morning, in case it would be any help. All the gnomes agreed that of course it should, but didn't quite see how.

**To be continued...**

— Dougal Davis

"Take some more tea," the March Hare said to Alice, very earnestly.
"I've had nothing yet," Alice replied in an offended tone: "so I can't take more."
"You mean you can't take less," said the Hatter: "it's very easy to take more than nothing."

# Join Paradox in 2014!

The rumours of Issue 3, 2013 have been confirmed: the long-time benevolent yet autocratic Editor, Kristijan 'I'm the only choice' Jovanoski, will no longer be a choice at this year's MUMS Annual General Meeting! Whether this is connected to the upcoming MUMS Committee's long-overdue investigation into the shocking embezzlement of the famed Paradox staplers remains unclear (as are the results of that investigation), but it is clear that our Editor's days are numbered.

In an attempt to stave off a coup, he is continuing his recent moves towards liberalization and recruiting others into this year's Paradox team, so that others may possibly get the blame instead:

- **Book/Film Reviewer:** You will provide a regular review of a new book or film relating to mathematics or logic in each issue of of Paradox to entertain and inspire readers to digest its goodness as well.
- **Comic Designer:** You will bring the next hero of Paradox to life by designing a new comic series that will be a regular feature of the next several issues. A flair for drawing is not critical, since a camera, a Rubik's cube, and a gripping narrative have been enough in the past.
- **Content Sub-Editor:** You will look over articles to make sure that the maths used is correct and easy to follow. This is a maths (and stats) magazine after all!
- **Copy Sub-Editor:** You will look over submissions to check whether everything was written for humans rather than cyborgs. Spelling and grammar fanatics are highly desired but a keen eye for detail will do.
- **Layout Manager:** You will use LaTeX typesetting to set out the final version of each Paradox issue elegantly and will convert submissions into LaTeX when necessary. If need be, you will be taught how to use LaTeX and brought up to speed with the custom files used for Paradox.

To apply, just express your interest by emailing `paradox.editor@gmail.com` to discuss things further. You need not be a member of MUMS or even a student at the University of Melbourne to apply. First-come, first-served!

# Upcoming MUMS Events

**Proof Machine**
**Seminar by Professor Arun Ram**
*Friday 7 March 1pm–2pm: TBA*

**Abstract**: There is one tool that has saved my mathematical confidence (and career) more times than any other, my Proof Machine. In this talk I will discuss the theory behind how (and why) it works, and power it up and show how it works on a few examples. With a little practice wielding the hammer anyone can use the Proof Machine to build rock solid proofs, both within mathematics and also outside mathematics..

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| 6 March | MUMS Barbecue |
| 14 March | Seminar: Dr Vanessa Teague |
| | MUMS Games Night |
| 21 March | Seminar: Prof Peter Taylor |
| 28 March | Seminar: Andrew Elvey Price |
| 4 April | Seminar: Prof Kerry Landman |
| 11 April | Seminar: Prof Hyam Rubinstein |
| 5 May | MUMS Puzzle Hunt |
| 16 May | Seminar: Prof Edmund Crampin |
| 23 May | MUMS Annual General Meeting |
| 30 May | Seminar: Dr Mark Fackrell |
| | MUMS Trivia Night |

Paradox would like to thank Dougal Davis, Ruwan Devasurendra, Jenny Fan, Sam Lyons, Matthew Mack, Simon Singh, Julia Wang, Jinghan Xia, and Jon Xu for their contributions.

Got a question? **Ask a Maths Student!** Any questions you place inside a new envelope on the MUMS Room door will receive a response within a week, and will also get a mention in the next Issue of Paradox. So give it a shot!