MATHSOC University of Greenwich

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PrimeTimes

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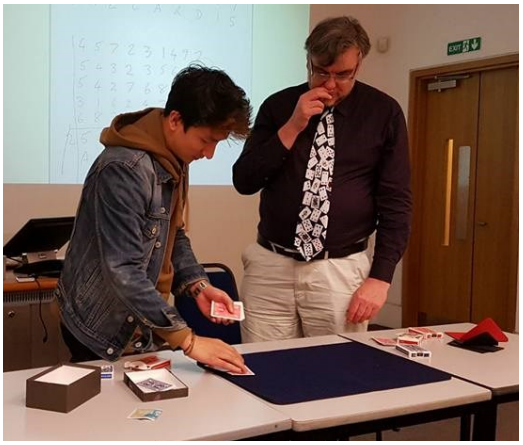
A Message from the Committee

What a wonderful academic year this has been for MathSoc. And this incredible growth is thanks to all of you mathematics students and teachers. The foundations that have been laid for our Society by our previous generation and especially the dedicated support of our lecturers catapulted us into the MathSoc that we are today.

Now, let's rewind to the good old days. We are proud to look at some highlights which reflect our achievements.

As usual, the start of the year, where we welcomed our new first year students, was very exciting. Then we were fortunate to attend a talk by Dr Nira Chamberlain (the first black mathematician to appear in the *Who's Who*) and a lecture given by Sir Andrew Wiles at the Science Museum. Furthermore, we applied to the IMA University Liaison Grants Scheme IMA and were awarded funding. This was followed by our glorious Christmas Jumper Day in which we raised £90.26. In early spring we had the fun-filled Hint Hunt event and we supported the stellar Maths Magic Event. To top this year off we have a brand new logo, designed by third year student Shahzeb, which we have used on our new hoodies (you can still order them).

Additionally, *Prime Times* has now published its third issue of the 2017/18 academic year and our Social Media presence is much stronger. And this year Greenwich MathsJam was given life, too! I know you are thinking it too so let's face the truth. It does set us free. – we are on fire! This process has been phenomenal because we worked together through challenges and our MathSoc executive members are passionate and serious about the growth of our Society. I conclude my proof saying that a family who calculates together stays together. And since we are in unstoppable revision mode I would like to share a quote by Dr Martin Luther King Jr. from his *Blueprint* speech:



"To top this year off we have had a brand new logo, designed by third year student Shahzeb, which we have used on our new hoodies "

"Learn Baby Learn
So that We can
Earn Baby Earn"

-Ruth Ejigayehu, Second Year

MathSoc Plan Their Escape at HintHunt Live Puzzle Rooms

Hint hunt was a team-oriented puzzle. We were placed in a room with a Japanese theme with 1 hour to figure out how to escape. Puzzles were very intricate and we worked methodically as there were many objects and dummy-hints designed to throw us off. Working as a team and communication were key to getting us through in the given time frame. Essentially, the escape room was like exams without a direct impact on our future! To summarise, it was a challenging experience and we just escaped with only minutes on the clock. I'm definitely planning to go there again, to try out one of the other three rooms.
-Jan Adamiak, Second Year

"Working as a team and communication were key"

The HintHunt was a killer experience like no other, especially the last 30 seconds where the adrenaline pumps in and the entire game becomes more or less a do-or-die situation. I will definitely recommend HintHunt as a tool of developing team work, communication and working under pressure. Even though HintHunt is a very discrete organisation, it most certainly does justice to serve the purpose of the game and keep students engaged. I will definitely recommend HintHunt to all my friends, as it's an enjoyable learning curve in every aspect.
-Pooja Prakash, Third Year

I'd never done anything like HintHunt Escape Game before and I wasn't sure what to expect. Our team was led into a room that belonged to a fictional detective. There were props everywhere. We were told that we had to try and escape and that the room contained many clues that would help us do this. Then the door was closed, and the time started. We stood for a few seconds, staring at each other, slightly confused, but then started hunting for clues like crazy; it was so much fun! We had to communicate with each other throughout because many of the objects in the room linked together. For instance, we found a torch in a drawer and batteries for it inside a walking cane on the other side of the room. We kept finding things inside of other items and saying to each other "I found this! I found this!", the rest of us would say "Okay, what do we do with that?" to which we would all shrug and say, "We don't know, let's keep looking!". Our team, worked together really well. We found ourselves absorbed in the story and desperate to escape. At one point we unlocked a draw. We huddled around and pulled it open - inside was a gun! We all backed away gasping and screaming. It took us a second before we looked at each other and laughed, realising of course that it was plastic and that we were not actually in any danger. There were lots of puzzles to complete and we were grateful for the little hints that popped up on the

"We found ourselves absorbed in the story and desperate to escape"

MathSoc plan their escape at HintHunt Live Puzzle Rooms

screen in the room. Some of these were more useful than others, for instance when we were using a magnet to retrieve a clue through a slit on a bottle lid and had failed to notice that the whole lid could actually come off. What can we say? The pressure had got to us! The HintHunt Escape Game was a great experience in building teamwork skills in an intense and time pressured environment. It was also a lot of fun and brought us all together. Most of our groups escaped the room within the time limit. My team crumbled in the last minute, ironically when tasked with the most basic maths we had ever come across! As disappointed as we were, we had a great time and it certainly motivated us to get back in the library and back to work!
- Robyn Goldsmith, Second Year

The trip to the HintHunt Escape Game was a great event put on by MathSoc. It was a great experience to meet new people and collaborate in groups to try and escape the rooms. The sense of achievement for beating the room was fantastic, especially when the time was ticking at the end.
-Alex Godbold, Second Year

The trip to the HintHunt escape game was an enjoyable experience and I would personally recommend it to anyone who might get a chance to do it in the future.

"The sense of achievement for beating the room was fantastic, especially when the time was ticking at the end"

Unfortunately, our group was not able to get out of the escape room but we were very close. I had never been to an escape room before and I was not disappointed by the experience. The experience was great fun and required a lot of lateral and creative thinking in order to get out.
-Craig Reece, First Year

Once in a life time experience – really glad to have gone to the event. Before I went, I didn't know what to expect, considering I had never been to such a place before, but I can certainly say I loved it and it was worth taking a break from revision for a couple of hours. We were a team of four, locked inside a room for an hour where my team and I felt like detectives trying to find small pieces of a big puzzle in order to solve a mystery. Sadly, we only managed to escape the room 10 SECONDS after we ran out of time. Nevertheless, it was a wonderful experience and I would definitely go again.
-Shahzeb Noureen, Third Year

Medical statistics and why it is useful

Those who know me personally know that I have immense enthusiasm for statistics. In a data-rich world, statistics is essential in making deductions and inferences; it provides the toolset to make profound conclusions that help us make informed decisions. It is fundamental to our understanding.

Statistics, unsurprisingly, is a broad science. It comprises many subtopics that have branched into disciplines in their own right. Having a passion for a subject leads to a thirst for knowledge and through research. I have become increasingly interested in the medical applications of statistics. The main reason for my love for this subject is its utility and applying this to one of the most widespread applications of aiding others is one that highly appeals to me. As I wish to go into research eventually within the statistical field, medical statistics may be the area in which I specialise.

Though medical statistics incorporates many applications in the realms of epidemiology (the study of the incidence of disease), clinical research (to test medicine effectivity) and forensic medicine, there are many areas of research within medical statistics. Like with many statistical applications, a focus on quantitative methods is essential for this specialism and an appreciation for descriptive statistics (for graphical representations) is important for effectively presenting findings to medical professionals. For this specialism, an academic focus on hypothesis testing, regression and risk is very important.

Though all applications could be explored, the main draw for me is in epidemiology. From research in the world of actuarial science, I was aware of the magic that statistics can be used to predict the future. In epidemiology, quantitative methods produce figures for the probability of a potential disease outbreak and it can make predictions into how it will spread thus previsions can be made to try and control it.

*Photo can be found at http://www.rss.org.uk/RSS/Get_involved/Statistic_of_the_year/RSS/Get_involved/Statistic_of_the_Year_.aspx?hkey=e5008987-fab9-4385-9110-4287e487b8d6

> "In epidemiology, quantitative methods produce figures for the probability of a potential disease outbreak"

Predicting the future involves considering how much emphasis should be made on the past; in some circumstances, looking at previous years' data can provide patterns that can be used to accurately forecast the future. However, in some cases, the past may not be the most accurate barometer for what will happen in the future. Sometimes, using a previous outbreak's model can be the most effective way to control a new outbreak if the new disease behaves in a similar way. In these circumstances, the original model for a disease can be used, but in other cases, different data may have to be inputted, parameters may have to be changed and this may produce a different model altogether.

Statistically modelling epidemics is a highly complex process. Though it has limitations, the risk factor of a disease is modelled by a generalised linear model where a simultaneous model is formed in the independent events of individuals becoming infected (which is highly variable). Also, the knowledge of the risk of the infection itself and the risk of transmitting the infection to another must be known and this can be difficult to quantify; within research, there is usually more emphasis on the former due to this difficulty. Generally, the risk factor is produced quantitively in terms of odds ratios though it is particularly useful for individual demographics to be given individual odds ratios as different groups of people may be more likely to contract the disease than others. Examples of factors that could affect the likelihood of an individual contracting the disease could be pre-existing health, age and culture. It is important to note that from reading papers on making these predictions, there is a huge emphasis on the difficulty in making accurate predictions on these risks; however, though these models may not be completely accurate to how the outbreak may progress, they provide a useful insight and a framework as to how to handle a new epidemic.

Overall, as statistical methods advance, so will the effectiveness of producing risk models so better provisions can be made in order to control and manage disease. Also, as better data collection methods are developed, this will also increase the reliability of these models as data quality plays a huge part in the quality of the models produced. Medical statistics is becoming increasingly accepted within the academic world and is a huge area of potential research; research within this area can have the potential to save many lives whether it be stopping an outbreak or making deductions about improving a new medicine.

-Freya Cary, First Year

The Indisputable Existence of Santa Claus — A Review

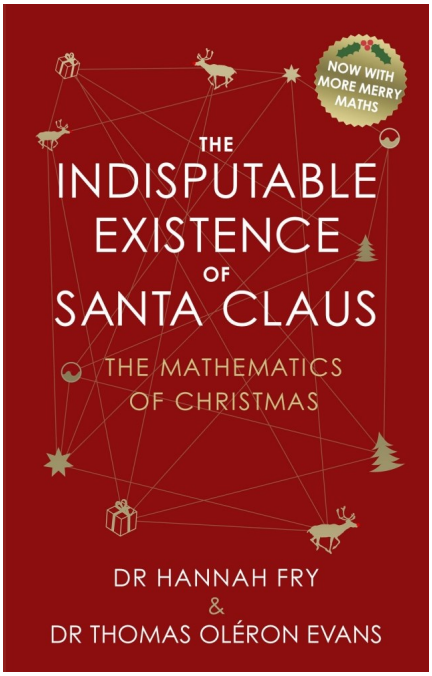
"By the time you get to the end of this book, you'll have all the tools you need to plan the perfect mathematical Christmas" - a claim made at the beginning of chapter 2. Granted no one asked for a 'perfect mathematical Christmas', but who am I to complain? As mathematicians are we not curious about how we can make everything more mathematical, if not simply to answer the obnoxious question "but when will you actually use that in life?" which guaranteed every mathematician is asked routinely! This book does exactly what it claims - solving potential Christmas problems - accompanied by sketches and diagrams to help visualise these unique problems.

The book has 11 chapters, beginning with a less mathematical, but humorous introduction suggesting the mathematical proof of Santa's existence, and ending with 'Watching Santa's weight'; a series of mathematical equations explaining the amount of calories Santa consumes. Each chapter covers multiple problems with different approaches. It's a discussion of the most 'efficient' way mathematically to do Christmas tasks. Realistically, most of these methods aren't as efficient due to how time consuming they are, but the thought that a tree can be wrapped symmetrically and neatly in tinsel is an interesting read. However, there are some tips many will appreciate - how to win Monopoly for example. Of course, each solution has loopholes and obvious questions, but if you're willing to overlook the ridiculousness of this; which you probably are if you're reading a book subtitled 'The Mathematics of Christmas', then you will definitely enjoy this book.

Dr Hannah Fry interviewing Sir Andrew Wiles at Oxford Lecture Series.
*Photo courtesy of Ruth Ejigayehu

The best chapter, in terms of providing a useful solution, was definitely 'Secret Santa', which presented the problem of people drawing their own names and discovering who has who, without using an online service (and ruining the fun of drawing out the hat). However, providing a genuine solution does not always mean one's favourite read. For me, this was 'The Queen,' which suggested how her speech could be predicted based on previous speeches. As a whole, this mathematical approach was unsuccessful - creating a speech that is correct in tone, but was nonsensical. This added to the amusement of the chapter, which included a bingo style game for predicting words and phrases used.

In terms of the actual mathematics, it's complex at times, with some problems involving higher level maths like calculus, however this is sparsely featured and the majority of the maths is simple, or at least explained well enough and with diagrams that I believe most readers would be able to follow and understand. If the reader wished to understand the more complex maths then the book provides useful footnotes (some of which add to the humour) and a endnote in most chapters which gives further reading and more extensive explanations. Because of this, I feel that the book is suitable for all readers with a general understanding of maths.



Publisher: Black Swan

Overall, does this book fulfil the objective of giving the reader 'all the tools to plan a perfect mathematical Christmas'? No. But was that ever really the aim of Fry and Evans? Probably not. This book was likely written to provide fun mathematical solutions to real life Christmas themed problems. Not all of them are realistic solutions, but I don't think they were ever intended to be; the book is well written, and left me smiling at the humorous remarks which made what could have been another boring maths book a fun and interesting read. I would recommend to anyone interested in maths - especially fellow students who are studying maths**!**

-Nicole McGrady, First Year

Staff share their favourite equations

The Dirac Equation describes the motion of a charged particle with spin, such as the electron in an electromagnetic field

$$[-i\gamma^{\mu}(\partial_{\mu} + ieA_{\mu}) + m]\psi = 0,$$

where $A_{\mu}, \mu = 0,1,2,3$

is the electromagnetic four-potential, $\partial_{\mu} = \left(\frac{\partial}{\partial t}, \frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z}\right)$, *e* is the electric charge

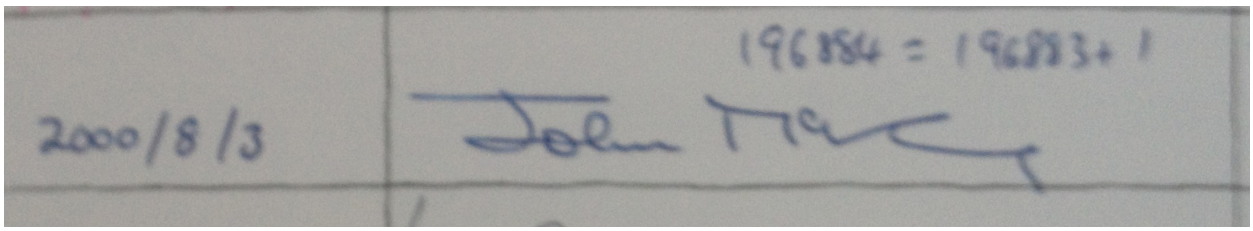
of the particle, *m* is its mass and ψ is the quantum mechanical wave function (which describes the probability of finding the particle at any point in space at a particular time). ψ is actually a four-component vector.

*Photo courtesy of Alan Soper

Unlike the Shrodinger equation, the Dirac equation is valid for high particle velocities. The equation correctly predicts the value of the magnetic moment of the electron (electrons behave like a small bar magnet), allows for the observed wave-like behaviour of electrons, and was used by Dirac to predict the existence of antiparticles. The positron was discovered shortly after its formulation. The equation describes the electron in a way consistent with Einstein's special theory of relativity. It is simple and elegant but has profound implications for physics. Dirac won the Nobel prize for physics in 1933. A memorial stone to Dirac lies near Newton's monument in Westminster Abbey.
- Alan Soper

196884 = 196883 + 1

This is obviously true, but why is it interesting? It relates to some very advanced topics in mathematics, so don't worry if you don't understand some of the words in the following. The key idea is that this equation indicates a deep connection between different areas of mathematics.
In the late 1970s the mathematician John McKay was working on the Monster sporadic simple group. The smallest number of dimensions in which it has a non-trivial representation is 196883. McKay's wife was working on a completely different area of mathematics, modular forms, and McKay happened to see that she had written the number 196884 in connection with her work. McKay thought that these big



The equation, written by Mckay in Tony's Visitor's Book.

Photos courtesy of Tony Mann

Staff share their favourite equations

numbers couldn't arise coincidentally and that therefore there must be a deep connection between these two apparently totally different areas of mathematics. This gave rise to a paper published in 1979 titled "Monstrous Moonshine" in which John Conway and Simon Norton proved there was a relationship, although the connections are still not fully understood. McKay told me that he thought they might never be.

*Photo courtesy of Neil Saunders

Symmetry underpins our world: from the laws of physics, to the evolution of biological organisms, through to our appreciation for architectural designs and artistic works. As a pure mathematician I'm interested in working with symmetry, looking into its abstract properties through to where and how it manifests.

One area of mathematics that devotes itself to the study of symmetry is Group Representation Theory. A group, call it G, can be thought of a set of symmetries that is closed under multiplication. One can study the structure of this group G using Group Theory but, just like in physics where we really see the properties of energy say when it's changing its form (for example from potential energy to kinetic energy), we really get to see the extra properties of the group when we allow it to act on some other object, usually some vector space V . We say that the group G is acting on the vector space V (which we assume to be defined over C). One fundamental question whenever we have an action of a group G on a space V is: **What are the vectors in V that G fixes?**

These are called the G-invariants. Amazingly, these vectors form a subspace of V which can be written as:

$$V^G = \{v \in V \mid g \cdot v = v, \forall g \in G\}.$$

This is called the *space of* ***G-invariants.*** And now to my favourite equation. Let us assume that G is finite. There is a map P from V to itself :

$$P : V \longrightarrow V$$

$$v \mapsto \frac{1}{|G|}\sum_{g \in G} g \cdot v$$

The map P is called the *projection onto the invariant subspace*. So my favourite equation is really a function:

$$P(v) = \frac{1}{|G|}\sum_{g \in G} g \cdot v$$

If anyone wants to learn more about Group Theory, Abstract Algebra or Group Representation Theory, you're always welcome to come and chat with me.

- Neil Saunders

Lights, Camera, Mathematics!

In the wake of the loss of one of history's greatest physicists, Stephen Hawking, we take a look back at the 2014 release "The Theory of Everything".

For my sixteenth birthday, I went to the cinema to watch "The Theory of Everything" – a biography of the early life and career of physicist Stephen Hawking, based on the memoir "Travelling to Infinity: My Life with Stephen" by his first wife, Jane. The film portrays Hawking's early life as a student at Cambridge University, his marriage to Jane, and the challenges they each faced as Hawking's health deteriorated after his diagnosis with motor neurone disease at the age of 21.

For those who do not know, Hawking is most notable for his ground-breaking work on black holes and the Big Bang Theory. Hawking realised that black holes were essentially the reverse of the Big Bang. He helped to establish the Big Bang Theory as the accepted theory of the origin of the universe! Hawking later went on to search for one single theory to unify general relativity and quantum mechanics. Right up until he died at the age of 76 on 13th May 2018, Hawking never ceased to work.

Eddie Redmayne and Felicity Jones do justice to the roles of Hawking and Jane. Do not take my opinion for it: Hawking himself told Redmayne "Well done Eddie, I'm very proud of you" and also went on to admit that he struggled to differentiate between real photos of his early life and those recreated by Redmayne during filming — high praise, indeed!

From a critical perspective, "The Theory of Everything" received a widely positive response from both film critics and the public. It won a multitude of Golden Globe awards, BAFTA nominations and other accolades, including the Oscar for Best Actor for Redmayne's portrayal.

Do not worry that the film is full of explanations of complicated scientific theorems and is inaccessible to the public – this is absolutely not the case. It is quite the opposite and it is for this reason that I think the success of the film is owed. The film gives a sensitive and intimate portrayal of the life of Hawking and Jane. It does not try to glamorise their story or edit their lives to suit the big screen. It is honest, humbling and real to see that Hawking and Jane were ordinary students - just like any of us. Hawking worked hard and maximised the potential of his extraordinary mind and simply continued to do so after his diagnosis. Hawking was not just intelligent, however. He was a strong character with a wicked sense of humour and he never lost this. The film encompasses all of these qualities, which is what makes it so watchable by both the scientific community and the public.

"Hawking and Jane were ordinary students –just like any of us"

Most people aim to achieve one or two great things in their life. Irrespective of his illness, Hawking achieved far greater than any of us can begin to imagine. The fact that he did so despite his illness only makes his incredible feats more amazing. The term "inspirational" is thrown around a lot with little significance, but I think Hawking really was inspirational. We can strive to learn from such an extraordinary person: aim high and refuse to quit – whatever challenges may be presented along the way!

"Life would be tragic if it weren't funny" ~ Stephen Hawking, 1942 - 2018

- Chloe Roebuck, Second Year

Studio: Universal Pictures International

Lights, Camera, Mathematics!

In September, MathSoc screened for its members the 2017 release, Hidden Figures. Based on a true story, the film is set slap-bang in the middle of the space race with the USSR and the USA in fierce competition to dominate the progression of spaceflight capability. The story follows a team of African-American female mathematicians, Dorothy Vaughn (Octavia Spencer), Mary Jackson (Janelle Monáe) and Katherine Johnson (Taraji P. Henson). They work for NASA and confront racism, sexism and some seriously tough mathematics to play their part in launching John Glenn into orbit. Hidden Figures was nominated for the Academy Award for Best Motion Picture as well as the BAFTA for Best Adapted Screenplay. It portrays the story of three incredibly intelligent and determined women who, despite being up against it all, refuse to back down.

We follow Mary Jackson, an assistant to the all-male team of engineers at NASA, who dreams of being an engineer herself. It is later explained that the schools that have the programs needed to qualify as an engineer do not allow African-American students. She's strong and unapologetically intelligent, at a memorable point in the film Jackson is told also that "the curriculum is not designed for teaching a woman", without a breath she plainly replies, "I imagine it's the same as teaching a man". The film also follows Dorothy Vaughn, who is, for all intents and purposes, the supervisor of the department of "human computers", though doesn't get paid the wage of one. Dorothy becomes the only person who can work the new IBM Machine, which was installed with the intention to replace the entire "human computer" department. Her success not only aggravates her male counterparts, that have been trying and failing to work the machine for weeks, but, as the only one able to operate it, secures the future employment of her team. Katherine Johnson, our main character, is assigned to help check the numbers in the department at the top of the chain. Her journey to secure credibility in this hostile and stressful environment is by no means smooth, not least portrayed by the repeated half a mile run we see her undertake to get to the only bathroom she is allowed to use on the site! It's a triumph when she is finally awarded common decency after gaining the attention and respect of the boss, Al Harrison (Kevin Costner), who takes a sledgehammer to the "White Only" sign on the nearest bathroom, shouting to all onlookers, "Here at NASA, we all pee the same colour." It's the succession of these small wins for our characters that make the film uplifting and empowering. It's a classic underdog tale and as an audience we are successfully placed right behind these women, willing them to succeed. Although classic, this film is still innovative. It's a story with three female African -American lead characters that are also skilled mathematicians – how often do you see that in everyday cinema?

This film won't educate you in the complexities of space orbit, you probably won't know any more about Euler's method after watching it, but this is not where I believe its significance lies. Its gravity is its ability to expose the idea that becoming a successful mathematician has anything to do with race, age or gender, as perhaps it has been displayed to us years previous. For me, watching Hidden Figures has unlocked an extra bit of self-belief and determination I wasn't aware of before. This could be down to the lively, upbeat soundtrack that features Pharrell Williams, it could be down to my immediate, uncontrollable love for Johnson's marvellous cat-eye glasses or it could just be because I'm a woman who has been told (sometimes subconsciously and sometimes purposefully) that science, technology, mathematics and engineering are a man's domain. Yet here I am, watching a woman solve equations longer than my arm and showing Kevin Costner who is boss. I am watching a woman succeed. This is why I think this film is so important and why, I for one, am so glad their story is no longer hidden. So, I would encourage you to show this film to your Granddad *and* you Grandma, your Uncle *and* your Aunts, your Sons *and* your Daughters because it's not only an Oscar-Nominated fun time - it's a piece of work that just might help change the world for the better.

-Robyn Goldsmith, Second Year

Studio: Twentieth Century Film Corporation

MathSoc Committee 2017/2018

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