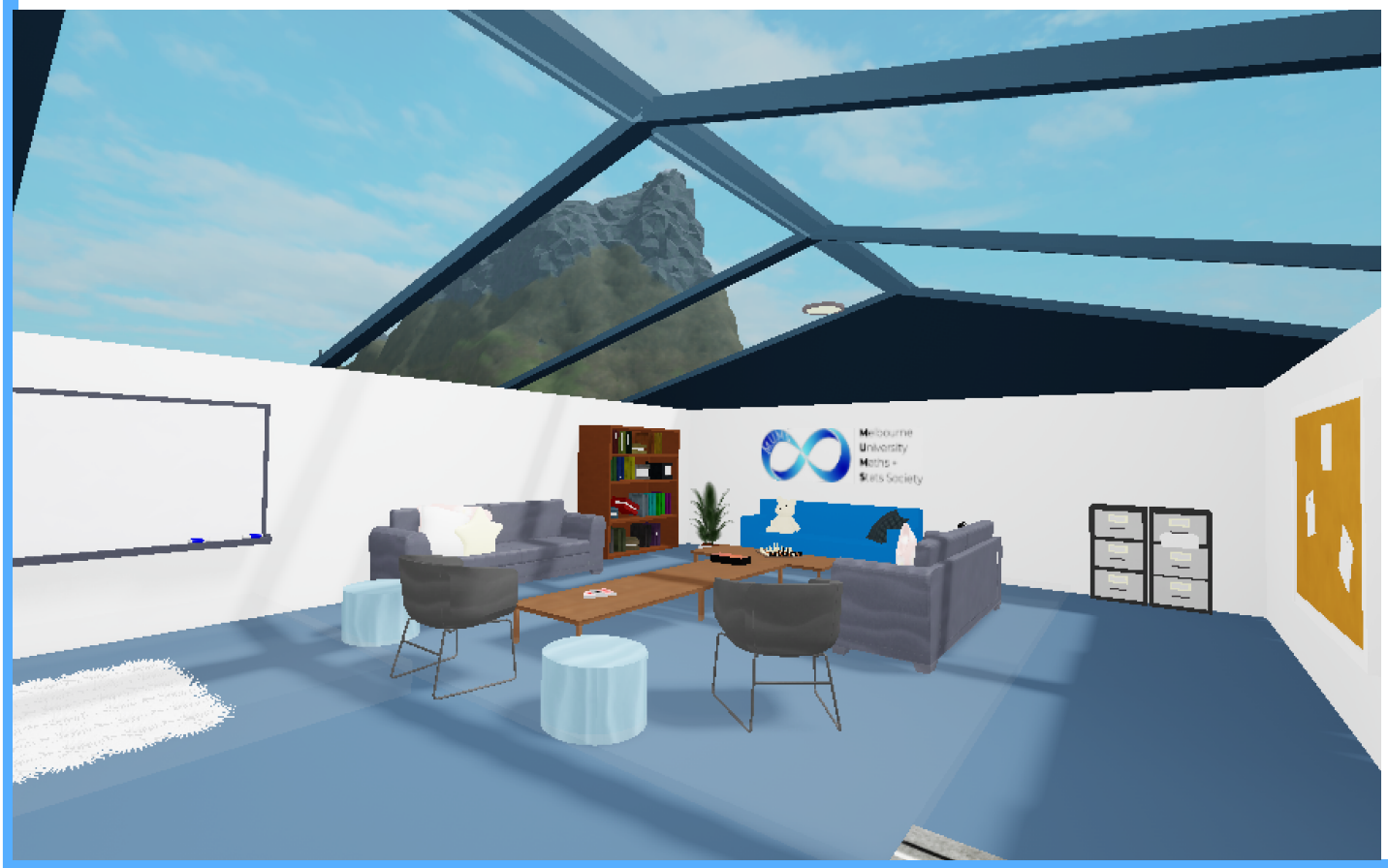
Paradox

ISSUE 1, 2021



THE MAGAZINE OF THE MELBOURNE UNIVERSITY MATHEMATICS AND STATISTICS SOCIETY

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PICTURED

- **Cover:** Our MUMS room recreated on Roblox by Yifan Guo
- **Contents page:** Frost crystals occurring naturally on cold glass form fractal patterns. Retrieved from <https://en.wikipedia.org/wiki/Fractal#/media/File:Frost_patterns_2.jpg>

Words from the President

Welcome to 2021 – what a “semi-prime” year to be alive!

To our new members, we are so excited to have you on board and can’t wait to get to know you. And to our returning members, welcome back!

Although it’s only been the start of the year, we already have tons of activities lined up for you. Here’re some things to look out for in Semester 1:

• In-person Welcome Back Picnic – MUMS is teaming up with Women in Science and Engineering (WISE) to help you kick start the year.
• A-math-zing Race – Complete challenges and meet other students on a virtual campus created by MUMS!
• Epsilon (First Year Representative) Election – Are you a first year student? Here’s your opportunity to be part of the MUMS committee.
• Wom*n in Maths Coffee and Catch ups – fortnightly meet up with other female and non-binary students in maths over a hot cuppa.
• Regular Seminars – Join us to explore interesting maths topics that you don’t usually get to see in lectures.
• LaTex workshop – A gentle introduction to LaTex in collaboration with Actuarial Student Society.
• Social events throughout the semester – Games Night, Trivia Night and so much more!

As we gradually transition into a COVID-normal semester, we are hoping to have more in-person events than the past year and see everyone’s lovely faces on campus again. We are also very aware that many students are unable to attend on campus at the moment. So we will continue to organise regular virtual and some dual-delivery events throughout the year.

One thing lockdown taught us is that distance is no longer a barrier. So this year, we are also planning more exciting events for you with other student maths societies from all around Australia and New Zealand!
More details will be released soon, so stay tuned with MUMS Newsletter and Facebook page!

As we welcome a new year, MUMS would also like to welcome Jane Street, IMC, SIG and Akuna Capital as our new sponsors for 2021. We’d also like to thank MAV and welcome back Optiver for their ongoing support for the School Maths Olympics and University Maths Olympics respectively. These organisations are leaders in their fields with an abundance of industry knowledge to share with our students. MUMS is looking forward to great partnerships with you all.

As always, MUMS welcomes everyone to join, regardless of whether you are studying 1 maths subject or 10! If you have any suggestions or questions, please don’t hesitate to contact us at mu-ms@unimelb.edu.au or message us on social media.

Have a fantastic 2021 everyone!

Yours Mathematically,
Yifan Guo

Words from the Editor

Hi there! I am extremely delighted to be your new Paradox Editor and bring you the first issue of our very own magazine for 2021. The Paradox has been a quintessential part of our club for a very long time and it is such a privilege to be able to continue this tradition.

I'd like to thank our committee and everyone who has contributed to this edition of the Paradox. We've had such a diverse range of submissions and I guarantee there will be something for everyone, whether you are still exploring the world of mathematics or have a math-related PHD and just looking for more mathematical content.

Need something to lighten the mood? We've got you covered with math jokes compiled by Eszter Benedek. Looking for something hands-on to do? Why not try one of the many different ways to make a Sierpinski Triangle in the article by Yifan Guo, Julie Zenou, and Bridget Gatt? Speaking of arts and crafts, don't forget to check out the amazing Golden Sunflower with beautiful mathematical patterns created by Imogen Temby.

Wanting to exercise your mind? Many of our committee members were eager to share their favourite puzzles which we've included in this issue of our Paradox.

Believe it or not, that's only a small sample of everything in this issue of the Paradox. There is still so much more for you to read and immerse yourself in. I hope that this edition brings you plenty of mathematical joy, inspiration, and ideas! If you have any feedback or ideas for the next issue of the Paradox, feel free to email me at mumsparadox.2021@gmail.com.

Yours mathematically,
Canis Nugroho, Paradox Editor

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The Sierpinski Triangle

BY YIFAN GUO, JULIE ZENOU AND BRIDGET GATT

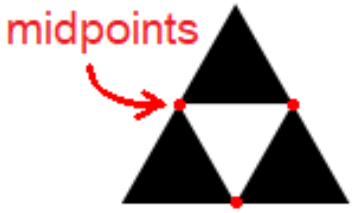
The Sierpinski Triangle, also known as the Sierpinski gasket or sieve, is a famous example of a fractal - a never-ending self-similar figure made up of smaller parts looking just like itself.

HOW TO CONSTRUCT THE SIERPINSKI TRIANGLE

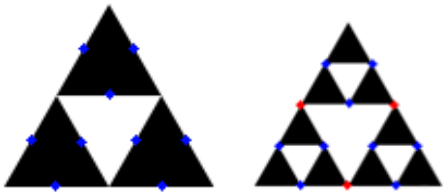
First let's examine how the Sierpinski triangle is constructed:

1. Start with an equilateral triangle

2. Divide it into four congruent triangles and remove the middle triangle, whose vertices are midpoints of the edges of the original triangle. Our new shape is made up of 3 sub triangles.

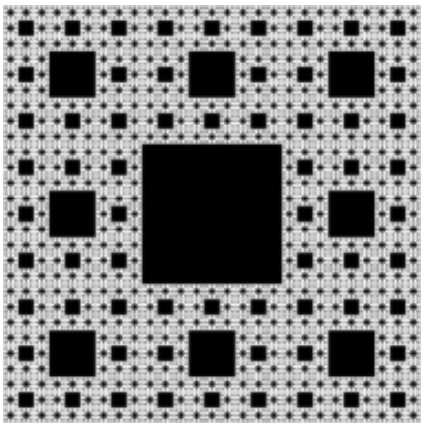


3. Now we repeat the same process with each of the three triangles that make up our new shape, dividing them each into four congruent subtriangles and deleting the middle triangles.



4. Repeat infinitely and you have the Sierpinski triangle!

Doesn't that look nice? Let's have a look at a few more fractals together!



FRACTALS

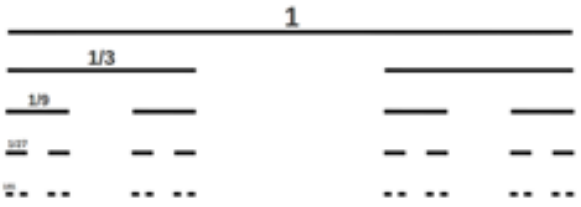
A similar fractal is the Sierpinski Carpet.

It is constructed by dividing a square into a 3x3 grid and removing the middle square. The remaining 8 squares are then also divided into a 3x3 grid. The middle square of each of these grids is also removed. The process repeats infinitely.

(Picture via Wikipedia)

Cantor Set

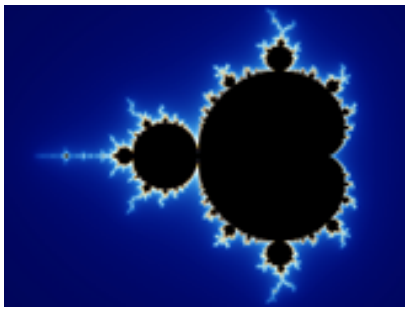
The Cantor set is constructed through iteration and removing a part of the shape (in this case the line segment). It is created by taking a line segment and deleting the open middle third. We then do the same thing to first and last third and repeat infinitely to get the Cantor set.



(Picture via Quora)

Other famous fractals are the Mandelbrot set and the Julia set.

The Mandelbrot set

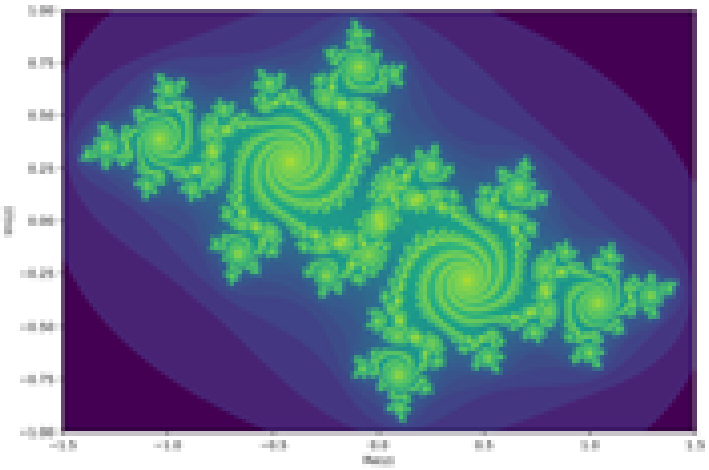


(Picture via Wikipedia)

"The set of complex numbers c where f(z) = z^2 + c does not diverge when iterated from z = 0 i.e. the sequence f(0), f(f(0)), etc. remains bounded in absolute value" - Wikipedia

The Julia set

(Picture via Wikipedia)



NOW LET'S PAY A CLOSER LOOK AT THE SIERPINSKI TRIANGLE AGAIN...

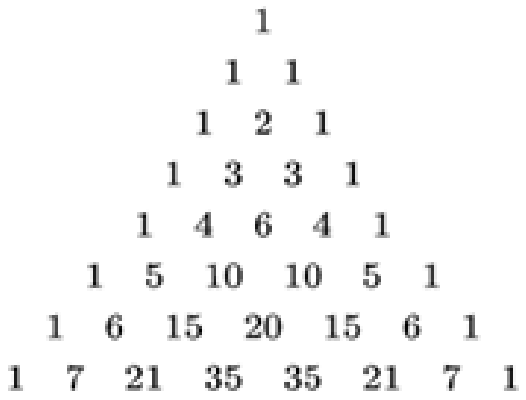
FUN FACTS

For an object with quite a simple construction, the Sierpinski Triangle is full of surprises! Its perimeter goes to infinity but it has zero area, since in each iteration, the perimeter increases by a factor of 3/2 but the area decreases by a factor of 3/4

$$As\ n \to \infty,\ P_n = P_0 \times \left(\frac{3}{2}\right)^n \to \infty\ and\ A_n = A_0 \times \left(\frac{3}{4}\right)^n \to 0$$

We start off with a triangle but end up with no area? Would that make the Sierpinski Triangle 1-dimensional like a line or 2-dimensional like a triangle?

Neither! We know that when doubling the side of an object, a 1D line gets twice the length, a 2D square gets 4 times the area, a 3D cube gets 8 times the volume… But when we double the side of the Sierpinski Triangle, we get 3 copies of the original – making it an object with Hausdorff dimension $log_2(3) \approx 1.58$!



(Picture via Wikipedia)

When talking about famous triangles in mathematics, another one that comes to the top of your mind is probably Pascal's Triangle. Besides both being triangles, these two seem pretty disconnected … right?

Let's make a Pascal's Triangle.

Now, highlight all the odd numbers. What do you see? As we add more and more rows, the Sierpinski Triangle starts to appear! Can you see why?

MAKE YOUR OWN!

Since we had so much fun with the Sierpinski Triangle, why don't we go to a higher dimension? Let's build the Sierpinski Pyramid together! (Feel free to use the template provided in the appendix.)

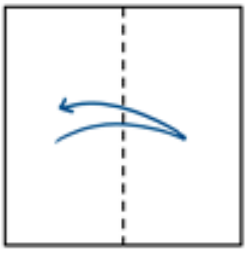
The first step is to make a single tetrahedron.

ORIGAMI TETRAHEDRON

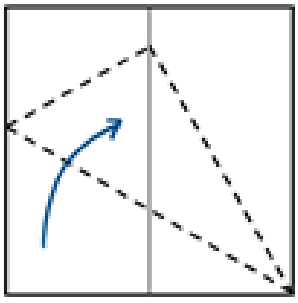
1. Prepare 2 pieces of square paper. (For square paper of side length x, your tetrahedron will have side length $\frac{x}{\sqrt{3}}$.)

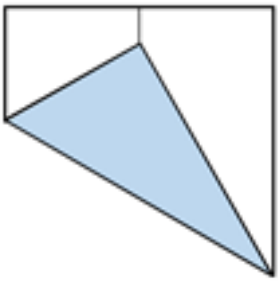
Phase 1: Creating Creases

2. Fold the paper in half then unfold so that we have a crease in the middle.

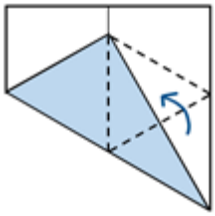


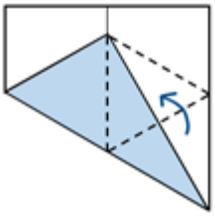
3. Fold the bottom-left corner up so that it now lies on the central line.



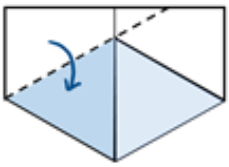


4. Similarly, fold the bottom-right corner up so that it now lies on the central line.

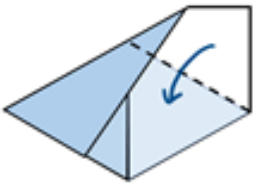


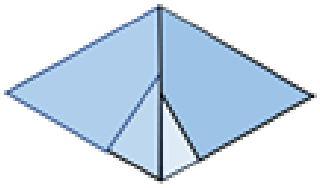


5. Fold the top-left corner down along the marked edge.

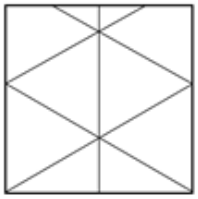


6. Similarly, fold the top-right corner down along the marked edge.





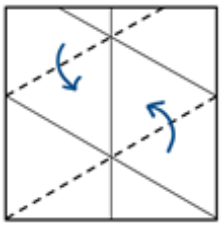
7. Unfold everything. Now you will see the following creases on your paper.

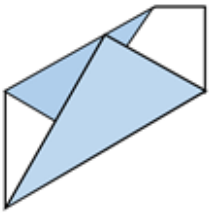


8. Repeat phase 1 for another piece of paper.

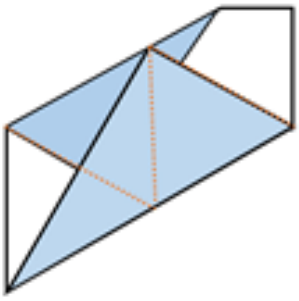
Phase 2: Creating units

9. Fold top-left corner down and bottom-right corner up as shown below.

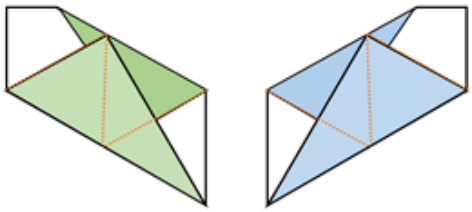




10. Sharpen the following 3 creases marked in orange.

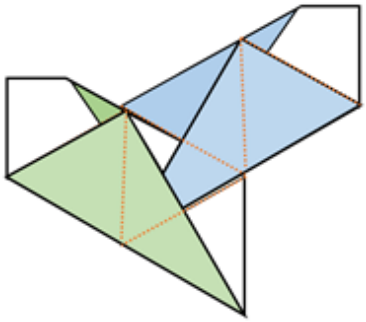


11. Repeat phase 2 for the other piece of paper, but doing the mirror image steps. (ie. This time we want to fold the top-right corner down and the bottom- left corner up.) Now we have two units that are mirror images of each other.

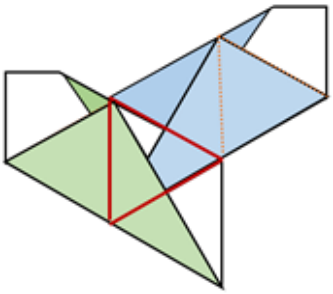


Phase 3: Putting units together

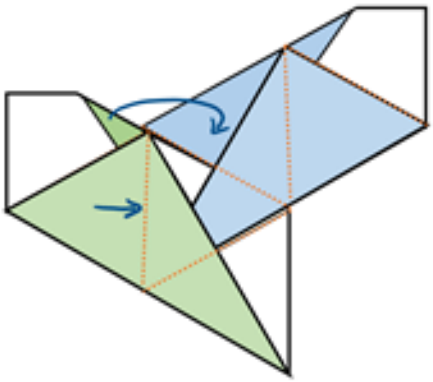
12. Tuck the bottom corner of the blue piece inside the green piece as follows:

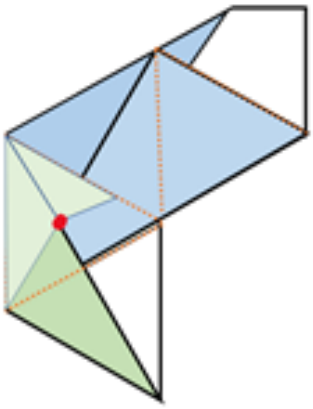


The red triangle below will become the base of your tetrahedron.

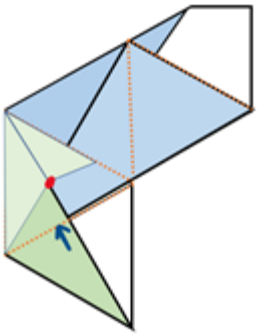


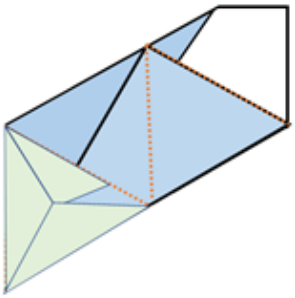
13. Bring the left green side up and tuck the partial side behind the blue piece. The red point depicts the apex of the tetrahedral out of the page.



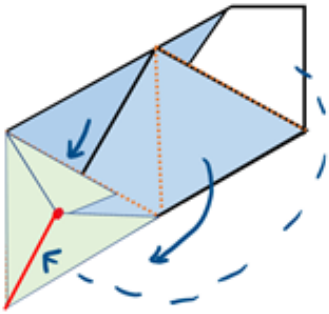


14. Bring the right green piece up to join the apex.

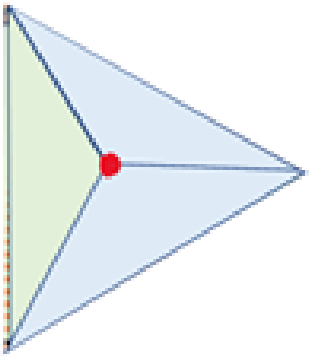




15. Lastly, bring the remaining blue side up, wrap around the green sides and tuck the partial side inside the gap marked by the red line.

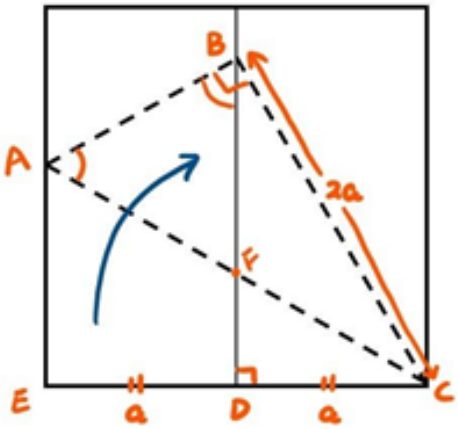


VOILA! HERE'S YOUR VERY OWN TETRAHEDRON!



But how do we know that the above steps will definitely produce a regular tetrahedron?

SHOW ME THE PROOF!



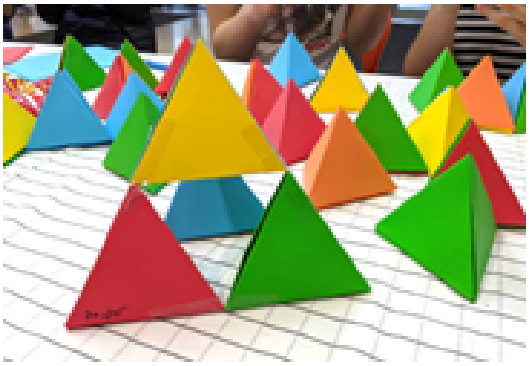
The key is this step!

When we fold the bottom-left corner up so that it lies on the middle line, the triangle ABF created will eventually be one of the sides of our tetrahedron. So now we just need to show that triangle ABF is indeed equilateral!

Let's look at the right-angled triangle BCD. BC = EC because of the reflection about AC, which also equals to twice of DC. Therefore, triangle BCD is a triangle with interior angles of 30, 60 and 90 degrees. It then follows that triangle ABF is indeed equilateral.

BUILD YOUR PYRAMID

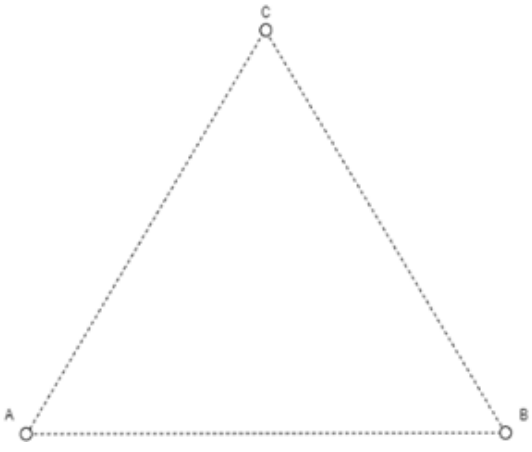
Now we just need to make lots of tetrahedrons. Whenever you have four, stick them together into a pyramid. Once you have four groups of four, combine to make an even bigger pyramid…



Until you get something like this!

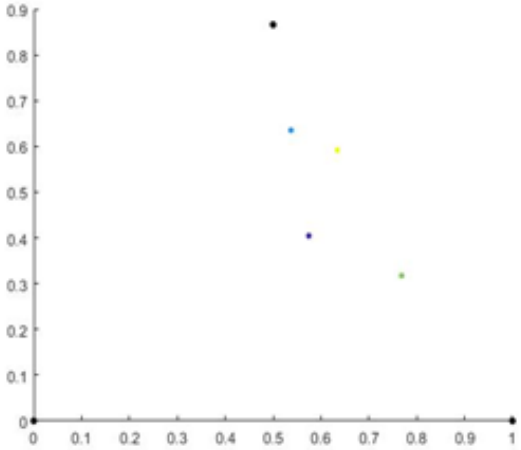
… or keep going :)
This is definitely not the only way to build the Sierpinski Triangle...

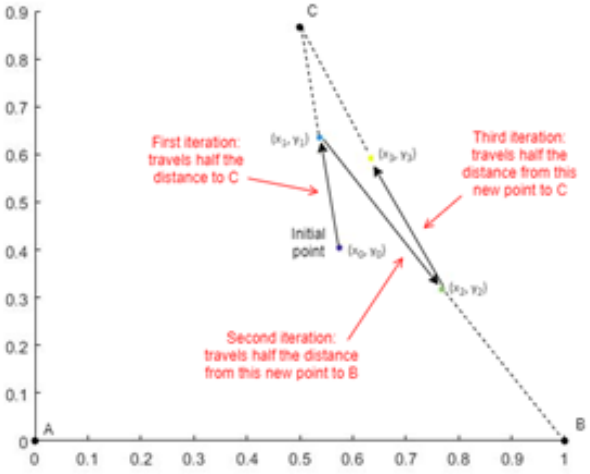
CONSTRUCTING THE SIERPINSKI TRIANGLE WITH A CHAOS GAME



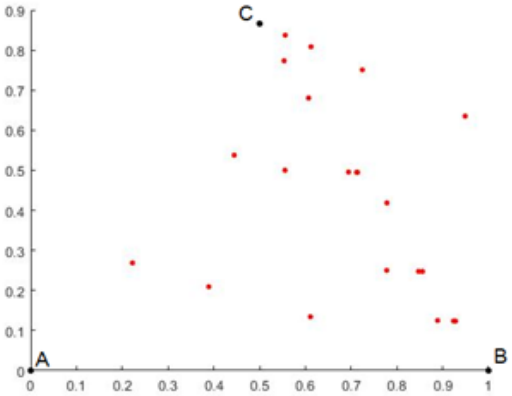
Start with an equilateral triangle and its three vertices, A, B and C.
The game works as follows:
1. Generate a random point in the plane and call it (x_0, y_0)
2. Flip a "three sided coin", with each side representing A, B or C. By this we mean let X be a random variable with 3 outcomes, A, B and C. $Pr(X = A) = Pr(X = B) = Pr(X = C) = \frac{1}{3}$.
3. Our new point (x_1, y_1) will be the point halfway between (x_0, y_0) and the vertex chosen by the coin flip.
4. Repeat..

Here is what we get after three iterations:

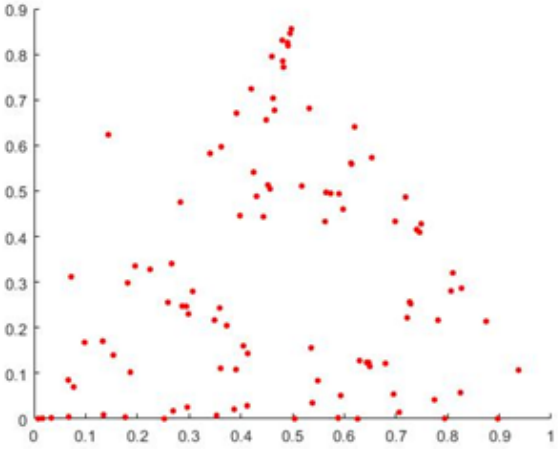




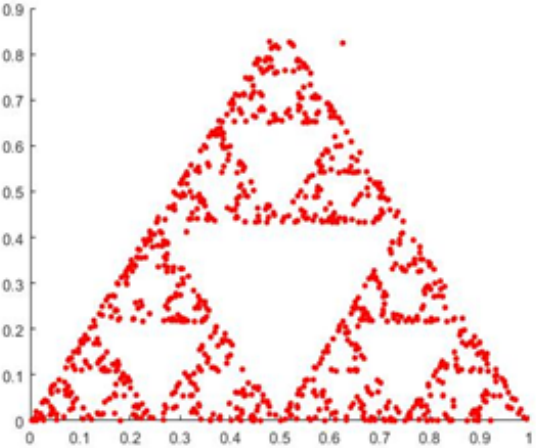
20 iterations:



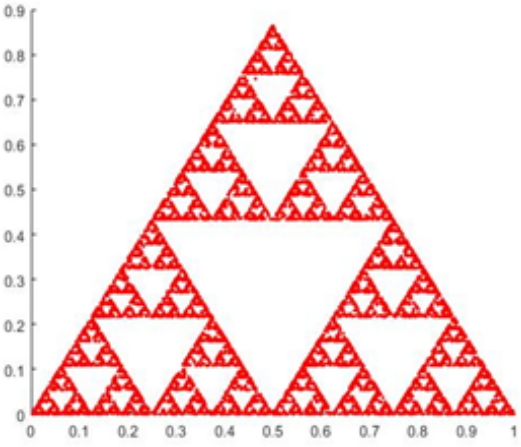
100 iterations:



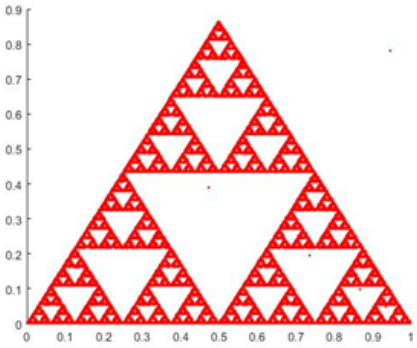
1000 iterations:



10,000 iterations:



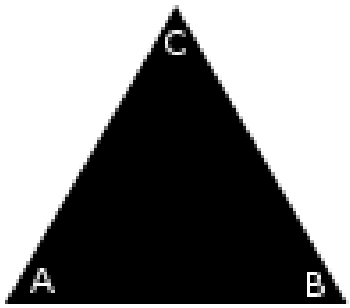
1,000,000 iterations:



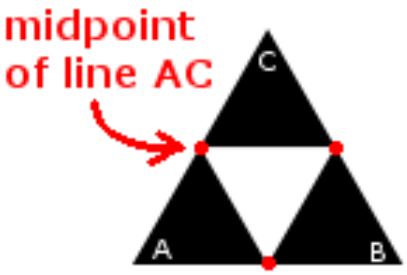
As the number of iterations increases, the points resemble the Sierpinski triangle! But why does this work?

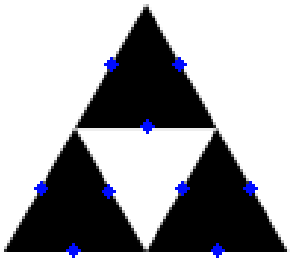
Recall how the Sierpinski triangle is constructed:

Let's call our initial equilateral triangle T_0.

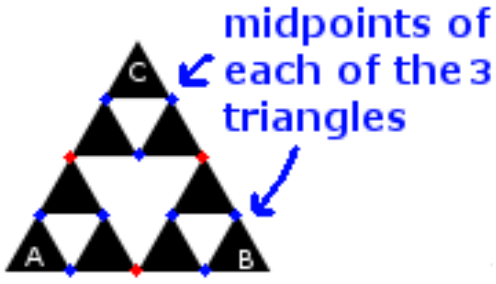


And let's call the shape we get in our next iteration T_1.



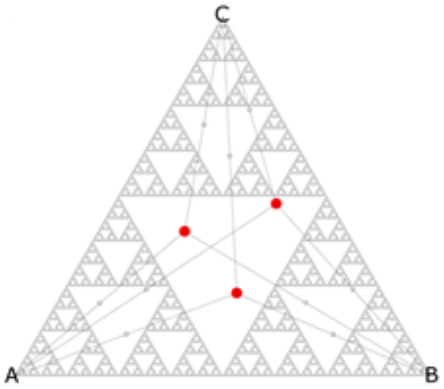


T_2 can be the shape we get after deleting the middle triangle of each of the three subtriangles in T_1.

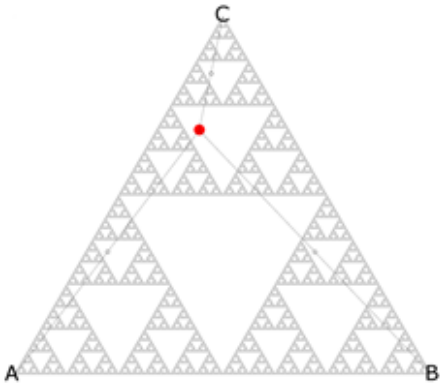


If your initial point (x_0, y_0) is anywhere in the middle triangle that was deleted as we went from T_0 to T_1, then after one iteration it will be moved to one of the smaller triangles deleted as we went from T_1 to T_2.

This can clearly be seen in the following diagram:



And then a point in one of the smaller triangles will be moved to one "the next size down" and so on



Points in the deleted triangles are always moved to smaller triangles, so if your point is in the middle gap, in all future iterations it will never return to that gap.

Through this principle we get the Sierpinski triangle shape as we increase our iterations. The points aren't actually on the perimeter of the triangle, but instead, since the size of the triangle that the points are in decreases with each iteration, most points are inside extremely small triangles.

You can run this simulation yourself in MATLAB with the following code!

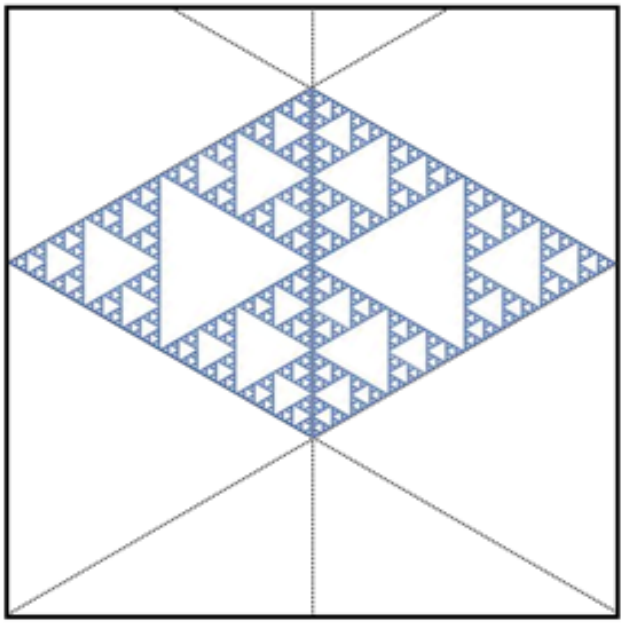
```
function sierpinski_construction(nreps)

% Constructs the Sierpinski Triangle with a chaos game.
% Bridget Gatt, 2021.
%
% Input:     nreps is the number of points we
%            will generate in the game

% The triangle is defined by 3 points, A, B and C.
A = [0 0];
B = [1 0];
C = [1/2 sqrt(3)/2];

% if nreps isn't given by the user, set it to 100000
if (nargin < 1)
    nreps = 100000;
end

vals = zeros(2, nreps+1);

% We will start with a random initial point in the unit square
vals(1,1) = rand;
vals(2,1) = rand;

for n=1:nreps
    % flip a three sided coin to decide
    % whether to move towards A, B or C

    flip = randi(3);

    if flip == 1
        % move towards A
        corner = A;

    elseif flip == 2
        % move towards B
        corner = B;

    elseif flip == 3
        % move towards C
        corner = C;
    end

    % we will now find our next point p, which is halfway between
    % our previous point and the corner we chose during the flip
    p = halfway(vals(:,n).',corner);
    vals(:,n+1) = p.';
end

plot(vals(1,:),vals(2,:),'k.')

    function p = halfway(p1,p2)
        % finds point p which is halfway between p1 and p2
        p = (p1 + p2)/2;
    end

end
```

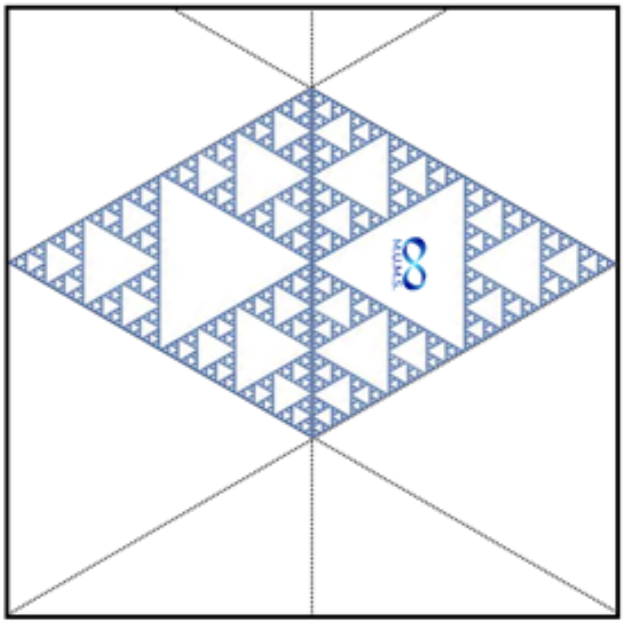
NICE! BUT WHY SHOULD WE CARE?

Fractals like the Sierpinski Triangle are not only pretty, but come in handy in the real world too!

- **Art:** The Sierpinski Triangle appears in the nave of the Roman Basilica of Santa Maria in Cosmedin built in the seventh century.
- **Computer science:** Fractals are used in image compression.
- **Fluid mechanics:** Some flows could be represented by fractals.
- **Films:** Fractals are used to create intricate visual effects in movies such as Guardians of the Galaxy Vol. 2.

APPENDIX





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A Golden Sunflower

A Friendly Introduction to the Beauty of the Fibonacci Sequence

The piece above and the following article were created by IMOGEN TEMBY

THE FIBONACCI SEQUENCE

Many know the nickname of mathematician Leonardo De Pisa, Fibonacci, in reference to the famous Fibonacci Sequence (despite there being evidence that the sequence arose prior to Leonardo's investigation). The Fibonacci Sequence can formally be written as:

$$\forall n \in \mathbb{N}\, F_n = F_{n-1} + F_{n-2}\ where\ F_0 = 0, F_1 = 1$$

This yields the following sequence of 'Fibonacci numbers':

0,1,1,2,3,5,8,13,21,34,55,89…

Albeit simple, this sequence is regarded as one of the most beautiful. It arises surprisingly often in mathematics and has frequently significant appearances throughout design in the natural world.

THE GOLDEN RATIO

The Golden Ratio (denoted φ) is equivalent to:

$$\varphi = \frac{1+\sqrt{5}}{2} \approx 1.6180339887\ldots$$

Coincidentally, φ can be approximated by selecting any two consecutive numbers in the Fibonacci sequence and taking their ratio. The larger the two selected numbers, the more accurate the approximation. Mathematically:

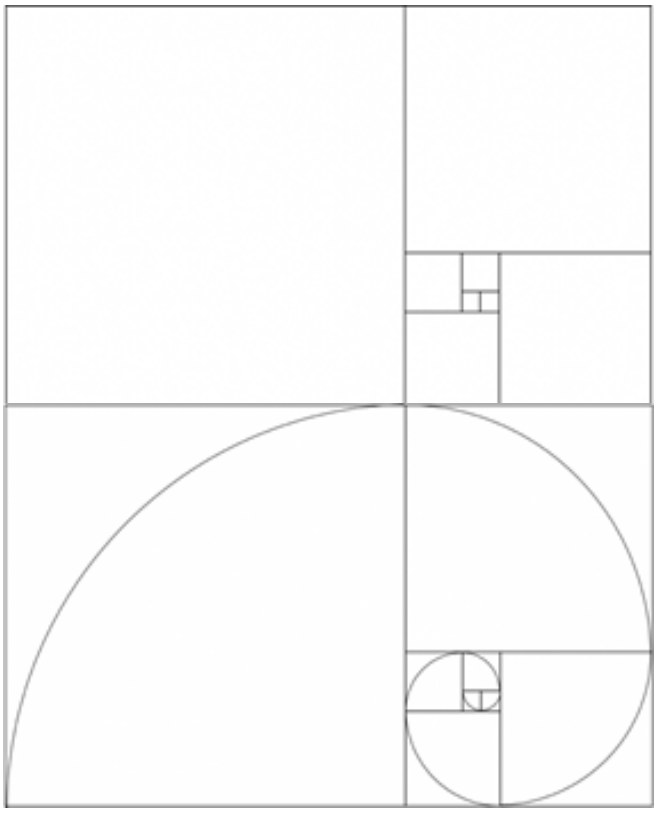
$$\forall n \in \mathbb{N} \lim_{n\to\infty} \frac{F_n}{F_{n-1}} = \varphi = \frac{1+\sqrt{5}}{2} \approx 1.6180339887\ldots$$
$$where\ F_n = F_{n-1} + F_{n-2}, F_0 = 0\ and\ F_1 = 1$$

Interestingly, this is the case regardless of what F_0 and F_1 equal. So now we have:

$$\forall x, y, n \in \mathbb{N} \lim_{n\to\infty} \frac{F_n}{F_{n-1}} = \varphi = \frac{1+\sqrt{5}}{2} \approx 1.6180339887\ldots where\ F_0 = x, F_1 = y$$

ARCHIMEDEAN SPIRAL

For those of us that prefer to think visually, a geometric representation of the Fibonacci sequence (where $F_0 = F_1 = 1$) could look like this.



Where the side lengths of the squares starting from the centre square and rotating outwards anticlockwise give numbers of a Fibonacci sequence.

If we were to draw a spiral through these squares passing the corners it would look as such.

This spiral is so significant it's named the Archimedean spiral. It beautifully pops up time and time again in nature, from sand dollars to snail shells to sunflowers. The closer you look, the more often you may notice this appear in not only nature but art and pop culture too. These reoccurrences have prompted some psychological research studies to find evidence suggesting that the Archimedean Spiral and Golden Ratio are integral to how humans perceive and appreciate beauty.

A GOLDEN SUNFLOWER

In the case of a Sunflower, it will either have 34, 55 or 89 petals (note that these are all Fibonacci numbers). In the simplest case of 34 petals, the centre of the sunflower will exhibit 55 Archimedean spirals in one direction overlapped with 34 in the opposite direction. This stunning pattern is what determines the petal formation.

Hence, the accompanying painting has been titled “A Golden Sunflower”. It’s an A1 waterolour painting that doubles as an as an ode to the simple yet breathtaking beauty of the Fibonacci sequence, Archimedean spiral, symmetry and golden ratio appearances in nature. It’s been painted in a way that intends to emphasize the mathematical patterns of sunflower petal formation. It was done with a pencil, watercolour paints, fineliner, ruler, protractor, compass and a little bit of help from google images for inspiration. It has the same number of petals and Archimedean spirals as a real sunflower.

FURTHER READING

Some starting places for recommended further reading on the Fibonacci Sequence:

- Woo’s Wonderful World of Maths by Eddie Woo: This is written in a way to be understood by not just mathematics lovers but also the average person (and even those that are not too fond of mathematics) too.
- The Beauty of Numbers in Nature by Ian Stewart: a step up from the above in difficulty but this too is a pop-science book and has been written in a way that is intended to be easy to understand.
- Fibonacci Quarterly is a mathematics journal that’s been published quarterly since 1963. It can be found online at https://www.fq.math.ca/. This is another step up and is recommended as more advanced university-level reading.

Women in Maths through the Ages

BY JULIE ZENOU

HYPATIA OF ALEXANDRIA, 355 CE - 415 CE

Hypatia, a leading mathematician, astronomer and philosopher of her time, is also the first known female mathematician. She continued her father's program (Theon of Alexandria), which aimed to preserve the Greek mathematical and astronomical heritage. She was a popular lecturer and teacher as well as being credited on works such as Apollonius of Perga's Conics (geometry) and Diophantus of Alexandria's Arithmetic (number theory). It is believed that Theon's work that established the Earth-centric model for the universe, was actually written by Hypatia. Hypatia was an open pagan during a time of religious divide as well as an established philosopher of Neoplatonism, a belief system in which everything emanates from the One.

Hypatia's life ended violently when a mob of Christian zealots beat her to death, partly due to her religious differences. She became a feminist symbol and a martyr for pagans and atheists alike and her death was seen as the end of the classical world. She's been referenced in Voltaire's work and her life was depicted in the 2009 feature film Agore, played by Rachel Weisz.

ADA LOVELACE, 1815 - 1852

Today Ada Lovelace is known as the first computer programmer. At 17, she met Charles Babbage, a widower in his forties, who introduced her to his current project, the "Difference Machine" which used numbered wheels to make calculations simply by turning a handle. This sparked an almost 20 year correspondence between the two and would lead Lovelace to creating the first computer program.

When Babbage started working on his next project called the "Analytical Engine", mathematician Luigi Federico Menabrea wrote a paper on it in 1842. Just a year later, Ada Lovelace translated and added her own notes, ending up tripling the length of the original paper and it is now seen as her greatest contribution to computer science. Her annotations included how the proposed machine could be programmed to compute Bernoulli numbers and explained that the machine "weaves algebraic patterns, just as the Jacquard-loom weaves flowers and leaves.". In essence, the "Analytical Engine" was a prototype of a digital computer, and Ada Lovelace had written a program for it.

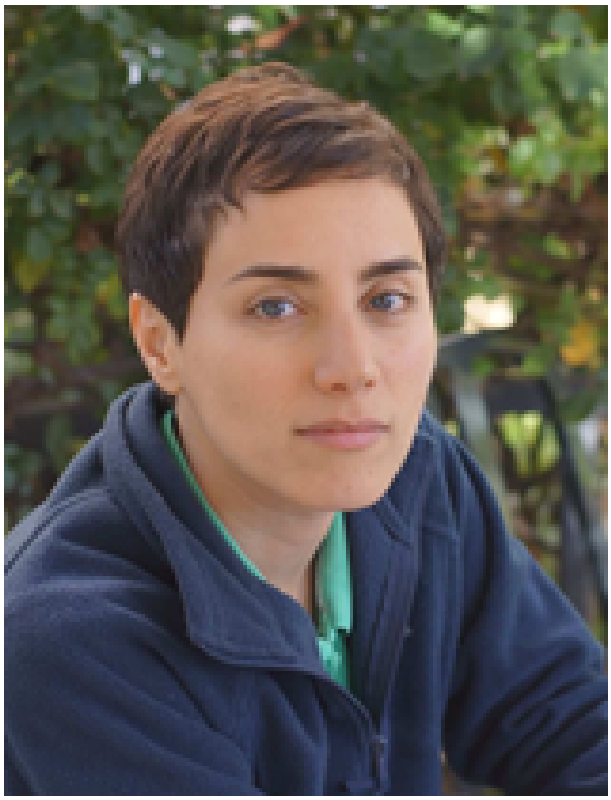
Today, Ada Lovelace has her own day and is celebrated every year on the second tuesday of october, a day founded in 2009 to recognise the achievements of Women in STEM across the world.

KATHERINE JOHNSON, 1918 – 2020

Katherine Johnson made crucial calculations of orbital mechanics for NASA which were critical to the success of the first and subsequent U.S. crewed spaceflights. Now made mainstream famous by the movie Hidden Figures, played by Taranji P. Henson, Johnson was one of the first African-American women to work as a NASA scientist. Johnson loved Mathematics from a young age and graduated from the all-black West Virginia State college at 18 with degrees in mathematics and french. In 1939 she was hand picked along with two other African-American men to integrate into West Virginia State College, but decided not to continue her studies in order to start a family. When she was 34, Johnson started working for NASA, originally in the all-black section as a "computer". She was soon promoted and joined meetings that were originally "men only". She became a part of the team and her crucial work allowed the US to send astronauts to the moon and back. Her most notorious work was for the orbital mission of John Glenn.

Glenn famously demanded to "get the girl" to double check by hand the computer generated numbers for the orbit. "If she says they're good, I'm ready to go". The mission ended up being both a success and a turning point in the space competition between the US and the Soviet Union. In 2015 she was awarded the Presidential Medal of Freedom by President Barack Obama. Katherine Johnson died on the 24th of February 2020 at 101 years old.

MARYAM MIRZAKHANI, 1977 - 2017



Maryam Mirzakhani is famous for being both the first woman and iranian to win a Fields medal, which is considered to be the equivalent of a nobel prize in mathematics. She won the award for her work with the dynamics and geometry of riemann surfaces and their moduli spaces. While Mirzakhani is one of the prominent mathematicians of our time, she started out dreaming of becoming a writer as a child. But while she had a passion for books, it was obvious she was keen on numbers. In 1994, Iran allowed women to join their delegation for the International Maths Olympiad for the first time in history, and among those students was Mirzakhani. She received a gold medal two years in a row, including a perfect score. No iranian had achieved this before. After finishing a bachelor of mathematics at the Sharif University of Technology in Tehrān, she continued with a PHD at Harvard University. After completing her PHD, she worked as a research fellow and assistant maths professor at Princeton University, and then became a professor at Stanford University, California in 2008. Only six years later, in 2014, she won the Fields medal. In 2017, Maryam Mirzakhani passed away from breast cancer at age 40 years. In honour of her memory, the 2020 documentary "Secrets of the Surface", directed by George Csicsery, follows her life and recognises the amazing achievements she made.

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Maths Jokes

COLLECTED BY ESZTER BENEDEK

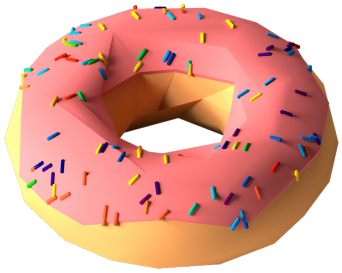
A mathematician has been invited to speak at a conference. His talk is announced as

> Proof of the Rienmann Hypothesis

When the conference actually takes place, he speaks about something completely different.
After his talk, a colleague asks him: "Did you find an error in your proof?"
He replies: "No - I never had one."
"But why did you make this announcement?"
"That's my standard precaution - in case I die on my way to the conference..."

Psychologists subject an engineer, a physicist, and a mathematician - a topologist, by the way - to an experiment: Each of them is locked in a room for a day - hungry, with a can of food, but without an opener; all they have is pencil and paper.
At the end of the day, the psychologists open the engineer's room first. Pencil and paper are unused, but the walls of the room are covered with dents. The engineer is sitting on the floor and eating from the open can: He threw it against the walls until it cracked open.
The physicist is next. The paper is covered with formulas, there is one dent in the wall, and the physicist is eating, too: He calculated how exactly to throw the can against the wall, so that it would crack open.
When the psychologists open the mathematician's room, the paper is also full of formulas, the can is still closed, and the mathematician has disappeared. But there are strange noises coming from inside the can...
Someone gets an opener and opens the can. The mathematician crawls out. "Damn! I got a sign wrong..."

Q: What is a topologist?
A: A person who cannot tell a doughnut from a coffee mug.



"What happened to your girlfriend, that really cute math student?"
"She no longer is my girlfriend. I caught her cheating on me."
"I don't believe that she cheated on you!"
"Well, a couple of nights ago I called her on the phone, and she told me that she was in bed wrestling with three unknows.

Let epsilon be less than zero...

"My life is all arithmetic", the young businesswoman explains. "I try to add to my income, subtract from my weight, divide my time, and avoid multiplying..."

At a conference, a mathematician proves a theorem.
Someone in the audience interrupts him: "That proof must be wrong - I have a counterexample to your theorem."
The speaker replies: "I don't care - I have another proof for it."

"The number you have dialed is imaginary. Please, rotate your phone by 90 degrees and try again..."

Q: Do you already know the latest stats joke?
A: Probably...

Q: How does one insult a mathematician?
A: You say: "Your brain is smaller than any (epsilon)>0!"

What is a rigorous definition of rigor?

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https://www.math.utah.edu/~cherk/mathjokes.html - collected by Andrej and Elena Cherkaev

7 maths references that you might have missed!

From your favourite movies, books and more!

BY GYPSY AKHYAR AND YIFAN GUO

THE QUEEN'S GAMBIT AND REPRESENTATION THEORY

In the first episode of the miniseries 'The Queen's Gambit', we saw young Beth picking up a book from a bonfire – her mother's PhD thesis on Representation Theory. Without going into any spoilers for the show, let us have a closer look at this interesting area of mathematics.

Since our first year in undergrad, we are introduced to linear transformations and matrices. On the other hand, algebraic structures, such as groups, are more challenging concepts to grasp. In Representation Theory, we try to better understand these algebraic structures by representing their elements as linear transformations of vector spaces.

If you are interested in learning more about representation theory, you can take the masters level subject MAST90017 Representation Theory and/or come along to the student seminar organized by Dr Ting Xue and Dr Gufang Zhao in 2021. (Check out the representation theory group website for more details: https://representationtheory.science.unimelb.edu.au/#tab430)

FUTURAMA AND THE TAXICAB NUMBERS

Flick on the TV when the animated sci-fi series Futurama is on and it's hard to miss the alcoholic, chain-smoking, kleptomaniac, and the all-round unholy robot that is Bender. Who would have thought that the writers of Futurama would have hidden such a niche reference to pay homage to two of the greatest mathematicians of the 20th century through this unruly bending unit?

This easter egg is hidden in Bender's unit number: 1729. I am sure a bunch of you will already know the story of the Indian mathematician Ramanujan (one of the people you can thank for the wildly controversial $1+2+3+\cdots=-1/12$) and how he made his mark on the mathematical world through the letters he wrote to the brilliant then-Cambridge mathematician G.H. Hardy. However, I would imagine that less of you know about this small story – what had happened once when Hardy visited Ramanujan near the end of his life at the hospital. Here is an account from Hardy:

'I remember once going to see him when he was ill at Putney. I had ridden in taxi cab number 1729 and remarked that the number seemed to me rather a dull one, and that I hoped it was not an unfavourable omen. "No," he replied, "it is a very interesting number; it is the smallest number expressible as the sum of two cubes in two different ways.'

The remarkable property Ramanujan revealed about 1729 has now been generalised to create a group of numbers called the taxicab numbers. The nth taxicab number, Ta(n), is defined as the smallest integer that can be expressed as a sum of two positive integer cubes in n distinct ways. Here are the first three:

$$Ta(1) = 2 = 1^3 + 1^3$$

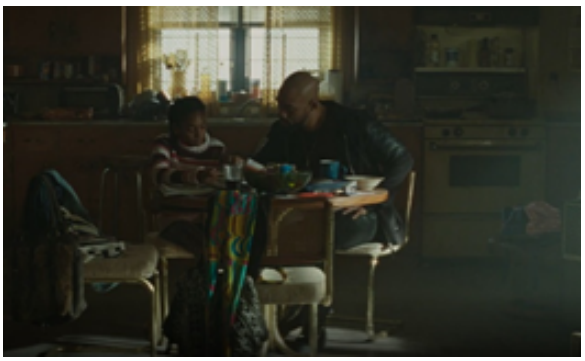
$$Ta(2) = 1729 = 1^3 + 12^3 = 9^3 + 10^3$$

$$Ta(3) = 87539319 = 167^3 + 436^3 = 228^3 + 423^3 = 255^3 + 414^3$$

How neat! So, if you are interested in Ramanujan and Hardy, sign up for MAST20026: Real Analysis -they both made many remarkable contributions to the field!

SUICIDE SQUAD AND HOW A SNIPER TEACHES GEOMETRY

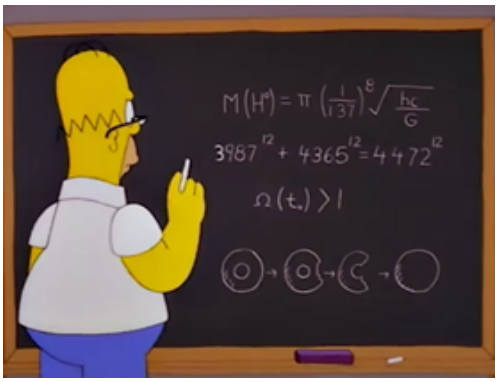
In the 2016 film Suicide Squad, 'Deadshot', played by Will Smith, helps his daughter with her maths homework. While not a deep or hidden reference, it is quite hilarious hearing the applications of finding the hypotenuse to being a sniper and killing targets. Here is a quote Deadshot's daughter:



'So, if you're up here, like in a building, and you shoot a man down here in the streets, that's how far the bullet actually goes?'

THE SIMPSONS AND FERMAT'S LAST THEOREM

In S10E2 of The Simpsons, 'The Wizard of Evergreen Terrace', Homer Simpson was hit with the realization that he had not yet accomplished anything in his life! With a new-found aspiration to be an inventor in his heart, Homer was seen writing down the following on a blackboard:



The first equation almost predicted the mass of Higgs boson 14 years before the particle was discovered (remarkable!), but the second line is even more interesting.

To understand why, let's first backtrack a little bit to the 17th century. In around 1637, French lawyer and mathematician Pierre de Fermat proposed the following theorem:

> *No three positive integers a, b, and c satisfy the equation $a^n + b^n = c^n$ for any integer value n greater than 2.*

He then wrote the (in)famous commentary in the margin:

'I have discovered a truly marvelous proof of this, which this margin is too narrow to contain.'

This theorem was later known by us as Fermat's Last Theorem. And the proof that couldn't be contained in the margin - no one was able to prove or disprove it for over 300 years! It was not until 1994 when Sir Andrew Wiles became the first person to successfully prove the theorem since Fermat.

Back to Homer. Put Homer's second equation into your calculator. Both sides of the equation seem to give us the same result: $6.397665635 \times 10^{43}$.

Wait, did we just disprove Fermat's Last Theorem?

It turns out that this is simply a rounding error in the calculator. Speculating more decimal digits would lead us to discover that the two numbers are not quite equal after all.

Although Fermat's Last Theorem was not disproven by a joke in 'The Simpsons' (unsurprisingly), it is very interesting that this equation was found by a specialized computer program written by the show's writer David X. Cohen, who has a master's degree in computer science! So, my fellow nerd friends – if our science degrees don't work out there is still hope for those of us with a secret writer's heart!

AVENGERS ENDGAME AND EIGENVALUES

Before finishing up his work for the night, Tony Stark tried one last idea, 'This time in the shape of a Mobius Strip, inverted please. Give me that eigenvalue, that particle factoring, and spectral decomp.' After a few seconds of futuristic CGI visual and melancholy soundtrack, the result for this time travel calculation was complete – model successful!

When this movie came out in 2019, we happened to be learning about eigenvalues and spectral decomposition in the first-year linear algebra course. You can imagine how exciting it was for a budding maths student to see one of the greatest superheroes of all time using a concept we had just learnt in lecture to figure out time travel! Of course, we know these terminologies were probably added to the movie for effects only, but that still didn't stop me (and you too right!) from doing an internal scream out of excitement when seeing it in the movie!

For our commencing students who are interested to learn more about eigenvalues, spectral decomposition and many more related topics, go to your MAST10007/MAST10022/MAST10008 first year linear algebra subjects! Besides the fictional application in time travel, eigenvalues are used everywhere in real life too, such as:

- **Building stable bridges:** Eigenvalues are linked to the natural frequency of a bridge.
- **Data Science:** Eigenvalues and eigenvectors identify the principal components of data for dimension reduction.
- **Quantum Computing:** Eigenvalues are needed to calculate the entanglement entropy between qubits.

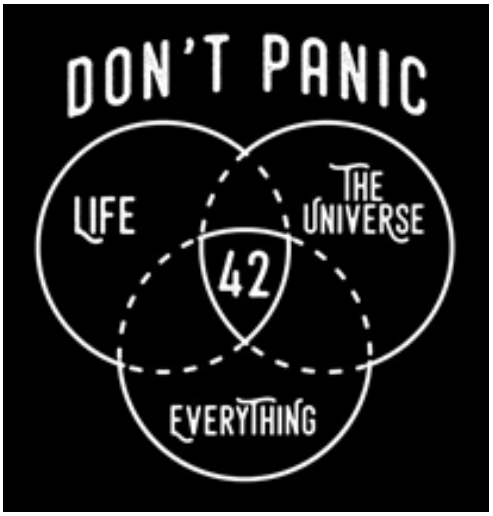
ALICE'S ADVENTURES IN WONDERLAND AND LEWIS CARROLL'S HIDDEN MATHEMATICS

In 1865, English author Lewis Carroll released a children's book, Alice's Adventures in Wonderland. With the novel being such a worldwide phenomenon, it is hard to come across someone who is not familiar with the Mad Hatter's antics, or the unsettling and mischievous grin of the Cheshire cat. However, did you know that Lewis Carroll was a practising mathematician? One full of mischief at that!

The story goes that Queen Victoria loved Alice's Adventures so much that she requested Carroll dedicate his next book to her. Carroll accepted but did not let her know that his next book would actually be one on mathematics. Consequently, there is now a very scholarly book called 'An Elementary Treatise on Determinants' dedicated to the queen herself!

Written over 150 years ago, you can now actually read this treatise for free online (since the copyright has expired). So, if you find yourself missing MAST10007: Linear Algebra on a cold night, check it out!

HITCHHIKER'S GUIDE TO THE GALAXY AND 42



In the beloved comedy science fiction series, 'The Hitchhiker's Guide to the Galaxy' by Douglas Adams, the answer to the ultimate question of life, the universe and everything is said to be, well, 42.

So, is 42 as special as the book suggested?

In 1954, a problem was set at the University of Cambridge that puzzled mathematicians for decades:

Find integer solutions to the equation $x^3 + y^3 + z^3 = k$, for $k = 1, 2, \ldots, 100$.

Solutions for all other values of k were gradually found throughout the years, but it was not until 2019 that a solution for the last value, k=42, was found by Professor Andrew Booker from the University of Bristol and Professor Andrew Sutherland from Massachusetts Institute of Technology.

Furthermore, 42 is Catalan number – a very rare type of number with only the first 14 being below 1 billion. Many counting problems lead to Catalan numbers being the solution. For instance, the number of ways to divide a convex (n+2)-sided polygon into n triangles by connecting vertices with non-crossing line segments equals to the nth Catalan number.

There have also been countless speculations from enthusiastic fans on why Adams picked the number 42:

- In the binary representation, $42_{10} = 101010_2$ which looks quite neat.
- Harry discovers that he is a wizard on page 42 of "Harry Potter and the Philosopher's Stone".
- It was also once suggested in the series that 42 is the answer to the question "What do you get if you multiply six by nine?" Well, $6 \times 9 = 54_{10} = 42_{13}$.

So why did Douglas Adams really pick the number 42?

> *'I sat on my desk, stared into the garden, and thought 42 will do. I typed it out. End of story.'*

We now know that 42 was just an arbitrary choice by Adams (probably). Nevertheless, this simple number has fueled the imagination and joy of millions of fans worldwide. People's love for the series and its author, as well as the beautiful mathematical properties of the number 42, are things that will never change, regardless of what is really the question to the meaning of life, the universe, and everything.

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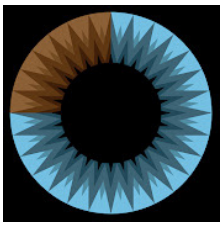
Podcast and YouTube Recommendations

Looking for a relaxing way to channel your inner mathematician? We have come up with recommendations for YouTube math channels and math podcasts for you to check out, complied by our very own Paradox Editor and President. Whether you're an auditory or visual learner, have five minutes or one hour, or want pure or applied math content, we've got you covered!

5 GO-TO MATH YOUTUBE CHANNELS – BY CANIS NUGROHO

For Understanding – 3Blue1Brown

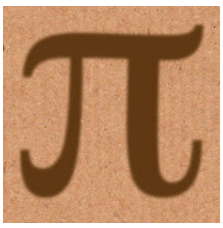
3Blue1Brown breaks down a wide variety of math concepts, from Bayes Theorem to the Monster Group, into ways that make them really engaging and easy to understand. As mentioned in their channel's description, what makes their channel unique is that their goal is "for explanations to be driven by animations and for difficult problems to be made simple with changes in perspective."



(Picture via YouTube)

For Exploration and Variety – Numberphile

The Numberphile YouTube channel, founded by Brady Haran, is pretty much what it says in its name – it explores numbers and anything to do with numbers, and in the most diverse ways too. From interviews with mathematicians to annoying McDonalds workers by ordering 43 Chicken Nuggets (the highest number of chicken nuggets you can't order with the boxes they have), you are surely will learn about a new area or concept in math in the most interesting ways.



(Picture via YouTube)

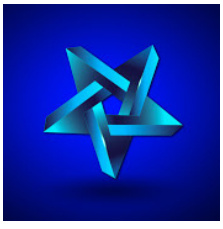
For Comedy – Stand-up Maths

Who knew that mathematics and stand-up comedy would ever come together? Matt Parker, the host of the Stand-up Maths YouTube channel has performed countless stand-up comedy routines that include math concepts. Many of his more recent videos include applications of math in modern day issues such as the US Election results and Apple iPhone Calendars, but his jokes and sense of humour will always 'stand-out'.

(Picture via YouTube)

For Applied Math – Zac Star

Whilst there are plenty of YouTube channels that are great for applied math including the ones above, the applications that Zac Star's channel incorporates will really get you thinking about and questioning the place of math in our world and universe. Does math belong in the courtroom? How much of our lives and the universe can be explained through math? These are only a few of the questions that he covers in his videos.



(Picture via YouTube)

For Keeping Up With MUMS - MelbUniMaths&Stats

Yes, we have our very own YouTube Channel that we created when the pandemic began. It has recordings of some our seminars that we organised with Lunchmaths, Monash University, as well as interviews with the panellists from our Women in Maths Careers Panel in 2020. And there is still plenty more to come!

MATH PODCAST RECOMMENDATIONS – BY YIFAN GUO

more mathematical

Available on iTunes

Mathematical Moments

A Podcast from American Mathematical Society.

Highlight: Snappy intro into many research projects that highlight the role of mathematics in science, nature, technology, and human culture.

Available on Spotify

The Random Sample

A Podcast Series from Australian Research Council Centre of Excellence for Mathematical and Statistical Frontiers (ACEMS).

Highlight: Perfect combination of discussions on cool research projects here in Australia and the mathematicians behind them.

shorter episodes

longer episodes

Available on Spotify

A Brief History of Mathematics

A ten part series first broadcast on BBC Radio 4, hosted by Professor Marcus du Sautoy.

Highlight: Very entertaining story telling about the life of some famous mathematicians in history.

Available on Spotify

Relatively Prime: Stories from the Mathematical Domain

Hosted by Samuel Hansen, Mathematics & Statistics Librarian for the University of Michigan

Highlight: Covering many interesting topics in the intersection of mathematics and life.

more diverse

Puzzles from our committee

Challenge your mind with some of the committee's favourite puzzles!

JAILER'S LIGHTBULB RIDDLE - SUBMITTED BY YIFAN GUO

A long time ago, in a galaxy far far away, there were a jailer and two prisoners. One day, the jailer was bored, so he decided to tease the prisoners a bit.

In a room, he prepared a 10 x 10 grid, where each square in the grid contains a light bulb. He then asked prisoner Alice to enter the room, while prisoner Bob was waiting outside. The jailer chose an arbitrary light bulb, then asked Alice to decide whether she would like to have it switched on or off. The jailer then chose a different light bulb and asked Alice again. They keep repeating this process until there is only one light bulb remaining that had not been chosen yet, which the jailer would then decide to switch on or off.

After this, the jailer asked Bob to enter the room. If Bob could guess correctly within 10 attempts which light bulb is the last lightbulb which the jailer decided to switch on or off, then both prisoners would be freed!

Can you help the prisoners come up with a strategy that always guarantees they will be freed?

A GIRL MEETS A LION AND UNICORN - SUBMITTED BY WEIZHENG LI

A girl meets a lion and unicorn in the forest. The lion lies every Monday, Tuesday and Wednesday and the other days he speaks the truth. The unicorn lies on Thursdays, Fridays and Saturdays, and the other days of the week he speaks the truth. "Yesterday I was lying," the lion told the girl. "So was I," said the unicorn. What day is it?

THREE LOGICIANS WALK INTO A BAR - SUBMITTED BY GYPSY AKHYAR

Three logicians walk into a bar. The barman says, 'Does everybody want a drink?'

The first logician says, 'I don't know.'
The second logician says, 'I don't know.'
What does the third logician say?

TWO FATHERS AND TWO SONS RIDDLE - SUBMITTED BY JULIE ZENOU

Two fathers and two sons sat down to eat eggs for breakfast. They ate exactly three eggs, but each person had only one egg. How is this possible?

BLUE, BROWN AND GREEN EYE(S) - SUBMITTED BY PHIL PHUNG

A group of people with differing eye colours live on a faraway island. Everyone on this island are perfect logicians - if a conclusion can be reached logically, then they will do it instantly.

No one on the island knows the colour of their own eyes. Every night, at midnight, a boat comes to the shore of the island. Islanders who figured out the colour of their eyes leave the island, and the rest stay. Everyone sees everyone else at all times and keeps a count of the number of people on the island with each eye colour (excluding themselves), but otherwise cannot communicate. Everyone on the island knows the rules explained above.

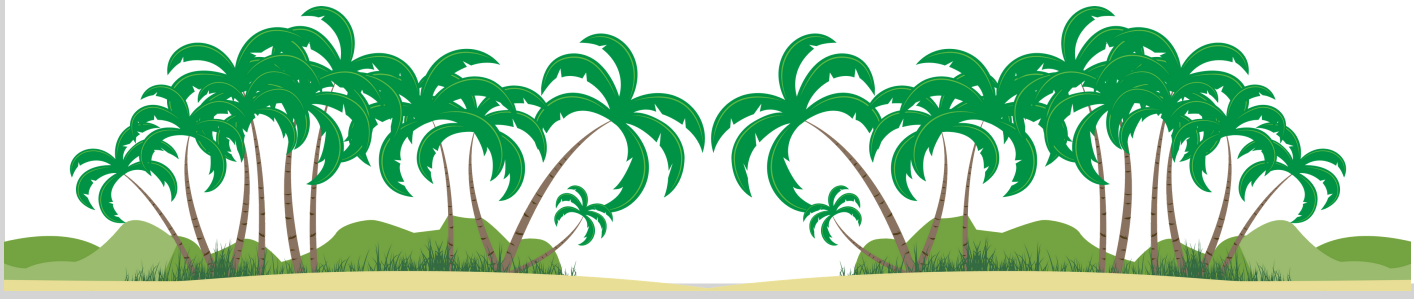
There is a total of 201 people on the island - 100 blue-eyed and 100 brown-eyed people. There is one person with green-eyes, called the Guru. The Guru is the only person who is allowed to speak on the island, and does not need to leave the island for any reason.

Note that the rest of the people do not know the actual split of blue/brown - consider the perspective of a blue-eyed person. They see 99 blue-eyed people and 100 brown-eyed people. They do not even know if their eye colour is blue or brown; for them it could be orange!

The Guru is allowed to speak once per day. She says the following: "I can see someone who has blue eyes." She says this to everyone on the island - i.e. not to a singular individual.
Who leaves the island, and on what night do they leave?

TIPS

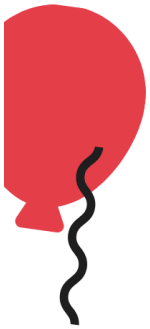
1) This is a logic puzzle, so there are no mirrors or reflections or any supernatural abilities here! The answer is logical... :). There is no wording puzzle here too.
2) Someone does leave the island...just who and when is the question!



SUBMITTED BY WENDY WANG

When is Barry's birthday?

Hannah and Elizabeth want to know when Barry's birthday is. This is a great opportunity for a puzzle, so of course Barry doesn't tell them his birthday straight away. Instead, Barry whispers to Hannah the month of his birthday, and then separately reveals to Elizabeth the day of his birthday.



Barry also provides them with a list of 10 dates that definitely includes his actual birthday.

May 15 May 16 May 19 June 17 June 18
July 14 July 16 Aug 14 Aug 15 Aug 17

Then the following conversation takes place:
Hannah: *I don't know when Barry's birthday is, but I know that Elizabeth doesn't know either.*
Elizabeth: *At first I don't know when Barry's birthday is, but I know now!*
Hannah: *Then I also know when Barry's birthday is!*

Can you deduce when is Barry's Birthday?

Looking back at MUMS' 2020 from above zero

Even a year like 2020 can't be all bad. As we say goodbye to the eventful year that is 2020, let's look back at some of the positives that happened in our society in the past year.

Communications and Publicity subcommittee, led by Canis and Hannah – If I have to describe Comms and Publicity subcommittee's work in 2020 with one word, that would be "new". We've got a new website, a new logo, a new Discord Server, a new YouTube Channel and the brand new "Maths Meme Monday" and "Fun Puzzle Friday". With all of us in lockdown this year, I think it is fair to say that Comms and Publicity subcommittee's work has been more important than ever to keep all of us connected while we are apart.

Diversity and Inclusion subcommittee, led by Julie and Thisuri – From adding acknowledgement of country for all MUMS communications and major events, to holding fortnightly Wom*n in Maths Coffee and Catchups, the Diversity and Inclusion subcommittee has been very busy in 2020 to keep pushing for a diverse representation in maths! On top of that, we started a new initiative called "Career Chat" – an interview series with women in maths, followed by a live Q&A panel later in the year. You can now watch all the interviews on the MUMS YouTube channel "MelbUniMaths&Stats". Check them out!

Education subcommittee, led by Sharon and Elizabeth – Amid all the buzz around online learning, a collaboration between MUMS and LunchMaths from Monash University was formed to create new academic opportunities for our members. A huge thanks to everyone for putting together this very successful series of virtual seminars on a diverse range of topics for students in both universities as well as the public. All seminar recordings are now also available on the MUMS YouTube channel. Enjoy!

Events subcommittee, led by Ryan and myself – It turned out that even a global pandemic wasn't able to stop us from providing you with the latest events! Movie screening, Set tournament, trivia night, virtual escape room, and of course, games nights … These events provided everyone with some much needed social connection during the lockdown, and most importantly, they were fun :)

With a grand total of 40 events in 2020, I am delighted to announce that MUMS won second prize for holding most online events in 2020 by UMSU Clubs and Societies. This is the collaborated effort of every single committee member. A huge thank you to our outgoing committee members – Adi, Anais, Brett, Bridget, Dellarymn, Grace, Steven, Josh, Keshav, Pulkit, Sharon, Young Rae, and our current committee – Canis, Chuanshu, Elizabeth, Eric, Eszter, Gypsy, Hannah, Ivy, Julie, Kate, Patrick, Phil, Ryan, Thisuri, Weizheng and Wendy! Of course, none of this could have happened without the constant support from our members! Thank you for being here with us and we hope to see you around in 2021!

- Yifan

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