Issue 22

SPRING EDITION

infinity

"If you must limit your dreams, at least tend them to infinity."

MATHS IN POPULAR CULTURE

REVIEWING OUR ALL TIME FAVOURITES

MATHS IS FOR EVERYONE

THIS SPECIAL SECTION EXPLORES EVERYBODY'S MATHEMATICAL POTENTIAL

WHAT'S YOUR OPINION

COMMENTS FROM AROUND THE CAMPUS.

MATHEMATICIAN'S CHECKLIST

BOOKS AND MOVIES HANDPICKED FROM OUR FAVOURITES

DERIVED BY US?

WAS MATHS DISCOVERED OR INVENTED? THE DEBATE GOES ON.

"I HAVE HAD MY RESULTS FOR A LONG TIME: BUT I DO NOT YET KNOW TO HOW TO ARRIVE AT THEM."

-CARL FRIEDRICH GAUSS

Cover designed by Raghav Saboo

EDITORIAL

Mathematics, as a subject, is one with applications in almost every field there is. As Rene Descartes put it, "apud me omnia fiunt Mathematicè in Natura" (… all things in nature occur mathematically). But the real question is, "What exactly is maths?" As a child, whenever I was asked the question, "Why is maths your favourite subject?", I had a standard response. I always said that math was, for me, 'a game of numbers' that I loved playing. However, this was before I had been introduced the world of 'outside-the-classroom' mathematics. It was the exploration of this, that proved to be my Nirvana. I finally saw mathematics for what it truly was. I saw it's true beauty and realised that maths was the key to the universe and its secrets. As Editor-in-Chief of this publication, I hope to share the beauty of this subject with everyone.

Having worked under three absolutely amazing Editors-in-Chief in the past, I know I have big shoes to fill. Luckily for me, I happen to have a great team that shares my vision and love for the publication. My Chief of Production, Raghav Saboo, is one of the most proactive and efficient people I know. He has always been my biggest source of support. My Editors, Shiven and Devansh, have served as incredible members of the team, whom I always knew I could count on. Then I have my amazing set of S-Formers, who have never failed to impress me and have even managed to surprise me on countless occasions. They have acted as inspirations, not only to the juniors, but also to me. Last, but certainly not the least, are the rest of the juniors, who despite being new on the board have worked remarkably well. Certainly, without their support, this issue of the Infinity would not have been possible.

This issue of the Infinity, features a report of the "Infinity Mathematics Quiz" held at the Aditya Birla World Academy, Mumbai earlier this year, the "Mathematics in Popular Culture" section, a rather interesting article by the Headmaster, Mr. Matthew Raggett, on the debate regarding whether maths was invented or discovered, and our special section for this term entitled "Maths is for Everyone", which includes articles that discuss the innate mathematical abilities possessed by humans and, for that matter, even by animals. Also included is a 'Letter to the Editor' from the first editor-in-chief of the Infinity, Mr. Akshit Batra. As always, we have some interesting problems for you and a list of mathematical books and movies that some of you may enjoy. To conclude, it is my sincerest hope that the following pages prove to be entertaining, educational and most importantly, worth every second of yours. Happy Reading!

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Editor-in-Chief

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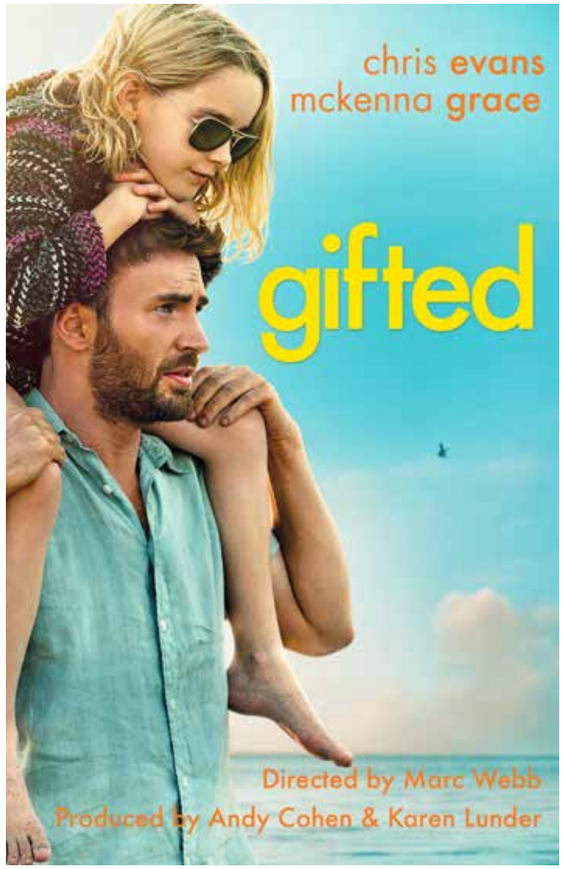


"3+3, really?" asks the 7-year-old Mary Adler (McKenna Grace) at her first day of primary school. Living with her uncle and de facto guardian, Frank (Chris Evans), Mary is portrayed as a child prodigy with immense talent in the field of mathematics. The main conflict arises when Frank's idea of Mary having a good social life is challenged by Evelyn (Lindsay Duncan), Frank's mother, who wants Mary to get an education where she is challenged, so that she can go ahead and one day, solve one of the seven millennium problems and continue her deceased mother's work.

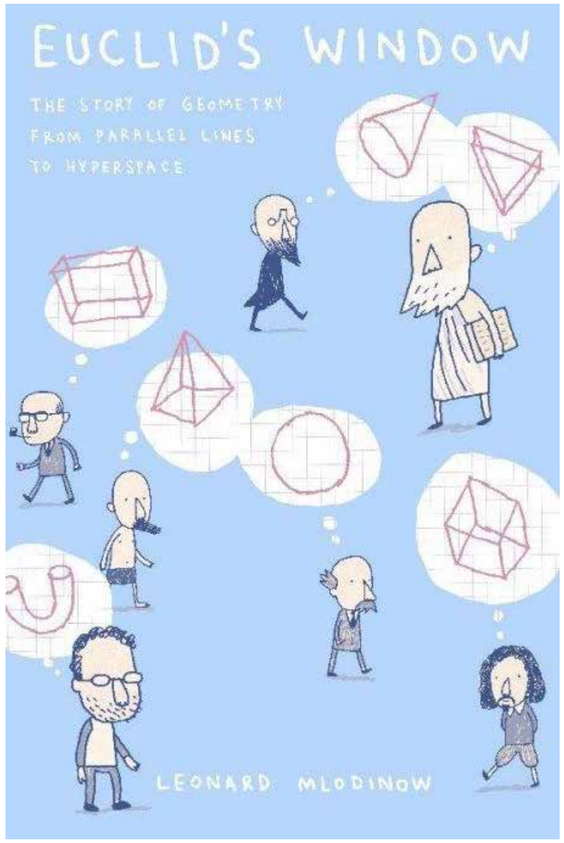
The movie explains the 7 millennium prize problems with ease. Back in the year 2000, to celebrate the coming of the new millennium, the Clay Mathematics Institute announced seven problems that are almost impossible to solve; these problems became renowned as the millennium problems. They include problems like the P vs. NP Problem, the Riemann Hypothesis, Hodge Conjecture, the Poincare Conjecture, the Birch, and Swinnerton–Dyer Conjecture and the Yang-Mills and Mass Gap problem. The movie is based on the Navier–Stokes Equation.

This movie explores the fact that many people who have a high IQ, just like Mary and her deceased mother, end up having a very low EQ. Although Mary is created by Hollywood, many mathematicians face the same kind of problems as shown in the movie, for instance Grigori Perelman, a Russian mathematician who solved the Poincare Conjecture (the only millennium problem that has been solved) and declined three prestigious prizes for mathematics (the Fields Medal, Millennium prize and the European Mathematical Society prize), the reason for his declination being that he did not "want to be on display like an animal in a zoo".

This is just one example, but there are many such people who have developed into anti-social beings just because they are intellectually gifted. Other examples include Steve Jobs and Albert Einstein. Whether or not being intelligent affects our social skills is still a huge question, but the movie teaches us a truly vital lesson of life while entertaining us with the ups and downs in the lives of Frank and Mary.

A huge takeaway from the movie is the fact that we have to sacrifice something in order to achieve a goal; Mary has to sacrifice her friends and social life in order to be able to solve the problem, and she has to sacrifice her intelligence in order to bond with her classmates and "dumber kids".

Knill, Oliver. "Gifted." The Math in the Movie Gifted, Harvard, 20 Aug. 2017.
Hans, Simran. "Gifted Review – Touching Family Melodrama." The Observer, Guardian News and Media, 18 June 2017.
"Millennium Problems." Clay Mathematics Institute, 20 Apr. 2018.
Thomas, Rachel. "Euclid's Window." '+Plus Magazine', 1 Nov. 2009



For a book to be a delight to both technical and non-technical persons alike, is a rarity. Euclid's Window, written by Leonard Mlodinow, brings the concepts of physics and math together to talk about the evolution of geometry right from the concept of parallel lines to the latest notions of hyperspace.

The book is a series of five tales of the "five geometric revolutions of world history", that explains not only the fundamental and simple concepts but also concepts such as relativity and the string theory. These five tales revolve around the lives of the five famous mathematicians who revolutionized the world of geometry - Euclid, Descartes, Gauss, Einstein and Witten. The storyline is written in the context of their time, place and culture. The triumphs of human discovery by Einstein and Witten and their peers gave answers to obvious questions arising from our struggle to understand reality. Mlodinow uses amusing analogies and everyday incidents to explain a variety of concepts, an example of this being explaining the concept of entropy of black holes in terms of the messiness of his son's bedroom.

Mlodinow's genius is the seamless way he blends together history and geometry. In the book, he brings important historical contexts and mathematical concepts to life, giving the book a very informal and humorous approach. He explains how important applied geometry was for the Egyptians due to the time they lived in while giving insight into some of the applied geometry that they used. The book recounts how we as humanity have continuously looked through the window of shapes and figures (i.e. geometry) to understand the reality we live in. It gives an insight into the evolution of this window and how this window is constantly the base for all the new discoveries that are made.

The plot conveys a sense of life and death in the world of geometry and teaches us that acceptance in not the only key to a good theory. It is a must read for all who hate geometry or math is general as they will see how geometry is shaping the world we live in. Those who have looked through Euclid's Window will find something new in the same old world just like Aristotle: "Aristotle saw in a flash of genius, a sign that the earth is curved. To observe the large-scale structure of our planet, Aristotle had looked through the window of geometry."

Arnav Agarwal
A-Form

Trinab Goyal
A-form

WHAT'S YOUR OPINION?

WHAT ARE YOUR VIEWS ON THE REPRESENTATION OF MATHEMATICS IN POPULAR CULTURE?

"I guess implicit to Mathematics is logic and reason. To what extent these two faculties play a role in what defines "Popular Culture" is debatable. It seems in most cases of what we see of popular culture has its own pace and 'logic' and it is transient, though definitely reflective of our times. Math of numbers definitely seems to be on the side of popular culture!"

Mr. Aseem Tripathi

"Mathematics is a strong intellectual weapon. It is a depiction of logic, a code to cracking every code and the means to connecting every dot, be it a simple puzzle or a code like Enigma. Mathematics is, very correctly, projected as the most powerful creation of the human mind and indeed the greatest cultural breakthrough."

Tarush Bansal

"When I think of Maths in pop culture I tent to think of film and visual art. Music may be mathematical but I don't see many people creating, singing or rapping about maths. In film however we have Heavenly Bodies, A Beautiful Mind, The Man Who Knew Infinity, The Imitation Game, Good Will Hunting, The Theory of Everything, 21 and, my favourite, Pi. These films have won awards for their actors and won the hearts and minds of millions of people. I think that what many see as the mystery of maths and the associated brilliance of those who can harness it captivates them. It gives me the sense that at some fundamental level there is a general appreciation of the beauty to be found in mathematics. Some of that beauty is then shared by artists in their work that has appeal and resonates with audiences the world over, Jacobus Verhoeff,, Daina Taimina, Charles Perry, M.C. Escher, Scott Draves and Monir Farmanfarmaian to name a few. I think that we are all innately in tune with mathematics, wihch is why the artistic and cultural sphere is full of it."

Mr. Matthew Raggett

"Representation of mathematics is very evident in Hindi fiction: Premchand's fiction, Badey Bhai Sahib etc. The play, "Ganit Desh" has characters according to numbers and basic mathematical functions. It is also there in Urdu fiction and poetry written by Ismail Merathi, Ibne Insha, Zakir Hussain, in Arabic stories from Egypt, Saudi Arabia, in Persian stories and films by Majid Majdi, in Malyalam poetry by Mohankrishan Kaladi etc."

Dr. M.H. Farooqui

MATHS IS FOR EVERYONE

Exploring the potential for mathematics innate in everyone

Introduction

"Every culture has contributed to maths just as it has contributed to literature. It is a universal language; numbers belong to everyone."

—Daniel Tammet

Often have we heard the saying: 'You can do it', but is it really true in the case of learning math. This section of this time's Infinity gives you an insight into how you really all have the ability of doing math, and how you utilize it so much in everyday life. It is just that in classes where we are taught math, our mind goes into a different thought process where it is conditioned to know that everything being taught is going to be difficult. This thought process evolves from one's childhood, where if a child does not do well in math in a particular test, he grows up thinking that he is bad at math. This contributes to his 'inability' at math, and not the fact that he was born.

What is even more surprising is that not only humans but all animals have this mathematical ability also. A person who has despised math all his life can go on to become the greatest mathematicians of all times, that is the power of nature of math.

Mathematical ability is innate i.e. you are born with it. You do not get an option of not doing maths. If you realize, you do basic math every day in life without even knowing or thinking about it. Where do you think your sense of numbers comes from, or how do you think a lion knows he is outnumbered. All of this is a direct consequence of the Math gene present in us. It is this mathematical sense in our sub-conscious that enables all animals alike in many aspects.

As coined by many great personalities of the past such as Plato, Galileo, Einstein and others, Math is definitely a very beautiful subject. It is so consistent with nature that all the equations and constants derived by physicists, geologists, historians all fall in place. It is like nature is saying something to us using math as a medium. The problem just that we choose to ignore this ability in us as that is the easier path. This section will just prove to you how it is all in us.

"WITHOUT MATHEMATICS, THERE'S NOTHING YOU CAN DO. EVERYTHING AROUND YOU IS MATHEMATICS. EVERYTHING AROUND YOU IS NUMBERS."

-SHAKUNTALA DEVI

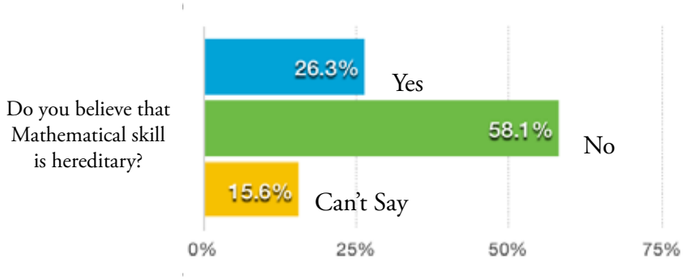
Genetic Genius

Anant Kakkar comments on the innate mathematical gene in humans

'Try thinking of maths as a subject that imbibes the whole universe in it, a subject that is the language in which nature communicates itself to us. Just try treating it as a language.' It is not a common manner in which people think of math. But if this perception is false, then why would nature put in our blood a combination of carbons, hydrogens, and nitrogens (a DNA strand) that makes such a difference in our perception of the universe? Studies conducted by various universities such as Johns Hopkins University, University College London and others, have all proven that there is a genome in the DNA strand of humans that gives all humans (and even animals) the ability of mathematical thinking. Very few people realise that this mathematical ability is inborn. These mathematical (and logical) abilities are caused by a specific genome: Chromosome 3q29, a Locus Associated with Autism and Learning Difficulties. This genome is hereditary and passes unaltered from parents to children. Few studies have directly investigated into its molecular genetic basis which shows it controls the direct cognitive ability to understand and grasp mathematics. This genome is also the cause of the micro-deletion syndrome which is basically a syndrome that deletes a part of any chromosome in the body. Due to the same reason, this genome may cause difficulty in learning any language.

In spite of this hindrance, this genome is responsible for all of our decisions and problem solving skills. This ability of thinking logically (which is all math) is not just restricted to this one particular gene. Researches show that SPOCK1 gene located on chromosome 5q31.2 is also responsible for this ability. Four new SNPs(DNA variations) which are variants of STOCK1 have been successfully replicated in labs and have achieved genome-wide significant level. This invention gives us more insight into our inherited cognitive abilities. These increase the percentage of grasping concepts manifold and also affect people in their childhood by helping them form neurological pathways easily. There is a new study on these genes, and scientists say that maybe in the future one can implant these genes into other people via genetic transplants and trigger them by certain chemical reactions. These SNPs will be a great booster to our mathematical ability, as every second person could then be a genius. It is scary to think of a world without this mathematical genome in humans. Without it, people will make all kinds of irrational decisions, none will know what to do. Every small decision in one's life is guided by this 'logical' DNA strand.

Note: *160 members of the school community were polled*



Anant Kakkar
C-Form

Chen, Huan, et al. "Math Gene in Humans." Scientific Reports, Nature Publishing Group, 11 Apr. 2017.
Sample, Ian. "Genes That Influence Children's Reading Skills Also Affect Their Maths." The Guardian, Guardian News and Media, 8 July 2014.
Libertus, Melissa. "Math Ability Is Inborn." Math Gene in Humans, 8 Aug. 2011.
Chen, Huan, et al. "A Genome-Wide Association Study Identifies Genetic Variants Associated with Mathematics Ability." Nature News, Nature Publishing Group, 3 Feb. 2017.

Math Hacks

Arnav Agarwal explores some time-saving arithmetic tricks

The Digit Sum Method for Checking

Firstly, it is necessary to know what a digit sum is (Note that a digit sum must be a single digit). To calculate it, one keeps on adding the digits of a number until a single digit is obtained, for example the digit sum of 93 is 3, as 9+3=12 and 1+2 (from the digits of 12 thus obtained) = 3. To use this method, one calculates the digit sums of the numbers supposed to undergo addition, subtraction or multiplication and then checks whether, if those digit sums undergo the same operation, the answer is equal to the digit sum of the actual answer. If it is, then the calculation is correct. For example, if we want to verify the calculation: 143 - 87 = 56, calculate the digit sums of each. The digit sum of 143 is 8, the digit sum of 87 is 6 and 8 - 6 = 2. As the digit sum of 56 is 2, this calculation is correct.

Vertical and Crosswise Method for Multiplication

To multiply large numbers for example, 98 and 91, there exists a very simple method. The first step is to calculate the number's complement. This is obtained by subtracting the nearest power of 10 from the number. The rest of the steps are summarised in the given table:

Number	*Complement*
98	2
91	9
(98-9) or (91-2)	**(2 * 9)**
89	**18**

Note: In the last step (in which we obtained 89), we subtract the complement of any one of the two numbers from the other number.

On combining the two numbers from the last row, we get 8918 which is the product of 98 and 91. The general form of the above table

x	Complement of x=a
y	Complement of y=b
x-b or y-a = z	a*b=c

So, x*y = zc

Squaring Numbers

To square any number, we can find its complement (using the same method as explained earlier) and then square it to obtain the latter part of the answer; the other half of the answer can be obtained by adding the complement to the number. For example, to square 91, we need to first calculate the complement which in this case is 9. Therefore, the latter part of the answer is 81, and the former part of the answer is 91+(-9) which is 82, so the square of 91 is 8281.

Multiplying by Five

This is a very simple mental trick in which one just has to multiply the number by 10 and then divide it by 2.

For example, 459274 multiplied by 5 would be 459274 divided by 2 into 10.

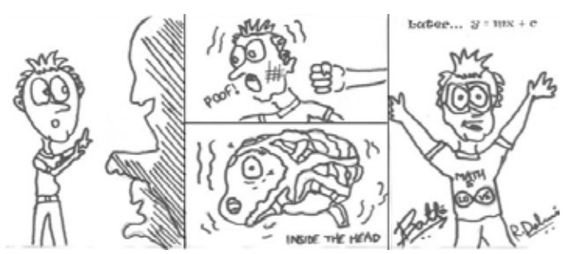
459274 * 5

= 459274 * 10/2

= 229637 * 10

= 2296370

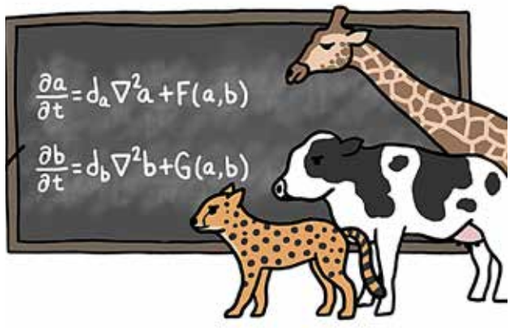
Would you believe me if I said that getting beaten up by two thugs outside a bar could make you an inspiring mathematical genius? Sounds unrealistic, but this is what made Jason Padgett the man he is today. Being nonchalant about getting good grades in school, Jason and studies never really went together, especially because he loathed maths. While in college, Jason spent most of his time attending parties and hanging out with friends. As described by Jason in one of his TED talks, he felt that 'his life was a mile wide but only an inch deep'. While picking up a friend from a bar, Jason faced two thugs who started beating him mercilessly. Jason says that at this point he saw a flash of bright light and was unaware of what was happening, similar to what boxers feel like when they get knocked out. The next thing he knew, he was in a hospital, suffering from a concussion and a bruised kidney. This was the point where Jason's 'relaxed' life took one of its most dramatic turns. When Jason woke up the next morning, everything seemed different to him. He says he saw things in stop-action frames, like individual discrete pictures connected by a line. Bright light seemed amplified to him and the jagged edges of these picture frames created an elegant pattern which mesmerised him. He saw his hands and drew pictures of them and noticed that they weren't smooth but were rough and contained irregular edges which can be described by the polar integral. Jason started describing this to people and was entranced by how he saw the world differently. However, his major discovery came when one day his daughter, Megan, asked him how the television worked. He told her that the television contained rectangular pixels that had the capability to change colour and that's how one could see things on television. At that point, an advertisement which showed the letter 'O' got screened and out of curiosity, Megan asked her dad how the rectangular pixels had managed to create a circle. That's when Padgett realised that even after shrinking the size of the pixels to infinity a circle couldn't be created, it would have jagged edges and hence, a perfect circle could not be made. Jason was then suffering from agoraphobia (irrational fear of public spaces) and began to isolate himself. Jason started drawing pictures and realised that they explained some advanced physics concepts like the big squeeze theorem. He was fascinated and wondered how he had failed to see all of that earlier. He began to learn maths again and is currently inspiring young achievers. One can surely say that Jason was 'struck by genius'.



Padgett, Jason. "How Math Saved My Life | Jason Padgett." YouTube, YouTube, 1 Nov. 2016.

Zootopian Math

Harshvardhan Agarwal reveals that the entire animal kingdom possesses mathematical skills

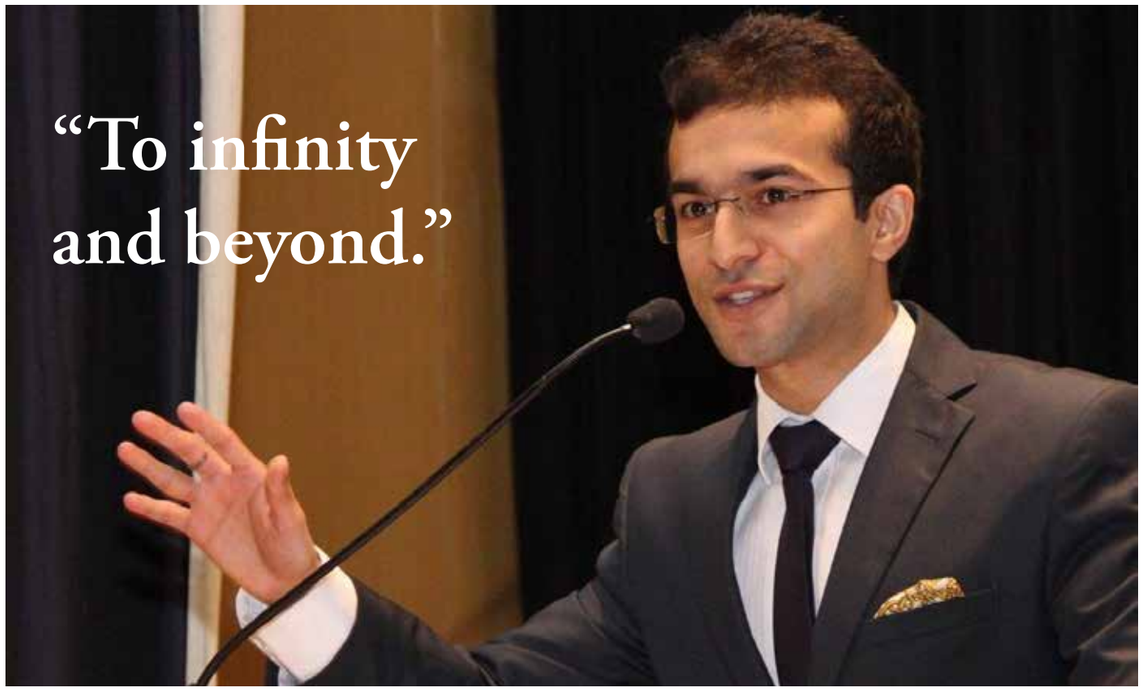


"The Book of Nature is written in the language of Mathematics"
—Galileo Galilei

More than a century ago, a peculiar case of a horse with abnormal capabilities surfaced. An Arabian stallion, 'a Hans', used to stomp out the answers to various mathematic problems. It was later discovered that the horse was actually taking subconscious non-verbal cues from its owner and was indeed no animal savant. Ever since, scientists have been cynical and incredulous of claims regarding animals having mathematical abilities. Now-a-days, such cases are simply treated as special occurrences or a result of conditioning. However, recent studies claim that mathematical skills are widespread in the animal kingdom. Ranging from a three-day-old domestic chick to a black bear, various animals are said to have a certain kind of mathematical ability. Chimpanzees, animals which are said to be closely related to humans, have a high aptitude in numerical tests as well. Some animals only possess the simplest of abilities, whereas certain species such as the Tunisian Desert Ants (Cataglyphis fortis) are proficient in even the most challenging math topics. These ants tend to use mathematical concepts such as geometry and arithmetic on a daily basis to find their way back home. Basic mathematical skills can be found in almost all animals and are used for various purposes such as navigation, mating and hunting. For example, lions have a unique way of applying their skills. They choose to attack or defend when they come across another pride only after comparing their own number with the enemy's. In a specially conducted experiment, a sound of a certain number of lions roaring was electronically produced in front of 5 lionesses; they made an attacking move only when they sensed a sound of 3 lions while they retreated when the roar was of 5-6 lions combined. Dogs have a lower mathematical aptitude than most of their fellow animals. However, wolves, the parent species of dogs, are ranked considerably higher on that list. Dogs can only sense the presence of creatures, their abilities not extending to distinguishing between numbers. On the other hand, wolves can differentiate between small and large numbers. This suggests that domestication of animals may result in the lowering of their mathematical aptitude. These studies, along with many others, suggest that animals indeed possess mathematical abilities in varying degrees. Perhaps, humans aren't alone in their exploration of the world of mathematics.

Harshvardhan Agarwal
S-Form

Tennesen, Michael. "More Animals Seem to Have Some Ability to Count." Scientific American, 1 Sept. 2009
Rowland, Noha. "Helix Magazine." Math - In Animals?, 14 Oct. 2009
Silver, Katie. "Earth - The Animals That Have Evolved the Ability to Count." BBC, BBC, 26 Aug 2015.



Letter to the Editor

I was laughed upon infinitely. There was a batch-mate of mine who stuck a photograph of Buzz Lightyear from Toy Story on my toye with the words, "To infinity and beyond." Not many people really fancied math, let alone a math magazine. For a second even I paused to think whether the idea of a math magazine would ever work.

But then I saw the rock solid resolve and the quiet confidence of Mr. Anjan Chowdhary. He stood behind his idea of this magazine with a supremely calm smile and in his characteristic encouraging manner, he told me not to care about the world – a lesson for life that has stuck by me. I have always considered him an exceptional teacher and an even greater human being. He had done so much for me and for all the students—I could not let him down. That first issue—I did it for him. From thereon, it was up and up. Knowingly or unknowingly, Mr. ANC and Infinity had taught me the value of that difficult first step that is the most crucial element in fulfilling dreams.

We were pretty primitive back then, in our size, content, style and readership. I see that a lot of great progress has been made and there is an Infinity Society now, which is brilliant. I read a couple of editorials from recent issues and I am very happy to see the depth of thought that was reflected in them. The content and presentation seem to be significantly better and therefore I would like to extend my deepest congratulations to the entire team of Infinity, to Mr ANC and to Chief Editor Abhiraj Lamba.

The Infinity is more than just a math magazine. It is a testimony to the fact that The Doon School celebrates every stream of learning and glorifies the conventional as well as the unconventional, consequently producing thinkers who boast of unparalleled breadth and ingenuity. It is very heartening to see this having not only survived but also bloomed over the years and I wish Infinity and everyone associated with it all the very best for the year and years to come.

Akshit Batra
Ex 158-H '09

Math in Mumbai

Aneesh Agarwal reports on a mathematics quiz held during the winter vacation

Three students from our school participated in the Annual Inter-School Infinity Mathematics Competition, held during the winter vacations in 2017. It was hosted by the Aditya Birla World Academy, Mumbai. The team comprised Gunit Mittal, Abhiraj Lamba and Aneesh Agarwal and was escorted by Dr. Mona Khanna.

The competition began with an inauguration ceremony, following which, the participants and escorts attended a lecture by mathematician and educator, Dr. James Tanton. His lecture revolved around 'symmetry' and its often overlooked relevance in mathematics. He also introduced the audience to some time-saving mathematical shortcuts. The lecture was followed by a short ice-breaking session. The participants were divided into groups and were assigned the task of walking around the campus, solving a maze by answering questions stuck on walls. In the first of the five rounds of the competition, 'Bulb your Ideas', schools were told to design creative

and humorous posters answering five questions. Our school's team, having solved four of the problems and provided a humorous response to the fifth, was among the top five teams, and was requested to present its work the following day.

The second day of the competition was a rather hectic one with four rounds planned for the participants. The first round was the 'Mathematician of the Year' round where the students participated on an individual basis.

Gunit Mittal was awarded the runners-up trophy. This was followed by the 'Relay Round' in which each member of a team solved only a part of the question. The idea of the round was to give participants easy questions and check how well they avoided 'careless mistakes'. The third round of the day was 'Math Challengers' in which the participants solved a set of questions, both individually and as a team. The top five teams from the previous rounds qualified for the final round, 'Quizzitch'. Our school's team failed to secure a place among these teams. However, witnessing the round was a great experience for its members.

Although the team did not live up to its own expectations, it found the experience to be an enriching one and they learnt from their failure.

Aneesh Agarwal
S-Form

Problems  to Ponder Over

1. How many two-digit numbers are there whose digits are both odd? How many such numbers have different digits (both odd)? [25, 20]

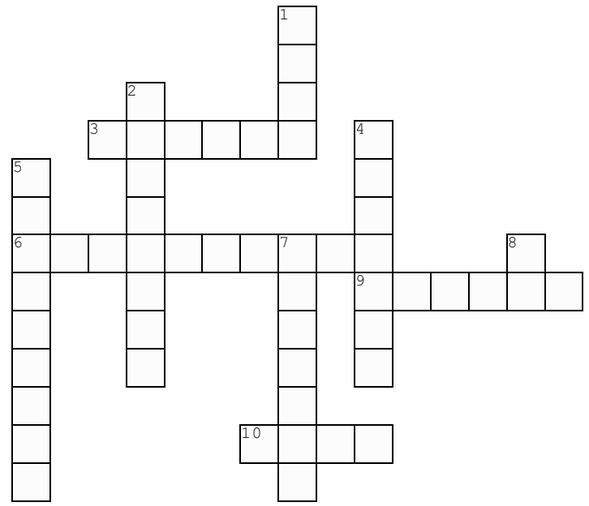
2. How many diagonals does an n-sided polygon have? [n(n-1)/2 - n]

3. How many multiples of 5 can be formed from the digits 1, 2, 3, 4, 5? (Repetition of numbers are not allowed, and multiples may not necessarily be 5-digit.) [65]

4. A pen costs 11 and a notebook costs 13. Find the number of ways in which a person can spend exactly 1000 to buy pens and notebooks. [7]

5. Two sides of a triangle have lengths 6 and 10, and the radius of the circumcircle of the triangle is 12. Find the length of the third side. [4.228]

Crossword



Across

3. Famed for his 'Little Theorem' and 'Last Theorem', this Frenchman was said to have inspired Isaac Newton.
6. John Napier introduced what system of notation as a computational tool in 1614?
9. He is known as the "Father of Geometry."
10. A selfish average.

Down

1. 12 inches.
2. An American Government polygon.
4. This author of Principia Mathematica was also awarded the 1950 Nobel Prize for Literature.
5. Give the equivalent roman numeral for 987.
7. The number of zeroes in a googol.
8. Archimedes described it as greater than 223/71 and less than 220/70. What is that number called today?

Answers to the Crossword

1. Foot 2. Pentagon 3. Fermat 4. 5. CMLIIVII 6. NapierBone 7. Hundred 8. Pi 9. 10. Mean

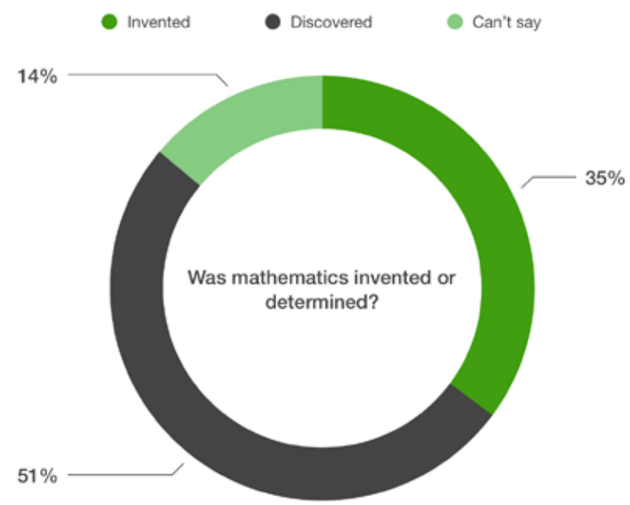
Mr. Matthew Ragget
The Headmaster,
The Doon School

DERIVED BY US?

Was Mathematics discovered or Invented? The controversial debate goes on.

"HOW CAN IT BE THAT MATHEMATICS, A PRODUCT OF HUMAN THOUGHT INDEPENDENT OF EXPERIENCE, IS SO ADMIRABLY ADAPTED TO THE OBJECTS OF REALITY?"

-ALBERT EINSTEIN



Note: *160 members of the school community were polled*

When I was teaching ToK on a regular basis I loved exploring mathematics as an area of knowledge with the students, helping them see the difference between an axiomatic system of knowledge like maths and an empirical system like science. Science is never certain and always on the edge of being undermined by the next experiment, although the way it is taught in schools could make you think otherwise!

With axioms of our choosing, it is easy to think that we have invented mathematics. Another axiomatic system that I came into contact with much later was economics, sometimes seen as a social science and increasingly as a behavioural science. Keynes's founding axioms allowed a whole system of knowledge to be built that attempted to describe the world of production and trade that we had been creating for millennia. It is easy to think that mathematics does the same. Of course, an iPhone doesn't have, in itself, an understanding or a disposition to play along with the laws of economics… there is something different about mathematics that every pinecone, sunflower and pendulum knows. I don't think that we are making this stuff up; I think we are discovering something deeper.

Scientists have long put boundary conditions around their work, simplifications and special cases that help them develop their ideas. The Bohr model of the H atom, the simple harmonic oscillator as a description of a mass on a perfect spring and the perfectly insulated calorimeter are all such conditions. Scientists have also happily used mathematics to describe what they observe and have made remarkable progress as a result. Newton's Principle helped to change the way that people understood and predicted what was happening in the physical world and began a more theoretical approach to physics that I enjoyed and followed all the way through university. Rather than seeing mathematics ,a language used to describe something, I see the thing being described as the mathematics itself. Rather like Plato's forms, there is the concept of the perfect circle that is being described by our drawings and our descriptions of a circle; we 'do' mathematics to describe it.

Something I learned at university about mathematics was that it was a tool to be used but to be recognized as such… don't worry too much about the number, just the order of magnitude and if you don't need both roots, just take the one that makes sense… the positive one.

Einstein's famous equation, $E = mc^2$ is one of those special case equations. It is the root of another equation that applies to stationary particles, $E^2 = m_0^2c^4 + p^2c^2$. If a particle is not moving then p, its momentum, is zero and you then have a simple equation that you can take the root of. Of course,x when you take a root you have two possible solutions but then, what would negative energy mean?

When Paul Dirac, who held the same chair at Cambridge University that Newton had in his day and Stephen Hawking recently, looked at Einstein's equation he was unable to ignore the negative root, coming as he did from the mathematical rather than the physical world. He postulated the existence of antimatter, positrons and a set of negative energy levels in which matter resides until given the energy to move up and into the corresponding positive level leaving a gap. These gaps in the negative energy levels would then be observed as an antiparticle. The excited electron would rapidly fall back into the gap, electron meets positron and annihilation occurs with the release of energy equal to $2m_ec^2$; all theory borne out of a conviction that the mathematics allowed it.

Dirac predicted this in 1928 and the positron was discovered in 1932 by Carl Anderson. The maths was right even though the idea of negative energy, electrons moving backwards in time and matter-antimatter annihilation were all science fiction at the time. Of course, we now know that it is this very matter-antimatter annihilation that powers the starship Enterprise and allows us to create other, more exotic matter at places like CERN.

The same faith in mathematics, accompanied by the creative genius that one nWormally attributes to those in the arts, led Wolfgang Pauli to theorise the neutrino in 1940 that was experimentally shown to exist in the 1950s and 60s. It is examples like these that convince me that mathematics is discovered, it lies there waiting to be found, like a fossil ready to share its secrets with us if we care to put in the work needed to find it. Our universe is indeed a mathematical one in which the rules are mathematics.

NETFLIX

"Screen Time"

Good will hunting

Theory of everything

Gifted

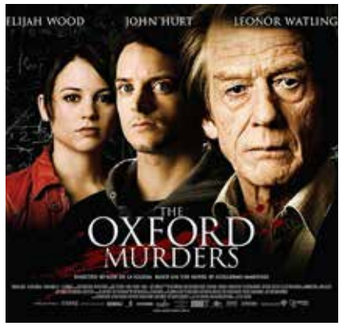
The Oxford Murders

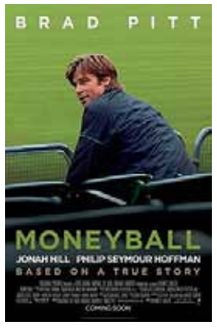
Fermat's Room

Enigma

The Travelling Salesman

Moneyball





Books

"Fun reads"

Problem Solving Through Problems by Larson L.C.

Winning Solutions by Lozansky E. Rousseau

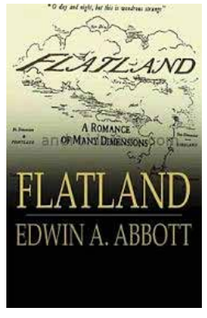
Excursions in Mathematics by C. Stanley Oglivy

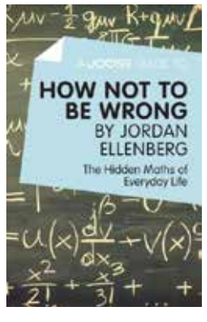
Flatland by Edwin Abbott Abbott

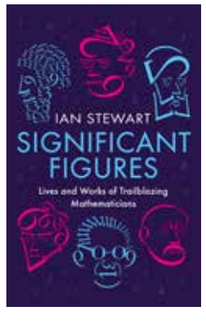
How Not To Be Wrong by Jordan Ellenberg

How to Solve it by George Pólya

Significant Figures by Ian Stewart

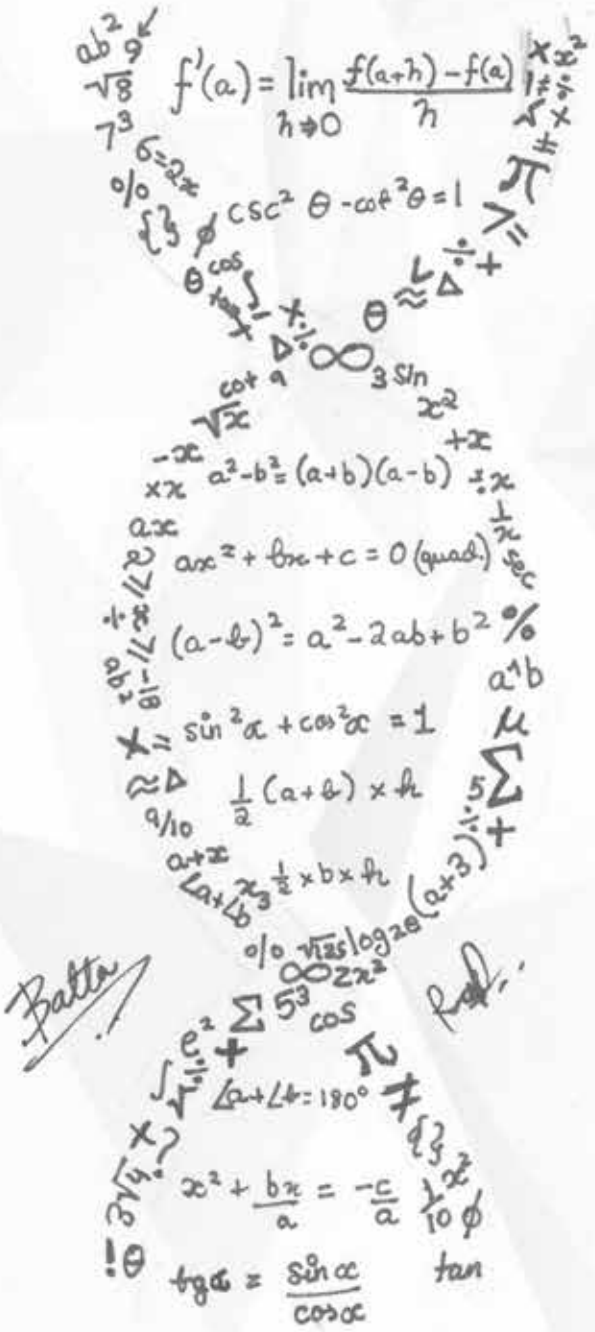






"THE BOOK OF NATURE IS WRITTEN IN MATHEMATICS"

-GALILEO GALLILEI



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