February, 2019
Issue No: 5

"You've reduced a second order equation you can't solve to a first order equation you can't solve. And that's called progress."
-Prof. Mattuck, MIT

From the editor's desk

Dear Readers,

As I sit down to write this editorial for one last time, I would be lying if I said that I don't have a blurred vision. I don't have to tell you what Pirate has transformed into over the last few months, from a newsletter to a magazine, and how it has inspired young minds not just to understand but also to create.

I remember wanting to do something great with my love for Math and Pirate has undoubtedly proved to be the perfect platform for it. Many of us are unaware of our potential interests. Very few people end up discovering their likes and dislikes early in their lives but, for many, Pirate has evoked a desire to discover, to know, to express.

Math is certainly not the toughest thing to do. You would know that by now. In this edition of Pirate, we have tried to present to you a unique perspective of infinity and the involvement of Math in a diverse range of fields. We have also brought to you the concept of Bizarre numbers, taking Mathematics beyond just textbooks.

It would only be appropriate to sign off by saying that I'm lucky to have been a part of something that makes saying goodbye too tough. As I thank you all for supporting me throughout, I wish the same for the upcoming ones as well.

Jagriti Saraf
Editor-in-chief

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DEGREES OF INFINITY

Infinity. A number that has caused fascination and confusion amongst many mathematicians and people alike. It's like time or space stretching out infinitely beyond the reaches of our imagination. The idea of infinity is already so abstract that the idea of dividing it into type might seem absolutely absurd but believe it or not, you can do so. The idea first occurred to a German mathematician, Georg Cantor, who demonstrated that there exists different kinds of infinities—some larger than others.

Let's take natural numbers for example: 1, 2, 3 … This set of numbers can be said to be infinite. On the other hand we see even numbers: 2, 4, 6 ... infinitely. Is the infinity of natural numbers larger than the infinity of even natural numbers? Though it might not seem so, they are actually considered equal.

To say two sets of objects are equal, we put them into correspondence to each other. For example, if I claim I have the same number of fingers as toes, I mean that for every one finger there is one toe, with no toes left over or no fingers left unmatched at last. Now do the same for natural numbers and even numbers: pair 1 with 2, 2 with 4, 3 with 6, and so on. There will be exactly one even number for every natural number. We can do this for an infinite number of times. Therefore, we can say that the infinity of even numbers is the same as that of natural numbers. The same goes for integers. These infinities are called countable infinities.

On the other hand we can see the amount of real numbers between 0 and 1. They are, obviously, infinite. If you pick out any two numbers between 0 and 1 you still have infinite real numbers between them. This can go on for an infinite number of times. We can, thus, say that the infinity of real numbers is clearly more than the infinity of natural numbers. This infinity is therefore called uncountable infinity.

The next time you think something is infinite, just remember that there may be infinities larger than it. Just like Albert Einstein once said: *"Only two things are infinite, the universe and human stupidity, and I'm not sure about the former."*

-Gaurika Bindal
Pre Sc

THE WONDER OF A MOBIUS STRIP

Ever thought of an object which has only one side and a single boundary? Well this might sound odd but such an object actually exists. This one-sided figure is called a Mobius Strip. This shape has been known to fascinate many environmentalists, artists, engineers, mathematicians and many others ever since its discovery in 1858 by August Mobius, a German mathematician. The fascinating fact about a Mobius strip is that if you take a pencil and draw a line along the center of the strip, you'll see that the line apparently runs along both sides of the loop! Well this is not it. The other amazing property of this loop is that if you try cutting the strip in half along the line you just drew you may be astonished to find that you are left not with two smaller one-sided Mobius strips, but instead with one long two-sided loop.

While the strip certainly has visual appeal, its greatest impact has been in mathematics, where it has helped in the development of the field of topology. Coming back to its boundary, a Mobius strip is homeomorphic i.e., it is topologically equivalent to a circle. It is possible to embed a Mobius strip in three dimensions so that the boundary is a perfect circle lying in some plane. Due to this property there have been several technical applications for the Mobius strip. Giant Mobius strips have been used as conveyor belts because the entire surface area of the belt gets the same amount of wear, and it keeps rolling around the plane as a continuous-loop recording tape.

This great discovery of a one-sided loop has led to many new inventions and it still continues to surprise mathematicians and topologists.

-Ishika Agarwal
Pre Sc

BIZARRE NUMBERS

How many number systems do we have? The answer is obvious for most of us: Two. Real and Complex number systems. But what if I tell you that there are 4 number systems in total? The last two numbers systems are strange and most of us will never come across them in our lives. But for physicists, they are more common and familiar than real and complex number systems. The other two number systems are Quaternions and Octonions. These Number systems were both developed for a specific purpose: to explain the underlying strangeness of the universe.

Quaternions were discovered by William Rowan Hamilton in 1843 while he was working with many "imaginary units". The quaternions are quite similar to complex numbers but they have additional square roots of -1 which Hamilton referred to as *j* and *k*. The quaternions were giving strange results in classical mechanics. To prevent a war among physicist, a Yale professor, Josiah Gibbs gave a little twist to quaternions giving us world famous "dot and cross product of vector multiplication". Even though Quaternions were rather useless in classical mechanics, they are being used in successful theories like Quantum Mechanics and Einstein's theory of relativity. Quaternions are also extremely useful in modelling rotation in 3-D space and computer graphics.

The next number system is Octonions. John Graves discovered octonions in 1843. Although Octonions are not as popular as the other three number systems, researchers have begun to show their interest in this particular number system. Cohl Furey, a postdoctoral researcher at University of Cambridge, has done prominent work in this field. She believes that Octonions hold the key to fill the missing places in the Standard Model in particle physics and is constructing an octonionic model for both the strong and electromagnetic forces. Octonions are unexplored territory, but seeing their exceptional properties, many Mathematicians are taking deep interest in this field. Moreover, Fields Medallist and Abel Prize winner, Micheal Atiyah believes that the final theory describing the universe will be Octonionic.

When these numbers systems are created, a property or two are lost in the process. Along with that these number systems become more unfamiliar. Exploring these number systems gives us unique ways of looking at the universe and may be that is what we need to solve the Cosmic Puzzle.

-Palak Porwal

Pre Sc

CALCULATORS

Calculators play a very important role in our life. A calculator is a device that is programmed to be able to conduct mathematical/arithmetic calculations such as addition, multiplication, taking the square root, graphing etc. The first pocket calculator was made in December 1972 by Jack Kilby, Jerry Merryman and James Van Tassel. This calculator was HP-35. But as the technology is advancing who knows what will replace these tools? Scientists are working on making different types of calculators such as Garrett 2020, Calculator 2.0 etc., but what struck me the most was the Calculator 2.0 by Nikhil Kapoor. With a cool, modern, monochromatic look, the Calculator 2.0 looks good on any desk. The case is the opposite color of the calculator and when the case is on, just three keys of the calculator are visible. It has all the basic as well as new functions installed on it .One of the cool features of the Calculator 2.0 is the smart strip that is located under its display. It detects finger motions. This makes it really easy to delete a step with a swipe of your finger. The equal key is the opposite color of the main calculator. It is packaged inside a white box with three square cutouts that align perfectly with the 2, 0 and the decimal key. This itself becomes the branding for the box containing the Calculator "2.0". In the future with the advancement of mathematics we will definitely see more exciting calculators in the market which would help the human race in solving further problems.

-Manya Ohri

BII

FROM BOOKS TO BUILDINGS

Math is all around us. It's almost impossible to think of something that's made without the help of mathematics. Buildings, transport, technology, medicine and even clothes; all rely on number measurements and sums. From simple shelters to futuristic cities, buildings, and structures math is everywhere. In simple words, it is essential to our existence. Math makes mind-blowing structures possible. Life would be different without its theorems and laws; bridges would collapse, skyscrapers wouldn't exist and buildings would be wonky and unsafe. In fact, we might still be living in caves!

Architecture and mathematics have always been closely knit. Studies show how early civilizations constructed buildings using mathematical calculations. As civilization and mathematics advanced, architects used more complicated math to master design and structure. For example, in medieval times when architects wanted to construct taller buildings, they relied on math to calculate shapes precisely which supported the weight of high walls. We can also see these forms in arches that distribute force evenly through key points in buildings just like a spider's web and relates to the modern day bridges.

Gravity is one of the main challenges in architecture that math helps to solve. Take a sky scraper for example, such a strong building needs a strong foundation. The lower storeys of a building are constructed of heavier materials than the upper floors so the building would not collapse. Math also helps architects to design buildings that will withstand strong forces like aggressive winds and earthquakes.

Mathematical principles supporting architecture has remained the same for centuries proving yet again that math is all around us.

-Vaanya Singh
Pre Sc

INFINITY'2019

On the 11th and 12th of January, Gaurika Bindal, Ananya Agrawal, and Vartika Khaitan escorted by Mr. Vishal Rawat, attended the Infinity Math Competition at Aditya Birla World Academy, Mumbai. There were 32 teams from South-East Asia that participated in the competition. In total there were 4 rounds followed by a Quizzitch.

The event begun with a talk from prestigious mathematician, Dr. James Tanton, who gave insights to the simple yet marvelous world of mathematics. He gave us a dozen proofs why 1=2, but don't mess up your math because they were all proven wrong over time!

The first round was an individual round followed by a team event. These rounds challenged our logical and higher order thinking abilities.

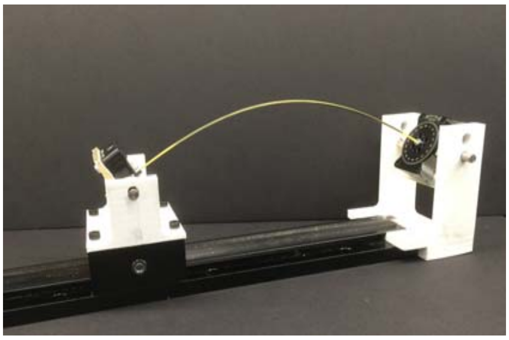
The next round was a team event called "Bulb Your Idea", a poster making round. It required us to display a perfect blend of our creativity, sense of humor and reasoning. One of the tasks required us to form a question whose answer was supposed to be a square palindromic number. Where on one side most of us were busy formulating complex questions, there was a team which used their sense of humor to form a simple question which won the hearts of the audience. The question they framed was, "Which square number will not be found on a plate?" The most challenging as well as exciting round was the 'Pass the Baton' round where we solved 3 questions in 5-8 minutes. This round required immense trust amongst all the team-mates.

The competition as a whole taught us time management, working under pressure and changed our outlook towards mathematics. It gave us the hope that even the hardest problem has a solution.

-Ananya Agarwal,Vartika Khaitan
& Gaurika Bindal

SOLUTION TO AN AGE-OLD MYSTERY

Have you ever tried breaking a dry piece of pasta into half? If you have, then you might have noticed how it never breaks into two, but three or four fractures, or maybe even ten at times.
Why does this happen? This is a mystery many knowledgeable minds have tried to solve, but in vain.
The first one to try this was Robert Kircchoff in 1850; however, he did not have the necessary equipment for this research at the time, though he did develop an equation for the experiment.
Now, it has finally been explained by French physicists Basile Audoly and Sébastien Neukirch from the Laboratoire de Modélisation en Mécanique at the University of Paris. After observing the spaghetti at quarter of a million frames per second, they noticed that when one held a piece of spaghetti at both ends and started to bend it, one was actually increasing its curvature. Once the curvature becomes too much for the piece of spaghetti, it will snap at the weakest point. This initial snap will send waves through the two halves, causing them to sway back and forth. Intuitively, you may think that these waves gradually peter out, so that the two halves eventually come to rest in a straight position. But, according to Audoly and Neukirch, the exact opposite happens.



To model the breaking spaghetti, they used the differential equation that was developed by Robert Kirchhoff in 1850. On solving it they found out that the curvature instead of decreasing, actually increased in some parts of the two halves, causing further breakages. These snaps in the spaghetti in turn sent out their own waves, starting a chain reaction that led to a whole avalanche of breakages.
This experiment might not seem significant, but it is very widely used around us, for example in very long and thin poles used to hold up heavier structures, such as dams and skyscrapers. Many future disasters may well be prevented by pasta!

-Naina Rastogi
Pre Sc

ANCIENT YOGA ASANAS

Many people around the world apprehended yoga as just a form of physical exercise like aerobics. But there are plenty of things that yoga has taught us, including mathematics and art. You would probably be thinking that I am blowing little ducks but I am not. Yoga was first developed in the Indus Valley Civilization and the word 'YOGA' was mentioned in Rig Veda. By this time some mathematical topics had already been discovered and studied by the Mesopotamian and Egyptian civilization such as arithmetic and algebra for purposes of taxation, commerce, trade and also in the field of astronomy and to formulate calendars and record time. There was a great contribution of mathematics in the formation of yoga. There are many mathematical values which came from yoga asanas like corresponding angles in sunbird pose, alternate angles from table pose, co-interior angle in low-warrior pose, opposite angles in side plank pose, even a right angle in just a seated meditation pose. Almost all the angles in mathematics are the contribution of Patanjali – the father of ancient yoga. So now angles can't only be learned with a protractor and a scale but also in a fun way- Yoga. Yoga doesn't only teach us angles but also triangles through yoga by the asana-Tree Pose. Now-a-days practicing math is also treated as mental yoga to keep our brain sharp and quick.

-Shambhavi Chandra
BII

WAS MATH INVENTED OR DISCOVERED?

People often mistake discoveries for inventions. While discoveries recognize the unraveling of any phenomena or item, inventions are innovations often crafted by man. When Newton saw an apple drop from an apple tree he had an epiphany. That epiphany was the concept of gravity. Even though no one before Newton had ever thought of gravity, it had always existed and had always made apples drop from trees. Newton "discovered" and put a name to the phenomenon; he did not "invent" gravity.

Math always existed in nature. For example, a hunter always knew that killing 30 deer would provide him with more food than rather killing 20 deer. He ,however, may not be a beautiful mind like John Nash; this tells us that math and number sense is innate in mankind but Pythagoras was the one who uncovered the mystery and is hailed as our very first mathematician.

Philosophers ,at least, as far back as Pythagoras have been asking themselves this question- "Does math exist in nature or is it just a human assumption?" For his part, Pythagoras thought that everything was pure number. Ever since then, most thinkers have had a somewhat less extremist view of it.

To make matters even more convoluted, the entire universe can be explained as math. It gets even better – leading physicists have shown that 4 mathematical equations can explain almost every process in the universe. Therefore, some philosophers argue that if the universe was not invented, it is incorrect to believe that math was invented for it seems to be perennial as the universe. Perhaps, it is the innate eccentricity of mankind to take credit for whatever we can get our hands on which led us to believe that math was invented by one of our own kind. Perhaps it was one of your ancestors who invented or discovered math (whatever you'd like to believe) but while the debate rages on our stances might change but the pivotal role that math plays in our life will never change.

-Paridhi Saboo
BII

MATH IN CRIME

Many would call Trishneet Arora a criminal but he is actually a professional ethical hacker. He neither has a great degree nor an ultimate score in 12th standard. In fact he was an eighth standard school dropout. But the reality behind the curtains is that he spent all his time in learning the probability and the statistics of maths in crime. In one his interviews he mentioned how he uses the useful and the essential methods of coding and decoding to solve crimes.

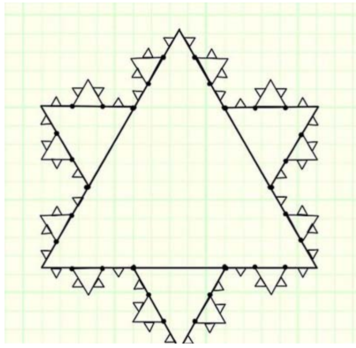
In banks, lockers and in other safety requiring places we hardly use lock and key any more. We use number codes, finger prints and patterns. It's just like a child's play to hack all these security codes. Math is just like a back bone to all this. Math, therefore, plays an important role to get the suspect to justice. There are numerous of ways of finding and solving a crime. If there was a crime at a jewellers shop and jewellery was robbed with two murder cases then science can tell us only about the blood on the carpet and the weapons used . But, maths can tell us an exact equation. The number of people can be x and footsteps can be traced. With the help of CCTV footage and the blood patterns this equation can be solved with accuracy. Maths can be used in a very efficient way in solving crimes. Probability is another part of maths which tells us about the rate of terrorist and criminals in a particular region. This can help the investigators in finding the most threatening criminal group. Maths is just so different and unique. It solves all problems. So open a maths book, peep into it, it might just help you to solve a crime case.

-Tejaswani Gupta
BI

THE KOCH SNOWFLAKE

There's nothing better than the first snowfall of winter. Fluffy white flakes slowly drift down to cover your hair and clothes in their crystalline patterns. Just like all of nature's most beautiful things, we can describe the beauty of snow with a little bit of math!

The Koch snowflake is just one of the more fascinating things from nature. In 1611 Johannes Kepler published a short report on the Six-Cornered Snowflake, which was the first scientific reference to snow crystals or snowflakes.



The Koch snowflake or Koch star demonstrates infinity, one of the most intriguing and misunderstood concepts of maths. Created by Swedish mathematician Niels Fabian Helge von Koch, it all begins with the development of the Koch Curve. The Koch Curve starts with a straight line that is divided into three equal parts. An equilateral triangle is then created, using the middle section of the line as its base. Each side of the triangle is then further broken up into four parts, only to form another triangle with its base removed. These steps are applied again and again to each flat side of the equilateral triangles formed indefinite number of times, creating a "snowflake" shape.

For every time the step is repeated, one side of the figure from the previous stage becomes four sides in the following stage. Since we begin with three sides, the formula for the number of sides in the Koch Snowflake after 'a' number of alterations is:

$$n=3*4^a$$

For iterations 0, 1, 2 and 3, the number of sides are 3, 12, 48 and 192, respectively.

Winter snowflakes form in a wide variety of intricate shapes and no two are alike. Although possible, it is very unlikely for any two randomly selected snowflakes to appear exactly alike due to the many changes in temperature and humidity the crystal experiences during its fall to earth. Unlike that the Koch Snowflake is an example of a figure that is self-similar, meaning that if we continue to magnify the Koch Snowflake, each magnified section continues to look similar to the larger.

-Manvi Gupta
Pre Sc

MATHEMATICS IN FASHION DESIGNING

Math is an important element of fashion designing. It is used to measure sample garments for fitting as a well as to keep sizes constant. Fashion designers use mathematics in measurements, angles, patterns, proportions, geometry, etc… Measurement is an important part of fashion. They need to measure the amount of fabric and what size the clothing is. Without measurement, the clothes you wear today would not fit you correctly and designs would not be as neat and comfortable. Fashion designers use patterns in their day to day life. Patterns make your clothes look more beautiful and attractive. Angles are also necessary in fashion. Designers use angles for things like neck line. With angles they can make clothes fit right on the person. Proportions are very important in the designing of clothes. People have different proportion and sizes. To find the proportions of people you need to measure the clothes and the size of the person. Geometry is needed the most when designers make a two-dimensional pattern that has to be designed to fit on a three-dimensional body. Fashion designers use their creativity to create variety of clothing. So next time when you wear your outfits do not forget to acknowledge the precision, geometry and proportion used behind the fabric.

-Gauri Rawat
BII

RANDOM TIDBITS

Pirate brings to you some interesting puzzles to solve!! Have fun!!

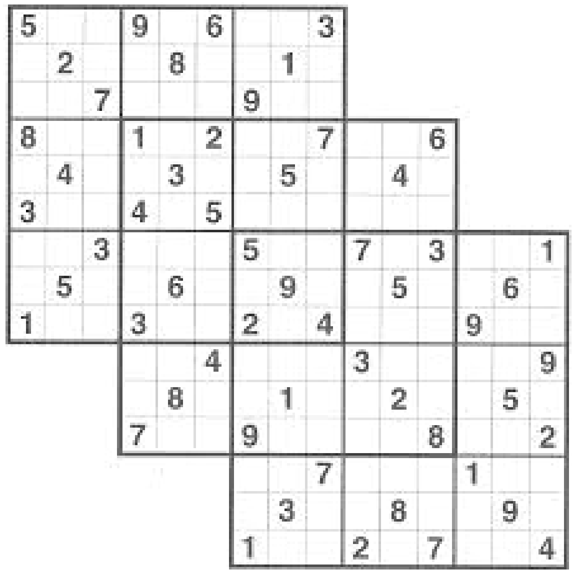
MAGIC SQUARE

The sum of every row, column and diagonal must be the same!

18				
9			3	11
	13			
21		2	15	8
		23	16	4

MULTI-SUDOKU

Place numbers in the grids such that each row, column and 3x3 box contain the numbers 1 to 9. The numbers placed in the overlapped region(s) should satisfy all the given sudokus grids.



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