WHAT'S INSIDE THIS ISSUE:

Credits: Dr. Khushboo Bussi

Mining of Bitcoin

WRITTEN BY AYUSHI TRIVEDI & DIVYANSHI CHAUDHARY

Digitalisation is the integration of digital methods in everyday life. It is also taking over on finance, in particular the monetary policies. The hard cash is getting replaced by virtual money, marking the beginning of virtual currencies. Cryptography is the backbone of such currencies, hence these are called 'Cryptocurrencies'. Ripple, Lite coin (LTC), Zcash, Bitcoin are few such cryptocurrencies used worldwide. In this article, we will try to shed some light on bitcoin, one of the most popular cryptocurrencies.

HOW BITCOIN WORKS: Bitcoin is based on a new technology called 'Blockchain' which is a revolutionary step in the era of information security. A blockchain is a decentralised network of computers which processes and collectively manages the record of all the digital transactions, operated through a computer or digital protocol. Bitcoin is actually analogous to gold, since its total amount 21 million coins is fixed. Also, the procedure of obtaining the bitcoin is called digital mining analogous to gold mining. Bitcoin mining is done for two purposes- One, for the generation of new bitcoins and the other for facilitation of transaction in the network. Bitcoin mining is the process of adding blocks of all the transactions to blockchain. Every bitcoin user needs to have a bitcoin wallet which is associated with its bitcoin address or digital address- which is nothing but an alphanumeric string that doesn't contain any personal information of the user. So, the user is anonymous here and only known thing is this digital address. The mining requires a mining program or software which uses computer to perform some complex mathematics. The procedure through which these mathematical problems are solved is called hashing. Once a miner succeeds in solving the problem and validating a transaction, he gets a "block reward"- a certain number of bitcoins which get halved every 4 years. Cryptographic hash functions play an important role here- it takes an input of arbitrary length and gives an output of fixed length. The ultimate goal of a miner is to keep feeding the different hash input until it gets a specific hash output. This hit and trial method is associated with difficulty of network which is called proof-of-work. If the network is quite strong, then the difficulty to find a valid hash would be less and vice versa. Now, as the bitcoin is getting popular, more and more miners have joined the network and competition for validating the transaction and getting rewarded has hiked up. Almost 17 million bitcoins have already been mined out of the 21 million. As the number is going low, the competition for generating new bitcoin is getting high. That is the reason proof-of-work and generating new bitcoin are getting really tough and needs huge computations and efficient hardware systems.

UNIQUE FEATURES OF BITCOIN: *Irreversible*: Digital currencies have a special characteristic of irreversible payments i.e once payment is made it can not be reversed under any circumstances, being a part of block chain mechanism. *Inexpensive*: Bitcoin is cheap since it broadcasts a valid transaction at the most in 10 minutes time which is quite fast. *Secure identity of the user*: In using bitcoin, there is no way to find the identity of the user. *Prevents double spending*: The major problem of digital currency is the assurance that it has not been spent twice. Due to virtual nature of cryptocurrency we need to have a check that the same bitcoin should not be paid to two or more vendors, that can occur only in virtual currency. *Peer to peer network:* Cryptocurrencies are usually decentralised in nature i.e there is no intermediary to manage its transactions that allows everyone to use it without the interference of third party. Bitcoin is still in the under progress state. It needs to be incorporated by many other softwares for better performance. This article was a mere attempt to understand bitcoin in layman's language.

The Department News

REPORTS BY NAMRATA VERMA AND SIMRAN GOYAL

TEACHERS' DAY

The Mathematics Society of students, Gradient, celebrated teachers' day with great zeal and enthusiasm on September 5th. The department was buzzing with energy and liveliness that day. Plethora of activities were planned for the teachers- including games and some delightful dance and music performances. Short poems and speeches were dedicated to the teachers. Students also presented the teachers with beautiful titles. Some teachers shared their experiences and encouraged students who wish to get into the noble profession of teaching. The event wrapped up with the cutting of a cake to embark the sincerest efforts of the teachers in playing a catalytic role in the development of every student.

AVGAAHAN

Avgaahan is an annual interdisciplinary academic fest organised by Maitreyi College during January – February. It is a unique attempt undertaken by all departments of the college to include 'technology' as a medium to interact and involve with students across the country. This year we had two online rounds for each department. The mathematics department conducted the Mathology quiz, witnessing a participation of around 400 students across the nation. Depending on the scores from the preliminary round, students were then shortlisted for the final round. The competition was open to all undergraduate students, providing them a chance to win attractive cash prizes.

FAREWELL TO MRS. ELIZABETH MICHAEL

The day was mellow but the air was rich with an emotional wave as the farewell for our beloved teacher- Mrs. Elizabeth Michael was organised on 13th of November, 2019. All the students of the department showed their affection for ma'am in different ways. While some students devoted beautiful speeches, poems and cultural performances, others prepared a slide show embracing their beautiful memories with her and gifting her with heart touching souvenirs. Some students presented her with hand-made cards and articles which was followed by a cake-cutting ceremony as a gesture of love and good luck for her future. The event ended by lovely speeches from the teachers and a lunch organised on behalf of the department. It was a day of which the memories still live in our hearts.

EDUCATIONAL TRIP

It is often said ethereal connections always have a calming and a soothing effect on one's soul. In September 2019, an excursion to ISKCON temple, Noida, was planned by the department. As the students and teachers entered the well known Krishna temple, they were spiritually enlightened by the view of the deities. They savoured the delicious Prasad and proceeded for the chants of a few mantras which are believed to instigate peace in one's life. This visit was followed by a visit to the botanical gardens in Noida. The gardens had a vast variety of flora; beautifying the atmosphere and pleasing the eyes of any visitor. These visits were an apt example of learning beyond the classrooms.

MOVIE SCREENING

"X+Y: A brilliant young mind", was screened on the 27th of August, 2019 to the students of mathematics department. The film revolved around a brilliant math prodigy, Nathan, played by Asa Butterfield, capturing the moments of how it is like to live with autism. He sees the world in a different way; patterns and numbers are what interest him the most. He is seen to be preparing for the International Mathematics Olympiad, tutored by his rather anarchic teacher, Martin.

The second half of the film mostly portrayed how he is able to uplift himself socially while he is at a two-week long math camp at Taiwan. Even though his social anxieties kept surfacing, he fought through his fears. While he is taking the final Olympiad with the best minds his age, he is triggered with the memories of his father and his new connections. He is finally able to connect to the people around him, including his mom, who he had shunned any physical contact with since the very beginning. And it was a win.


TALK BY DR. ASHISH PANDEY

A very engaging and informative talk session was organised by the department on the topic 'Applications of mathematics in the real world' on 17th September, 2019. It was attended by the undergraduate students having maths as a subject of study.

Dr. Ashish Kumar Pandey, an alumnus of NISER and current assistant professor at IIIT Delhi, was invited as the guest speaker for the day. He started off by telling about women in math association of his institute and encouraged the audience to come forward and participate in the live projects at IIIT-Delhi and other summer internships. He made an engaging presentation about the developments in science which required a major contribution of Mathematics. He talked about X-Ray scans, credit card security and went on to explain the Page Rank algorithm involved in Google search engine in sorting the most relevant pages related to a search.

He also discussed about black holes, dark matter and was especially enthusiastic to state that it was a woman who made it possible to get the first pictures of black hole and contributed to further research in this field of study. Towards the end, he briefed us about one of the projects he is involved in: Instability in water waves and also his project with the NICU (Neonatal Intensive Care Unit) which makes efforts for saving lives of new born children by using existing survival/mortality data to predict the chances of survival of the new borns. Throughout the talk, he motivated the students to apply the mathematical tools known to them to participate in projects that are taken up by various institutions. He concluded by saying- "If a person knows math, then there are no limits!"
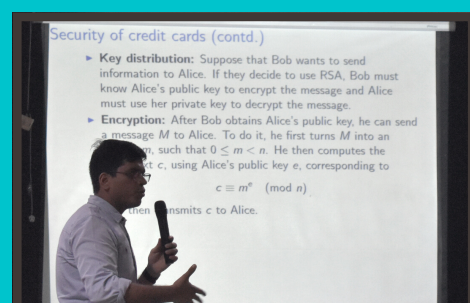
ABSCISSA

On 27th February 2020, Gradient, the Mathematics Society of Maitreyi College, organised its Annual Departmental Fest-**Abscissa**. The fest was inaugurated with the lightning of the lamp by the honourable principal of the college, Dr. Haritma Chopra.

Many engrossing and gripping events were planned for the day. While events like **Luck By Chance** and **Bidding of Thrones** were a treat to the brain, Cody Cross and Just A Minute tested the vernacular. The former two were based on basic mathematical questions yet were a challenge to the best of minds. **Cody Cross** was a game based on grid puzzle using mathematical terminology to find all words engraved in it. **Just A Minute** was a simple and an intelligible idea of the extempore competitions.

Some convivial events like Erase your E-waste and **Stand-up comedy** were organised too. A robot structure made from a damaged Wi-Fi box, old earphones, charger and torn off data cables was awarded the winner in the **E-waste competition**. A mob dance by the terpsichorean-troop of students from the department was also staged on the day of the fest.

A number of filler events such as Blind man's Bluff, Wrong to the Right, Buzz Wire, Dominoes and Spin the Wheel were arranged by the students from second year. The day ended with the ultimate **Fandom Relay**, a three- round event based on famous tv shows and movie franchises.

Winners from all the events were awarded with exciting cash prizes and certificates. The participation was in great numbers and all the events hosted were conducted really well. In all, the fest was a great success.

MATH MUSE

How is mathematics related to poetry?

BY AWANYA DABAS

Nature has everything in plenty,
But Ah! The poets choose figures and geometry?
You bet they.

April as they say,
Is the month of Poetry day;
But as we say,
Is the month of mathematics and statistics awareness and that's certainly the other way!

Both require economy and precision,
Verily, to have the best vision.
Each perspective do enhance each other,
The way each makes the decision.

Inspiring the wordsmith,
Are the figures and the patterns,
Gladly do they define,
The shape of the globe, the galaxy and the saturn.

Both conveyed several meanings the other day
Poetry and Mathematics intersect,
that is the verse's say.

गणित एक विचार

-सुश्री मोनिका मीणा
मैत्रेयी पूर्व छात्रा

गणित की है महिमा न्यारी, अंको में ही हो जाये भारी ।
गणित का है अजब बखान कैसे बताऊँ मित्र सुजान ।
सांख्यिकी का मानक विचलन, प्रायिकता सिद्धांत का ज्ञान ।
त्रिकोणमिति है बतलाती उन्नयन, अवनयन कोण का मान ।

अवकलनीयता है कराती सांतत्यता की पहचान ।
समूह का जो है ज्ञान, कराता सहकारिता, सहचारिता का मान ।
सदिशों का सदिश, अदिश गुणनफल कराता है, सदिश को दिशा प्रदान । सम्बन्ध हमे यह सिखलाता कैसे है फलन बनता ।

द्विआधारी यह सिखलाती, कैसे हैं संक्रियाएँ आतीं ।
बाइनरी है सबकी प्यारी, दो अंको की कहानी सारी ।
समान्तर, गुणान्तर श्रेणी कहलाती, ज्यामिति भी निर्देशांक बताती।

पाइथागोरस है बतलाती, आधार, लम्ब से आता कर्ण ।
सम्मिश्र संख्या का मापांक व कोणांक कराता, सम्मिश्र संख्या का ध्रुवीय निकपण ।फलनों का तुल्यता सम्बन्ध, आव्यूह का रूपांतरण ।
वास्तविकी है कराती, पूरे गणित का है विश्लेषण ।

गणित हमे ये सिखलाती जीवन है एक सकारात्मक विचार ।
सीमा हमे यह सिखलाती, जीवन में हो कुछ परिसीमा ।
चरवातांकी है बतलाता, स्वयं से ही है संसार ।
गणित है बतलाता, सांतत्य है जीवन का आधार ।

The Achievers Fragment

Alumni Talks

Our student alumni, **Yashaswini Singh**, currently pursuing Masters in Applied Operational Research, writes about the roller coaster ride her college life has been. Here's what she says-

"Mathematics has been my favorite subject since the time I was in school. After my 10+2, I pursued my passion for mathematics as my subject for graduate studies. I feel extremely grateful to complete my graduation from one of the prestigious colleges of Delhi University.

My journey at Maitreyi College had been an amazing one- the one I'll cherish forever. The environment is so calm and tranquil, it welcomes you to step into the beauty of peace the college brings with itself. We had faculty members who are the best support systems we could ask for. They are not just great teachers, but great mentors too. Even though they used to put up with so much during their workday, I have always been appreciative of how they have always been there for us. They taught us with such enthusiasm that one would not want to miss even a single lecture; and that would be true on any given day. Then there were monthly activities they conducted- like the science workshops and screening of sci-fi movies so we don't get bored of the daily schedules. Also could never forget the fun and adventure our annual educational trips were.

One of the major moments of my college life was being elected as the president of my department. That position helped me to become what I am today, to hone my leadership and social skills. From conducting something as simple as the seminars to planning our annual fest, there's a lot I learned throughout. It helped me come out of my comfort zone and made me a more responsible person. It had been an experience of a lifetime.

In all, Maitreyi College has given me the love, lessons and memories which will stay with me forever."

AWARDS AND ACHIEVEMENTS

LOVELY SACHDEVA

An asset to the department then, Lovely Sachdeva has always had a dream of joining the forces. She talked about how privileged she feels to having come a step closer to her dream. She has cleared the Airforce Common Admission Test (AFCAT) and went on for Service Selection Board (SSB). She also got recommended for the flying and the administration branch in The Indian Air Force. She's a laudable example of determination and passion combined.

NANDINI UPADHYAY

Our student from 3rd year, Nandini Upadhyay, stood 1st in the Mathematics Deparment and received a scholarship of ₹10,000 from DU in the year 2019 alongside her internship at Helpage India.

BHUMIKA SHARMA

The nightingale from 3rd year, Bhumika Sharma has won the 1st prize in many cultural fests like Nexus, Synapse, Hamsadhani and other classical choir competitions in the year 2019. She's also cleared a paper from the IFoA.

SHOAIBA KHAN

An exemplary Campus Ambassador in more than three companies, Shoaiba Khan has served as the Vice-President in the Placement Cell of the college. She's also been nominated for the Karamveer awards instituted by ICONGO and the US.

VANI PANT

A former active participant at the School Games Federation of India, Vani Pant- our 1st year student, has secured the 3rd position at All India Football Federation and the Prime Minister's Cup.

Courtesy: Akanksha Mishra

LIFE AND WORK OF MATHEMAGICIAN

Srinivasa Ramanujan

Srinivasa Iyengar Ramanujan is one of the greatest Indian mathematicians in the history of India. He was born on 22nd December, 1887. Although he received almost no formal training in pure mathematics, he offered substantial contribution in mathematical analysis, number theory, infinite and continued fraction including the solution to mathematical problems then considered unsolved. He died at a young age of 32 on 26th April, 1920.

He was born in a small village in the southern part of the country. After a short span of time, he along with his family moved to Kumbakonam, where his father served as a clerk in a cloth shop. He attended the local grammar school there. He demonstrated a strong affinity towards mathematics at a very tender age.

At the age of 15, an outdated book called 'A Synopsis Of Elementary Results In Pure And Applied Mathematics' gave him a chance to glorify his talent- resulting in a new theorem of his own. He was rewarded for this with a scholarship from the government of Kumbakonam.

However, his greatest asset proved to be his Achilles heel. He lost his degree to both the Government College and later to the University of Madras as his devotion towards math let his other course fall by the wall side.

Despite of all the setbacks, he continued his work and in 1911, published a 17 page article on The Bernoulli Number in the 'Journal of The Indian Mathematical Society'. In 1912, he was able to serve at a low level clerical post. Gradually, he began working at The Madras Port Trust and came to be recognized as a gifted mathematician.

G.H. Hardy, an English mathematician at the University of Cambridge, England, recognized Ramanujan's work as exceptional and offered him to come to England. There he got a formal education in mathematics and became one of the youngest Fellow of The Royal Society and the first Indian to be elected as a Fellow of Trinity College, Cambridge.

While working in Madras, Ramanujan recorded bulks of his results in loose leaf-papers as he was quite likely influenced by the style of G.S. Carr's book, which stated results without proofs. Ramanujan was also known as "The Live Conjecture Machine" who pulls formula out of thin air as if received from a higher being, as if from a dream.

Based on his work, researchers from the Israel Institute of Technology have sought to replicate this approach using computing power. They have built a device named as the 'Ramanujan Machine' which automatically generates conjectures. A research paper has been written and a web page too is open for contribution to its computer process cycle.

In most computer programs, when we input a problem, we expect the algorithm to come up with a solution, but the Ramanujan Machine does the opposite. If we input a constant in the program, say Pi, the algorithm outputs an equation which would involve an infinite series that is exactly equal to the constant Pi.

The Ramanujan machine is more of a concept than an actual machine- it exists as a network of computers running algorithms dedicated to finding conjectures about fundamental constants in the form of continued fractions. The purpose of the machine is to come up with conjectures (in the form of mathematical formulas) that humans can analyze, and hopefully prove to be true in a mathematical sense. This idea of unveiling mathematical structures out of numerical data reverses the conventional approach of sequential logic in formal proof and is providing leads to new research in this area.

WRITTEN BY SALONI GARG, SHUBHANGI SINGH
AND SUNIDHI CHADHA
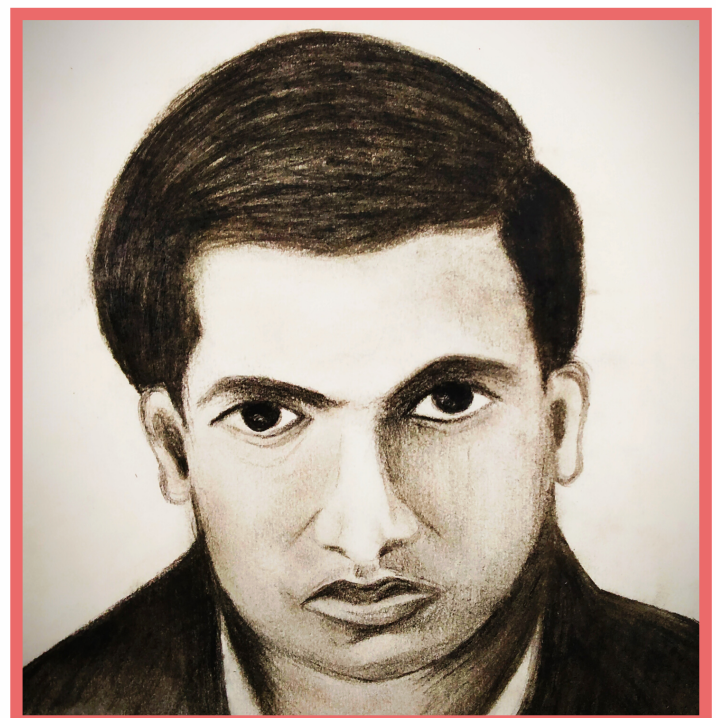
In his notebooks, Ramanujan wrote down 17 ways to represent 1/pi as an infinite series.

Portrait by Saloni Garg

THE MIND LAB

ACROSS

1. A point where a curve changes from increasing to decreasing.

2. The point of intersection of coordinate axes or planes.

3. A special number which does not change the other number with which it is multiplied.

4. Made up of two curves that are like infinite bows.

5. A statement that puts a balance on its left and right hand sides.

6. Rays extending in same direction, never converging or diverging.
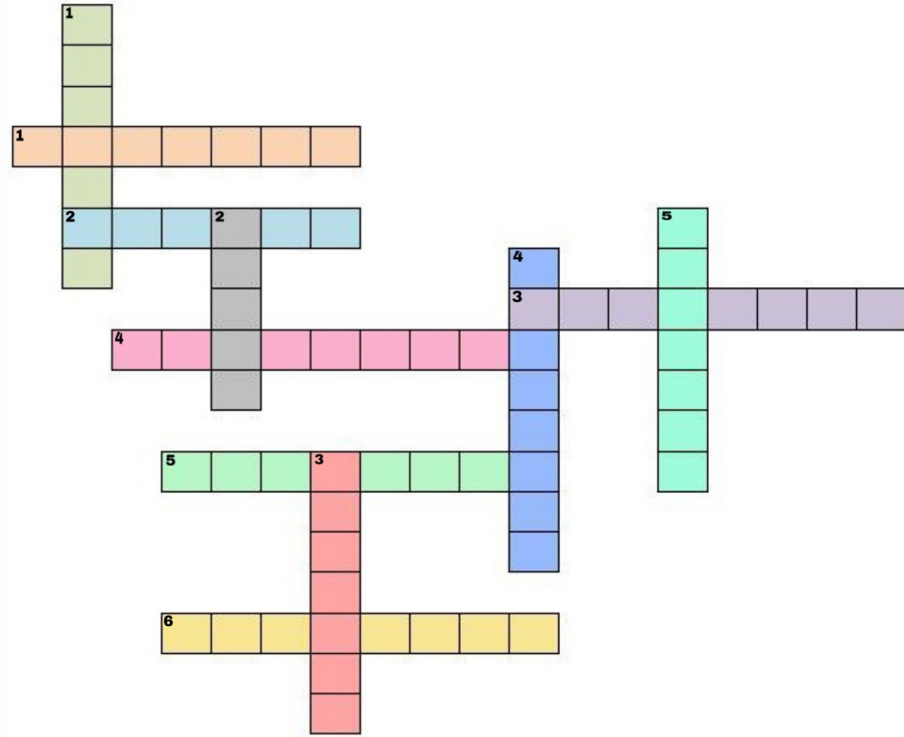
DOWN

1. A polygon with eight vertices.

2. A drawing depicting the relation between certain sets of numbers by means of series of lines or dots.

3. What is sum divided by the count called?

4. A line that connects two non-adjacent vertices of a polygon.

5. A line or plane touching, but not intersecting, a curve or curved surface.

Two trailblazers of Probability and Dynamics- Hillel Furstenberg and Gregory Margulis were jointly awarded the 2020 Abel Prize.

Multiplication Kakuro Puzzle

1. Numbers should be between 1 to 9.

2. No number should be repeated in any row or column.

3. Numbers in the upper triangle correspond to the product of numbers in that row and ones in the lower triangle to the product of numbers in respective column.

Kakuro grid clues: 63, 2, 3, 14, 504, 144, 432, 32, 27, 8, 42, 72, 2, 27, 144, 36

Crossword answers

Across: 1.Maximum 2.Origin 3.Identity 4.Hyperbola 5.Equation 6.Parallel
Down: 1. Octagon 2.Graph 3.Average 4.Diagonal 5.Tangent

Designed by Bhumika Sharma and Simran Goyal

A Beautiful Mind: A Movie Review

WRITTEN BY PEARL KHURANA

"People look to the order of numbers when the world falls apart."

A Beautiful Mind directed by Ron Howard and starring Russell Crowe is a biographical film based on the life of mathematician John Nash. John Forbes Nash Jr. was a Nobel Prize laureate and has been credited for his work in game theory, differential geometry and the study of partial differential equations. It's an inspiring account of a mathematician, in a quest for meaningful things and his battle with schizophrenia. This Academy award-winner of 2001 was adapted from the book by Sylvie Nasar.

The story begins with his time as a graduate student at Princeton. He has Charles Herman, a literature student, as his roommate. A firm believer that classes kill one's imagination and insistent about only publishing an original idea, he works on the concept of governing dynamics. On successfully publishing his paper, he is accepted at MIT as a tenured professor. Due to his extraordinary ability to crack ciphers just by looking at them, he is also approached to work on a classified project for the Department of Defence. No sooner had he begun working on it, his paranoid schizophrenia worsened. The narrative further tells the impact of his conditions on the people around him, especially his wife Alicia.

The character of John Nash is beautifully written and portrayed. His sufferings are told not through sensationalistic but subtle traits throughout the movie. The plot is furthered by how he regained his position in the academic world. It was provoking in regard to his acknowledgment of his disease, his understanding of its impact on his family and his work. It was motivating to see him accept it and strive to re-establish the academic world. His mind, which served humanity a great deal, had betrayed him; it couldn't help him find a solution for a problem that rested there, which gives the movie its title. To quote another one of Nash's dialogue, " Perhaps, it is good to have a beautiful mind but an even greater gift is to discover a beautiful heart." As the character developed from an arrogant graduate student to a humble Nobel laureate, one notices that there is an innate goodness in his character which made everyone around him to support him.

The movie is recommendable to all the students who wish to make a mark in this world.

Mathematical Sorcery: A Book Review

WRITTEN BY PEARL KHURANA

'Mathematical Sorcery: Revealing the Secret of Numbers' is a recreational book of mathematics by Calvin C. Clawson.

Clawson is a mathematician and teacher of Mathematics at Seattle Community College. The introduction of the book is engaging for everyone as the author speaks about all the myths surrounding mathematics as a subject, and squashing them all through real-life examples. The further chapters require a basic knowledge of calculus and algebra but the author keeps the reader entertained and motivated to put the effort to study the topics. He narrates every concept by talking about its discovery and applications in the modern world. Right from early counting and the contributions of the Greeks, Sumerians, Babylonians and Egyptians to the discoveries made by various mathematicians in the field of mathematics, all are recorded in a simple yet absorbing narrative.
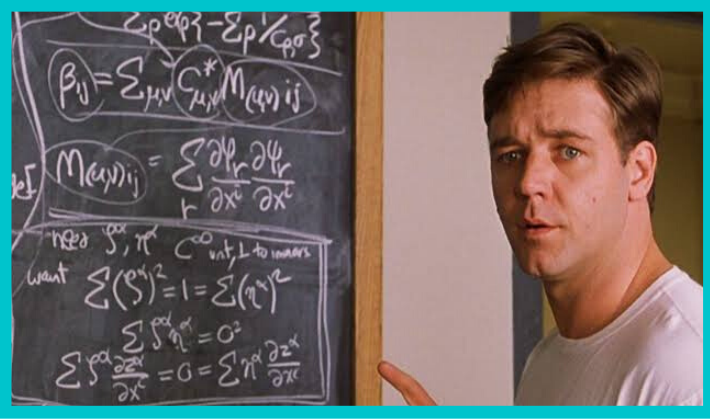
The book lays emphasis on the importance of geometry to understand calculus and encourages the reader to perceive these concepts through its help.

Every concept is steadily assembled by first discussing the need which leads to the discovery of the concept and is further explained in mathematical terms. The journey of mathematics begins at early counting, the number line, the concept of zero and infinity, furthered by axioms into the need for proofs and analytical geometry to explain the results. These components, in turn, enabled the mathematicians to explore the nature of sequences, series, and functions. The functions, which at first were drawn in 2D space through imagination and sketching, were visualized in 3D. Calculus of infinitesimal or simply calculus is the study of continuous change, thus composed of these concepts and is employed in various subjects including physics, astronomy, biology and other sciences.

The book teaches about the basic building blocks of the subject without divulging much into every topic or magnanimous proofs. The subsequent use of the knowledge being applied to real-life situations only strengthens one's belief in the practicality of the subject and the necessity of it in every phase of life. The author began the book by questioning if it's a simple complex subject that might vanish with the civilization or is it something much deeper which speaks as the universe and the humanity manifest. The reader slowly and steadily finds the answer which is gratifying to the mind.

As the author speaks in the introduction, that the subject like any other art might not be captivating to the eye or directly pleasing to the physical senses but it offers a deeper understanding. It is an enthralling amusement of the mind. In the words of the author, "To appreciate mathematics requires us to arouse our intellectual faculties, not our senses." The book is recommended to be picked by everyone who likes or dislikes mathematics.

The author of this review urges every person to atleast read the introduction of the book and be the further judge.

PICTURE PERFECT

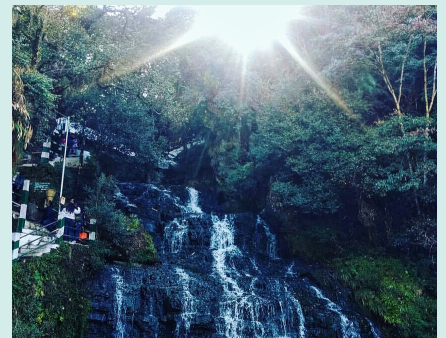BY SAACHI SINGH

BY RUCHI MALARA

BY RUCHI MALARA

BY SHAKSHI KAIM
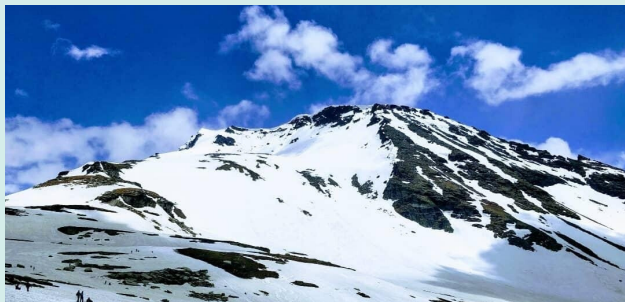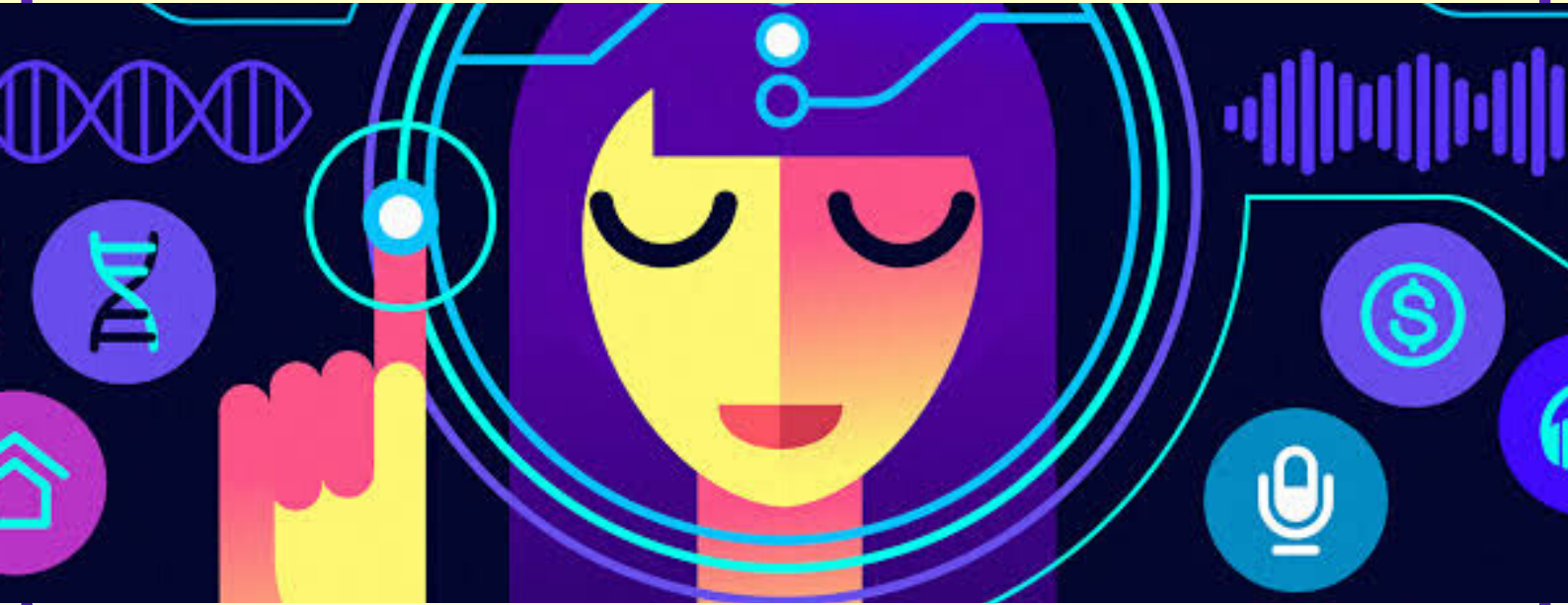
BY AASTHA SHEORAN

BY BHUMIKA SHARMA

BY AKANKSHA MISHRA

BY BHUMIKA SHARMA

BY SAACHI SINGH

GREAT MATH AND BEYOND

Math and Machine Learning

WRITTEN BY SAACHI SINGH

There's no magic that makes certainty out of uncertainty. But there lies a sorcery to identifying the dangerous risks or the profitable opportunities the future could hold; the sorcery we call Machine Learning- "a subset of Artificial Intelligence". What helps a bank combat frauds? Or the same bank knowing about their most valuable account holders? The answer lies in the subset of Artificial Intelligence we talked about above and the math behind it we talk about next.

Let us begin by taking a dataset, which we train to build a model. This data could be in the form of an object, a sequence, a vector or even a matrix- which are some of the key data structures in linear algebra. Clearly, the concepts of linear algebra like vector spaces, eigenvalues, matrix operations and LU decomposition are transparently used everywhere in machine learning; making it a building block to devise algorithms. Consider the linear regression model, which has been old in use to describe the relationships between variables, is solved via least squares optimisation which requires LU or singular-value decompositions. This model could be used in analysing the sales of a product by generating insights on customer behaviour and therefore asses the risks and factors influencing the profitability of a company.

Additionally, topics like gradient descent and partial derivatives from multivariate calculus too form a structural part of machine learning. They are fed into numerical optimisation algorithms and are of significant use while working on variational inference and related techniques. Portfolio optimisation, i.e. how to choose the best stocks by gauging projected and current profitability from a company's cash flows or credit card companies setting minimum payments due on credit card statements is a real world example relating to these techniques.

Moving further, real and complex analysis are used in studying algorithms, particularly topologically-based algorithms and are essential while designing principles within machine learning research. For instance, in deriving theorems regarding the working of an algorithm and how long it can take to converge, or analysing if the data is enough, we need concepts from real analysis. Some procedures like optimal estimation and filtration problems are even dealt with on complex planes. They are also used in studying the limit behaviours for extreme sample sizes, that is, data samples which are very small or very large.

Talking of samples, another major intersection of the field of machine learning is with probability theory and statistics. Probability deals with predicting the likelihood of future events, like in weather forecasts or assessing future risks before signing insurance contracts. Statistics pertains to the collection, analysis and interpretation of data in account. When a population to be surveyed is too large, random samples are drawn and studied. Inferential techniques like estimation and hypothesis testing are then used to extract meaningful deductions about the population under scrutiny. These branches, along with the algorithms generated using the concepts in dialogue, are used to discover hidden insights from data and draw inferences to build 'intelligent' applications. This is spot on what Machine Learning is about: to create an algorithm that learns for itself and becomes more accurate in its predictions without being explicitly programmed to do so.

What makes machine learning different from conventional programming is that the latter uses software engineering as a tool to feed the system with rules for a defined data to generate answers to a problem. Machine learning, on the other hand, uses data and answers to discover the rules behind a problem. It comes into play when it is infeasible to comprehend a definite solution and hence uses a trained model to provide an output without actually calculating the result. The recommender systems are a great application of machine learning. They encompass algorithms which rank items in terms of their "relevancy" to a user.

Ever thought how your Netflix recommendations are on point? Netflix uses image thumbnails as a bunch of unstructured data. The system assigns metadata to each thumbnail with numerical representations to describe what's in that thumbnail. These representations are then plotted in the form of vectors. Netflix starts building spatial relationships between these data points- those relatively near to each other representing similar consumer interests- thus turning unstructured data into mathematical representations to make thumbnail predictions. So the next time a Netflix recommendation pops up or Google suggests a news article for you, know that the "magic" of an application being intuitive enough to perceive your interests lies in the math. The magic lies in Machine Learning.

Machine Learning can only discover correlations, not casual relationships.

Mathematics behind Black Holes

WRITTEN BY ANMOLDEEP AND GARGI KANSAL

"These black holes are so mathematical, there's nothing more to them than mathematics." Richard Henry, an astronomer at Johns Hopkins University, once said. Black holes are the ultimate believers in privacy: they let no information about themselves escape into space. Rather than searching with their eyes, however, scientists have found a way to peer inside black holes using math.

What are Black Holes?: A normal star has a lifetime of over billions of years. It supports itself against its own gravity created due to thermal pressure from nuclear processes which convert hydrogen into helium. Eventually, the star exhausts its nuclear fuel and contracts. In some cases, it exists as a white dwarf star; the maximum mass of it being about 1.4 times that of Sun. The stars having mass much greater than the maximum mass of dwarf stars would contract to a single point of infinite density called singularity. All singularities are formed by collapsing of stars or any other non-rotating neutral body. A body that fits the mass of several suns inside a region, not larger than proton, has such an intense gravity that even light could not escape from it. This body is what we call a black hole. In 1967, John Wheeler introduced this term to replace the earlier name- 'frozen star'.

A black hole has a boundary called the event horizon, where gravity is strong enough to drag light into it and not let it escape. The radius defining the event horizon is called the Schwarzschild radius, given by:

$$R = 2GM/c^2$$

where G is the universal constant of gravitation, M is the mass of the object and c is the speed of light. The Schwarzschild radius is, more or less, the size that a given object, with a given mass, should have in order for it to be a black hole. For example, the Schwarzschild radius of the Sun is of the order of a few kilometres. So if we managed to concentrate the mass of the Sun into a sphere of a few kilometres, that would be a black hole (but the Sun will not become a black hole as it is too small for that).

Time distortion near a black hole: Black holes are important in understanding the concept of general relativity. This is because of their simplicity- as they are made of the fundamental building blocks of the theory- time and space. In order to understand them, let's have a look at Einstein's theory of general relativity near massive objects. General relativity predicts that massive objects, such as planets and stars, can warp the very fabric of space and time. The warping of space- time changes the trajectory of objects that are less massive than the body that causes the warping- they move towards the massive body or orbit around it. This is what we interpret as the force of gravity. A black hole is a region of space- time that is extremely warped. If the theory is to be believed, then the curvature of space- time is infinite within a black hole.

Event Horizon
Accretion disc
Singularity
Relativistic jets
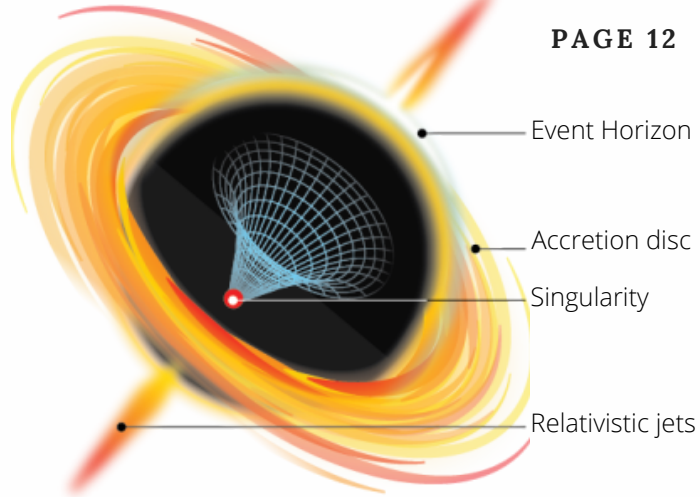
The Event Horizon Telescope captured the first ever image of a back hole on April 10th, 2019.

But we don't know whether this is really true for black holes that exist in nature, it might just be an artefact of the theory. In any case, gravity is so strong within a black hole that not even light can escape from it. But Einstein's theory also says that nothing can travel faster than light. This includes information, because information must always be conveyed via some physical signal, such as sound or light. Since light cannot escape from a black hole, neither can information i.e. whatever happens in a black hole cannot be communicated to the outside world. Once you have passed the event horizon, you can never come back; if the black hole is small, then the difference of curvature of space- time between your head and your feet will be so large that you will get stretched. But if the black hole is big, the gravitational field is very uniform. So, even though it's strong, the difference in gravity at your head and at your feet wouldn't be that large. You could approach the horizon of a very big black hole, such as the one at the centre of a galaxy, and not feel anything at all. But close to the black hole, because gravity is strong, time runs slower for you. For a person observing you far from the black hole, you would not have aged much but the observer would have become much older. However, general relativity tells us that once you are inside the black hole you will eventually hit the singularity at its centre and you will be destroyed.

ASSISTED BY AKANKSHA MISHRA AND NANDINI UPADHYAY

Editor's note 📝

Greetings to everyone!

I would like to take this opportunity to thank our Principal, **Dr. Haritma Chopra** and our teachers of the department for taking us through the expedition of knowledge this newsletter has been. This journey has taught me the deligence and the determination one needs to succeed in any task. I have learned how talented and ardent my teammates are and would like to express my gratitude to each and every one of them for being so willing and accommodative as we grew and learned together. I also want to appreciate every one who showed confidence in us and submitted their work to be published. Lastly, I want to thank all the readers who we owe this paper to. I hope it was a pleasant read!

- SAACHI SINGH

THANK YOU FOR READING!