DEMYSTIFYING THE COMPLEXITIES OF MATHS

MATHELOGICS

A MATHS MAGAZINE

ANSWERS THROUGH TRIGONOMETRY

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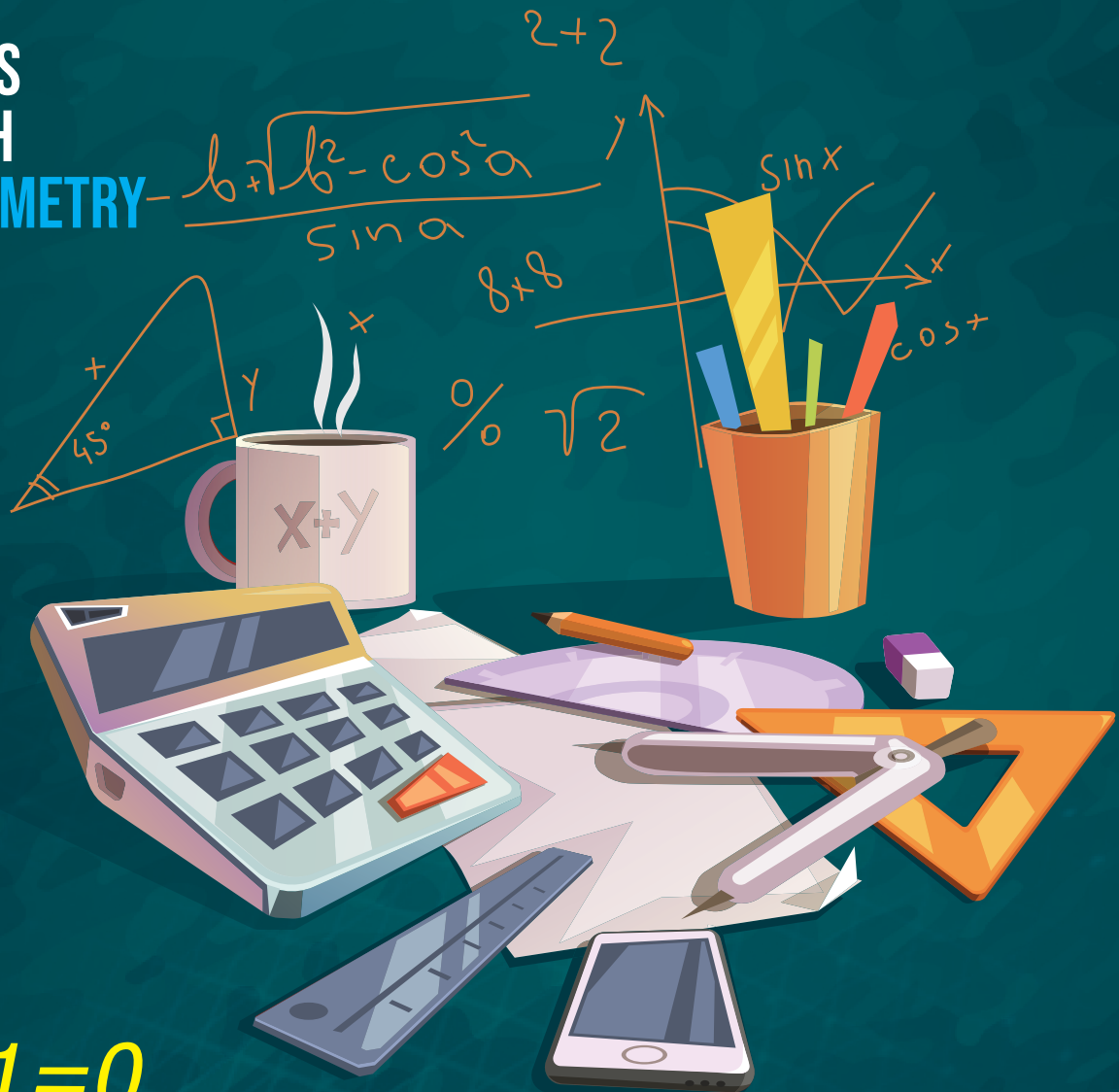
$$e^{i\pi}+1=0$$

THE BEAUTIFUL EQUATION:
WHERE MATH AND ART CONVERGE

THE ENDLESS FASCINATION:
WHY I LOVE MATHEMATICS

TOPOLOGY AND GEOMETRY:
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Fellow Math Enthusiasts,

I am delighted to introduce the inaugural edition of Mathelogics Magazine, a magazine that marks the latest addition to Mathelogics. This publication serves as a platform for budding mathematicians to display their exceptional talents and unwavering passion. Within the pages of this magazine, you will encounter articles penned by students from various schools who participated in Mathelogics, the annual mathematics symposium organized by Neerja Modi School.

Mathematics is not merely a subject; it is a universal language that transcends geographical boundaries, cultural differences, and the passage of time. It stands as the bridge connecting the tangible and the abstract, forming the bedrock upon which our understanding of the universe rests. It is a discipline that harmonizes subjectivity with objectivity, making mathematics the quintessential universal language.

Within the pages of this inaugural edition, readers will discover a diverse array of articles, each offering a distinct perspective on mathematics and its practical applications. I can assure you that whether mathematics is an intimidating enigma or your closest ally, you will find an article here that will wholly engage your curiosity. Our talented authors delve into a wide spectrum of topics, from the use of calculus in determining the optimal tilt angle for solar panels to explaining why mathematics ranks as the most captivating subject.

As you scroll through the pages of Mathelogics Magazine, you will be captivated by the depth of thought, creativity, and commitment exhibited by our authors in their exploration of the world of mathematics. Their enthusiasm stands as a testament to the timeless beauty and relevance of this field.

We extend our heartfelt appreciation to all the participating schools, students, and teachers who have made Mathelogics and this magazine a reality. I would also like to express my sincere gratitude to every student who devoted their valuable time to craft an article and bring this magazine to life.

I hope that you derive as much enjoyment from reading the inaugural edition of Mathelogics Magazine as we have had in creating it. May the mathematical insights and fervor shared within these pages kindle your own curiosity and deepen your admiration for the world of numbers.

Happy Reading!

Arav Dhoot
Editor-In-Chief, Mathelogics Magazine

THE PHILOSOPHY OF CALCULUS
by Arav Dhoot

The Philosophy of Calculus: Explore the philosophical underpinnings of calculus, including the concepts of limits, infinity, and the role of mathematics in our understanding of the world

My relationship with Calculus began on very cordial terms right from the beginning. When I was introduced to this branch of mathematics, it seemed like just another set of rules and formulas to memorize, but a deeper understanding of the subject made me realize there was much more to this topic. Calculus is not just a tool for solving problems; it is a philosophy that has profound implications for our understanding of the world.

One of the central concepts in calculus is the idea of limits. A limit is a value of a function as the input approaches a certain point. Knowing what appears to be trivial has significant implications for broadening our understanding of the world. The idea of a limit implies that certain things are beyond our grasp. No matter how close we get to them, we can never quite reach them. Reflecting on the world around us is exactly how we know a person or situation. There will always be something beyond our understanding.

Infinity is another tricky concept that is difficult for many people to grasp. It is not a number traditionally but rather a notion representing something unbounded and unlimited. In calculus, infinity describes the behavior of functions as the input approaches certain values. Infinity has profound philosophical implications regarding our understanding of the universe.

It is too vast and too complex for us to comprehend fully. The concept of infinity also raises questions about the nature of reality. Is the universe truly infinite? Or is there some ultimate limit beyond which nothing can exist? This can be juxtaposed with the question of the creator of this universe. We might have our own interpretations of him, but an apt word to describe him can be just- Infinity.

Mathematics is often seen as a tool for solving problems, but it is much more than that. It is a language that allows us to express and communicate ideas about the world precisely and rigorously. Calculus, in particular, allows us to model and understand the behavior of complex systems.

As I have studied calculus, I have come to appreciate the power and beauty of mathematics. It is not just a collection of rules and formulas but a way of thinking about the world to help us understand the complex and subtle relationships between things. Mathematics is a way of seeing the world in a new light, and calculus is an important part.

Concepts like limits, infinity, and the role of mathematics are not just abstract ideas but powerful tools that can help us make sense of the complex and often confusing world around us. As I continue to study calculus, I am excited to see where this philosophy will lead me and what new insights and discoveries I will uncover.

Arav Dhoot
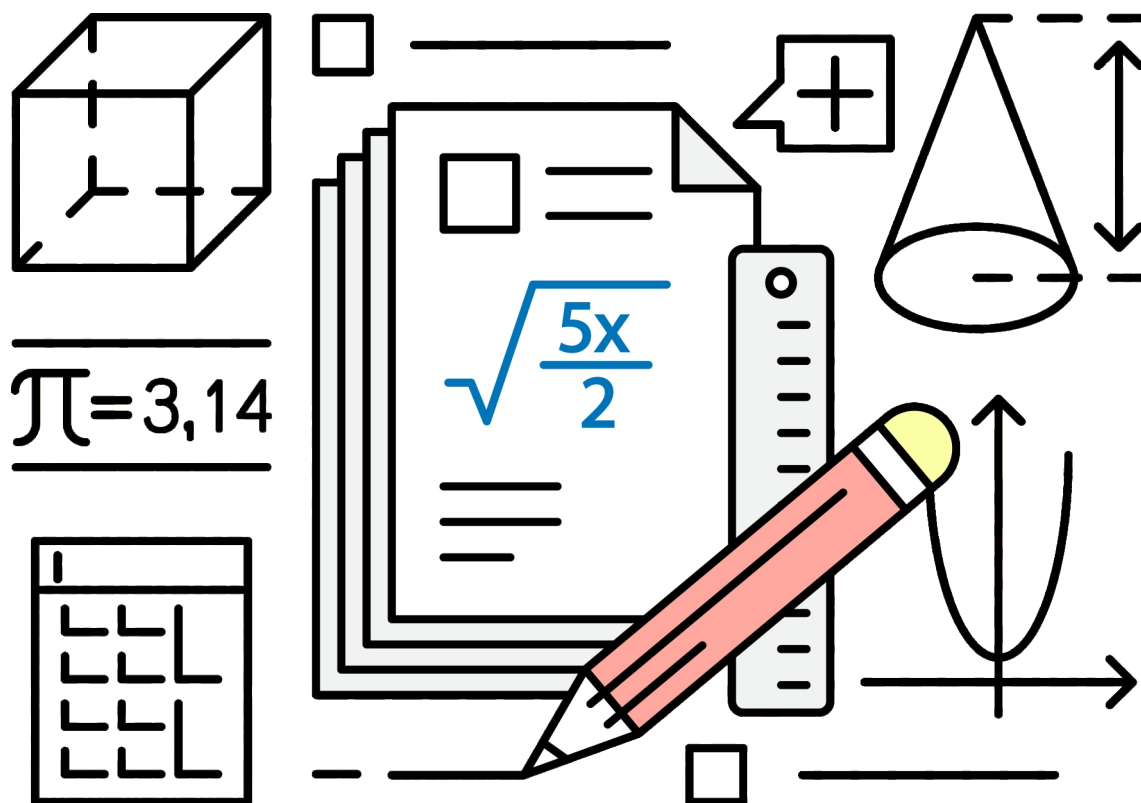
THE ENDLESS FASCINATION- WHY I LOVE MATHEMATICS
by Aditya Agarwal

The Endless Fascination- Why I Love Mathematics

From the moment I started school, there was a subject that sparked my curiosity and filled my heart with wonder - mathematics. It's a love story that began in primary school and has only grown stronger with time. While I may not be the most modest person when it comes to this particular subject, I assure you that my passion for math is not rooted in arrogance but rather a profound appreciation for its inherent beauty and logic.

One of the primary reasons I love mathematics is its unwavering simplicity. Unlike many subjects, it offers unwavering consistency and predictability through its precise rules and principles. But even then, math offers a unique sense of flexibility. There's rarely a single solution to a problem, and multiple approaches can lead to the same result. This encourages creativity and problem-solving, allowing us to explore different paths and discover novel solutions; it's a realm where thinking outside the box is celebrated.

Moreover, being good at math is not about memorizing countless formulas; it's not about "knowing a lot of math". But rather, it's about understanding these formulas and applying them creatively. This, to me, is the essence of mathematical beauty. It's not just about solving equations but about uncovering deep connections between seemingly disparate ideas and concepts.

Mathematics isn't just about finding answers; it's about exploring new questions. It's a playground for innovation, where thinkers are encouraged to break the mold and venture into uncharted territory. The beauty of math lies in its adaptability. It provides a canvas for creativity, inviting mathematicians to devise novel solutions and tackle real-world problems. In the realm of mathematics, thinking outside the box is not just encouraged; it's essential. The most groundbreaking discoveries often arise from unconventional approaches. Mathematicians are constantly challenged to push boundaries, question assumptions, and embrace unorthodox ideas.

This spirit of innovation and open-mindedness keeps mathematics perpetually fresh and exciting, reminding us that there are always new perspectives to explore, new questions to ask, and new discoveries to be made.

In conclusion, my love for mathematics goes far beyond mere proficiency or pride. It's a deep-seated appreciation for the order and precision that mathematics brings to the world. It's the beauty I find in the elegant proofs, the creative possibilities it offers, and the endless opportunities for exploration. Mathematics, to me, is not just a subject; it's a lifelong journey filled with wonder and curiosity.

This journey is one that promises a lifetime of wonder. The world of mathematics is vast and uncharted, with mysteries waiting to be unraveled and problems waiting to be solved. It's a love affair that began in primary school and continues to flourish, reminding me that in the realm of numbers and equations, there is a world of infinite fascination waiting to be explored.

Aditya Agarwal

CALCULUS AND CREATIVITY
by Arav Dhoot

Calculus and Creativity: Explore the ways that calculus can be used as a tool for creative expressions, such as in art, music, or literature, and how it can inspire innovation and imagination

The idea of calculus can be intimidating to some. I shared a similar opinion initially while dealing with the subject. It appeared to be a never-ending series of complex equations and formulas. However, as I began to walk up the trajectory of this topic, I discovered that calculus could be much more than just a collection of mathematical concepts. It can be a powerful tool for creative expression, inspiring innovation and imagination in fields ranging from art and music to literature and beyond.

It is intriguing to know that there exists a mathematical art that uses calculus as a tool for creativity. Mathematical art uses mathematical concepts and formulas to create visually stunning, aesthetically pleasing, and intellectually stimulating artwork. For example, the Fibonacci sequence, wherein each number is the sum of the previous two, can be used to create beautiful spiral patterns that have inspired artists for centuries. Additionally, fractals, complex mathematical patterns that repeat infinitely at different scales, have been used to create intricate and mesmerizing artworks that challenge our perceptions of space and geometry.

Music is another field that has been inspired by calculus. Many of the principles of calculus can be applied to the study of music theory and composition. For instance, calculus can be used to analyze the frequency and amplitude of sound waves, which are the building blocks of music. Additionally, calculus can be used to model how different musical notes interact, allowing composers to create complex and beautiful harmonies that are mathematically precise and emotionally evocative.

Literature is yet another field that has been influenced by calculus. Many writers have used mathematical concepts and principles to explore abstract concepts such as infinity, time, and space. For example, in his book "Flatland," Edwin Abbott uses the principles of geometry and calculus to explore the concept of dimensions and how they affect our perception of reality. Similarly, Jorge Luis Borges, in his short story "The Library of Babel," uses calculus to explore the idea of infinity and how it relates to knowledge and truth.

Finally, calculus can also be used for innovation and invention. Many of the most groundbreaking inventions of our time, from smartphones to self-driving cars, rely heavily on calculus and other advanced mathematical concepts. Calculus allows engineers and scientists to model complex systems and predict their behavior with incredible accuracy, allowing them to design and create efficient and effective products.

I appreciate calculus as a collection of mathematical concepts and a powerful tool for creativity and innovation. From mathematical art to music, literature, and beyond, calculus can inspire imagination and push the boundaries of what we think is possible. As I continue to explore this appealing subject, I look forward to seeing how it will continue to shape the world around us and inspire future generations of artists, musicians, writers, engineers, and scientists.

Arav Dhoot

THE BEAUTIFUL EQUATION:
# WHERE MATH AND ART CONVERGE
by Charvi Bansal

The Beautiful Equation: Where Math and Art Converge

Mathematics and visual art are generally considered to be poles apart with close to no similarities between them with one involving the least amount of creativity possible and the other with the most. To a majority of artists, mathematics may seem alien, tedious and too much work to handle. However, what they do not realise is that visual art does combine a lot of mathematics, which may be inputted knowingly or unknowingly. These include aspects like ratio and proportion, symmetry and geometry and finally creativity.

Talking about the ratio and proportion involved in visual art, an example of this can be taken as an art piece titled- "The Vitruvian Man" by Leonardo Da Vinci, a very famous renaissance artist and scientist. The artwork illustrates the concept of ideal human proportions, as described by the ancient Roman architect Vitruvius. In order to represent the optimum proportions of the human body, it shows a man inside both a square and a circle. The significance of ratio and proportion in visual art is emphasised by this masterpiece. Leonardo believed that harmonious proportions, governed by mathematical principles, are necessary for producing aesthetically beautiful and lifelike representations in art, as seen by his rigorous measurements and exact anatomical details. Though this art piece is used to understand human anatomy by doctors and scientists, it is also used by a number of artists to apply the principles of proportion. Another series of artwork which uses mathematics are the sculptures by Polykleitos, where each body part progressively was $\sqrt{2}$ times the previous one, starting with the fingers. The artist believed that this ratio created sculptures which were highly aesthetically pleasing.

Illusions play a major role in representing the symmetry and geometry connection as in visual art, illusions frequently use symmetry and geometry to distort vision. Bridget Riley's Op art, for instance, combines contrasting colours and repeated patterns to give the impression of depth or movement. The illusions show the deep connection between mathematics and art, where mathematical ideas like symmetry and geometric transformations are essential to producing captivating and thought-provoking visual compositions. They also highlight the mathematical precision necessary to achieve visual effects.

Overall, In the realm of art and mathematics, ratio, proportion, symmetry, and geometry unite to craft exquisite visual experiences. Together, they reveal the harmonious relationship between precise calculations and artistic creativity.
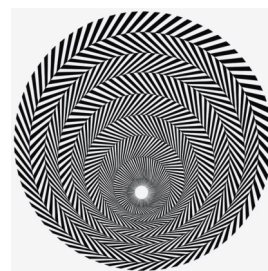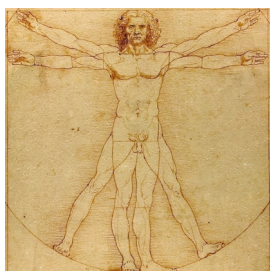
The Vitruvian Man by Leonardo daVinci (left), A sculpture by Polykleitos (centre), Op art by Bridget

Chaarvi Bansal

CALCULUS AND THE HUMAN MIND
by Arav Dhoot

Calculus and the Human Mind: Investigate the connection between calculus and the human mind, including the ways that learning calculus can impact cognitive development and critical thinking skills

My interest in Calculus has recently traveled an upward motion. I am enchanted by the connection it shares with the human mind. At first glance, calculus may seem like a purely mathematical concept. Upon closer inspection, it becomes clear that learning calculus can significantly impact cognitive development and critical thinking skills.

The study of rates of change and the accumulation of small quantities in Calculus is used in a wide range of fields, like physics, engineering, economics, and medicine. However, its impact on the human mind goes far beyond its practical applications.

It fosters a deeper understanding of abstract concepts. Calculus is not just about memorizing formulas and equations – it requires a fundamental shift in thinking about numbers and patterns. We must learn to think critically and creatively to solve calculus problems and develop a keen sense of intuition to identify and manipulate complex relationships.

By developing these capabilities through calculus, we are better equipped to tackle complex problems in science, business, and our personal lives. It leads us to become more solution-oriented, effective communicators, and confident decision-makers.

In the Genz world, when social media can trigger anything and everything, it is sad to see people lose logic and analytical skills. This wonderful subject I take delight in writing, takes care of this aspect of the human mind, provided we see it in the right light. Calculus problems are often challenging and require careful attention to detail, forcing us to slow down and think critically about each step in the problem-solving process. This focused attention can help improve our concentration and memory and enhance our ability to identify and solve problems systematically and logically.

Moreover, the mental agility and flexibility required to master calculus can also help improve our overall cognitive function. My whole point is that not just the human body but the mind, too, needs regular work out. Research has shown that individuals who regularly engage in challenging mental activities, such as learning calculus, have better memory, concentration, and reasoning skills than those who do not. In addition, learning calculus can also improve our spatial reasoning abilities, which are critical for many scientific and technical fields.

Learning calculus can positively impact our overall mindset and outlook on life. Calculus problems can be difficult and frustrating, but mastering them can be incredibly rewarding. By persevering through challenges and setbacks, we develop a sense of resilience and confidence that can carry over into other aspects of our lives. We become more willing to take risks, more open to new experiences, and more confident in overcoming obstacles.

The connection between calculus and the human mind is alluring and complex. We can improve our cognitive development, critical thinking skills, and overall mindset by learning calculus. We become better problem solvers, effective communicators, and confident decision-makers.

Furthermore, the mental agility and flexibility required to master calculus can also help improve our overall cognitive function. As a high school student who recently completed a calculus course, I can attest to the many benefits of learning calculus.

I look forward to continuing to explore this fascinating subject and its impact on the human mind. Calculus is a metaphor for creative thinking, which no book can explain. It is realized and not read.

Arav Dhoot

CALCULUS AND GEOMETRIC BROWNIAN MOTION IN STOCK PRICE PREDICTION
by Daksh Jain

Calculus and Geometric Brownian Motion in Stock Price Prediction: Apple Inc. Case Study and Limitations

For investors, predicting stock prices accurately is a never-ending challenge in the complicated and fast-paced world of the financial markets. Academics constantly search for creative solutions since traditional valuation models usually fail to consider the complexity of the market. Calculus, a branch of mathematics that deals with rates of change and accumulation, offers an intriguing field of study. Calculus ideas like derivatives, integrals, and differential equations may be used to gain insight into the hidden patterns behind stock price swings. I wanted to shed some insight on the possible advantages and restrictions of using calculus to forecast stock prices through this research. I want to contribute to the creation of more precise prediction models for the benefit of investors and market players by exploring the untapped possibilities at the confluence of mathematics and finance. Because the stock market is unpredictable and there are too many stocks that can be evaluated, I have chosen Apple Inc. where it has increased in its value over the past year.

I was analyzing various simulation models and arrived at geometric Brownian motion differential equations. I will assess the stock prices of Apple Inc. on its past year's performance and compare it with the current stock prices. I will be using Python simulations for solving the differential equations and will analyze how well the equation holds up against the stock prices. The purpose of this study project is to forecast how a certain stock will perform over time, including when its value will increase or decrease. Using my understanding of calculus, this would be crucial for making wise and timely stock purchase decisions that might be beneficial to investors and traders. Allowing students to connect Calculus and classroom-based learning to money is my inspiration for this.

The method of using the geometric Brownian motion can actually be a hit or miss because in some cases the error rate is higher than 50% whereas in some it is as low as the prices being almost the same. This shows that there are several other factors affecting the stock market and there is no certain way in which an accurate prediction can be made of the value of the stocks. Such factors could include the condition of the market, sudden loss in demand, scandals, and many others. However, the average error rate was off by 25.4%, which is not exponential in terms of difference, based on my simulations and calculations.

Therefore, the GMB can be a good way to predict the market as increasing the number of iterations will give more predicted graphs and an average of those can help provide a closer value. Research on stock prices and geometric Brownian motion differential equations can help in understanding and simulating complex financial systems. It enables the mathematical community to develop advanced methods and tools for risk management, option pricing, and portfolio optimization, advancing understanding of stochastic processes and its applications in other fields.

Stock price prediction using geometric Brownian motion (GBM) differential equations has some serious limitations. First, GBM assumes constant volatility and does not take into account the changing nature of stock price movements under different market conditions

and economic scenarios. Furthermore, the model's reliance on normal distributions ignores the occurrence of fat-tail events, such as extreme market swings and crashes, which are more common in practice.

Additionally, GBM does not consider sudden spikes or gaps in stock prices and ignores the potential impact of sudden shocks from unexpected news or events. The model also misses the "mean reversion" phenomenon observed in stock prices. Stock prices tend to converge toward their long-term average over time. Additionally, GBM does not consider market sentiment, investor behavior, or other external factors that influence stock prices, limiting its ability to capture the complexities of actual market dynamics. Furthermore, its simplicity prevents adaptation to changing market conditions and makes long-term forecasts less reliable in the event of unforeseen events. Finally, the sensitivity of the GBM's parameter estimates can lead to large variances in predictions, leading to inaccuracies and uncertainties in results. GBM is still valuable for certain financial applications, but it is important to be aware of these limitations when using it for stock price prediction. This leads to more sophisticated models being considered to make more accurate predictions. My selection of the simulation model is also a limiting factor in the accuracy of this methodology.

Daksh Jain

CALCULUS AND SOCIAL JUSTICE
by Arav Dhoot

Calculus and Social Justice: Analyze how calculus can be used to address social justice issues, such as the distribution of wealth and resources, and how it can be used to promote equity and inclusion.

Calculus is a useful tool for solving difficulties in the real world, but I've recently wondered how it may be applied to promote social justice. I was curious to find out more about how mathematics may contribute to someone enthusiastic about equity and inclusion.

The well-being of society is seriously impacted by the widening wealth disparity that has occurred in recent decades. We need to address the disparity between those with a lot and those with little.

Calculus can be used to build a resource allocation and wealth distribution model. The study of calculus can be used to investigate income inequality, which quantifies the gap between the richest and lowest earnings in society. Examining how income is allocated might help us understand the causes of inequality and suggest solutions to eliminate it. If the rate of change in the wealth distribution is excessively high, it can mean that a small number of people hold most of the money.

Calculus may also be used to determine the pace of change in resource allocation over time by examining the distribution of resources. By doing this, we can determine whether resources are dispersed properly. It may be a sign that resources are being distributed unfairly, which can result in social injustice if the pace of change in resource distribution is too low.

Moreover, the study of Calculus can be used to evaluate the effects of laws that support inclusion and equity. Affirmative action initiatives, which strive to boost the representation of historically underrepresented groups in higher education and the workforce, may be a part of these policies. Calculus additionally has the potential to evaluate the effects of social justice-related legislation. For instance, the effects of programs like progressive taxation that address economic inequality. Progressive taxation is a type of taxation where people who earn more money pay a larger proportion of it in taxes. Calculus can be used to examine whether or not this policy supports social fairness and how it affects the distribution of wealth.

We can use Calculus to address environmental justice challenges by going one step further. Environmental justice is the equitable treatment and meaningful participation of all people in creating, implementing, and enforcing environmental laws, regulations, and policies, regardless of their race, color, country of origin, or level of income. Calculus can be used to assess how various environmental justice-related policies, such as those that support clean energy, would affect society.

Thus, Calculus as a branch of study effectively resolves social justice concerns and advances equity and inclusion in society. Mathematics might help us better comprehend the causes of inequality and help us build a more just society by modeling and analyzing its complicated systems and structures.

Arav Dhoot

THE POINCARÉ CONJECTURE AND
ITS PROFOUND IMPACT ON MATHEMATICS
by Ishaan Avi Gupta

The Poincaré Conjecture and Its Profound Impact on Mathematics

In the intricate landscape of mathematics, certain problems stand as towering monuments of complexity and intrigue. The Poincaré Conjecture, proposed by the brilliant French mathematician Henri Poincaré in 1904, is undoubtedly one of these formidable enigmas.
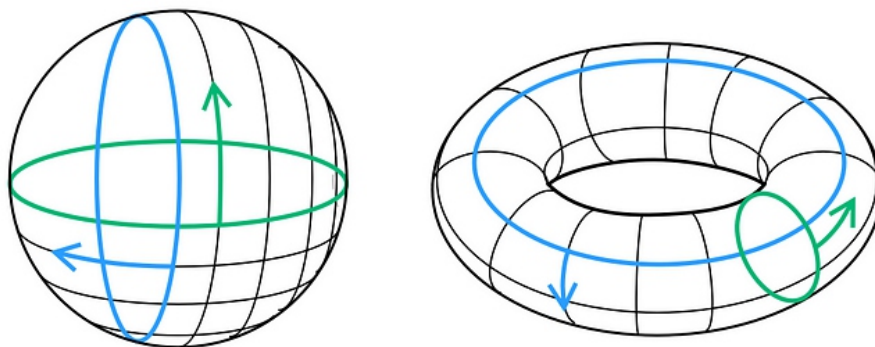
(Image credits – cantorsparadise.com)

This conjecture, which revolves around the fundamental understanding of three-dimensional shapes and their connection to the 3-sphere, has deep implications that extend far beyond the realm of pure mathematics.

In this article, we embark on a journey to explore the history, implications, and ultimate resolution of the Poincaré Conjecture.

The Poincaré Conjecture's Foundation

To grasp the essence of the Poincaré Conjecture, we must first acquaint ourselves with the concept of three-dimensional shapes, particularly compact manifolds.

At the heart of this conjecture lies the notion of a three-dimensional sphere, a mathematical construct existing within a four-dimensional space. This sphere is defined as the set of points equidistant from a specified point, much akin to the familiar two-dimensional sphere representing the surface of the Earth or an orange.

However, there is a twist. When dealing with spaces beyond our three-dimensional reality, we encounter the challenge of visualization. How can we determine whether a given shape is, in essence, a three-sphere through measurements and operations confined within that shape? This is where Poincaré's curiosity led him to formulate the conjecture. He sought to identify all three-spheres, even if they were highly distorted, by introducing the criterion of "simple connectivity."

The Universe's Shape and Topology

The concept of the Poincaré Conjecture takes us on a journey that extends beyond mathematical abstraction and connects to our understanding of the universe itself.

Albert Einstein's groundbreaking work in the early 20th century revealed that the universe we inhabit is not limited to the three spatial dimensions we perceive but encompasses a fourth dimension: time. This notion led to the concept of spacetime warping, where matter and energy interact in this four-dimensional space.

Understanding the universe's shape and its temporal evolution is a complex empirical challenge. In this pursuit, the foundations laid by Henri Poincaré and the development of topology, specifically involving n-spheres and n-dimensional manifolds, play a crucial role. These mathematical constructs aid in comprehending the intricate geometry that governs our universe, allowing us to explore its deformations, stretching, and bending.

The Journey of Henri Poincaré

Henri Poincaré, born in Nancy, France, on April 29, 1854, was a mathematical prodigy from a young age. His remarkable academic journey included studying mathematics under the tutelage of Charles Hermite at the École Polytechnique.

Poincaré's intellectual versatility transcended traditional boundaries, and his contributions spanned various fields, from topology and analytic functions to algebraic geometry, number theory, and relativity theory. His breadth of knowledge earned him the epithet "The Last Universalist" due to his profound impact on mathematics and science.

Poincaré's Work on Topology

Poincaré's foray into topology began with his seminal work, "Analysis Situs," where he introduced the concept of Betti numbers and their potential in classifying manifolds. He initially believed that simply-connected n-dimensional closed manifolds were homeomorphic to n-spheres, but this notion had its limitations, as pointed out by Danish doctoral student Poul Heegaard.

Poincaré's journey into the world of 3-manifolds and the Poincaré Conjecture led to the introduction of the Poincaré homology sphere as a counterexample to his earlier claims. He introduced the fundamental group as a new topological invariant, effectively establishing a significant condition for distinguishing 3-spheres from other 3-manifolds.

The Poincaré Conjecture

At the heart of Henri Poincaré's 1904 conjecture is the fundamental question: "Is every simply connected, closed 3-manifold homeomorphic to the 3-sphere?" In essence, this conjecture posits that if every closed curve within a manifold can be continuously tightened to a single point, the manifold must be a 3-sphere.

This concept is easier to grasp in two-dimensional analogs, where loops on a sphere can be effortlessly tightened and moved off the surface, while those on a torus require slicing to remove. The Poincaré Conjecture thus aids in discerning whether a manifold is topologically equivalent to a sphere.

Implications Beyond Mathematics

The profound implications of the Poincaré Conjecture extend beyond the confines of mathematics. The conjecture's connection to the shape of the universe is particularly intriguing. In simple terms, if the universe is a closed 3-dimensional space that is also simply connected, it must be topologically equivalent to a sphere. This implies that the shape of our universe, its topology, holds critical information about its fundamental nature.

Concluding Remarks

In the world of mathematics, the Poincaré Conjecture stood as a challenging puzzle for over a century, captivating the minds of countless mathematicians. It posed a fundamental question about the nature of three-dimensional manifolds and their possible equivalence to the 3-sphere. Through meticulous mathematical investigations and the introduction of innovative concepts like homology and the fundamental group, mathematicians like Grigori Perelman finally unraveled the mystery.

Grigori Perelman's proof in the early 21st century validated Henri Poincaré's conjecture, confirming that any simply connected, closed 3-manifold is indeed topologically equivalent to the 3-sphere. In doing so, it not only resolved a century-old mathematical puzzle but also shed light on the profound interplay between mathematics and the universe's shape, leaving a lasting legacy for generations of mathematicians and scientists to come.

Ishaan Avi Gupta

CALCULUS AND PERSONAL GROWTH
by Arav Dhoot

Calculus and Personal Growth: Reflect on how learning calculus can help individuals develop skills such as problem-solving, analytical thinking, and perseverance and how these skills can translate to personal and professional success

As a high schooler, I assumed calculus was a subject reserved for nerds and geeks. I found it complex and daunting with all those perplexing equations and formulas. However, when I delved deeper into this part of mathematics, I learned that it teaches vital life skills in addition to solving complicated issues. Learning calculus can help people grow both emotionally and professionally, from problem-solving to analytical thinking and tenacity. So strap on and accompany me on this fascinating trip of discovering how calculus may improve one's life.

Calculus is a field of mathematics that studies change and motion. It entails analysing and solving problems involving rates of change, slopes, and curves utilising sophisticated equations and formulas. Although it may appear difficult, mastering calculus can benefit both personal and professional development.

Problem-solving is one of the fundamental abilities that calculus may help people develop. In calculus, there are frequently several approaches to a problem, and individuals must apply critical thinking skills to select the most successful solution. Individuals can learn to recognize patterns and techniques to tackle even the most difficult issues through experience and repetition. This talent is useful not only in mathematics but also in real-life situations where problem-solving is required.

Analytical thinking is another talent that mathematics can help people improve. To comprehend the core concepts of calculus, students must examine and evaluate data, graphs, and equations. They must be able to break down complex knowledge into simpler bits in order to solve problems and make informed decisions. This skill is useful in mathematics and sectors such as science, technology, and business.

Perseverance is another important quality that individuals can gain by learning calculus. Calculus is a difficult topic that demands time, effort, and commitment to learn. To achieve this, people must work through difficult situations outside their comfort zones. This skill is important for personal and professional development since it helps people overcome difficulties and achieve their goals.

In addition to these skills, learning calculus can positively impact personal and professional success. For example, in the field of engineering, calculus is essential for designing structures, analysing data, and predicting outcomes. In finance, calculus models and analyses financial markets and investment opportunities. In medicine, calculus is used to analyse data and accurately predict patient outcomes.

Furthermore, mastering calculus can increase an individual's self-esteem and sense of success. The capacity to handle hard problems and comprehend difficult concepts can give

someone a sense of pride and accomplishment. This self-assurance can be transferred to other aspects of their lives, such as academics, careers, and personal relationships.

To summarise, knowing calculus can tremendously impact personal growth and development. Problem-solving, analytical thinking, and tenacity skills obtained by calculus education are valuable in mathematics and real-life circumstances. These abilities can lead to personal and professional success, as well as increased self-confidence and a sense of accomplishment.

Although learning calculus may appear frightening at first, I believe it is a fantastic method to challenge oneself and grow as an individual.

Arav Dhoot

$$a^2+b^2=c^2$$

USING CALCULUS TO CALCULATE OPTIMUM ANGLE FOR MAXIMUM PRODUCTION OF ENERGY OF A SOLAR PANEL
by Laksh Goyal and Manyaa Doshi

Using Calculus to calculate optimum angle for maximum production of energy of a solar panel

As the world is plunging into an energy crisis, fossil fuels are already becoming scarce and less affordable as seen by the study of Post Carbon [1]. Hence, the demand for effective, renewable energy sources is at an all-time high. Therefore, maximising the pre-existing power output of solar panels is quintessential to efficiently utilise the potential of solar panels. Solar panels are made of photovoltaic cells that absorb sunlight [2] to generate DC that can then be converted to AC and thus converting solar energy to electrical energy. The angle at which the solar panel faces the sun while taking into consideration the latitude of the solar panel affects how much energy is absorbed, hence it also affects the power output of the solar panel. This research paper looks at finding the optimum tilt angle of a solar panel situated on the rooftop of our school in June: Prabhavati Padamshi Soni International Junior College.

Research Methodology: Power output from the solar panels is maximum when the angle of incidence of light is equal to the tilt angle of the solar panel. OpenSolar has been used to create a prototype simulation of solar panels on the roof of the school [3]. SunPower® X-Series Residential Solar Panels SPR-P3-335-BLK have been used that have an approximate efficiency of 21% and a power rating of 355 Watts for this investigation[4]. The area is 104.6 cm in width by 155.90 cm in length[5]. Hence the area is 1.63 square metres.

27.135 kW	₹5,197	₹67,838	₹67,838
System Size	Estimated Annual Electricity Bill Savings	Total System Price	Net System Price

*Figure 1: Screenshot of the simulator [3]*

There are 90 panels on one section of the rooftop and the tilt angle is 0° and it is treated as a control set-up. The amount of sunlight received is another factor affecting energy absorption. Hence, solar energy that reaches a square metre of a surface per day ('insolation') needs to be calculated as well.
Moreover, the season of the year also affects sunlight due to rain and moisture levels as well as the arrangement of clouds.

Figure 2: Amount of energy absorbed by the solar panels during different times of the year.
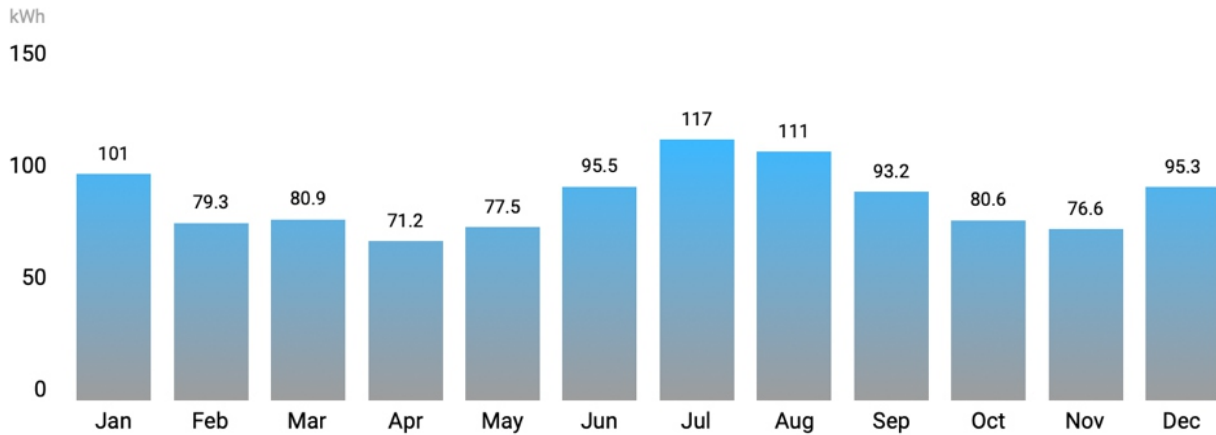
The following variables will be used in the calculation of performance of photovoltaic cells.

$$\alpha = angle\ of\ elevation\ of\ sun\ above\ the\ horizon$$
$$\beta = latitude\ of\ a\ given\ position$$
$$\gamma = inclination\ of\ axis\ of\ Earth$$
$$\delta = time\ of\ year,\ from\ june\ in\ the\ northern\ hemisphere$$
$$\varepsilon = time\ of\ day$$
$$\sigma = energy\ received\ in\ joules$$

Mathematical working:

$$sin(\alpha) = cos(\beta)\sqrt{1 - sin^2(\gamma)cos^2(\tfrac{2\pi\delta}{365})cos^2(\tfrac{2\pi\delta}{24})} + sin(\gamma)sin(\beta)cos(\tfrac{2\pi\delta}{24})$$

Then we integrate both sides taking the energy equation into account

$$\int_{\varepsilon^!}^{\varepsilon^2} sin(\alpha) = \int_{\varepsilon^!}^{\varepsilon^2} cos(\beta)\sqrt{1 - sin^2(\gamma)cos^2(\tfrac{2\pi\delta}{365})cos^2(\tfrac{2\pi\delta}{24})} + sin(\gamma)sin(\beta)cos(\tfrac{2\pi\delta}{24})$$

$$\varepsilon^1\ is\ the\ time\ of\ sunset\ and\ \varepsilon^2\ is\ the\ time\ of\ sunrise$$

At the time of sunset or sunrise, the sun is at the level of horizon therefore α is 0:

$$\int_{\varepsilon^!}^{\varepsilon^2} sin(0) = \int_{\varepsilon^!}^{\varepsilon^2} cos(\beta)\sqrt{1 - sin^2(\gamma)cos^2(\tfrac{2\pi\delta}{365})cos^2(\tfrac{2\pi\delta}{24})} + sin(\gamma)sin(\beta)cos(\tfrac{2\pi\delta}{24})$$

$$0 = \int_{\varepsilon^!}^{\varepsilon^2} cos(\beta)\sqrt{1 - sin^2(\gamma)cos^2(\tfrac{2\pi\delta}{365})cos^2(\tfrac{2\pi\delta}{24})} + sin(\gamma)sin(\beta)cos(\tfrac{2\pi\delta}{24})$$

Then we simplify this equation using trigonometry and integration.

$$cos(\tfrac{2\pi\delta}{24}) = \frac{-tan(\beta)sin(\gamma)cos(\tfrac{2\pi\delta}{365})}{\sqrt{1-sin^2(\gamma)cos^2(\tfrac{2\pi\delta}{365})}}$$

$$\varepsilon^2 = \frac{12}{\pi}cos^{-1}\frac{-tan(\beta)sin(\gamma)cos(\tfrac{2\pi\delta}{365})}{\sqrt{1-sin^2(\gamma)cos^2(\tfrac{2\pi\delta}{365})}}$$ Derivation ε adapted from [7]

Substituting values of inclination of earth, which is at a constant at 23.5°, and latitude of the panel which is 19.0843N [6].

$$\varepsilon^2 = \frac{12}{\pi}cos^{-1}\frac{-tan(190843)sin(23.5)cos(\tfrac{2\pi\delta}{365})}{\sqrt{1-sin^2(23.5)cos^2(\tfrac{2\pi\delta}{365})}}$$

Based on this, throughout the year, the following energy equation can be generated:

$$\sigma = \sum_{\delta=1}^{365} \frac{12}{\pi}cos^{-1}\frac{-tan(190843)sin(23.5)cos(\tfrac{2\pi\delta}{365})}{\sqrt{1-sin^2(23.5)cos^2(\tfrac{2\pi\delta}{365})}}\ \sigma = 550045J$$

This is for the 4 panel in M -shaped solar panel derived from [8]

$$Optimum\ tilt\ angle\ =\ latitude\ +\ (declination\ *\ cos(hour\ angle))$$

This is the equation to find the optimum tilt angle and this gave us a 45 angle and at which we got the energy as 550045J.

Figure 3: this shows it has reached 21% efficiency which is the maximum efficiency the solar panel can reach.

Conclusion:

There are multiple factors like the latitude and Earth's rotational axis that have an impact on the efficiency of absorption of energy of the solar panel. There has been a derivation of a formula that can calculate energy at every angle of the solar panel tilt hence one can experiment and find their optimum angle for themselves.

Evaluation:

To write a more efficient research paper, the following steps could have been taken.

The best, most thorough research papers include a variety of methodologies. If time permitted, careful consideration of different types of research methods would've been taken such as conducting interviews with experts in the field; solar engineers. A survey focused on knowing where people place their solar panels and the energy output could be used as evidence that not many are aware of the effects of the placement of the devices and how they impact the maximum production of energy.

Further research could have helped derive a mathematical formula that would have allowed individuals to input the latitude of their home and the placement of the solar panel with the metres fixed to help calculate the cost of solar fixing as well as to achieve optimum energy production every time.

Citations:

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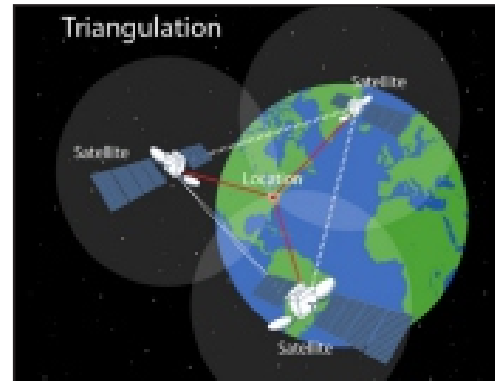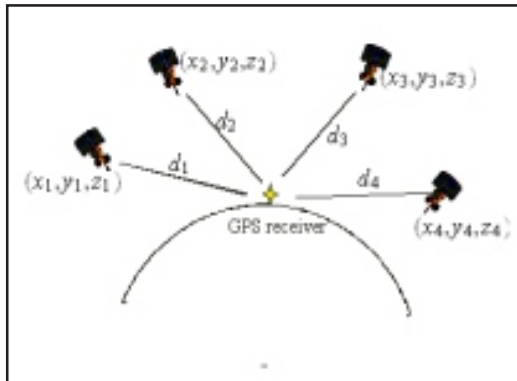
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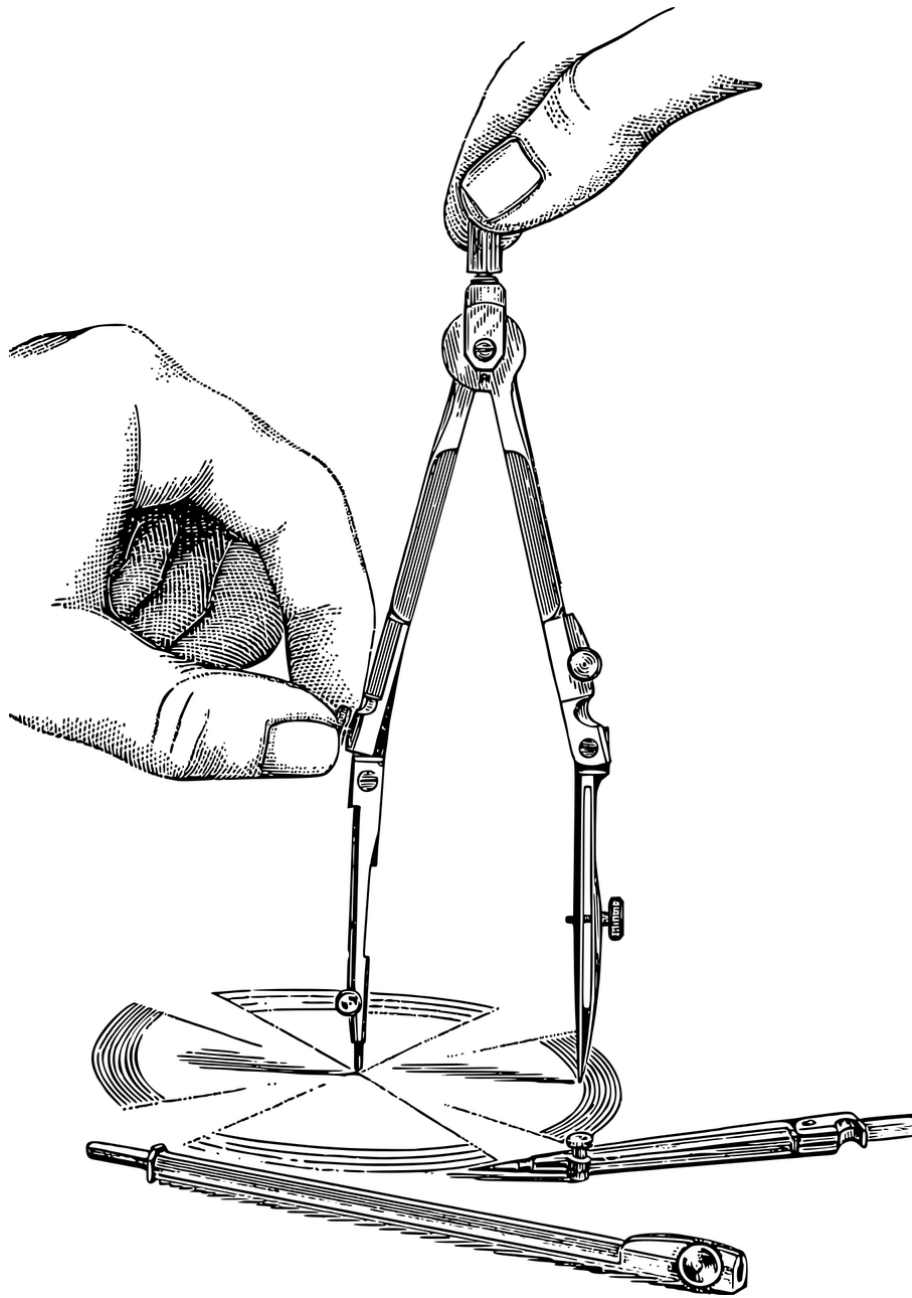
UNLOCKING THE MYSTERIES OF GLOBAL POSITIONING SYSTEM
by Yaksh Dharoda

Unlocking the Mysteries of Global Positioning System: How Trigonometry Powers Location Tracking

When you switch on the location button, how does your phone know your location? This is a thought provoking question! How is it possible that the GPS system can be used to find your location? The explanation to this question lies in a wonderful mathematics concept: Trigonometry!

Trigonometry is a field in mathematics which is based on calculating sides and angles. This branch is helpful in various fields such as engineering and physics. However, the most important application is seen in navigation and positioning.

To understand how a GPS system works we first have to dive into the basics. Let us assume that the Earth is a sphere and to know our exact location we need to use the coordinate system. The coordinates are found using coordinate geometry.

The limitation of this method is that it is very difficult to accurately measure the angle. To overcome this we use trigonometry. Trigonometry helps us determine the angles and distance between satellites and the receiver.

For better understanding, we can visualize this using an example. Imagine that you are at a fixed point and you wish to find your exact location. To accomplish this, a software in the phone computes angles, to calculate the degree between the landmark or satellite and the horizon.

Three GPS satellites are 'visible' whenever you seek to find your location. Each satellite transmits information about its position and the current time at regular intervals. These signals are intercepted by the receiver. The receiver measures the time taken for the signals to reach. These signals travel at the speed of light. Using the information the intersection point is calculated and your location is pinpointed.

The incredible branch of mathematics known as trigonometry is both intriguing and imperative, possessing an abundance of practical uses in reality. The concepts of trigonometry are essential for progress in the world. It is used for practical purposes such as traversing the Earth's terrain or delving into the vast unknowns of space.

Yaksh Dharoda
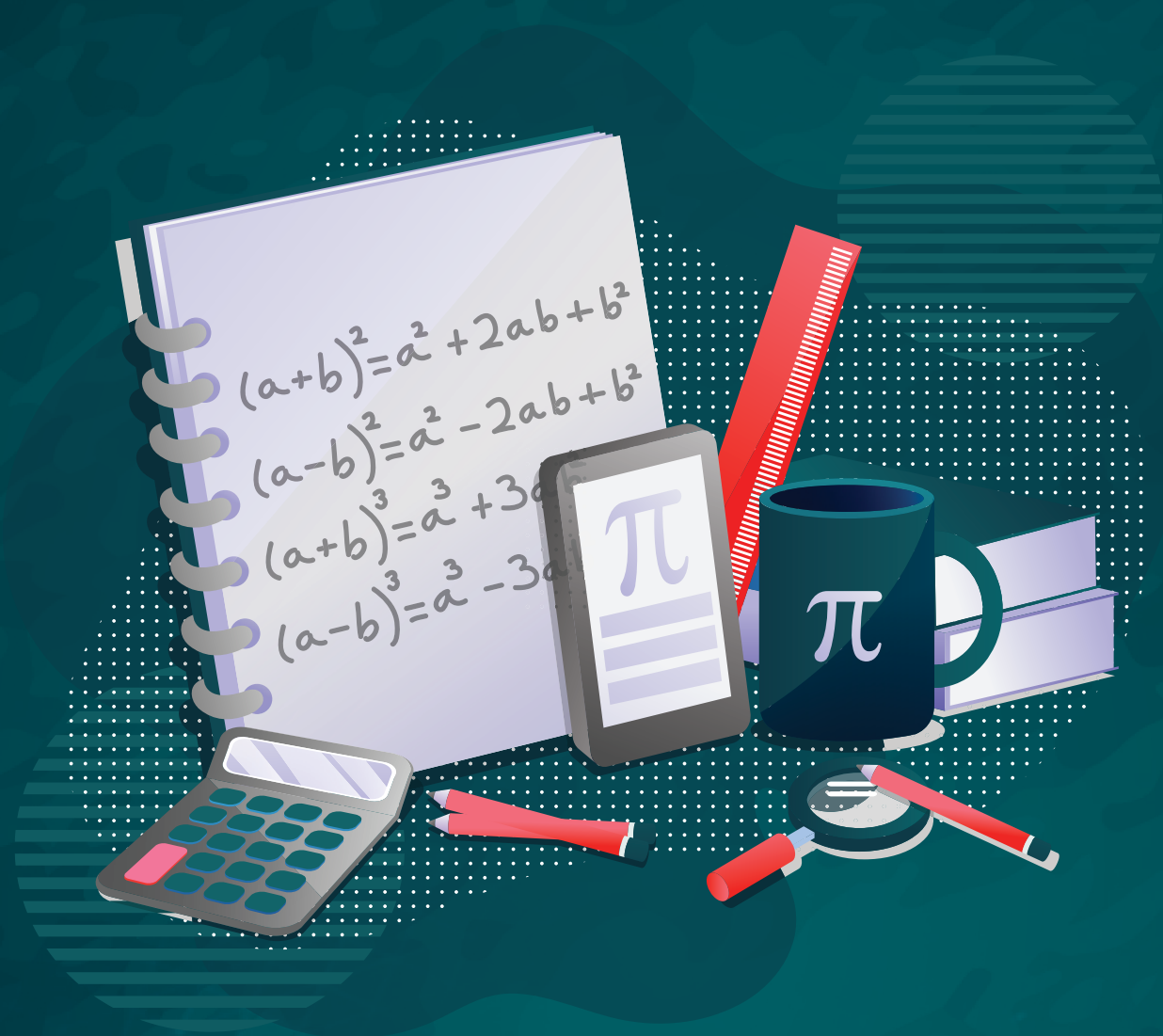
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