KESHAV MAHAVIDYALAYA
NAAC ACCREDITED INSTITUTION "A" GRADE
UNIVERSITY OF DELHI

DEPARTMENT OF MATHEMATICS

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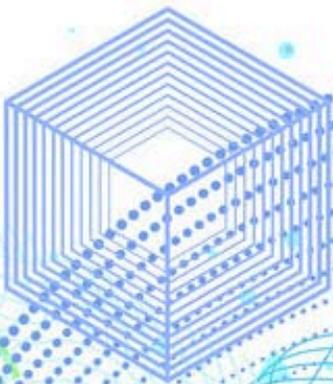
"Only Knowledge can provide salvation"
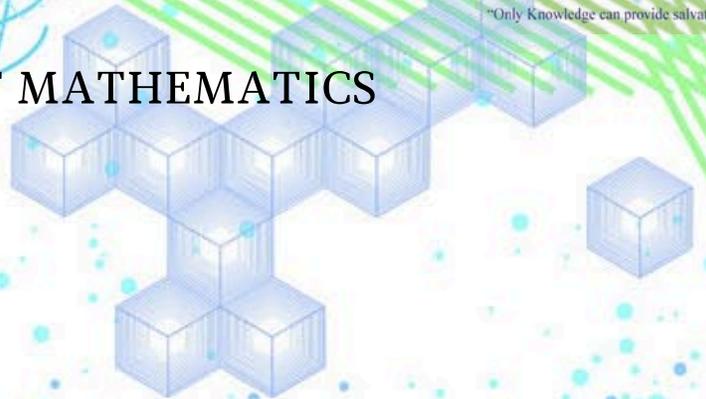
CONTINUUM

THE ANNUAL MAGAZINE

2021-2022

INAUGRAL ISSUE

MESSAGE FROM THE HEAD, DEPARTMENT OF MATHEMATICS

It is very heartening to know that the Department of Mathematics at Keshav Mahavidyalaya, University of Delhi, is bringing out its first Annual Departmental Magazine which will include informative articles written by its students and faculty members. We are all proud that this College has recently concluded its silver jubilee after completing 25 years and is doing exceedingly well. Department is offering an undergraduate course in Mathematical Sciences since 1996 and Honors Program in Mathematics since 2006. With the help of committed teaching staff providing value-based quality teaching, students from this department have been performing very well on various platforms and some of them have been doing pretty good on the research front getting admission to many of the prestigious research institutes in our country

Starting such a magazine is a very positive step and I am sure with the passage of time, it will provide a wonderful platform for undergraduate students to express their creativity. In addition to the various remarkable achievements of the Department of Mathematics, this is yet another milestone in the series of academic activities being performed by the department.

I wish the students and faculty members of the Department of Mathematics at Keshav Mahavidyalaya a great success in this initiative.

Prof. Ruchi Das
Professor and Head, Department of Mathematics
Dean, Faculty of Mathematical Sciences
University of Delhi

MESSAGE FROM THE PRINCIPAL'S DESK

It gives me immense pleasure to pen down the introductory lines for 'Continuum' the first edition of the Annual Magazine of the Department of Mathematics.

"No matter what people tell you, words and ideas can change the world."- Robin Williams

Keshav Mahavidyalaya has been a premier institution that provides not only provides education to its students but also a positive attitude to look at the world. Department of Mathematics offers two courses,

B.Sc.(H) Mathematics and B.Sc. Mathematical Sciences mainly and B.Sc. (Prog) Physical Sciences, an interdisciplinary course shared with the Department of Physics and Department of Computer Science. The subject is taught with more emphasis on learning mathematics through applications leading to exceptional achievements. The department is coming up with the first edition of their annual magazine "Continuum". The magazine aims to provide space and scope to nurture the creativity and potential talent of young students.

I am sure the editorial team has worked wholeheartedly in ensuring high standards of the first issue and shall also work with the same vigour in all coming issues of the magazine. I take this opportunity to congratulate the students and the faculty members for their contribution to the success of the Magazine.

Best Wishes

Prof. Madhu Pruthi

Principal

MESSAGE FROM THE VICE-PRINCIPAL'S DESK

The only way to learn mathematics is to do mathematics.
- Paul R. Halmos, Hungarian-American mathematician

It's a privilege for me to pen down my thoughts on the very first issue of the E-magazine of the Mathematics department of Keshav Mahavidyalaya. Mathematics is everywhere and we can do nothing without maths. It might not teach us to add or subtract feelings but surely it gives us the hope that every problem has a solution.

This E-magazine will provide the students a platform where they can play with numbers and pour in their creative ideas. Apart from studying theoretical maths in class, this magazine will give them the opportunity to use their skills and apply the mathematical concepts to write interesting articles. I congratulate the faculty and students of the department for this initiative under the able guidance and support of our Principal Prof. Madhu Pruthi. Wishing all the very best for the successful launch of the E-magazine.

Prof. Priti Sehgal
Vice-Principal

MESSAGE FROM THE TEACHER-IN-CHARGE'S DESK

"Excellence is a continuous process and not an accident" –
APJ Abdul Kalam

Education is a process that transforms our finest thoughts, and feelings into deeds and elevates the lived experience. It liberates us from ignorance and lights the path to cultured and compassionate human minds. It enables us to translate intent into action, equipping us with efficient working skills and a dedicated mindset to do more than a dream – Work.

Nurturing creativity and inspiring innovation are two of the key elements of a successful education, and a college magazine is the perfect amalgamation of both.

It harnesses the creative energies of the academic community and distils the essence of their inspired imagination in the most brilliant way possible. Hence, I am gratified to share that the Department of Mathematics, Keshav Mahavidyalaya, University of Delhi is bringing out the inaugural issue of its magazine *Continuum*. It's will serve as a tool to enhance mathematical skills for the students. Students from the Mathematics department are energetic and it's a good initiative. I sincerely wish *Continuum* establishes enthusiasm and inspires young minds towards innovations.

My greetings to Editorial Board to keep up the good work. I sincerely appreciate the coordination and commendable efforts put forth by the team to bring out this issue. I congratulate the team of students and the faculty for their tireless efforts that have come to fruition in the form of this magazine. I wish it all success and hope that this tradition that has been set by the current students will be carried through by the   following generation of students to come.

Dr. Rajni Mendiratta
Teacher-in-charge

MESSAGE FROM THE EDITORS' DESK

We are really proud and energized to acclaim that we are ready with all new hopes and hues to bring out the first edition of the Mathematics Department's annual magazine 'CONTINUUM', which is going to surely unfold the unravelled world of the most unforgettable and precious moments of the Department of Mathematics. It captures the momentous moments of the department's journey. We have tried our best to make sure this magazine helps in recapitulate the eventful journey of the department on some pages. This issue is a treasure of articles, poems, stories, beautiful pictures, various events of the department, achievements of the faculty members and the students. This collection not only reflects the creative talents of the contributors but also their analytical thinking. We feel it an honour to congratulate all of them.

This was another splendid year, with our students bringing laurels to the department in all possible spheres. Their achievements were so vivid that all our efforts to include their accomplishments in one issue went in vain. This magazine is not the outcome of the effort put in by an individual but is the immense effort put forward by all teachers and students of the department. We are sure that the positive attitude, hard work, sustained efforts and innovative ideas exhibited by all contributors will surely stir the mind of the readers and take them to the surreal world of unalloyed joy and pleasure. We have put in relentless efforts to bring excellence to this treasure trove.

We are extremely thankful to our Principal, Prof. Madhu Pruthi and vice Principal, Prof. Preeti Sehgal for supporting us in our endeavour to bring out the first issue of the magazine. We are also grateful to our Teacher In-charge, Dr. Rajni Mendiratta and our colleagues for their faith in the team. We are also thankful to the student members of the editorial team for their cooperation and putting in their best for accomplishing the magazine. We sincerely hope that all of us will enjoy reading it.

Prof. Ritu Arora

Dr. Richie Aggarwal
Assistant Professor

Dr. Ram ChanderVerma
Assistant Professor

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DEPARTMENT OF MATHEMATICS

Exposure to mathematics provides the ability to develop an analytical approach to real-world situations. The Department of Mathematics of Keshav Mahavidyalaya offers courses namely, B.Sc.(H) Mathematics and B.Sc. Mathematical Sciences mainly and B.Sc. (Prog) Physical Sciences, an interdisciplinary course shared with the Department of Physics and Department of Computer Science. It has highly professional and experienced faculty dedicatedly imparting their knowledge to the students. The eminent teachers of the department handhold the students for better career prospects. The teachers through the mentor-mentee groups make efforts to counsel the students in their family-related problems as well. The Mentor-Mentee program has helped the students, especially during the pandemic time in the last two years.

The department stimulates the understanding of the students through practical education in Information and Communication Technologies (ICT) Lab. The ICT lab sessions are very enriching and thought-provoking in developing the logical and rational thinking of the students. The Department of Mathematics is organizing its annual mathematical meet – Modulus since 2008. During this meet, students along with the faculty members conduct various insightful learning sessions, workshops, and events. The aspiration of this meet is to develop the mind of students in logical and mathematical skills to enhance their thinking and build up their confidence. This inter-college event has a varied range of activities including talks and seminars.

Many students of our college have secured top ranks in the University. They have excelled in different fields and got placements in reputed companies. Many students from our college further opt for master in various prestigious universities in India and abroad.

ONLINE EVENTS

1. One-week Interdisciplinary Online *Faculty Development Program* on **"Creation and Development of MOOCs while managing online classes"** from *24th August 2021 to 31st August 2021*, in collaboration with MHRDC.

2. **"Fascinating anecdotes of the history of India as a knowledge economy"** on 29th October 2021. The speaker for the seminar was one of the brightest minds in the world, ***Padma Shri Professor Dinesh Singh***, former Vice-Chancellor of the University of Delhi.

3. **Freshers 2k22** was organized on *8th January 2022*, with the aim to welcome first-year students of courses under the Mathematics Department. The event commenced with an address by our faculty members who actively participated in the event and played a crucial role in making it a success. The event witnessed the participation of more than 70 students. Many fun games were organized to encourage the students to participate and interact.

4. **"Remembering Famous Indian Mathematicians from Pre-Independence Era"** Our eminent speaker ***Dr Vandana Khaitan*** from the department of Operational research, university of Delhi delivered gratified words on the same topic, on *5th February 2022*.

5. The whole department, society members and faculty did not lose hope during the pandemic and worked with the same enthusiasm to organize and manage our annual departmental fest: **Modulus '22** in virtual mode on *5th March 2022*. As a result, the departmental fest was a huge success. A variety of different events, each involving a deep connection to the subject of mathematics itself were organized.

6. A two-day workshop on **Learning Excel from Basics** was organized on *24th March 2022 and 2nd April 2022*, with ***Prof Prabhat Mittal*** as our eminent speaker, to help students figure out the software and how to make even the most complex calculations easier with just a few steps.
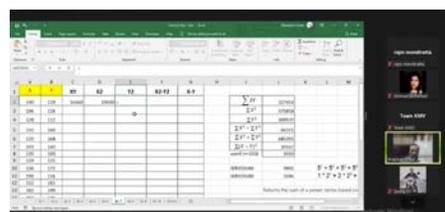

Fascinating anecdotes of the history of India as a knowledge economy

Remembering Famous Indian Mathematicians from Pre-Independence Era.
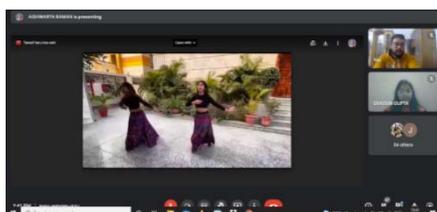
Cultural Performance during Freshers 2k22

Worksheets during the workshop: Learning Excel from Baiscs

NEENA GUPTA
THE THIRD WOMAN TO RECEIVE THE RAMANUJAN PRIZE

Neena Gupta (born in 1984) is an Associate Professor at the Statistics and Mathematics Unit of the Indian Statistical Institute (ISI), Kolkata. There are many prestigious accolades to her credit. She became the youngest person to receive the Shanti Swarup Bhatnagar Prize in 2019 at the age of 35.She solved a 70-year-old mathematics puzzle called the Zariski Cancellation Problem. Dr Gupta is the third woman to win the honour till date. In 2022, she was awarded the Ramanujan award. She is the second female from India who got this award.

Moreover, she received the Nari Shakti Puraskar from the President of India, Shri Ram Nath Kovind, on March 8, 2022.

AWARDS

• She received the Saraswathi Cowsik Medal by the TIFR Alumni Association for her work on the Zariski Cancellation Problem in positive characteristics in 2013.

• Associateship of the Indian Academy of Sciences in 2013.

• In 2014, She was awarded the Ramanujan Prize from the University of Madras . Also, she got the Indian National Science Academy Young Scientist Award. The Indian National Science Academy described her solution as "one of the best works in algebraic geometry in recent years done anywhere".

Further, in 2014, she was also awarded the inaugural professor A. K. Agarwal Award for best research publication by the Indian Mathematical Society.

• In the next year 2015, she got the Swarna Jayanti Fellowship award from the Department of Science and Technology of India.

• The World Academy of Sciences Young Affiliates in 2020.

• She was awarded DST-ICTP-IMU Ramanujan Prize for Young Mathematicians from Developing Countries in 2021. Also, she has been a fellow of the Indian Academy of Sciences.

• She was invited to speak at the International Congress of Mathematicians (ICM) in 2022.

Prof. Ritu Arora & Dr. Richie Aggarwal

PROF. MANJUL BHARGAVA

Prof. Manjul Bhargava (born in 1974) is a Canadian - American mathematician of Indian origin. At present, he is a Professor of Mathematics at Princeton University. His area of research is Number theory. Prof. Bhargava was awarded the Fields Medal in 2014. According to the International Mathematical Union citation, he was awarded the prize "for developing powerful new methods in the geometry of numbers, which he applied to count rings of small rank and to bound the average rank of elliptic curves".

AWARDS AND HONOURS

Bhargava has won the Fields Medal award, which is the most prestigious and the highest award in the field of mathematics. He also has won several other awards, a few of them are listed below:

- He has conferred a fellowship at the Royal Society in 2019.
- He is the third-youngest professor at Princeton University.
- In 2005, he won SASTRA Ramanujan Prize at Thanjavur, India, for his outstanding contributions to Number Theory.
- In 2008, Bhargava was awarded the American Mathematical Society's Cole Prize.
- In 2009, he was awarded the Face of the Future award at the India Abroad Person of the Year ceremony in New York City.
- In 2011, he was awarded the Fermat Prize.
- He was awarded the 2012 Infosys Prize in mathematics for his "extraordinarily original work in algebraic number theory".
- In 2013, he was elected to the national academy of Sciences.
- In 2015, he was awarded the Padma Bhushan, the third-highest civilian award in India.
- In 2017, Bhargava was elected as a member of the American Academy of Arts and Sciences.
- In 2018 Bhargava was named as the inaugural occupant of The Distinguished Chair for the Public Dissemination of Mathematics at The National Museum of Mathematics (MoMath). This is the first visiting professorship in the United States dedicated exclusively to raising public awareness of mathematics.

Another angle of Prof. Bhargava is that he is an accomplished tabla player. He has also studied Sanskrit from his grandfather Purushottam Lal Bhargava, a well-known scholar of Sanskrit and ancient Indian history.

Dr. Rajni Mendiratta & Ms. Manisha Saini

BLOCKCHAIN AND CRYPTOCURRENCY

Blockchain is a revolutionary technology that allows people to record transactions on a digital, decentralised, distributed ledger, without any central authority. Some consider this technology as "the trust machine" and cryptocurrency is, without doubt, the most notable by-product of the blockchain revolution. Initial Coin Offering (ICO) is a new way to raise finance, newly created cryptocurrencies are being sold to the public by startups in exchange for capital. In the blockchain, each block not only stores the transaction's detail and timestamp but also saves the hash values of the previous block with a nonce (a random number). Given below is a typical example of a basic blockchain. When storing transaction details, blockchain technology employs the nonce for verifying the hash to ensure the integrity of the entire blockchain.
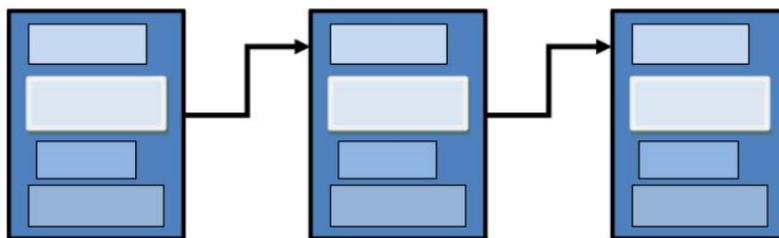
A hash value is produced by the cryptographic hash function that maps a given set of data to a fixed-size string of numbers and letters (Drescher, 2017). For example, the hash value of a single word "hello" and the hash value of a sentence with 10 words will be two unique values but exactly the same size and length. In addition, transactions of a block are hashed through the Merkle root, which is already the hash of all the transaction hashes in the block. As a result, hashing a block with 100 transactions takes exactly the same amount of effort as hashing a block with only one transaction (Bhaskar & Chuen, 2015). In addition, fraudulent transactions could be effectively prevented since any change in a block would also change the respective hash value.

A new block will only be added to the chain when the majority of nodes in the network were agreed by a consensus mechanism on both validities of transactions in a block and the block itself, This consensus mechanism is a process to ensure the information of a newly added block is valid and it records the latest transaction. It ensures the majority of network validators agree on the state of the ledger. It is also a set of rules and procedures between multiple participating nodes to ensure the validity of the ledger. In addition, new transactions will be stored in a block for a particular period by the consensus process (time may vary depending on the blockchain, for example, 10 mins in the Bitcoin blockchain) before being added to the ledger and after that, the information can no longer be changed.

Types of blockchain

Depending on the nature of the ledger, blockchains can be classified into three categories which are public, private and hybrid blockchains. The ledger of a public blockchain is

completely decentralised, and any internet user can access it. Public blockchains are usually based on the PoW consensus mechanism mentioned above. For intense use, the Bitcoin blockchain is a public blockchain since it allows anyone to (a) run Bitcoin full node and mine Bitcoins; (b) check and review the whole ledger; (c) make transactions on the blockchain. On the other hand, an entirely private blockchain is monitored by a central authority.

The evolution of blockchain

As blockchain technology is developing rapidly in recent years, research claims that the evolution of blockchain technology could be identified into three different categories: Blockchain 1.0, 2.0 and 3.0. Blockchain 1.0 is currency, the development of cryptocurrencies, that are related to cash or payments, such as Bitcoin.

Blockchain 2.0 is about the functionalities, that lie beyond only as "currency", especially smart contracts. A smart contract is a piece of code that is stored on the blockchain. It could be executed automatically without the control of a third party, but only when certain conditions are met. Thus, different types of applications could be built on blockchains through this kind of "contract". Ethereum is a prime example of blockchain 2.0.

Blockchain 3.0 is all about applications. Blockchain is no longer limited to finance and transactions due to the further development and application of smart contracts. This technology now has the potential to be merged into various sectors, such as government, education and more (Gatteschi et al., 2018; Swan, 2015). In addition, some studies share a similar view of blockchain 3.0, also suggesting that blockchain technology could be beneficial for both financial and non-financial industries. The music industry, Supply chain are two such industries, which are using blockchain to track their products.

Dr. Rubina Mittal

FUN FACTS

▶ If you multiply 111,111,111 × 111,111,111 you get 12,345,678,987,654,321 - a palindrome number that reads the same forwards or backwards. And that works all the way back down to 11 x 11 (121) or just 1x1

▶ You can cut a cake into 8 equal pieces by using only 3 cuts.

▶ There are exactly 10! seconds in 6 weeks.

▶ A baseball field is of the perfect shape of a rhombus.

▶ The numbers on opposite sides of a die always add up to seven.

▶ Multiplying ones always gives you palindromic numbers.

A FACEBOOK THEOREM

It's very likely that you have a Facebook account, and of course, you have many friends on Facebook. Suppose Aman is your friend on Facebook, then you too are Aman's friend on Facebook. Then you and Aman can have all the three possibilities:

1. You and Aman have some common friends.
2. Some of your friends are not friends with Aman.
3. Some of Aman's friends are not your friends.

A group of three people is said to form a trio if either all are friends with each other, or none are friends with each other. If we denote people with dots and we draw a blue line connecting them to denote that they are friends on Facebook, and a red line between them to denote that they are not friends, then a trio is depicted as a blue triangle or a red triangle. Now here is a question for you.

What is the smallest number n of people on Facebook such that there is definitely a trio among them?

To answer this question, let us start with the number 3 itself. With three people, say A, B and C, we can consider A and B to be friends, neither of whom are friends with C. So we have a situation in which trio is not formed with 3 people.
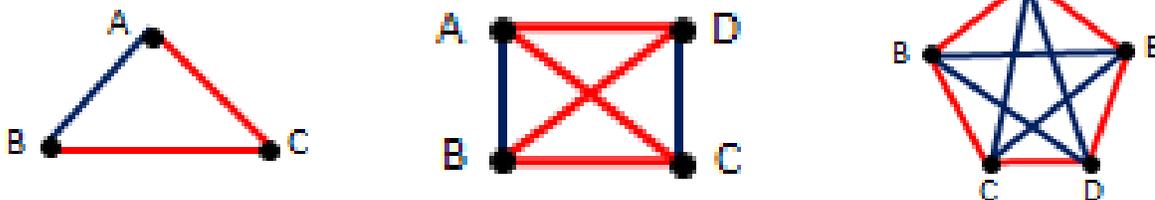
What about four people, A, B, C and D? It is also an easy case to handle. We make A and B friends, C and D friends, and no more. Thus this situation confirms that a trio may not be found with 4 people. If we have five people A, B, C, D and E, then we can draw a red pentagon with the persons on vertices and blue lines on 'opposite' vertices. You should be convinced that the trio may not be formed with five people.

Next, we consider six. You take some time off now to draw pictures like the above. The hexagon with its diagonals does not help (as A, C, E form a trio). Another hexagon may be tried but it does not work (like A, B, C forms a trio). While we get many interesting pictures, but we get none that works.

At this point, we start suspecting that six might indeed be the smallest number we seek. But then we need proof for the same. We would like to show that among any six persons on Facebook, we have a trio, i.e., either all of whom are friends, or not friends.

Let the six people be A, B, C, D, E and F. If we consider the first five, then we may not find a trio among them. When we connect F to other five people, we get five line segments. Out of these five-line segments, there are at least three line segments of the same colour.

Let the line segments of F with A, B and C be of the same colour (either blue or red).

First, we consider the case when the line segments of F with A, B and C are of blue colour. In this case, F is friends with each of A, B and C. If any two of A, B, and C are friends with each other, then these two together with F form a trio of friends. If no two among A, B, or C are friends with each other, then A, B, or C form a trio of non-friends.

Similarly, we can handle the other case. In both the cases, we get the trio we need.

So we have proved a Facebook Theorem which states

> If we pick any 6 users out of the millions of users of Facebook, then we are certainly going to get a trio, i.e., three of those chosen six are either all friends or all non-friends.

We have established the validity of results for any six of the millions of members, who use that site and know nothing at all about them!

Dr. Ashish Bansal

INTERESTING FACTS ABOUT PLAYING CARDS

1. The Jack of Spades (J), Jack of Hearts (J) and King of Diamonds (K) are shown as seen from one side, while the rest of the court cards are shown in full face. These cards are commonly called one-eyed.

2. The King of Hearts (K) is the only King with no moustache. He is also shown with a sword behind his head, making him appear to be stabbing himself. This leads to the nickname suicide king. It can also be thought of as if he is hiding the sword behind him. This and his missing moustache have led him to be named the false king.

3. The King of Diamonds (K) is traditionally armed with an axe, while the other kings are armed with swords. That is why he is sometimes referred to as the man with the axe. The axe held by him is behind his head with the blade facing towards him.

4. The Ace of Spades (A) is sometimes called the death card because of its unique large ornate (i.e., decorated) spade (a sharp-edged metal blade with a long handle).

5. The Queen of Spades (Q) usually holds a sceptre (a kind of stick held at the crowning ceremony) and is sometimes known as the bedpost queen. More often, she is called the black lady.

6. All Queens are depicted with a flower styled according to their suit.

THE FIBONACCI SEQUENCE

The Fibonacci sequence is the sequence 1, 1, 2, 3, 5, 8, 13, … having the property that any term is precisely the sum of the preceding two. More precisely, it is the sequence (an) that is implicitly defined as a1=a2=1 and an=an-2+an-1. It is named after the 13th-century Italian mathematician Leonardo of Pisa who was later known as Fibonacci. It is great to note that long before his time, in around 200 BCE, the sequence was used by the Indian mathematician, who is also a poet, named Acharya Pingala while enumerating possible patterns of Sanskrit poetry formed from syllables of two lengths1.

The numbers occur in the sequence are called Fibonacci numbers, they appear very often in mathematics. The terms Fobonacci search technique and Fibonacci heap data structure that appear in computer science shows its importance in modern technology. More than that, it is exciting to see the numbers appear in nature, for example, in branching in trees, the arrangement of leaves on a stem, the fruit sprouts of a pineapple etc. The number of florets in a spiral of flowers like the sun flower appears as adjacent Fibonacci numbers, giving a suitable configuration that does the space management.
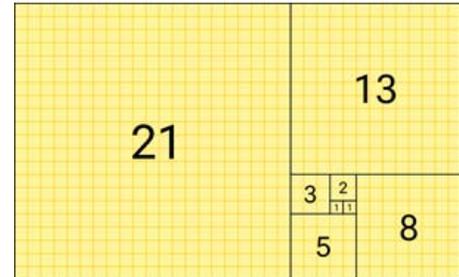
Fibonacci, in his book titled Liber Abaci, expressed a puzzle on the rabbit population as follows: A breeding pair of rabbits are put in a field, under the ideal assumption that each breeding pair mates at the end of every month producing another breeding pair at the end of the next month. The number of breeding pairs at the beginning of each month written sequentially is precisely the Fibonacci sequence.

Fibonacci numbers also appear in the family tree of honeybees. Consider an ideal situation as the following. If an egg is laid by an unmated female, it hatches a male or drone bee, and if an egg was fertilized by a male, it hatches a female. Now consider a male bee. He has a single parent, 2 grandparents, 3 great-grandparents, 5 great-great-grandparents, and so on, giving the Fibonacci sequence! A closely related situation is the inheritance of X chromosomes in humans.

The main reason for the appearance of the consecutive Fibonacci numbers in abundance everywhere is because the limiting ratio of two consecutive Fibonacci numbers is precisely the Golden ratio, the irrational number (1+√5)/2. There are certain generalizations of the way the sequence is defined. One of them is choosing a1=1, a2=3 and keeping the relation an=an-2+an-1 intact. The initial points a1 and a2 may be chosen suitably so that the sequence does not have any prime numbers. It is also to be noted that even though there are infinitely many composite numbers in the Fibonacci sequence, it remains an open problem whether there are infinitely many Fibonacci primes (Fibonacci numbers that are prime) or not; however we have a list of Fibonacci primes up to thousands of digits.

Mr. Janson Antony

MAGIC SQUARE

A magic square is a very interesting mathematical object. It is a square matrix with all the entries as positive integers such that the sum of entries in each row, each column, and both diagonals (principal and anti-principal) is the same constant. This constant sum is called the magic constant or magic sum.

The magic square has a very long history and many ancient had worked on the construction of the magic square. There are many methods to construct a magic square of a given order n. These methods can be classified as general methods and special methods, in the sense that general methods allow us to construct more than a single magic square of a given order, whereas special methods allow us to construct just one magic square of a given order. Special methods are specific algorithms whereas general methods may require some trial-and-error.

When a magic square has all entries equal, it is called trivial and they are not interesting. A magic square of order 1 is, of course, trivial and a magic square of order 2 does not exist. For this, consider a magic square of order 2 as

So, we have a+b= c+a, which implies b=c, similarly c=a and a=d, we get a trivial magic square.

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix}$$

A Method to Construct a Magic Square of Order 3

A magic square of order 3 is made up of three numbers namely, a, b and c, and the general form of a magic square is

$$\begin{pmatrix} c-b & c+(a+b) & c-a \\ c-(a-b) & c & c+(a-b) \\ c+a & c-(a+b) & c+b \end{pmatrix}$$

The magic sum of this magic square is 3c. We see some examples to construct a magic square of order 3 with three given numbers.

1. First, we will construct a magic square with the following entries.

$$\begin{pmatrix} \cdot\cdot & \cdot\cdot & \cdot\cdot \\ \cdot\cdot & 3 & 5 \\ 4 & \cdot\cdot & \cdot\cdot \end{pmatrix}$$

Here, c=3 the magic sum is 9. Anti-principal diagonal entries sum equal to 9 gives

$$\begin{pmatrix} \cdot\cdot & \cdot\cdot & 2 \\ \cdot\cdot & 3 & 5 \\ 4 & \cdot\cdot & \cdot\cdot \end{pmatrix}$$

Third column and second-row entries sum equal to 9 gives

$$\begin{pmatrix} .. & .. & 2 \\ 1 & 3 & 5 \\ 4 & .. & 2 \end{pmatrix}$$

Third row and diagonal entries sum equal to 9 gives

$$\begin{pmatrix} 4 & .. & 2 \\ 1 & 3 & 5 \\ 4 & 3 & 2 \end{pmatrix}$$

Now, second column entries sum equal to 9 gives

$$\begin{pmatrix} 4 & 3 & 2 \\ 1 & 3 & 5 \\ 4 & 3 & 2 \end{pmatrix}$$

2. We construct the magic square for the following entries

$$\begin{pmatrix} .. & .. & .. \\ 11 & .. & 1 \\ 5 & .. & .. \end{pmatrix}$$

Here, we are not given the central entry mean, c. the sum of each row (column or diagonal) entry is 3c, therefore the sum of entries in the second row is 2c. So, we have c=(11+1)/2 =6 and the magic sum is 18

$$\begin{pmatrix} .. & .. & .. \\ 11 & 6 & 1 \\ 5 & .. & .. \end{pmatrix}$$

Now, as done previously, we obtain the complete magic square as

$$\begin{pmatrix} 2 & 9 & 7 \\ 11 & 6 & 1 \\ 5 & 3 & 10 \end{pmatrix}$$

Ms. Manisha Saini

Magic Square Game

	9	
3		
8		6

RULES:

Using the numbers 1-9, place numbers in the squares so that the sum of any three numbers in a horizontal, vertical or diagonal row equals 15. You may only use each number once.

THE FOUR COLOR THEOREM

The fundamental quality of a mathematician that differs from a physicist or a computer scientist or a biologist is the stubbornness in demanding rigorous proofs to even the most trivial-looking statements. In fact, science, other than mathematics, will not work without relying on experimental evidence, where an experiment is repeated a sufficient number of times. But, this procedure has no place in mathematics. And, this makes the subject challenging. A suitable example is the history of the four colour theorem.
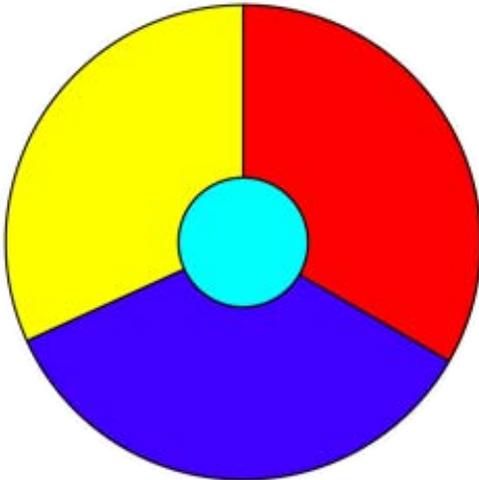
The theorem states that only four distinct colours are required to colour the regions of a map under the condition that if two regions are sharing a common boundary (a curve, not just a single point), then they have different colours. It is an interesting exercise to take the map of India, and colour the states in this manner using not more than 4 sketch pencils. You may even succeed with only 3 pencils! You may proceed to do the same with a map of all districts/taluks of your state, or just randomly draw a map and do the same.

This is precisely what the mathematicians did until 1976, when it was successfully proved, after several failed attempts, by two elegant mathematicians named Kenneth Appel and Wolfgang Haken.

Before it was proven, the conjecture was attributed to Augustus De Morgan. However, the question came to the thought of Francis Guthrie while colouring the map of counties of England, and was communicated to De Morgan through his brother. De Morgan wrote: "A student of mine asked me to give him a reason for a fact which I did not know was a fact—and do not yet. He says that if a figure be any how divided and the compartments differently coloured so that figures with any portion of common boundary line are differently coloured—four colours may be wanted but not more—the following is his case in which four colours are wanted. Query cannot a necessity for five or more be invented…".

Note that even if you succeed in illustrating the theorem in a million different examples, unless you prove it, it cannot be accepted. During the 1960s and 1970s, methods of using computers to search for a proof was developed. Appel and Haken were assisted by algorithmic work by John A Koch. As it was the first major theorem to be proved with extensive computer assistance, some controversies around the proof were reported. As a result, some small corrections were also done later. This is one example where a human cannot verify the proof by hand without help from computers.

The theorem also has a long history of people coming up with the wrong disproofs. When we try by hand to construct a counterexample by successively plotting boundaries and colouring one by one, we may sometimes feel that the theorem is false. In most cases, one may be focused on a particular region that is drawn and coloured first and then proceeds to plot and colour the neighbouring regions. In fact, there are many maps where if the colours of some regions are fixed beforehand, then it is not possible to colour the whole only using 4 colours.

Long before the four colour theorem was proved, the five colour theorem, which is formulated analogously, was proved. Nowadays, even though most of the maps of countries and regions can be coloured using only 3 colours, people are being very generous and use even more than 5 colours for it.

Mr. Janson Antony

Spiced up Sudoku

RULES:

1) Each row, column and box should have all the numbers(1-9) once.

2) The numbers written on the top of the dotted boxes should be the sum of the numbers in that dotted box.
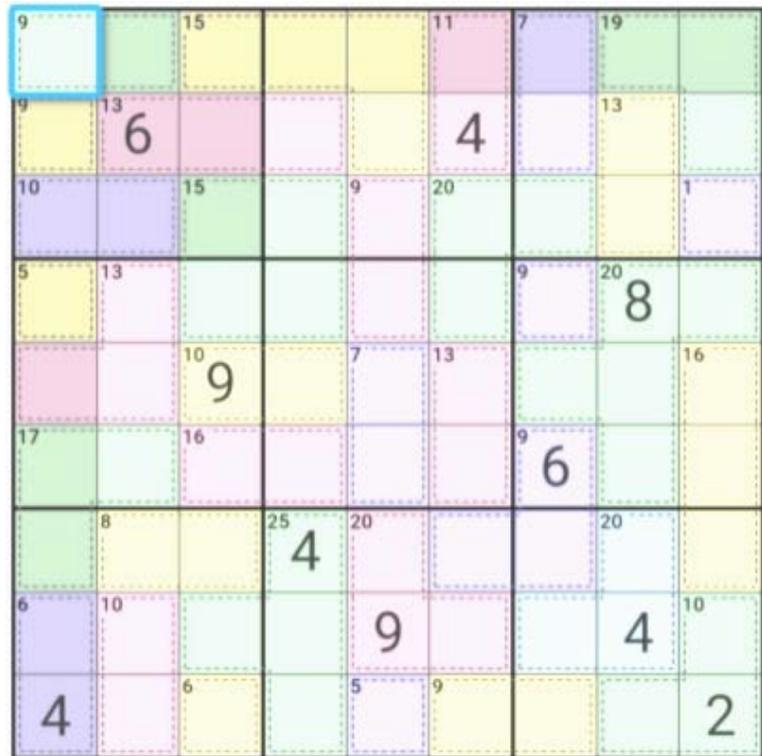
THE MATHEMATICAL MUSE FOR ART

Many people consider mathematics and art to be two very different concepts. In a way, they are. But mathematics and art are also two concepts that go hand in hand and have been so for a very long time.

Mathematics is considered art motivated by beauty. It is perceived in various art styles such as music, dance, architecture, sculpture, and textiles. But their most prominent presence lies in visual arts. Artists have been using math as early as the 4th century BC. Greek sculptor Ploklietos wrote his Canon prescribing proportions conjectured to have been based on the ratio 1:√2 for the ideal male nude. Greeks predominantly treated math as geometry and symmetry while in India, it was treated as a primary concept.

One of India's contributions to the current universal number system in the form of 0, is quite widely known. Another concept that the world adopted from India is infinity. Infinity or, as it is in Sanskrit, Anantha refers to the coiled snaked atop which Lord Vishnu rests. Anantha, as a symbol, was widely depicted in the form of sculptures, paintings, poetry, literature, textiles, handicrafts, and motifs all over the medieval era of India. As exports used to take place to various regions during that time, these Anantha motifs traveled to Arabia, from 1415 to 1600s, following which they traveled to Europe.
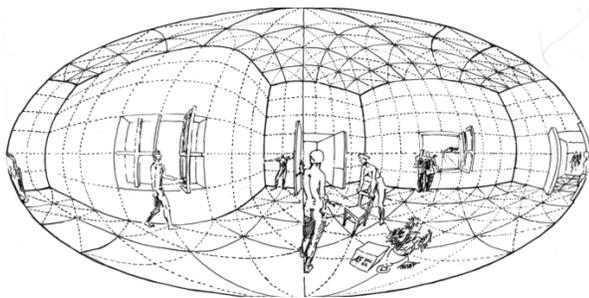

Another mathematical concept that is widely used in visual arts is the curvilinear perspective. The history of its presence in art dates back to the 15th century. Curvilinear perspective and 3D space were something that has easily been represented with great detail in art, especially technical drawing, by means other than perspective. Oblique projections were also regularly used in art forms. They are mostly seen in Chinese artforms who adopted it from India, who adopted it from Ancient Rome.

Similarly, planar symmetries have been utilized for over millennia in artworks such as carpets, lattices, textiles, and tilings. A good example of such would be the Indian jali work carves in marble at the tomb of Salim Christi, Fatehpur Sikri.
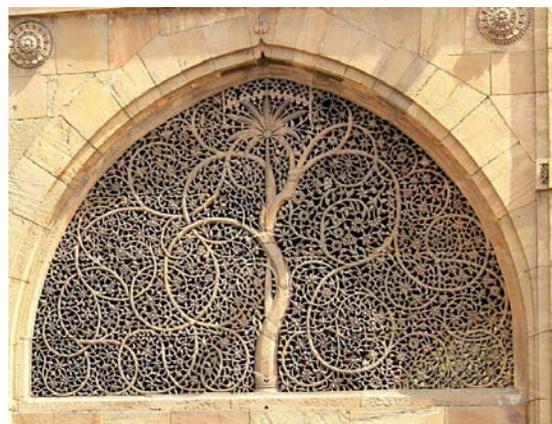
Another example of such is the art of kōlam of southern India, mainly Tamil Nadu.
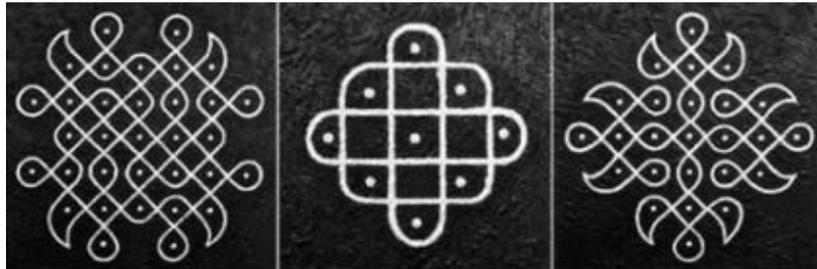
It incorporates perfect symmetry, straight and curved lines drawn around a grid of dots that require spatial precision to achieve symmetry. Sometimes these designs are finite and other times, they have continuous loops, slithering to infinity. Intersecting into infinite figure eights, in a style known as pulli kōlam, the kōlam is also believed to be a representation of infinity, of the infinite cycle of birth and rebirth that forms a foundational concept in Hindu mythology.

Despite their different domains, art and math go hand in hand. Both hold a gorgeous puzzle that gives such a calming rush when solved and finished.

Aishwarya Raman
B.Sc. Physical Sciences, Sem VI

The nonogram

RULES:

• The clues are the numbers at the ends of rows and columns.
• Each number is the number of consecutive black squares.
• Two adjoining consecutive squares blocks are separated by one or more than one white squares.

Matrices [->] Base of Graphics!

Usage of matrices in computer graphics is widespread. Many industries like architecture, cartoons and automotive that were formerly done by hand drawing now are done routinely by computer graphics. In gaming industries, matrices are the major mathematical tool to construct and manipulate a realistic animation of a polygon figure.

Like the matrices operations of translation, scaling and rotations are used to play with points in space. Simplifying complex math let's discuss some aspects in brief.

- Translation: Basically means adding a point to a vector i.e., making it transform into a new point. So far, for example, a plane is a simple game space that has to be shown as moving, we add all the plane points by a vector (x_i , y_i , z_i)[say]. This can simply be obtained by taking the points in matrix form and multiplying it by the vector. The same concept is then applied to multiple planes and we get a flying helicopter or moving superman.
- Scaling: Applied to diagonal matrices by multiplying an R3 matrix with Sx, Sy, Sz (respectively) helps to increase or decrease the size of any object in the space.
- Rotation: The matrix concept of rotation along a particular axis is used for either moving vehicles in GTA V or carriages in Assassins creed.

In short, complex polygons can be broken into matrices and manipulated by using matrices operations on a professional scale.

Vibhor Thakur
B.Sc. Mathematical Sciences, Sem I

**The answer key:

Magic Square Game

4	9	2	= 15
3	5	7	= 15
8	1	6	= 15

‖ ‖ ‖ ↘ 15
15 15 15

Spiced up Sudoku

1	8	5	3	6	7	4	2	9
9	6	2	5	1	4	3	7	8
3	7	4	8	2	9	5	6	1
5	3	1	2	7	6	9	8	4
6	4	9	1	3	8	2	5	7
8	2	7	9	4	5	6	1	3
7	5	3	4	8	2	1	9	6
2	1	8	6	9	3	7	4	5
4	9	6	7	5	1	8	3	2

The Nonogram

THE BUTTERFLY EFFECT

Mathematics is very vast, every being, every planet, every structure, has a different geometry, and different concepts to understand. Mathematics is the only answer to all the mysteries of the universe. Mathematics is a boon to mankind.

As Sir Paul Dirac said,

"If there is a god, he's a great mathematician."

A half-century back in the 139th meeting of the American Association for the Advancement of Science, Edward Lorenz asked the question "Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?" This question is also responsible for the name of this effect. It is also known as chaos theory.

As well on hearing this type of question the answer is like no it is impossible, but, according to Edward Lorenz, the prediction has many complexities, there are many variables that are responsible for the future circumstances, the integral summation of every possibility can tell us exact future. Sir Isaac Newton suggests that nature is a probabilistic mechanical system, this statement posed a question that if we knew all the physical laws of nature, then nothing becomes uncertain, the future is always in front of our eyes at present.

The butterfly effect is a deterministic nonlinear system's sensitive dependency on beginning circumstances, in which a slight change in one state can result in significant alterations in a later one. It puts the concept of atmospheric instability on a quantitative footing and connects it to the attributes of broad classes of dynamic systems that are undergoing nonlinear dynamics and deterministic chaos. American mathematician and philosopher Norbert Wiener also contributed to this theory. In terms of weather, the butterfly effect is most well-known; it can be easily proved in common weather prediction models, for example. Chaos is vital in the development of weather prediction tools, according to climate scientists James Annan and William Connolley; models are sensitive to beginning conditions.

They add the following caveat: "Of course, the presence of an unknown butterfly fluttering its wings does not influence weather forecasts because such a minor disruption will take far too long to grow to a considerable magnitude, and we have far more pressing concerns. As a result, the direct impact of this phenomenon on weather forecasting is frequently inaccurate."

This effect is also useful in quantum mechanics. The butterfly effect's potential for sensitive dependency on initial conditions has been investigated in a variety of semi-classical and quantum physics applications, including atoms in strong fields and the anisotropic Kepler problem. Authors suggest that the butterfly effect can be observed in quantum systems.

The butterfly effect is a small concept of Mathematics, but as we read above, this small part has great use.

Mandeep Singh
B.Sc. Mathematical Sciences, Sem I

THE MAN WHO KNEW INFINITY – SRINIVAS RAMANUJAN

"An Equation means nothing to me until it expresses a thought of God" words of probably the best mathematician of our motherland India, Srinivas Ramanujan, a man whose commitment to the hypothesis of numbers has been a significant contribution to the world of Mathematics. He was for sure a numerical peculiarity of the 20th century. This incredible virtuoso of India positions among the unsurpassed greats like Euler and Jacobi.

It is believed that he was a great devotee of the Hindu goddess of creativity and that the goddess used to visit him in dreams and she wrote equations on his tongue. His interest and devotion to mathematics were to the point of obsession. He ignored everything else and would play with numbers day and night on a slate and in his mind. He was a specialist in the translation of dreams and soothsaying. These characteristics he had acquired from his mom who was an astrologer.

Ramanujan was brought into the world in Erode on December 22, 1887, in his grandma's house. Born in a poor Brahmin family, his introduction to formal mathematics began at age 10. Math was like bread and butter for him and he yearned to learn new things more than any normal lad. He made short work of Looney's Trigonometry in his school itself which degree students had a tough time getting through. A sensation at the age of 12 he made a mark for himself as a 'Child Mathematician', he demonstrated unusual mathematical skills at school, winning accolades and awards.

Ramanujan had conducted his mathematical research on Bernoulli numbers. He received a scholarship to study at Government College in Kumbakonam but lost it when he failed his nonmathematical coursework. He joined another college to pursue independent mathematical research, working as a clerk in the Accountant-General's office at the Madras Port Trust Office to support himself.

In 1911 he published the first of his papers in the Journal of the Indian Mathematical Society. His genius slowly gained recognition, and in 1913 he began a correspondence with the British mathematician Godfrey H. Hardy, a year after which he went to Trinity College where he honed his craft under the Englishman's tutelage.

He received his degree from Cambridge in 1916 and went on to publish several brilliant papers on his subject with Hardy's help, and the two even collaborated on several joint projects and publications. He was elected to the London Mathematical Society in 1917 and was elected a Fellow of the Royal Society for his excellent work on Elliptic Functions and the theory of numbers. He was also the first Indian to be elected a Fellow of the Trinity College.

Despite not having any formal training in pure mathematics, Ramanujan's knowledge of mathematics was startling most of which he had worked out for himself.

Although he was almost completely unaware of modern developments in mathematics, his mastery of continued fractions was unequalled by any living mathematician. He worked out the Riemann series, the elliptic integrals, hypergeometric series, the functional equations of the zeta function, and his theory of divergent series, in which he found a value for the sum of such series using a technique he invented that came to be called Ramanujan summation, a famous example of which is if we add all the natural numbers, that is 1, 2, 3, 4, and so on, all the way to infinity, you will find that it is equal to -1/12. Ramanujan summation was used in the original string theory and the Casimir effect as its solution.

The mathematical contributions of Ramanujan have also been widely used in solving various problems in higher scientific fields of specialization. The diverse specialized higher scientific fields include particle physics, statistical mechanics, computer science, space science, cryptology, polymer chemistry, medical science. His mathematical methods are being used in designing better blast furnaces for smelting metals and splicing telephone cables for communication, as well.

One of the most popular discoveries by the 'Man Who Knew Infinity` to date is the Ramanujan-Hardy number. Once when Mr Hardy had gone to visit Ramanujan in hospital, he quipped that he came in a taxi with the number '1729' which seemed a fairly ordinary number, Ramanujan replied that it was not. 1729, is the smallest number which can be expressed as the sum of two different cubes in two different ways: 1729 is the sum of the cubes of 10 and 9 - a cube of 10 is 1000 and a cube of 9 is 729; adding the two numbers results in 1729. 1729 is also the sum of the cubes of 12 and 1- a cube of 12 is 1728 and a cube of 1 is 1; adding the two results in 1729.

This is how this number came to be known as Ramanujan number or Hardy Ramanujan number. While the Ramanujan number is not his greatest combination, it is certainly a fascinating discovery that is the easiest to remember among all of his discoveries.

Ramanujan had contracted tuberculosis due to which he came back to India on March 27, 1919. He breathed his last on April 26, 1920, at Kumbakonam at the age of 32 years. He only for 32 years however during this limited capacity to focus created such hypotheses and formulae which even today stay inconceivable in the current period of supercomputers. He left behind him around 4000 formulae and hypotheses. He gave the whole mathematics fraternity a new dimension and left behind useful conclusions which are being used as a base for new findings.

Ayush Rai
B.Sc. Mathematical Sciences, Sem IV

HOW A 19TH CENTURY MATH GENIUS TAUGHT US THE BEST WAY TO HOLD A PIZZA SLICE

There is a very interesting and surprising geometrical link between the curvature and strength of shapes. We understand this link using the example that, why does bending a pizza slice help us to eat it? And, How Does a Mantis shrimp's punch use a Pringles chip?

Let us take the example of a pizza slice, when we pick up a pizza slice and about to take a bite but usually it flops over and this is because the crust isn't stiff enough to support the weight of the slice. But there is a way to deal with this situation, we can hold the slice into U shape and this keeps our slice from flopping over. As shown in the figure below:
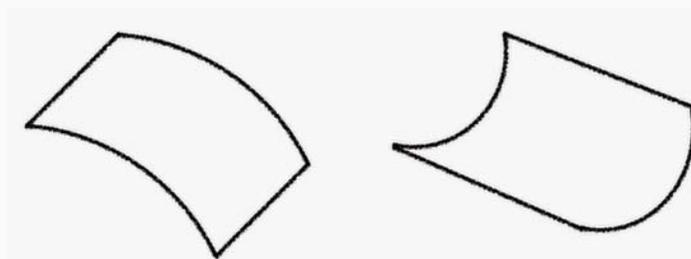

Behind this pizza trick lies a powerful mathematical result about curved surfaces, one that's so startling that its discoverer, the mathematical genius Carl Friedrich Gauss, named it Theorema Egregium.

Take a sheet of paper and roll it into a cylinder. It might seem obvious that the paper is flat, while the cylinder is curved. But Gauss thought about this differently. He wanted to define the curvature of a surface in a way that doesn't change when you bend the surface.

Behind this pizza trick there lies a powerful mathematical result about the curved surfaces, the mathematical genius Carl Friedrich Gauss named it Theorema Egregium. Let us understand the theory of Carl Friedrich Gauss with the help of an example.

For the ant which is on the cylinder, the two extreme paths are available to it and they are the circle-shaped path and the straight-line path. That is one path is curved and another one is flat. But since the curvature of a flat path is zero, when you multiply the two curvatures together you get zero. As mathematicians say, a cylinder is flat – it has zero Gaussian curvature.
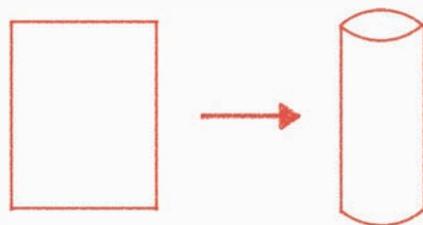
This reflects the fact that you can roll one out of a sheet of paper i,e. when you take a sheet of paper and roll it into a cylinder it might seem that the paper is flat, while the cylinder is curved but the fact is the curvature of a surface does not change when you bend the surface. And this is what Gauss wants to define.

For the ant which is on the cylinder, the two extreme paths are available to it and they are the circle-shaped path and the straight-line path. That is one path is curved and another one is flat. But since the curvature of a flat path is zero, when you multiply the two curvatures together you get zero. As mathematicians say, a cylinder is flat – it has zero Gaussian curvature. This reflects the fact that you can roll one out of a sheet of paper i,e. when you take a sheet of paper and roll it into a cylinder it might seem that the paper is flat, while the cylinder is curved but the fact is the curvature of a surface does not change when you bend the surface. And this is what Gauss wants to define.

A consequence of the above result is that you can take a surface and bend it any way you like, so long as you don't stretch, shrink or tear it, and the Gaussian curvature stays the same. There is a real-life consequence of this, if we cut an orange in half, empty it from the insides, then place the peel on the ground and try to press it as hard as we can. The peel will never flatten out into a circle. Instead, it'll tear itself apart. That's because a sphere and a flat surface have different Gaussian curvatures, so there's no way to flatten a sphere without distorting or tearing it. Now, if we take our example of a pizza slice again, the pizza slice was flat before we picked it up that is it has zero Gaussian curvature. It does not matter how you bend the pizza slice it must retain a trace of its original flatness. Gauss's remarkable theorem assures us that one direction of the slice must always remain flat. The best way to hold a pizza slice is by folding the pizza slice sideways, now you are forcing it to become flat but in the other direction which points towards your mouth. Theorema egregium, indeed. Engineers frequently use curvature to add strength to structures.

Because Curvature creates strength. To understand this fact let us take our example which we discuss in the beginning. Pringles potato chip which is hyperbolic paraboloid in shape, it gets it strength from double curvature.

The mantis shrimp is infamous for having one of the fastest punches in the animal kingdom, a punch so strong that it vaporizes water, creating a shock wave and a flash of light. To deliver its impressive death blow, the mantis shrimp uses a hyperbolic paraboloid shaped spring. It compresses this spring to store up this immense energy, which it releases in one lethal blow. So basically the question is that what makes the pringles shape so strong? It has to do with how it balances pushes and pulls. All structures have to support weight, and ultimately transfer this weight down to the ground. They can do this in two different ways. There's compression, where the weight squeezes an object by pushing inwards. And then there's tension, where the weight pulls at the ends of an object, stretching it apart. The hyperbolic paraboloid combines the best of both worlds. The concave U-shaped part is stretched in tension while the convex arch-shaped part is squeezed in compression. Through double curvature, this shape strikes a delicate balance between these push and pull forces, allowing it to remain thin yet surprisingly strong. Strength through curvature is an idea that shapes our world, and it has its roots in geometry.

Deepti Sharma
B.Sc. Mathematical Sciences, Sem VI

DREAM:
A SWEET ONE OR A NIGHTMARE

I would love to see you mixed up in imagining and filling up with the idea of curiosity with me. It was just another day but something was different, something was missing, and I always want that. It was morning, I took my breakfast, did my daily duties, and started packing my bag, but I couldn't find my mathematics book, my one and only 100 rupee geometry box, or my notebooks. It seemed real, my one and only wish was granted by some miracle, someone really heard my desire, but as I wasn't ready to believe, I thought maybe it was my friends. Once I entered my class, the class started, then 1st period, then 2nd, then finally our mathematics class. Suddenly, I realized it was time for 'THE MATHS TEST.', "Oh no..", now I had done it. There were no books, no notes, and none of my lectures popped into my mind. I could hear my mother scolding me and the blame being put on the overuse of my phone.

My heart was pounding like a horse in a race pushing forward. "What!" I heard my teacher's footsteps approaching. I was shocked and at the same time a little happy in my heart. It was my physics teacher, I thought he was a substitute, so I asked him why our mathematics teacher was absent, and he laughed and said, "Snap out of your dream, what are you talking about, and what is math?" I stood there and saw everyone's faces, all their faces were asking the same question, I apologized, and the class continued. Yes, this was happening in front of my eyes.

There wasn't any subject called mathematics, the world wasn't aware of mathematics at all. I was very much confused, yet thankful to know that there is no longer a subject called mathematics in my life. It soon became something I could never have imagined, everyone was having trouble with simple additions, with way too simple calculations that were anything but simple. Daily, disasters were happening due to the falling of buildings which were due to miscalculations in their construction which was way too easy with mathematics. It was taking hours for something involving calculations. Slowly the perfect ideal world changed into a nightmare. It was hard to do the counting, accounts were tough, no engineers and eventually it was like a big missing part of a puzzle.

Later on, I found my mother scolding me to wake up as I was late to school and yes it was just a sweet dream, or wait was it sweet. Anyway, I snapped out of that dream now it's time for you. On that day I gave my tests it was not that great but I was happy to know that it was fine, it was just me being lame and not giving my best. A world without mathematics can't exist at least not in this dimension. Thank you for joining me today, at last, I would like to end up with a quote by William Paul Thurston, " Mathematics is not about numbers, equations, computations, or algorithms: it is about UNDERSTANDING ".

Suyash Pandey
B.Sc. (H) Mathematics, Sem IV

VIEWPOINT ON MATHEMATICS

Let us draw the mathematical curtain,
And grasp all the knowledge we can attain,
Because Mathematics is like a deep sea,
You understand more every time you study,

High school teaches mathematical application,
But college gives us the root reason,
In school we learn 0 and 1 give 0 on multiplication,
And college teaches the reason behind this solution,

Students fear to learn how theorems are derived,
But it can be interesting once given a dive,
If you become serious and strive,
Maths can make your brain sharp as a knife,

At times it puts you in dilemma,
But all the solutions lie in theorems and lemma,
You need to learn the mathematical theory,
To find solution to your every query,

Maths can be solved at every age,
It always keeps you engaged,
It can be your pillar,
And it can make your life thriller,

Maths can always be fun,
It's use in daily life can make you stun,
Every mathematician is a magician,
When he brings out a mathematical application.

Vibhuti Kukreja
B.Sc. (H) Mathematics, Sem VI

MATHS, MATHS, MATHS!

Down with old Pythagoras
And down with rotten Maths,
Down with Archimedes
And drown him at the baths.
If anyone had to do it,
I'd make sure it was me.
Firstly I'd wholly immerse him.
Then kick him up a tree.
When he had been disposed of,
I'd turn on old Pythag.
I'd drag him through a holly bush
And he'd come out like a rag.
Now my pipe dream's over
And I've nothing more to say
Except that Maths. still lives on
To be taught another day.

Sarita Bhagat
B.Sc.(H) Mathematics, Sem I

EXPLORING PIE WITH AN INNOVATIVE EYE

I am Smaller than four yet bigger than three,
To make me your food, you need to add 'e'
Despite being irrational, I am like your family member
When calculations arrive It's me who you remember
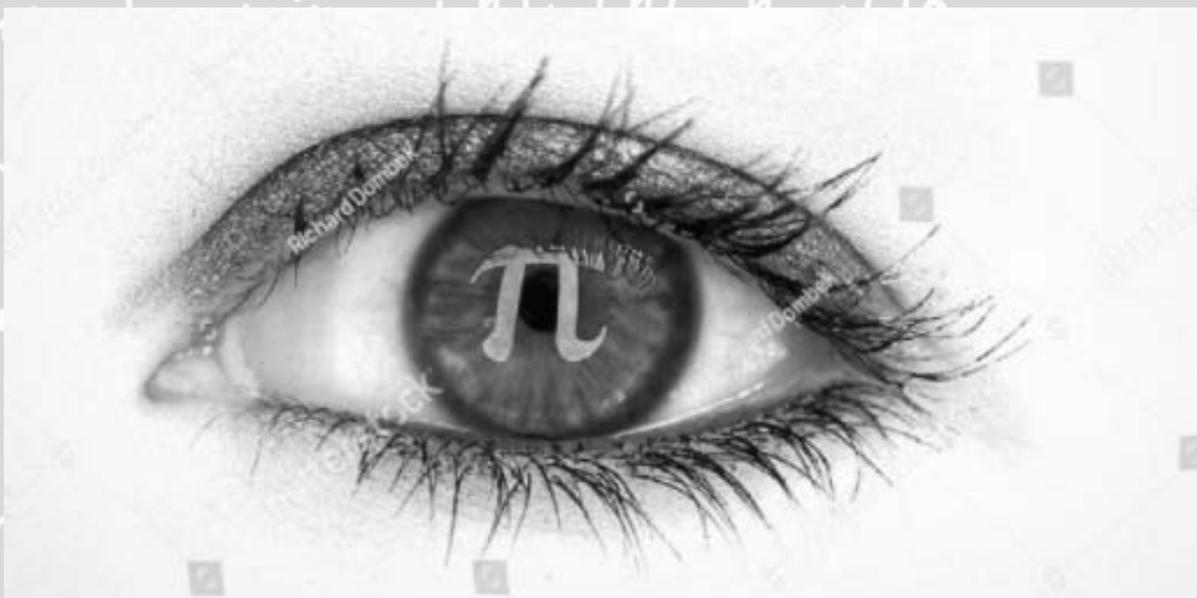People believe I have the answer of the universe,
look I am so so so diverse….
My birthday is celebrated as Albert Einstein's day,
even if you try you can't tell my value in a single day!
I am the maths's eye, everyone respectfully call me Pi.

Sanya Jain
B.Sc. Mathematical Sciences, Sem I

THE PROUD MOMENTS OF FACULTY

DR. RUBINA MITTAL

- Identification of challenges to implementing industry 4.0-A case of Indian MSME -Presented at International Symposium on computational Operational research and Game Theoryheld online during March 9-21 2021.
- An integrated QFD-AHP Approach to enhance the IoT enabled Logistic system- Presented at International Conference on Business Analytics and Intelligence, 20-22 Dec 2021(ICBAI 2021)
- 4 Day workshop on HOW TO START A BUSINESS Feb 15-18 2021
- WASTE MANAGEMENT DURING PANDEMIC AND ITS IMPACT ON CIRCULAR ECONOMY organised by MHFDP centre from 22-26 Nov 2021.
- published 2 chapters in Soft computing for problem-solving Springer, Singapore
- My student Amna OBaid was granted a M.Phil degree and I have 3 PhD students under my supervision.

DR. RAJNI MENDIRATTA

- Participated in the creation and development of MOOCs while managing Online Classes, from 24 Aug 21 -31st Aug 21
- Created prospects and challenges for Interdisciplinary studies and higher education from 26 July 21-31 July 21

DR. ARPANA SHARMA

- Participated in 2 Faculty Development Programs.
- Supervised an M.Phil student.

PROF. RITU ARORA

- Presented a research paper entitled 'Fuzzy Programming for Bilevel Fractional/Quadratic Transportation Problem with Multi-choice Parameters' in International Conference on Applications of Operational Research in Business and Industries, AORBI 2021; held during 17-19 Dec 2021.
- Participated in one week online Faculty Development Programme on "Interdisciplinary Studies and Higher Education: Prospects and Challenges" Organized by Dyal Singh College, the University of Delhi in collaboration with Mahatma Hansraj Faculty Development Centre, Hansraj College, University of Delhi, a centre of MoE, Govt. of India under PMMMNMTT held from 26-31 July 2021.

DR. ASHISH BANSAL

- Contributed as "Convenor" in One Week (Online) Interdisciplinary Faculty Development Programme on 'Creation and development of MOOCs while managing online classes' organised by Keshav Mahavidyalaya, University of Delhi in collaboration with Mahatma Hansraj Faculty Development Centre Hansraj College, University of Delhi from 24 August 2021 to 31 August 2021.
- Participated in Online Author Workshop titled "Understanding research workflow, Science Direct & Mendeley" organised by Researcher Academy, Elsevier on 25 November 2021.Participated in Aryabhata Ganit Challenge 2021 organised by Ministry of Education and My Gov on 1 September 2021.

- Contributed as "Coordinator" in an online seminar on "Remembering Famous Indian Mathematicians from Pre-Independence Era" under "Azadi Ka Amrit Mahotsav" organized by the Department of Mathematics, Keshav Mahavidyalaya on 5th February 2022.Participated in one-week (online) Faculty Development Programme on "Basics of Research" organised by Mahatma Hansraj Faculty Development Centre under Pandit Madan Mohan Malaviya Mission on Teachers and Teaching, Hansraj College, University of Delhi in collaboration with Paramarsh Scheme, UGC from 18 June 2021 to 24 June 2021.
- Participated in Online Author Workshop titled "Understanding Publication workflow & Science Direct" organised by Researcher Academy, Elsevier on 21 December 2021.

DR. DHANPAL SINGH

- Convened an (online) seminar on 'Remembering famous Indian from Pre-Independence Era' organized by Department of Mathematics, Keshav Mahavidyalaya, the University of Delhi on February 5, 2022.
- Participated in two weeks (online) Interdisciplinary Faculty Development Programme on "Usage of ICT in Education: Challenges and Opportunities during Covid 19" organized by Mahatma Hansraj Faculty Development Centre (MHRFDC), Under Pandit Madan Mohan Malaviya National Mission on Teachers and Teaching (PMMMNMTT), Hansraj College, the University of Delhi in collaboration with Department of Mathematics, Chaudhary Charan Singh University, Meerut.
- Worked as a member in one day (online) session on "NADI KO JANO" organized by Keshav Mahavidyalaya, the University of Delhi in collaboration with Bhartiya Shikshan Mandal Delhi Prant on January 28, 2022.
- Worked as Coordinator in one week (online) Interdisciplinary Faculty Development Programme on "Creation and development of MOOCs while managing on line classes" organized by Keshav Mahavidyalaya, University of Delhi in collaboration with Mahatma Hansraj Faculty Development Centre (MHRFDC), Under Pandit Madan Mohan Malaviya National Mission on Teachers and Teaching (PMMMNMTT), Hansraj College, University of Delhi from August 24, 2021 to August 31, 2021.
- Worked as Convener in one day (online) webinar on "Understanding & Embracing NEP: the way ahead" organized by Internal Quality Assurance Cell (IQAC), Keshav Mahavidyalaya, University of Delhi on July 30, 2021.

DR. RICHIE AGGARWAL

- One Week (Online) Interdisciplinary Faculty Development Programme on ' Creation and development of MOOCs while managing online classes, during 24th August to 31st August 2021, organised by Keshav Mahavidyalaya, University of Delhi in collaboration with Mahatma Hansraj Faculty Development Centre Hansraj College, University of Delhi.

MS. RAJAT ARORA

- One Week (Online) Interdisciplinary Faculty Development Programme on ' Creation and development of MOOCs while managing online classes, during 24th August to 31st August 2021, organised by Keshav Mahavidyalaya, the University of Delhi in collaboration with Mahatma Hansraj Faculty Development Centre Hansraj College, University of Delhi.
- Arora, R. & Aggarwal, A.G. (2020). Testing effort based software reliability assessment incorporating FRF and Change point. Yugoslav Journal of Operations Research, 30(3), 273-288.

DR. RAM CHANDER VERMA

- One Week (Online) Interdisciplinary Faculty Development Programme on ' Creation and development of MOOCs while managing online classes, during 24th August to 31st August 2021, organised by Keshav Mahavidyalaya, the University of Delhi in collaboration with Mahatma Hansraj Faculty Development Centre Hansraj College, University of Delhi.

MR. PANJABI SINGH

- One week (Online) Faculty Development Programme on "Mathematical Analysis and its Applications" organized by Vivekananda College, the University of Delhi in collaboration with Mahatma Hansraj Faculty Development Centre Hansraj College, the University of Delhi during July 26 – 31, 2021.
- One week (Online) Interdisciplinary Faculty Development Programme on "Creation and Development of MOOCs while managing online classes" organized by Keshav Mahavidyalaya, the University of Delhi in collaboration with Mahatma Hansraj Faculty Development Centre Hansraj College, the University of Delhi during August 24 – 31, 2021.

MR. DEEPAK KUMAR MEENA

- One Week (Online) Interdisciplinary Faculty Development Programme on ' Creation and development of MOOCs while managing online classes, from 24th August to 31st August 2021, organised by Keshav Mahavidyalaya, the University of Delhi in collaboration with Mahatma Hansraj Faculty Development Centre Hansraj College, University of Delhi.

MR. ANKIT KUMAR

- Participated in the creation and development of MOOCs while managing online

MR. JANSON ANTONY

- Janson Antony and Ajay Kumar, Spectra of elements in operator space tensor products of C*-algebras, Positivity 25 (2021), no. 5, p. 1973-1987. DOI: 10.1007/s11117-021-00856-z
- Taught an 8-days long 'Real Analysis' online course in the 'OFCM2021 Follow Up' camp organized by the MTTS Trust from January 9 – January 21, 2022.
- Served as the coordinator of one of the 6 regional 'OFCM-2021 (Online Foundation Course in Mathematics)' camps organized by the MTTS Trust from September 20 – to October 11, 2021.
- Participated as a mentor at the 'MTTS 2021 (Mathematics Training and Talent Search Programme)' and the subsequent 'Follow Up Programme' held online during June 11, 2021 – July 05, 2021, and July 28, 2021 – August 8, 2021, respectively.
- Attended 'Workshop on Geometry of Banach Spaces and its Applications (WGBSA)' organized by IIIT Allahabad, December 31, 2021 – January 02, 2022.
- Attended 'One Week (Online) International Faculty Development Programme on Advanced Linear Algebra', Organized by Miranda House, Delhi, in association with Mahatma Hansraj Faculty Development Centre, Hansraj College, Delhi, during September 27 – October 1, 2021.

MS. MANISHA SAINI

- A thesis submitted in Nov. 2021 entitled "The Growth of Solutions of Complex Differential Equations with Entire Coefficients"
- D. Kumar and M. Saini: Order and hyper-order of solutions of second-order linear differential equations, Bull. Malays. Math. Sci. Soc. 44, no. 2, 1035-1056 (2021), MR4217100.
- D. Kumar and M. Saini: The growth of solutions of non-homogeneous linear differential equations, Kodai Math. J. 44, no. 3, 556-574 (2021).
- G. Pant and M. Saini: Infinite order solutions of second-order linear differential equations, Communicated [arXiv: 2102.11748v1].
- S. Kumar, N. Mehra and M. Saini: Growth of Solutions of Second Order Linear Differential Equations, Communicated [arXiv: 2001.10729].
- G. Pant and M. Saini: Study of Solutions of Certain Kind of Non-Linear Differential Equations Communicated [arXiv: 2202.04062].

STUDENTS WHO MADE US PROUD

Daksh
IIT JAM 2022(MA) AIR-23

Abhiraj
AIR-16, DUET-OR 2021 | Gold Medalist, DU

Mohit Rana,
AIR-2, MOR 2021

Raghav Gupta
AIR-281, NIMCET 2021

Shubham Kumar Sah
IIT-JAM 2021

Sarchit Gupta
Cleared 5 Actuarial
Exams from IOFA

Anurag Pandey
AIR-3009, CMAT 2021

Kishor Kumar
Got into M.Sc. Maths,
DTU,2021

Shubham Gupta
IIFT, 2020

Ankit Goyal
AIR 828, IIT JAM 2020

Priyanshi Khanna
AIR-23, MSOR 2020

FUTURE PROSPECTS

- **IT Industry:**

If you are fond of constructing computer algorithms, you can choose the Information and Communication Technology industry. This industry can provide you with the perfect opportunity to harness your Maths honours degree.

- **Accountancy & Management:**

If you have got a fervor for business, a career in Management, Mathematics, Accountancy, and professional service is an implausible way of using the skills you've gathered during your degree. The industry offers great career prospects for a mathematics graduate.

- **Actuarial Sciences:**

If you like to play with numbers and have an interest in probability and statistics, then you can think of a profession in Actuarial Sciences. Actuaries use mathematical and statistical modeling to envisage future events that help to appraise financial impact on an organization. The actuarial profession offers great opportunities in a rapidly expanding province.

- **Investment Banking**

Investment banking offers financial advice and services to large industries, governments and high-net-worth individuals. A career in investment banking can be highly lucrative and fast-paced. Retail banking covers the events of the many high street banks, providing financial services and products to individuals and businesses. There are a huge number of jobs in retail banking, many of which are customer handling and allow you to utilize your maths degree.

- **Operational Research Analyst:**

Want to be an operations research analyst? Operations research is the science of improving efficiency and making best decisions. As an operational research analyst, you will be able to use your mathematical and statistical knowledge to improve the strategies of organizations. Applying your mathematical skills to solve real-world problems is incredibly rewarding.

- **Teaching:**

Aspire to be a Teacher? Going for a Master's degree program and acquiring a Ph.D. will help you to fulfil your desire. This will enhance your knowledge in a particular field. You may gain professional qualifications or change your field of study as well. Achieving a PhD in mathematics proposes an incredible opportunity to make an original contribution to mathematics.

- **Mathematician**

Mathematicians review data and use mathematical and statistical techniques to solve problems in fields like business, healthcare and engineering. Their specific duties depend on their field of work. Typically, mathematicians create new mathematical theories and rules, collect data, identify patterns and relationships in datasets and determine the data's validity and sampling error
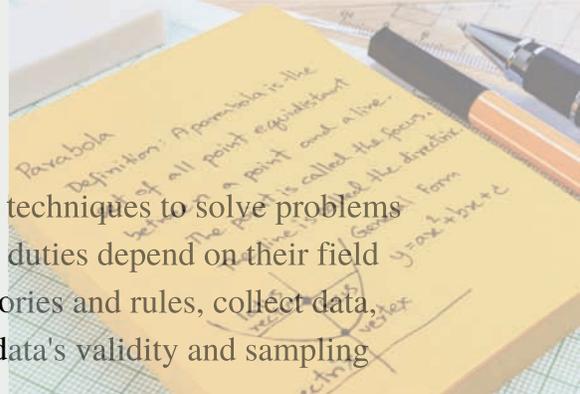
- **Government Jobs**

People find a suitable job in government institutions and other sectors. There are some added incentives and benefits attached to it. Most of these jobs need reasoning. These aspirants seem to have an upper hand over such jobs. Some competitive exams come with these jobs which one has to crack. Therefore a graduate can easily hit the bull's eye.

Jobs offered in various public sectors and institutes like ISRO and DRDO.

After BSc mathematics, it is one of the most attractive careers .

An aspirant can also go for some competitive government exams like UPSC, railways, banking, etc. and can easily get into various government departments.

- **Financial Analyst**

After pursuing BSc mathematics one has to wonder what next. Therefore, investment analyst seems to be one of the options in the range.

The job is to provide information to help traders which involves rigorous analysis to make important decisions. An analyst provides information to various fund managers, investment banks, investment management companies etc.

Therefore, this career opportunity requires meritorious mathematical and analytical skills and helps a mathematical graduate to apply his/her knowledge into the respective field. A career as an investment analyst is a very reputed job. Every business needs it irrespective of size, nature and hence it requires a maximum number of candidates to apply for the job.

DID YOU KNOW?

Born in 1882, Emmy Noether was a German mathematician who made important contributions to abstract algebra and theoretical physics, described by Einstein as the most important woman in the history of mathematics.

DEPARTMENT OF MATHEMATICS:

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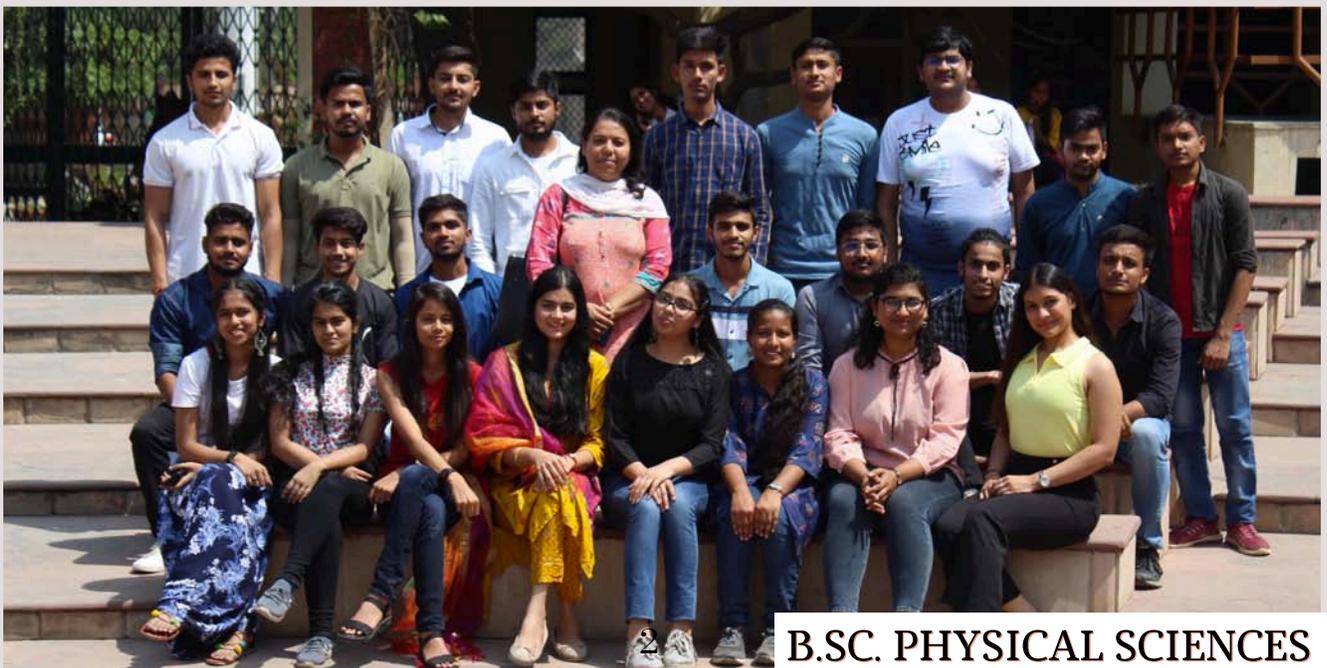
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B.SC. (H) MATHEMATICS

B.SC. MATHEMATICAL SCIENCES

B.SC. PHYSICAL SCIENCES

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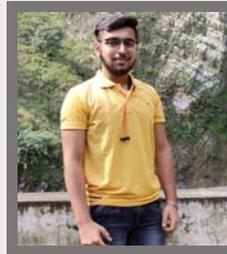
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