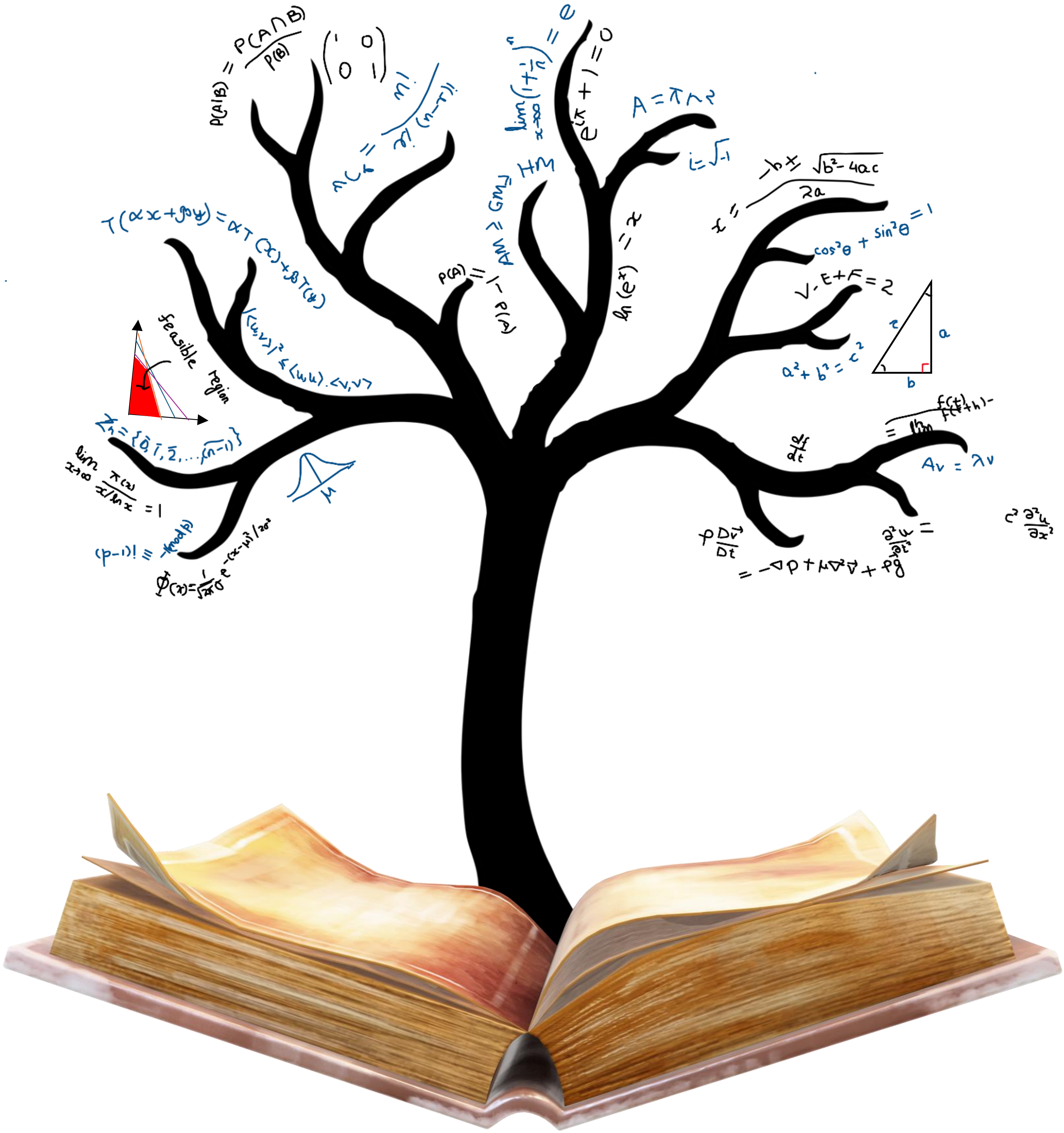
NITM Mathematical Bi-monthly

Department of Mathematics,
National Institute of Technology Meghalaya

April-May 2025
Issue No. 5


P(A|B) = P(A∩B) / P(B)
nCr = n! / r!(n−r)!
lim x→∞ (1 + 1/n)^n = e
e^iπ + 1 = 0
A = πr²
i = √−1
x = −b ± √(b² − 4ac) / 2a
cos²θ + sin²θ = 1
V − E + F = 2
a² + b² = c²
a
b
c
AM ≥ GM ≥ HM
ln(e^x) = x
P(A') = 1 − P(A)
T(αx + βy) = αT(x) + βT(y)
|⟨u,v⟩|² ≤ ⟨u,u⟩.⟨v,v⟩
feasible region
(p−1)! ≡ −1 (mod p)
Av = λv
μ

"It is not knowledge, but the act of learning, not the possession of but the act of getting there, which grants the greatest enjoyment."

— Carl Friedrich Gauss

(30 April 1777 – 23 February 1855)

DIRECTOR'S MESSAGE

Dear Students, Faculty, and Readers,

I am immensely pleased to introduce the 5th edition of the Department of Mathematics' bimonthly magazine. This magazine represents a significant step forward in creating a platform where the department can showcase our students and faculty members' intellectual curiosity, talent, and dedication.

Mathematics is not just a subject confined to classrooms and textbooks; it is a dynamic and evolving field with the power to shape the world around us. I am proud of the department's commitment to fostering academic excellence and a spirit of innovation.

This magazine is a testament to that pursuit of knowledge. It will serve as a medium for not only disseminating new ideas and research but also for encouraging discussions, collaborations, and creativity within our vibrant mathematical community. I encourage each of you—students and faculty alike—to contribute actively to the growth of this magazine and make it a reflection of our collective brilliance.

As we move forward, let us continue to strive for academic distinction, intellectual curiosity, and a passion for solving the complex problems that mathematics presents. The journey is as important as the destination. I believe that together, we will continue to make strides toward a brighter future for the department and the world of mathematics.

I congratulate the editorial team on their hard work in bringing this publication to life, and I look forward to seeing the magazine evolve in the years to come.

With best wishes,
Prof. Pinakeswar Mahanta
Director, NIT

HoD's Message

As the Head of the Department of Mathematics (MA), it is truly an honor for me to write for the 5th issue of our departmental magazine. This platform allows our faculty, staff, and students to showcase their achievements, express their opinions, and explore new mathematical concepts. I believe that this magazine will become an essential channel for sharing knowledge, ideas, and research insights that will inspire us all.

The Department of Mathematics, which started functioning in June 2012, currently offers 2-year M.Sc. and PhD programs. M.Sc. students are selected based on their ranking through CCMN and the institution mode, while PhD students are selected through interviews based on their GATE/NET scores. In addition to our core programs, the department also plays a vital role as a supporting pillar for various B. Tech and M. Tech programs within the institute.

The creation of this magazine stems from a collective desire to share our thoughts, accomplishments, and aspirations. Working together as a team to ensure its successful publication brings immense delight. I feel privileged to be part of this process and am filled with joy in nurturing our students, contributing to society, and fostering academic excellence.

My team and I remain dedicated to the holistic development of our students within the institute. I extend my best wishes to all MA family members and sincerely hope that this tradition of the departmental magazine continues for generations to come, fostering happiness, unity, and intellectual growth.

Warm regards,
Dr. Adarsha Kumar Jena
Assistant Professor, HoD, MA

Editor's Message

The only way to learn mathematics is to do mathematics. — Paul R. Halmos.

This profound statement not only serves as a guiding principle but also emphasizes the importance of active engagement in mathematics. It brings me great joy to inform you that starting from August 2024, the Department of Mathematics at the National Institute of Technology Meghalaya is introducing its very own publication, the "*NITM Mathematical Bi-monthly.*"

This publication is a collective endeavor by our students and faculty members, designed to ignite a love for mathematics and offer a stage for students to share their insights. Magazines transform the creative potential of our students into tangible contributions, allowing them to identify and showcase their talents through writing. Through this magazine, we aspire to highlight contributions, departmental events, achievements, and the scholarly work of both faculty and students. I encourage all students to participate by submitting interesting mathematical problems, engaging puzzles, stories, and intriguing facts about mathematicians.

I want to express my deepest appreciation to the editorial team—Bankit, Sanchita, Dixita, and Dibyasman—for their tremendous dedication and hard work in making this magazine a reality in such a brief period. Our minds are filled with boundless curiosity, and we are continually striving to explore beyond the known. I wish all our students' immense success as they delve into the magazine's contents and set out on fresh intellectual journeys. May this initiative inspire us all to deepen our grasp of mathematics with steadfast determination.

Thank you, and best wishes.

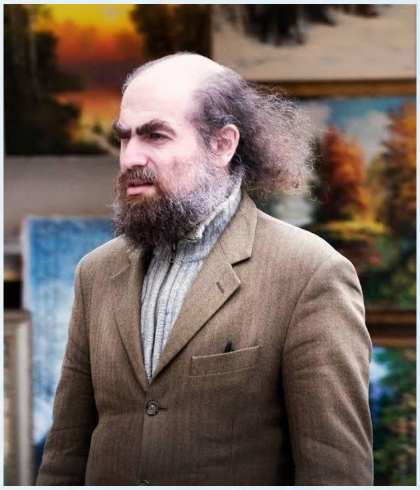
Dr. Timir Karmakar
Assistant Professor
Department of Mathematics

Featured articles

The "Main Character" Aura of a Mathematical Genius

Bankitdor M. Nongrum, Research Scholar

"*Emptiness is everywhere and it can be calculated, which gives us a great opportunity. I know how to control the universe. So, tell me, why should I run for a million? "- Grigori Perelman*



In the modern internet dictionary, the term "aura" has been redefined as the energy that a person gives off. This energy is usually based not just on the individual's appearance or personality, but on their brain power as well. In the story of mathematics, there is but one math genius that emits so much aura, it is as if he himself was the main character in this story. Yes, this is the very same math genius that declined the esteemed Fields Medal in 2006. Yes, I am talking about the one and only Grigori Perelman. Ever read a wild biography before? His, is like one of those. He solved one of the hardest math problems ever, and then saying "no, thanks" to fame and fortune.

The prodigy's glow up:

Perelman, born in 1966 in Leningrad, Soviet Union (now Saint Petersburg, Russia), was not just another ordinary mathematician. As a child, he was already out there winning math competitions. By the time he was in his teens, he snatched gold at the International Mathematical Olympiad in 1982. He went on to study at Leningrad State University, where he had some heavy-hitting mentors in geometry and topology. This set up the stage for him to become a legend in the mathematics game.

Perelman's work was all about differential geometry and topology. He was a prodigy in the study of Ricci flow, a mathematical process that is like giving a manifold some kind of glow-up by smoothing it out over time. This tool was his secret ingredient and he cooked solutions to problems like a professional, that has every mathematician alive shook in awe to this day.

How do you prove a conjecture?

Let us get down to the reason that you have reached to this point of this article. The Poincaré conjecture was one of the seven Clay Millennium Prize Problems. It was dropped by Henri Poincaré in 1904. For anyone to be the main character, this conjecture had to be the final boss battle in the mathematics game.

In simpler mathematics terms, it just asked whether every simply connected closed 3-manifold is homoeomorphic to a 3-sphere. In layman's terms, any 3D shape with no holes is basically just a fancy sphere. Sounds simple, right? Maybe, but it had mathematicians all over the world sweating for answers, for more than a century. Then,

ENTER PERELMAN…

In 2002, Perelman casually dropped a series of papers uploaded to arXiv, which is a site for preprints. There was no fanfare, there was no announcement, no press release. Using Ricci flow with surgery – a technique he pioneered - he showed how to smoothen manifolds and classify them, proving not just the Poincaré conjecture, but also the broader Thurston Geometrization Conjecture. By 2003, his work was peer-reviewed, and the math community was in shock and awe.

The Plot Twist:

In 2006, the International Mathematical Union was ready to crown Perelman with the Fields Medal, the mathematical world's equivalent of a Nobel Prize. This is the highest honour any mathematician can get, and of course, major fame comes with it. But Perelman straight-up rejected the medal, citing his ethical dislike for the math establishment. He proved beyond the conjecture; he just did it for the vibes. Similarly, in 2010, the Clay Mathematics Institute tried to hit him with a $1M prize. Perelman was again too humble to accept it. He reportedly wanted neither the money nor the attention. He also believed that the prize should have gone to Richard Hamilton, who laid the groundwork for Ricci flow.

The Vibe Check?

Perelman's rejection of the honours and fame was about the pursuit of truth, not the applause. This resonates immensely in a world where people are constantly chasing external validation. He did the math, he proved the thing, he wanted to be alone and to live in peace. His contributions go way beyond anything than just proving a conjecture. The Ricci flow techniques he developed are still applicable by researchers and mathematicians to explore new areas in topology.

The Math Icon

Grigori Perelman has some of the most unimaginable brain power, he solved the Poincaré conjecture, put a proof of it on a webpage without publishing it in a journal, refuses Fields Medal and $1M for solving a millennium problem and does not elaborate further! This man is the ultimate math icon, not just for his brain-exploding proof, but for how he moved the world. He solved a century old problem, changed the game for geometry and topology, and then stayed away from all the spotlight. His story is a reminder to stay true to your craft, make things happen and stay humble. One doesn't really need a medal or millions of dollars to know one's worth.

Source: Internet

When Water Climbs: The Curious Case of Reverse Waterfalls

Siddhartha Shankar Gayen, M. Sc (Batch 2023-2025)

Imagine standing near a scenic cliff, watching water fall downward as it always does due to gravity. Now imagine the opposite: the water is flowing upward, an unusual incident in nature where the fundamental rule appears broken. Water seems to flow upward, curling and lifting skyward in decent arcs. This rare and dramatic phenomenon is known as a reverse waterfall. This kind of waterfall made a room of mystery to its first-time observers as well as to scientists.

So how can water fall upward? The truth lies in a balance and sometimes a reversal of the forces acting on falling water. A reverse waterfall occurs when a powerful upward directed wind meets a falling stream of water with such force that it stops its decent or even sends it back upward. Isn't it thrilling – water curling into the air, spiraling back toward the sky, misting as it rises. Though it sounds impossible, it's real and such phenomena can be explained through gravity, fluid mechanics and atmospheric physics.

To know this phenomenon in depth, we need to look at the forces acting on the falling water. In normal conditions, a water stream accelerates downward due to gravity approximately 9.8 m/s^2 (gravitational force). If a vertical wind with sufficient upward velocity (sometimes velocity more than 70 km/hr. or 19.44 m/s) strikes the falling water, it exerts a counteracting aerodynamic drag force. Mathematically, if this drag becomes equal to or greater than gravitational acceleration on the water droplets, the net force becomes upward. As a result, it makes the water rise or hover in mid-air. In fluid dynamics, this interaction can be described using drag force equations, where the force depends on the wind's velocity, air density and the surface area of the water exposed to the air.

What makes reverse waterfalls more complex is the transition from laminar to turbulent flows. Initially, the water may fall in a smooth stream (laminar flow), but the sudden interaction with fast rising air breaks it into mist, turbulent droplets. This behavior can be demonstrated using Reynolds number (Re), a dimensionless quantity that helps predict whether a flow will be laminar or turbulent. When $Re > 2300$, flow tends to become turbulent. In reverse waterfalls, the turbulence gives the rising water to its cloud-like appearance.

In places like Naneghat Pass in Maharashtra or cliffs along the Scottish coast, monsoon rain creates falling streams while storm winds race up the cliff face. When these winds are blown through narrow valleys, they gain speed and strike the water directly, igniting the reversal of water flows.

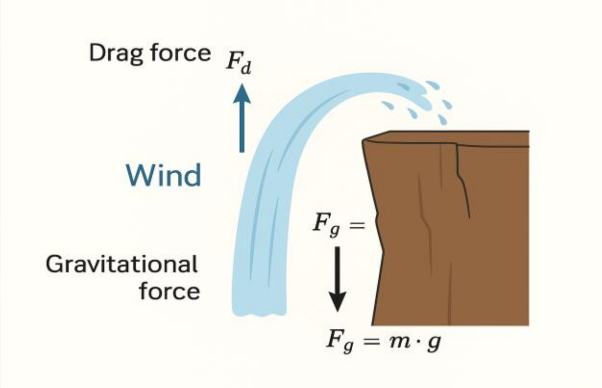


FIGURE 1: FORCES ACTING ON REVERSE WATERFALL

FIGURE 2: WATERFALL AT NANEGHAT PASS, MAHARASHTRA

This clash of forces not only create a visually striking waterfall but also teaches us the importance of force equilibrium, flow instability and wind–fluid coupling. Even engineers designing wind turbines, aerosol delivery systems, or erosion-resistant structures study similar drag-based interactions. In environmental physics, the same principles are used to model particle suspension, such as pollen, pollutants or droplets in the atmosphere.

So, while it may look like a natural phenomenon, the reverse waterfall is really a lesson in the elegant tug-of-war between gravity and air. The next time you see a stream of water tumbling from a height, imagine the hidden vectors pulling it in all directions and how sometimes, nature chooses to let water fly.

References

- Edwards, B. F., Wilder, J. W., & Scime, E. (2001). *Dynamics of falling raindrops*. *European Journal of Physics, 22*(2), 113–118.
- NDTV. (2022, July 12). *Watch: Reverse Flow Of Waterfall in Maharashtra's Naneghat Mesmerises Internet*. Retrieved from https://www.ndtv.com/offbeat/watch-reverse-flow-of-waterfall-in-maharashtras-naneghat-mesmerises-internet-3149214.

A Woman Ahead of Her Time: Emmy Noether's Mathematical Revolution

Dibyasman Sarma, Research Scholar

The beauty of mathematics only shows itself to more patient followers.

-Maryam Mirzakhani

Amalie Emmy Noether (1882-1935) was a pioneering German mathematician whose groundbreaking contributions to abstract algebra and theoretical physics distinguished her as one of the most influential mathematicians of the 20th century. Her profound insights revolutionized entire disciplines of study, and her legacy continues to motivate mathematicians and physicists. Although she encountered significant challenges as a woman in academia, Noether's groundbreaking ideas had a lasting impact on the field of science.

A Life Dedicated to Mathematics

Emmy Noether was born into a Jewish family in Erlangen, Germany, and her love of mathematics was apparent from an early age. By auditing classes and finally getting her Ph.D. in 1907 with a dissertation on algebraic invariants, she overcame the restrictive rules that were in place against women in higher education. She made substantial contributions to the field while working for years at the Mathematical Institute of Erlangen without receiving compensation.

Noether joined the esteemed mathematics department at the University of Göttingen in 1915, upon the invitation of Felix Klein and David Hilbert. Nevertheless, she was initially denied a formal faculty position on account of her gender and lectured for four years under Hilbert's name. She was finally granted the title of "unofficial associate professor" in 1922. With the rise of the Nazi regime in 1933, Noether, along with other Jewish academics, was dismissed from her position. She emigrated to the United States, where she taught at Bryn Mawr College and the Institute for Advanced Study in Princeton until her premature demise in 1935.

Revolutionizing Abstract Algebra

Noether's most significant contributions were in the area of **abstract algebra**, where she developed a new, axiomatic, and conceptual method. Her work can be broadly categorized into three significant periods:

- **Algebraic Invariant Theory (1908-1919):** In her early career, Noether made significant advances in the theory of algebraic invariants, a field that deals with properties of mathematical objects that remain unchanged under certain transformations.
- **Ring Theory (1920-1926):** This period marked a paradigm shift in algebra. Noether's seminal 1921 paper, "Theory of Ideals in Ring Domains," laid the foundation for modern commutative ring theory. She introduced the concept of **Noetherian rings**, which are rings in which every ascending chain of ideals stabilizes. This concept has become fundamental in algebraic geometry and number theory. Her work on ideals provided a powerful tool for studying the structure of rings.
- **Noncommutative Algebra (1927-1935):** In her later work, Noether made significant contributions to the study of noncommutative algebras, which are algebraic structures where the order of multiplication matters. Her work in this area had far-reaching implications for representation theory and the understanding of the structure of algebras.

Noether's Theorem: A Pillar of Modern Physics

Beyond her contributions to pure mathematics, Emmy Noether is celebrated for a theorem that has become a cornerstone of modern theoretical physics. **Noether's theorem**, formulated in 1915 and published in 1918, establishes a fundamental connection between **symmetry** in a physical system and its **conservation laws**.

In essence, the theorem states that for every continuous symmetry of the laws of physics, there must exist a corresponding conserved quantity. For example:

- The symmetry of physical laws with respect to **time translation** implies the **conservation of energy**.
- The symmetry with respect to **spatial translation** implies the **conservation of linear momentum**.
- The symmetry with respect to **rotation** implies the **conservation of angular momentum**.

This elegant and powerful theorem provided a profound and unifying principle for physics, demonstrating that the conservation laws, which were previously considered fundamental but separate principles, are in fact direct consequences of the symmetries of the universe. Noether's theorem remains an indispensable tool in many areas of physics, including classical mechanics, quantum mechanics, and general relativity.

Emmy Noether's legacy is not solely evident in the specific theorems and theories she developed; it is also evident in the abstract and structural approach she championed. Her work revolutionized algebra and provided a new language for comprehending the fundamental principles of the universe. In a letter to The New York Times following her demise, Albert Einstein aptly characterized her as "the most significant creative mathematical genius thus far produced since the higher education of women began."

Source: *Internet*

Research Publications

1. Ashif Mustafa and Manideepa Saha, A Maximal Residual Two Subspace Projection Algorithm for Solving Least-Squares Problems, ***Communications on Applied Mathematics and Computation*** (2025), https://doi.org/10.1007/s42967-025-00495-1

Problems for Readers

The following problems are open to all the readers to solve:

Problem 1. (Proposed by Dr. Timir Karmakar)

For the beta function, prove with the usual meaning that

$$\sum_{n=1}^{\infty}\big(\beta(2,n)-\beta(3,n)\big)=\frac{1}{2},\quad n\in\mathbb{N}.$$

Problem 2. (Proposed by Dr. Timir Karmakar)

For the beta function, prove with usual meaning that

$$\beta(k,n)=\frac{(k-1)\beta(k-1,n)}{(n+k-1)},\quad k,n\in\mathbb{N}.$$

If you can solve the problems, then send your answer to

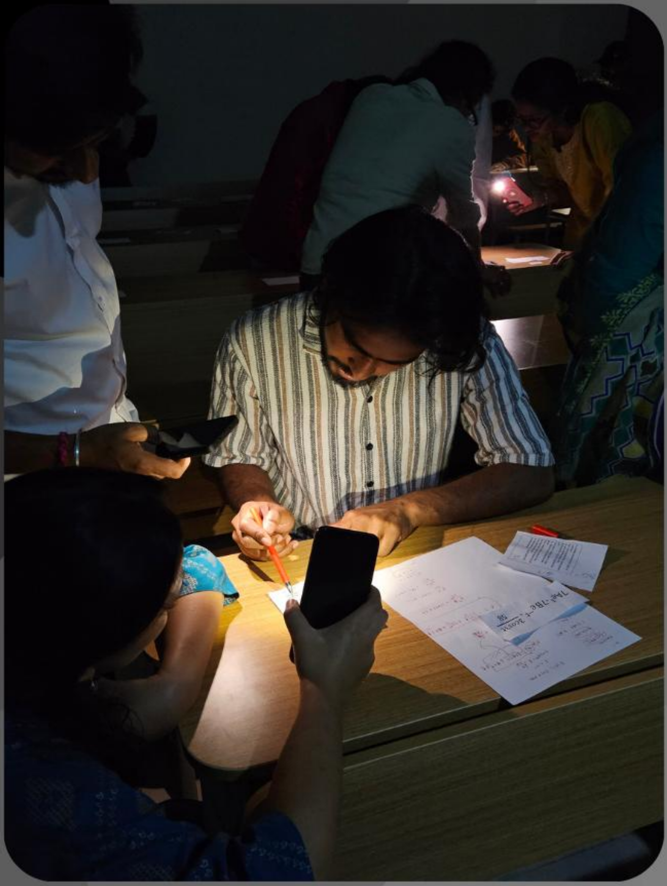
✉ tkarmakar@nitm.ac.in

If you provide the correct solutions, your name will be published alongside the best solutions in the next edition!

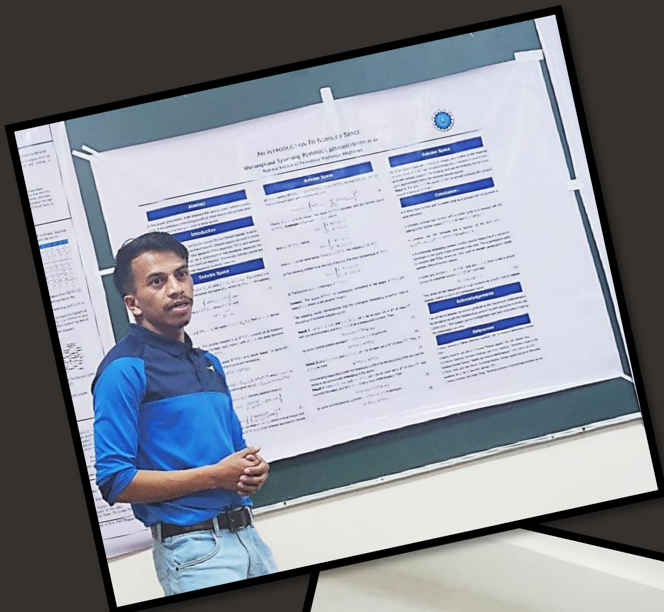
Departmental Activities

Institute Day Celebration by the Department of Mathematics

SOLVING RIDDLES AND HUNTING TREASURES...



POSTER PRESENTATIONS




QUIZ
MARKS
Institute Day
Celebrations


QUIZ
MARKS
Team
6 → 10 X
18 → 50 → (2nd)
Alpha
Beta
Delta


Team
MARKS
6 → 10 X
18 → 50
Alpha → 20
Beta → 20
Delta → 50

Editorial Team

	Dr. Timir Karmakar (Assistant Professor)
	Bankitdor M. Nongrum (Research Scholar, P22MA008)
	Dixita Sonowal (Research Scholar, P23MA001)
	Sanchita Pramanik (Research Scholar, P23MA002)
	Dibyasman Sarma (Research Scholar, P22MA007)

CONTACT US

Department of Mathematics

National Institute of Technology Meghalaya

Saitsohpen, Sohra (Cherrapunji)-793108

Meghalaya, India

Phone No: 0364-2501294, FAX: 0364-2501113

Editor’s Contact Number: +91 8101058282