Navi Mumbai Science Foundation

EdUREKA

Education for Spirit of Science

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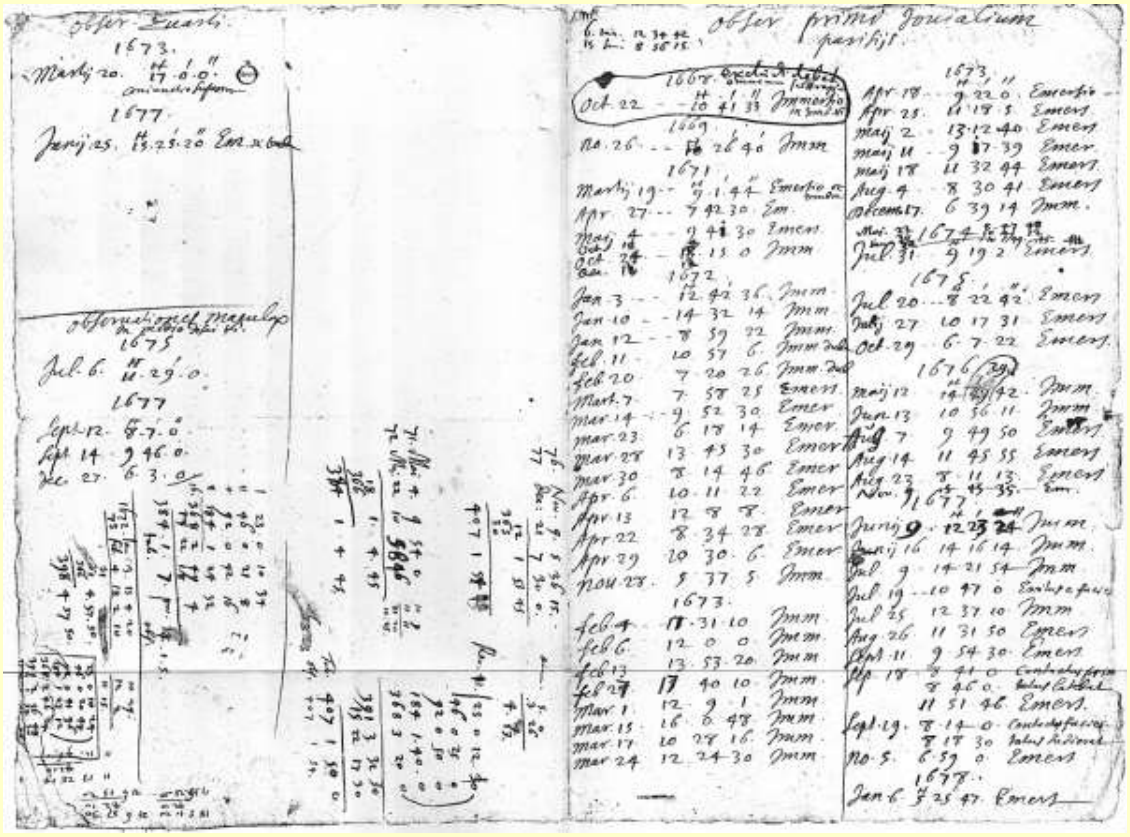

Navi Mumbai Science Foundation

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Editor-in-Chief: **Dr. P. K. Joshi**
Reach me: pkkjoshi@gmail.com / 9969000848

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Address
B-51, Gitanjali, Plot No.52, Sector-17,
Vashi, Navi Mumbai-400703.

Webpage
www.navimumbaisciencefoundation.org
Email: edureka.nmsf@gmail.com
Contact No.: 022-27891475
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This is a quarterly e-magazine published by Navi Mumbai Science Foundation, a society engaged in spreading science education and scientific temperament among students of Navi Mumbai region for the last one decade. The magazine will mainly cover activities and articles on science education useful to students, teachers & society at large.

Contents .....

1.	From Editor's Desk	1
2.	National Mathematics Day: Srinivasa Ramanujan	2
3.	Great discoveries without sophisticated equipment (…cont.)	9
4.	Why I like Science	12
5.	The Ancient Indian Science Trinity	13
6.	Titration without indicator	16
7.	Forthcoming Activities of NMSF	18

Views expressed in the magazine are from authors and editor may not agree with it.

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From Editor's Desk!!....

Editor's Corner

Dear Readers, students and teachers, we continue with our endeavor to bring articles to you which will give you a different perspective to things that you already know or introduce you to new concepts. Walking in that direction, this time we bring you articles written by people who have devoted their lives to science and science popularization.

First article deals with our great luminary, Srinivas Ramanujan, whose birthday is celebrated in the month of December, as National Mathematics Day. These great thinkers of Indian history had given new direction to mathematics and education in India. This article by Dr. A.M. Bhagwat, deals with his life and achievements.

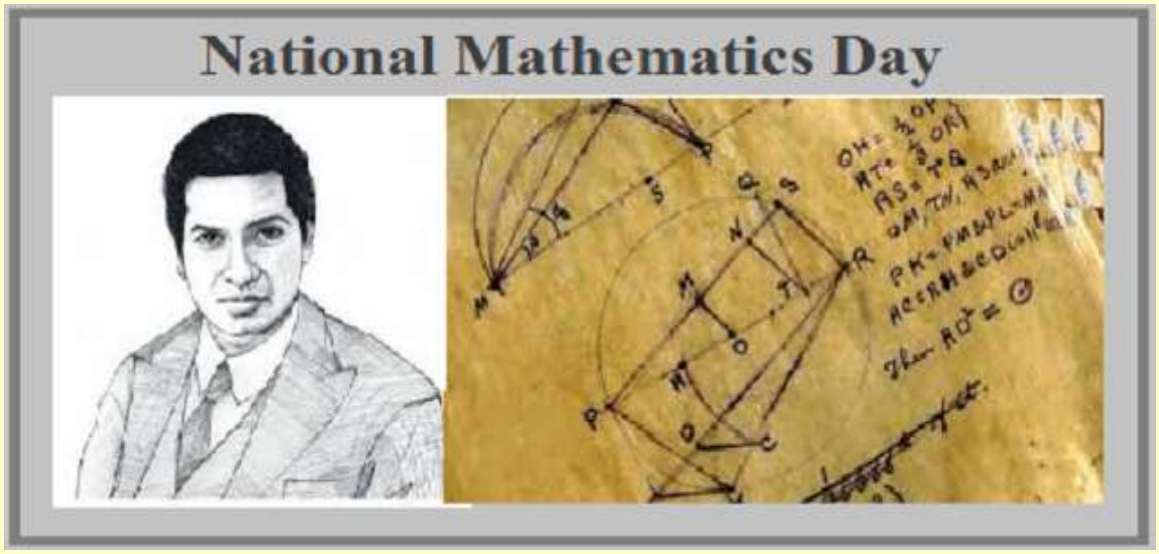
The second article is part of the series which deals with great discoveries without much equipment or sophistication. It continues with the measurement of speed of light four centuries ago. The series will carry few more articles along these lines.

We bring an article by a young student of class VI on why she likes science. We all have it hidden in us but very few can articulate it like the way she has done it. I am sure this will trigger a similar search within you on similar issues.

We then have an article from a young writer who has already published a book of his own, when he is still in class 6. Writing in your own words, is a good way to clarify one's thoughts, ideas and concepts. It improves one's ability to express his/her thoughts with clarity and in a crisp way. This article deals with contribution of Indians to Astronomy/Astrophysics.

Finally, my favorite topic, science experiments. It is great fun to do science experiments when we understand the process that is told to us, and we do it. But the fun (and challenge) increases when we can improvise the experiment so that it gives more concept clarity, transparency and a new way of approaching the same goal. We are all aware of titration with indicators, but can we do titration without colour changing indicators? Is there any connection to the process of titration and living beings? The last article will deal with one such experiment which can be carried out easily in our classrooms and even in our homes.

This issue will end with some announcements and news items and preparation for the next one.



On 26 February 2012, the then Prime Minister Manmohan Singh announced "December 22 to be National Mathematics Day", at Madras University during the inaugural ceremony of the celebrations to mark the 125th anniversary of the birth of the Indian mathematical genius Srinivasa Ramanujan. Born on Dec. 22, in 1887, he was considered on par with pioneers in the world of Mathematics.

.....

"SRINIVASA RAMANUJAN"

A GENIUS DRENCHED IN TRIBUTES GALORE

Srinivasa Ramanujan Iyengar was one of India's greatest mathematical geniuses the world has seen in recent centuries. He was a perfect example of the notion of a genius: he had passion for the unexpected, strange, and the odd.

He was a self-educated mathematician, known for his theorems that contributed significantly to the understanding of number series, infinite series and continued fractions.

Ramanujan was born on December 22, 1887, in a Brahmin family with strong religious beliefs. His birth place was Erode (near Kumbakonam) - a small village about 400 km southwest of Madras (now Chennai).

He joined his father at Kumbakonam when he was a year old. His father worked in the shop of a cloth merchant as a clerk. **In December 1889, he contracted smallpox (a highly contagious and deadly disease) at the early age of two. He, however, miraculously survived while several hundred other children died.**

When he was nearly five years old, Ramanujan was sent to a Brahmin primary school in Kumbakonam (the Prayag of the South, for it is the only place in South where a Mahamakham - a function resembling the Kumbh Mela - is held once in 12 years). **In**

the school, he had earned a name for his mathematical abilities as a child. As a 3rd grade student, he was asking questions like "Is zero divided by zero equal to unity?"

He entered the Town High School in Kumbakonam in January 1898. **In the high school, Ramanujan performed well in all the subjects and earned the reputation of being an able all-round scholar.** He had read Loney's Trigonometry and made short work of it (while he was still a student of the 8th class) which even degree students had a tough time to get through. **He succeeded in establishing his identity as a 'Child Mathematician' right at the age of 12.** Maths was like bread for him and he yearned to learn new things more than any normal lad.

While at school he succeeded in borrowing one or two books on pure mathematics. He mastered them unaided and with a poor knowledge of English. Gifted boys have done this sort of thing fairly frequently, but Ramanujan did not rest on his learning. **He began to invent theorems on the slender knowledge he gained from these books and succeeded in rediscovering some of the best theorems in mathematics.**

It was in the Town High School that Ramanujan, while in Std. 6, came across a mathematics book titled "Synopsis of elementary results in pure mathematics" by an Englishman (a teacher in London) named G. S. Carr. The book was a collection of 6165 results from various branches of mathematics. This book had a profound influence on the subsequent developments in the life of Ramanujan because the book contained only theorems, formulae and short proofs or no proofs.

This Maths lover had many discoveries done and some are still being worked on by mathematicians. He left behind such a legacy in the world of mathematics. He also earned the title of **patron saint of pi explorers** for his infinite series for pi. An example of one of the several rapidly converging infinite series of π as found by Srinivasa Ramanujan in 1910 is:

$$\frac{1}{\pi} = \frac{2\sqrt{2}}{9801} \sum_{k=0}^{\infty} \frac{(4k)!(1103 + 26390k)}{(k!)^4 396^{4k}}$$

The Carr's book allowed Ramanujan to teach himself mathematics. The book, published in 1886, was, however, totally out of date by the time Ramanujan started using it. The book helped Ramanujan to go further and develop his own ideas and theorems.

He passed his matriculation examination at Kumbakonam at the age of 16 and secured junior Subramanyam Scholarship for further study at the Government college at Kumbakonam which he entered in 1904. **During his college studies, he was so much engrossed in mathematics that he hardly paid any attention to any other subject with the result that he failed in other subjects and lost the scholarship.** Thereby he failed to enter the University of Madras. In the years that followed, he

continued to work on mathematics. He developed his own ideas without any help and without any real idea of the then current research topics other than that provided by Carr's book. He, however, had begun to undertake deep research & calculated Euler's constant up to 15 decimal places. He also began to study the Bernoulli numbers.

[The number e (Euler's constant) also known as Euler's number, is a mathematical constant approximately equal to 2.71828, and can be characterized in many ways. It is the base of the natural logarithm. It is the limit of $\left(1+\frac{1}{n}\right)^n$ as n approaches infinity, an expression that arises in the study of compound interest].

[In mathematics, the Bernoulli numbers Bn are a sequence of rational numbers which occur frequently in number theory. They were discovered by the Swiss mathematician Jacob Bernoulli. Ex.: 5/66 = 0.075757575.....;]

In 1909, he was married to 10-year-old girl Srimati Janaki Ammal. He tutored students while he looked for a permanent job to enable him to look after his family. He, however, continued his work without employment and living in the poorest of the poor circumstances. **At times, he had no money to buy even a pencil or paper sheets and often went to bed hungry. He was plagued by illnesses through most of his life, primarily driven by malnutrition.** Still, Ramanujan continued his work and studied continued fractions and divergent series.

In 1911, he published a research paper on Bernoulli numbers in the Journal of the Indian Mathematical Society. This paper helped him to gain recognition for his work. Though he did not have university education, he was able to establish his credentials as a mathematical genius, in the Madras area, through his work and ideas. Later on, in 1912, he got a job of a clerk in the office of the Madras Port Trust. Here, there was another mathematician who could recognize the caliber of Ramanujan. This colleague referred him to Professor G. H. Hardy, at Trinity College, Cambridge University. Hardy took pains to go through the results sent by Ramanujan and congratulated him at his work. Prof. Hardy was so highly impressed by the quality of Ramanujan's work that he apprehended no difficulty in getting him to Cambridge despite his lack of a university degree. Prof. Hardy also enquired whether Ramanujan could be sent to Cambridge?

Though Hardy extended an invitation to him to come to Cambridge, he was shocked when Ramanujan did not jump at the chance, due to local caste prejudices. Ramanujan was a Brahmin by birth which did not allow him to cross the oceans. Further, his mother too was totally opposed to the idea of his voyage. But, a little later, she consented in a very unexpected manner. The mother announced one fine morning that she had a dream the previous night in which she saw her son sitting in a big hall amidst a group of Europeans. Further, the goddess Namagiri did not want her to stand in the way of her "son's purpose of life" getting fulfilled. Finally, Ramanujan gained

his mother's consent in early 1914. This news made Hardy extremely happy, as though Ramanujan's visit was a GOD sent gift.

Ramanujan sailed from India on 17th March 1914. The voyage was not unusual for him in the sense that he did face seasickness on 3 days during his 28-day travel. He reached London on 14th April 1914. By 18th of April, he was able to join Trinity College as a research scholar on a scholarship of 250 pounds per annum. **Though Ramanujan did not have proper qualifications, he was allowed to enrol at Cambridge University in June 1914.**

Although only 36, when Ramanujan joined him, Hardy was already the leading mathematician in England. At that point of time, Hardy and another titan of Trinity College, J. E. Littlewood were dominating the mathematical scene in England. It was a legendary partnership between the two which remains unique to this day.

According to Hardy, Ramanujan was exceptional in several ways; however, in spite of his amazing depth of knowledge in mathematics, he had poor exposure to the basic tools of the trade of a professional mathematician. According to Hardy, Ramanujan needed a solid foundation in mathematics (that of the best Cambridge graduates), if he was to reach his full potential.

Ramanujan's arrival at Trinity College, earmarked the beginning of an extraordinary collaboration with Hardy. Right from the start, the two produced important results. Hardy, however, had a problem always - that of Ramanujan's lack of formal education. According to **him the limitations of Ramanujan's knowledge were as startling as its intellectual acuity.**

In 1915, during the first world war period, Hardy reported that 'one teacher is not enough for so fertile a pupil", and that "in some ways, Ramanujan is the most remarkable mathematician I have ever known". It seemed likely that Ramanujan would develop into the greatest pure mathematicians of modern times. **In March 1916, Ramanujan completed his graduation from Cambridge University. He received "Bachelor of Arts" degree by Research for his work on highly composite numbers. The same degree was later upgraded to Ph.D. degree from 1920.**

While in England Ramanujan continued to receive honours in several ways. In 1917, he became a part of the London Mathematical Society. Thus, for almost three years, things went extremely well. **In May 1917, however, he showed symptoms of having contracted tuberculosis.** Despite this, on 18th February 1918, Ramanujan was elected a Fellow of the Cambridge Philosophical Society. He was the first mathematician whose name was accepted for the Fellowship of the Royal Society at the first proposal.

Ramanujan thus became the second Indian to be elected to the Royal Society (way back in 1841, Ardaseer Cursetjee, a shipbuilder and engineer, was the first Indian to

be so elected). However, Ramanujan was the youngest Fellow at the Society at the age of 30. Then on 10th October 1918, he was elected a Fellow of Trinity College, Cambridge (the first Indian at Trinity). The fellowship was to run for six years.

According to Prof. Hardy "there has been no one in the history of mathematics, who could remotely match Srinivasa Ramanujan". He further said, as the years pass by, I admire more and more the astonishing body of work Ramanujan produced in India before he made contact with any of the top mathematicians in the world. It was not because the results he got at the time changed the face of mathematics but because, he worked all by himself. Ramanujan attacked many problems in analysis and number theory – some important and some not so important – in a fearless manner. It only demonstrated his love for mathematics.

The honours which Ramanujan received, while in England, seemed to help his health improve a little occasionally. Every time this happened, he renewed his efforts at producing mathematical results. Hardy also stated that "Ramanujan returns to India he would enjoy scientific standing and reputation that no Indian has ever had before. **I am also confident that India will regard him as a great treasure that he is.** Further, his natural simplicity and modesty were never affected in the least by his successes.

Ramanujan was also considered as the magician of equations and inequalities. For someone to contribute substantially to a pre-existing work is as good as coming out with new theories but to produce something from scrap is an achievement in itself.

Ramanujan was recognized for his theory on highly composite numbers which stated that "highly composite numbers had more divisions than the preceding number". The most interesting one was the theory of numbers which he arrived at from the special number 1729, which as per Hardy was an unlucky number (1729 was the Taxi's number which Hardy had hired during one of his visits to a hospital where Ramanujan was admitted). Who knew at that time that an unlucky number for Hardy would bring "Good Luck" to Ramanujan that he needed most?

Ramanujan lived in England for five years. They were the most fruitful and productive years of his life. His collaboration with Hardy and Littlewood produced some of the most outstanding work. He, however, showed no signs of improvement until late in 1918, as the cold climate of Cambridge did not suit him.

His illness continued to grow from bad to worse and it was decided in 1919, that he should be sent back to India where the warm climate might help in his recovery. But alas, that was not to be! He arrived in Madras on the 2nd April, 1919, and passed away a year later (at the age of 32), on the 26th April 1920, at Chet-pet near Madras. Even on his death bed, Ramanujan used to ask his wife Janaki Ammal for loose sheets of paper to write down his new found results. Janaki Ammal, though not having school

education, was wise enough to know the value of those sheets and preserved them. After Ramanujan's death, she delivered them to the University of Madras from where they were sent to Hardy. Eventually, G N Watson in Birmingham, the world's premier authority in the field of special functions, came across them.

Since his death, Ramanujan's writings have been studied extensively – especially during the last quarter of the 20th century when there have been many admirers of Ramanujan. An American Mathematician, Professor George Andrews of University of Pennsylvania, was one of them.

During the summer of 1976, George Andrews, was looking through some of the old papers of the late Prof. G. N. Watson. It was there that he accidentally found some 140 sheets, written by Ramanujan, that contained some 600 formulae. All this work was done by Ramanujan in the last year of his life, after returning to India, when he was literally in his death bed. These sheets have been subsequently referred to as a "**Lost Notebook**" when they were rediscovered in 1976. Andrews has since then been studying them and has written extensively on the contents of those papers. This important work of Ramanujan would have been lost to eternity and not seen the light of the day if Andrews had failed to locate it.

Some of conjectures and assertions of Ramanujan have created new fields of study. **Some of his formulas, though not yet proven, are believed to be true.** His death at the height of his prowess was a huge blow to world of mathematics. **His like may never be born again. Equally certain is the fact that his partnership with Hardy will not be duplicated either.**

According to Ramanujan, "An equation was an expression of a thought of GOD and nothing else". These were the words of the greatest mathematician of our motherland and a great devotee of goddess Kali. For Ramanujan, the equations were the language he spoke through.

Ramanujan was a deeply religious person. He always gave credit to divinity for his substantial mathematical capacities, and said that all his mathematical knowledge was displayed to him by his family goddess Namagiri, who used to inspire him with formulae in his dreams. It is a remarkable fact that frequently, on rising from bed, he would note down the results & verify them, though at times, he was not able to offer a rigorous proof for the same. Ramanujan had independently compiled nearly 3,900 results (mostly identities & equations) in his short life time, many of them being completely novel.

Ramanujan was also called **"The man who knew infinity"** because, his love for mathematics knew no boundaries. He added a new dimension to the world of mathematics and gifted several useful conclusions to the fraternity of mathematicians. Even today, they continue to be used as a base for new findings.

Paul Erdos, the Hungarian mathematician of 20th Century, has passed on to us Hardy's personal ratings of mathematicians. As per that rating, using a scale from 0 to 100 and pure talent as the basis, Hardy gave himself a score of 25, Littlewood 30, David Hilbert (a German mathematician) 80 and Ramanujan 100. Ramanujan was often compared to the great 19th-century German mathematician Carl Gustav Jacobi, who made ground breaking advancements in mathematics.

It will not be an exaggeration if it is said that Ramanujan will be remembered as long as our planet continues to exist in the Universe, and as long as civilization exists on our planet. It is because of his outstanding research contributions to Number Theory and Analysis & also because his work has kept first rate mathematicians busy till this date. Further, his work had a tremendous impact & influence on modern mathematics which has opened up new vistas for research. His greatness lies in the fact that he could achieve all this despite the fact that he had no formal training, was without any means of support, and continued to produce the work of the highest order even in the face of death.

"The story of obscurity, the rise, and the tragic end of Ramanujan is thus one of the most romantic episodes in the history of science".

Note: This write up is only a compilation of information from various sources on Internet which were viewed through a unique lens that allowed only the rays of praise to pass through.

A. M. Bhagwat,
Chairman,
Navi Mumbai Science Foundation.
ambhagwat@gmail.com; Mobile: 93241 68510.

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Navi Mumbai Science Foundation has started celebrating "National Mathematics Day" from the year 2020. The above article is a humble tribute to that extra-ordinary soul known as "Srinivasa Ramanujan Iyengar", in whose memory this day is celebrated each year in India.

Great discoveries without sophisticated equipment

…Continued from last issue.

In last article we saw the time scale and/or distance involved to measure the speed of light. In one second the light would go around 7 times the circumference of earth.

The distance measurement of this scale was difficult in the early 1600s when this speed of light was measured. In those days even if one could measure a distance of few hundred km, it would mean measuring a time scale of few milliseconds. And in those days the pendulum clock was just being developed and so the least time that could be measured was one hour, using sand glass. Yet the great scientists of those times measured the speed of light as 225000 km/s. Even though it took nearly 50 years and concentrated effort of several scientists, they did achieve this measurement with reasonable accuracy.

How did they do that? Even if they had desired, they had no means to bend the light around the Earth's circumference, and measure those kinds of distances. They did not have any sophisticated equipment, but that did not deter them from one of the most important measurement of the history. They had two important things with them. Observation and analysis/understanding of what they observed.

The story behind the measurement is as follows. In those days the astronomical observations were fairly accurate. Of the several moons of Jupiter, Io has an orbital time period of 42.459 hours. Which means that if one observed the movement of Io (pronounced as eye-O), it will go behind Jupiter after every 42.459 hours. This number was fairly accurately known, but while observing, it the observers noticed that for six months, this time period was a little larger than 42.459 hours, but for the remaining six months the time period was a little smaller than 42.459 hours. This was the keen observation by scientist Ole Roemer who listed about 60 observations between 1668 and 1678.

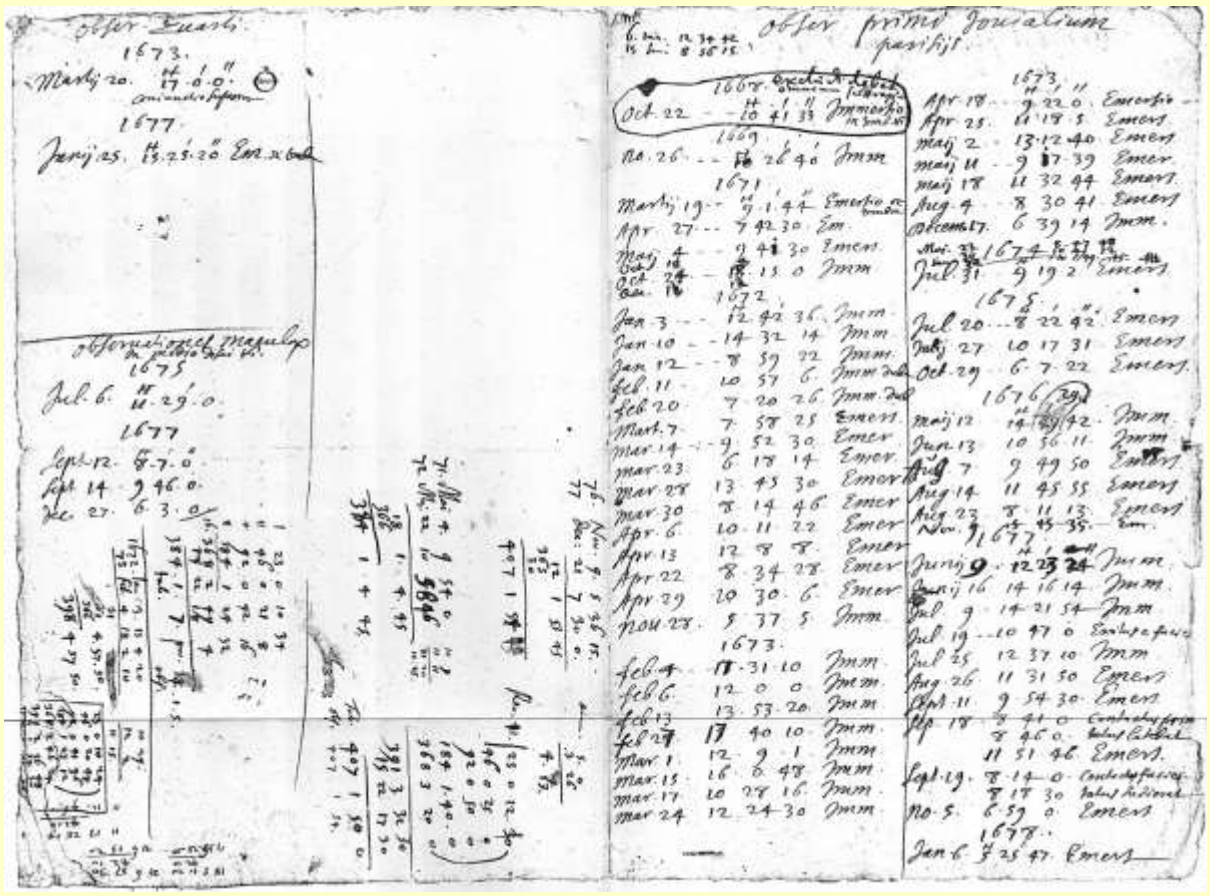


Figure 1 Log entry of Romer. Note the precision of seconds in the reading.

By Ole Rømer - Meyer, Kirstine (1915) Om Ole Rømers Opdagelse af Lysets Tøven, Det Kongelige Danske Videnskabernes Selskabs Skrifter, 7. Række, naturvidenskabelig og mathematisk Afdeling, XII. 3, København. Own scan., Public Domain, https://commons.wikimedia.org/w/index.php?curid=7645744

Even though exact details are not available, I am sure there must have been days when there were clouds which made observers miss some of the data. There could have been other reasons why the observations were not possible on certain days. There must have been times where Earth and Jupiter were on the opposite side of Sun, ie no observations during broad daylight. Hence it took around 10 years to make 60 readings when in that duration Io must have gone around Jupiter at least 2000 times. But those 60 observations were fairly accurately recorded.

Now imagine the scenario where Io disappears behind Jupiter. After it emerges and goes once around Jupiter, Earth too is moving at a constant speed of around 30 km/s around Sun. So next time around when the Io goes behind Jupiter, Earth would have moved to a different location than the previous occultation (going behind Jupiter).

The circumference of earth around sun is 924,375,700 km. The radius of earth's orbit is 149,597,870.691 km. Which means it moves 29.789 km/s. So in 42.459 hours it moves 4553338 km. Light takes 15 seconds to travel this additional distance.

In the duration of 7 March 1672 to 29 April 1672 Io had made 30 rounds around Jupiter. For 30 times the "emergence" or eclipses was delayed by 11 minutes. In 30 rounds of Io around Jupiter Earth moved by around 1.366×10^8 kms. Assuming that Earth was moving linearly along a straight line away from Jupiter then it would have moved around 1.366×10^8 km. If the light had to travel this extra distance in 11 minutes it would amount to a speed of light of 206969 km/s. Taking all the other motions into account, Huygens gave a velocity as 225000 km/s, about 2 or 3 decades after the observations of Roemer.

The speed of 225000 km/s is 75 percent of the current value which is fairly accurate. But obtaining this value around 350 years earlier was a really great achievement considering what they did not have. Even with current technology it is not very easy to measure the velocity of light in modern laboratories.

Readers, who are interested to know more about Io should read *Io after Galileo A new view of Jupiter's Volcanic moon* by Rosaly M C. Lopes and John R Spencer, by Springer

In the same time period, which is described above, there was yet another discovery of great importance in physics. It was the relationship between distance and time, for a body falling under the influence of gravity. The relationship of $s=\frac{1}{2}at^2$, will be described in the next article.

STUDENTS' CORNER

Why I Like Science

succulentandsunshine.com

Science is a subject that teaches people about different things around us. It is about our surroundings, environment and different changes and events that happen every day but go unnoticed. I like science because it is interesting and fun. I like biology as we get to learn about nature. I want to become an environmental scientist so that I can invent something to save animals and protect nature. I could create a chemical mixture which would help plants grow faster, so that we could easily restore the different habitats that have been lost. I would try to stop people from destroying animal habitats. I got interested in biology after I read about people saving animals and protecting endangered species of animals and plants. I also watched a video in which some people found a faster way to plant trees and also help them grow a bit faster. This process is helping a lot in Africa as many forests and savannas were destroyed. So, they are trying to restore the habitat. I also subscribed to National Geographic Kids to know more about the world of nature and science.

https://www.winknews.com/

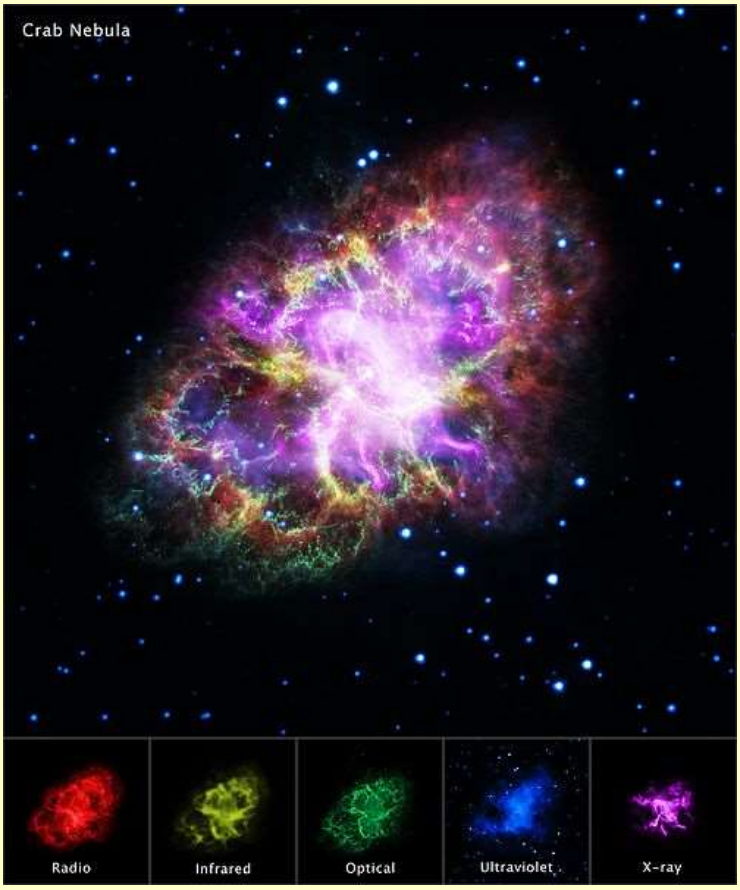
Contributed by

Ananya Mitra, Std VI, AECS 4, Mumbai 400094.

Dear readers, as many of you already know, our beloved country India has the upper hand in Scientific Knowledge among its people and technological advancement. But here, I will tell you about the great Indian Scientists of the past, and how we have been maintaining scientific knowledge for several centuries.

First and foremost, we will begin with the Great Aryabhatta. He was among the Navaratna ("Nine Jewels"), the most important ministers in the court of King Vikramaditya. Some of his achievements are-

1) ***Proper Usage of the Scientific Method***: The Scientific Method is a process used by scientists to explain events and to research many fields. First, one has to observe a certain event and based on those observations, that person will have to come up with a hypothesis about why that event occurred, after which the hypothesis will be tested using trials called experiments. If the theory is proven true, it will be declared as a theory- a proper explanation of an event. This version of the Scientific Method was however, proven to be invalid by Aryabhatta. He claimed that one must *not* attempt to prove their hypothesis, but they should try to *disprove* it. He reasoned that if one makes a conscious effort to prove something, that person will be unwilling to conduct some of the riskier experiments that could possibly disprove the hypothesis, thus leaving it partially untested, and hence unworthy of obtaining the title of a theory. On the other hand, if one makes a conscious effort to disprove something, he will leave no stone unturned to disprove it, thus fully testing it. He used this method to prove his new theory on his argument for the shape of the earth. The Greek biologist and philosopher, Aristotle had theorized that the Earth was round as he saw elephants in Libya, and after sailing for hundreds of kilometers he saw elephants in another place (India). Through this, Aristotle concluded that he must have sailed around the Earth and landed in Libya again. Aryabhatta then disproved this theory using the new and improved version of The Scientific Method, and thus used his own theory to prove the curvature of the Earth, using the movements of the celestial bodies as an explanation. Black Hole Theory: During Aryabhatta's time, a massive star exploded, and the explosion was visible across the world, from Egypt to China. Several centuries later, nobel laureate Chandrashekhar developed a theory that like all living



https://en.wikipedia.org/wiki/Crab_Nebula

creatures, stars have a lifespan and grow larger as time progresses. When they grow so large that they are unable to support their own mass, they reach the end of that lifespan. The death of a star is not withering away, but collapsing under its own weight. After this collapse, the star transforms into a black hole and then withers away.

2) Calculation of the Number Pi (π) to 53 decimal points

3) Invention of the number 0, 365 day calendar and place-value system.

4) Writing the tome Aryabhatiya

5) Explaining eclipses and heliocentric models of the cosmos.

Now, I will highlight about Varahamihira, another Navaratna and Scientist. He had come up with another theory regarding the curvature of the earth, but Aryabhatta discredited it and rebuked Varahamihira frequently, calling his theory a bunch of hogwash and then calling Varahamihira a flat earther. This then led to great fights between them. But despite his hatred for Aryabhatta, Varahamihira was a man of great accomplishments. Some of his contribution to mathematics and science are-

1) Authoring many books on astronomy: He had written several scriptures in partnerships with other scientists, such as Hora Shastra on horoscopy, co-authored by Lilavati, Surya-Siddhanta, co-authored by Latadeva, Vashishta Siddhanta, co-authored by Vishnuchandra and Romaka Shastra on philosophy and Paulisha Shastra on trigonometry, co-authored by Paul of Alexandria.

2) Recording the first 3x3, 4x4 and 5x5 magic squares.

3) Reflection & Refraction Theory: Varahamihira proposed that reflection of light is caused by the scattering of light particles off a surface. Refraction occurred, when the light particles are thrown into disarray, and absorption of light due to the ability of the light particles to move through transparent objects in the manner that fluids pass through porous objects.

Now, I will write about the achievements of the great Bhaskaracharya the Learned of Chedi. His achievements were-

1) Writing treatises on calculus 750 years before Newton.
2) Inventing algebra.
3) Inventing the perpetual motion machine- Bhaskaracharya invented a machine which could generate an infinite amount of energy. The machine was a wheel which had a certain amount of mercury in it. As soon as it would stop turning, the mercury in the spokes would be forced to turn downward by gravity and thus propel the wheel to turn further.

You can see that this trinity of our ancient Indian scientists provided some great contributions, which paved the way for a scientifically advanced modern world.

Contributed by

Vivaan Sharma Class VI, Delhi Publish School

Navi Mumbai, Maharashtra

Vivaan Sharma has already published a book.

Title: "Stranger than I thought"

Titration without indicator

Titration is a process to achieve controlled acid-base neutralization. In the laboratory, titration is used to quantify the concentration of titrants and normally an indicator is used to flag the end point or the balance point of the titration. Biological systems like human body carry out titration in almost all parts of the body e. g. in our digestive system where there are series of titration processes starting from mouth, till the large intestine.

In schools, the process of titration is studied mostly using an indicator, which changes colour when the nature of the solution changes from acidic to alkaline. However, there are several ways where one can observe this change. One such way is to measure the conductivity (or current passing through the solution) to determine the change from acidic to alkaline nature of a given solution. The titration process in the biosystems, like human body mostly depends on similar processes that sense the concentration of ions. **This out of text book technique can give different perspective to the students about the concept of titration. It links the concept of number of ions to current and also to the value of pH, thus integrating concepts of physics and chemistry.**

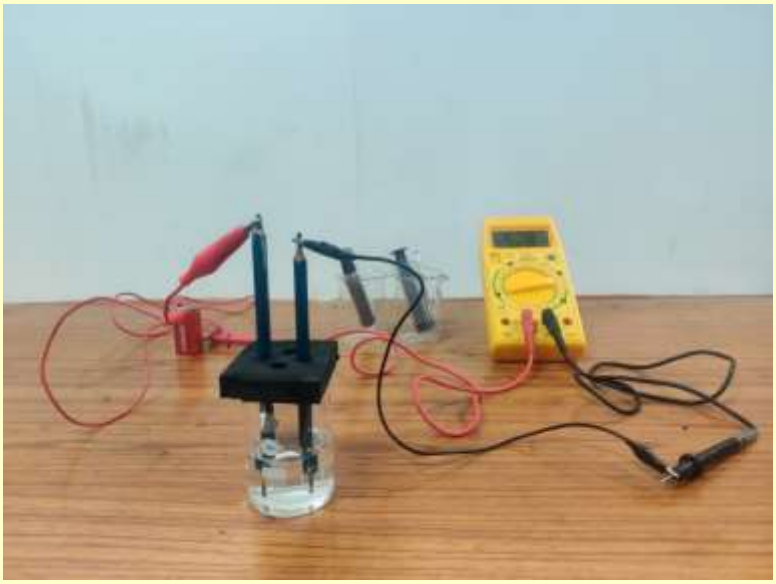


Figure 2 Electrical conductivity titration equipment with DC source

The equipment used is very simple and hence can be fabricated (and assembled) in schools, developing creative skill among students and teachers. Equipment consists of a beaker to hold the solution, two syringes, two pencils (2B or darker) sharpened on both the ends, a multimeter to measure current. Ideally an alternating source of power is desirable. The power can be obtained from a TAB or a mobile phone using the software SIGNAL Generator described in reference [1]. However, in absence of alternating source, a 9 V battery can be used. However, teachers should be aware that this connection should be active only during the measurement of the current and then immediately discontinued.

The setup can be seen in figure 1 attached.

Take 20 ml of HCl in the container using one of the syringes. Connect the circuit as shown and measure the electric current. Start adding NaOH using another syringe and the change in current can be noted. The plot of current vs the volume of NaOH is as observed in the graph attached.

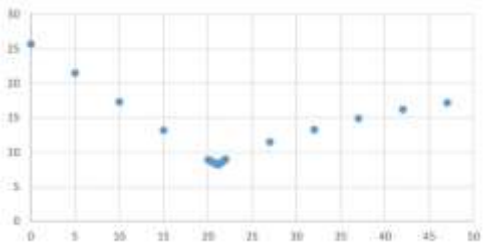


Figure 3The end point is the minimum in the graph.

From the graph it can be seen that the end point is at 21.2 ml, which is also the result one obtains with colour change of indicator added.

1 . S.B. Kanade, A.P. Malandkar, Prakash Nawale and P.K. Joshi, *Volume changes during dissolving of ionic compounds in water*, GPG Journal of Science Education Vol. 2 Issue 2, 2021: pp 1 – 7

contributed By



P.K. Nawale, A. Malandkar P.K. Joshi
Homi Bhabha Centre for Science Education (TIFR), Mumbai

Forthcoming events of NMSF

I. WNED-2021 (2nd Dec 2021)

Navi Mumbai Science Foundation (NMSF) decided, in the year 2013, to introduce Dec. 2, as **World Nuclear Energy Day** so that constructive abilities of Nuclear Energy are remembered with due intensity and are not lost into the background of Hiroshima and Fukushima disasters. NMSF also wishes to highlight the fact that radiation associated with Nuclear Energy is a tool which is being effectively used for improved services in health, agriculture, industry & research.

Dec. 2, is of special significance as on this very day, in the year 1942, Enrico Fermi demonstrated to the world that nuclear energy can be released in a controlled manner. This day thus gave a clear message that nuclear energy is equally usable for peaceful applications.

The main attraction of the event is presentation of **"Enrico Fermi Memorial Lecture"** by an eminent scientist on a topic which is socially as well as strategically critical for our society. Since last 3 years, student-oriented activities have also been added to the programme to ensure their greater participation. They include a MCQ test & an essay competition on topics related to nuclear energy.

NMSF has been celebrating this day each year for the past 8 years now, together with Karmaveer Bhaurao Patil (KBP) College, Vashi, Navi Mumbai, which hosts the event. **It is a major activity for both of us as we are the only people on the surface of the earth to initiate & celebrate it regularly.** The event has also received support from Atomic Energy Regulatory Board & Indian Association for Radiation Protection in the past.

This year onwards, NMSF has decided to expand the scope of the "Enrico Fermi memorial Lecture" beyond nuclear energy to give the student community an overview of the energy scenario. In that regard, the topic chosen is **"hydrogen energy"** which is a promising source of future energy. **Dr. D. Parvatalu, working presently as a Domain Expert in Hydrogen Program of ONGC Energy Centre, Mumbai,** will speak on the topic on Dec. 2, 2021, in the morning. The event being in the online mode, its link will be displayed on the website of NMSF & also forwarded to all those who convey their interest in the event to NMSF or KBP College, Vashi.

II. National Mathematics Day-2021

"National Mathematics Day" is celebrated across the country in India on **December 22** each year. The Indian mathematical genius Srinivasa Ramanujan was born on this day in the year 1887. Srinivasa Ramanujan is a name to reckon with among pioneers in the world of Mathematics. **This Day was celebrated for the first time on December 22, 2012.**

The main objective behind the celebration is to raise awareness among people about the importance of mathematics for the development of humanity. Several initiatives are taken to motivate, enthuse and inculcate a positive attitude towards learning mathematics among the younger generation of the country.

Navi Mumbai Science Foundation (NMSF) started celebrating this day, in association with Karmaveer Bhaurao Patil (KBP) College, Vashi, Navi Mumbai, which hosts the event, from the year 2020.

Its highlights are: The event is celebrated under the title **"Mathematics in Perspective"** and the chief guest delivers his talk as **"Srinivasa Ramanujan Memorial Lecture"**. This is followed by a quiz titled **"Ignite your Brains".**

This year also, the event will be celebrated on Dec. 22, 2021. The event being in the online mode, its link will be displayed on the website of NMSF & also forwarded to all those who convey their interest in the event to NMSF or KBP College, Vashi.

III. "An online" essay competition

"Dr. Vikram Sarabhai Essay-cum-Elocution Competition-2021 (VSEEC-2021)"

on the topic "Recycling technologies – A must for survival in space"

The New horizon Public School (NHPS), in association with Navi Mumbai Science Foundation (NMSF), is organizing an Inter-School essay competition referred above under the general head "Space Exploration"; the specific essay title this year being **"Recycling technologies – A must for survival in space". This competition was introduced in the year 2020 – the birth centenary year of late Dr. Vikram Sarabhai.**

Students of class IX & X only, from schools in Navi Mumbai region are eligible for participation.

The Annual essay writing competition was held on Saturday, **20th November 2021**". The results will be announced in January, 2022, after the 2nd round of oral presentation-cum-interview of toppers of the written test are conducted.

Participation in such competitions goes beyond winning prizes. The students here imbibe the art of critical thinking which is so very essential for choosing an appropriate career in today's world. It also helps develop soft skills such as leadership, communication and a problem-solving approach, to mention a few. A good response to the competition will only be an endorsement of the fact that the time was ripe for introducing the event.

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IV. Homi Bhabha Bal Vaidnyanik Competition Practical (HBBVC - Practical)

(To be held in Jan 2022)

Guidance Sessions for Students of Std. VI.

(A general introduction to practical science at VI std – IX std level)

Get practical experience of laboratory equipment, measurement devices and learn methods of carrying out scientific experiments – even at home. (An online event)

For enquiries, parents may write a mail to nmsfscienceutsav@gmail.com

DON'T MISS IT

Coming up in Next issue (January-March 2022)

1. How was the relation between displacement and time established?
2. Student's corner
3. Teacher's page
4. Activity question AND MUCH MORE……

DO YOU HAVE ANY INTERESTING EDUCATIONAL STORY TO TELL? JUST SEND YOUR STORY TO US AT edureka.nmsf@gmail.com for putting in EduREKA.
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