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# CONTRIBUTION BY A GREAT MATHEMATICIAN: SRINIVASA RAMANUJAN

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**Abstract:** In this paper, we will discuss the journey of the great mathematician Srinivasa Ramanujan. We will mention his background including his family, education and early achievements. This paper will certainly contain his mathematical discoveries in different topics and formulas he worked on.

**Keywords**: Srinivasa Ramanujan, The World's Greatest Mathematician, modular functions


## INTRODUCTION

### About the Srinivasa Ramanujan:

Srinivasa Ramanujan, sometimes described as 'The World's Greatest Mathematician' was born into a poor Indian village, Erode, on the 22nd of December, 1887. He lived in Erode for only a year and then moved with his mother to Kumbakonam, the town where Kuppuswamy Srinivasa Aiyangar (Ramanujan's father) worked as a clerk in a cloth merchant's shop.

In this town, Ramanujan attended several primary schools where he achieved a distinction in his primary examination which placed him in Town High School in 1898. Interestingly enough, Ramanujan chose to create his own path into mathematics at only the age of 13, he focused on the sum of geometric and arithmetic series. In 1902, Ramanujan created a method for solving quartric equations and just two years later, he explored Euler's Constant and was able to calculate it to 15 decimal places as well as looking deeply into the series of S(1/n) and Bernoulli numbers.

In the same year, Ramanujan gained a scholarship due to his outstanding performance in his studies and therefore was a F.A student at Kumbakonam's Government College. Throughout the year he got more and more fascinated by the subject and his passion grew for mathematics. Hence, he failed all his formal education but mathematics at KGC. This failure had cost Ramanujan depression because neither he nor his parents could afford for his studies and as a result he ran away to Vizagapatnam in 1905 without the acknowledgment of his parents. At that time he decided to focus on the relationship between series and integrals.

One year later, Ramanujan returned to study at Pachaiyappa's College hoping to pass the First Arts examination in order he gets into the University of Madras. However he failed all but mathematics, again, because he paid all his focus towards mathematics at that time.

Just like any random person, Ramanujan had a source of inspiration. He was influenced by a famous book of G.S.Carr, A Synopsis of Elementary Results Pure Mathematics, which was basically a condensation of 5000 algebraic, calculus, trigonometric and analytical geometric equations of the late 19th century. The book significantly affected his mathematical work.

In 1908 Ramanujan began experiencing health problems while studying continuous fractions and divergent series but did not take any actions; instead he got married the following year to his nine year old distant relative, S. Janaki Ammal. However, she moved to live with him at the age of 15. In 1910 Ramanujan's hard work got paid off as he was recognised by the Collector of Nellore, Diwan Bahadur Ranchandra Rao, who was generous enough to financially help Ramanujan.

Amazingly enough, Ramanujan astonishingly published his first paper based on Bernoulli numbers in 'Journal of the Indian Mathematical Society'. This major achievement enabled him to work as a clerk at Madras Port Trust in 1912. Ramanujan earned 30 rupees a month which was enough for him and his family.

At that stage, Ramanujan got popular to various professors throughout Madras who wanted to take his talent and intelligence up to a higher point. C.L.T Griffith was the first to help Ramanujan. Griffith who graduated from London University College was a professor in Civil Engineering and had written to M.J.M. Hill, a Mathematics professor, discussing about Ramanujan's brilliance including some of his work. However Hill's respond wasn't very helpful.

Similarly there were another five important mathematicians at that time including Professors Baker and Hobson who were Cambridge mathematicians who did not react towards Ramanujan as much as Mr. G.H. Hardy. Godfrey H Hardy, also a Cambridge mathematician, supported Ramanujan through a number of letters. In the same year, 1913, Ramanujan was offered a two-year funded scholarship from the University of Madras of 75 rupees per month. The following year Hardy wished for Ramanujan to receive better financial support therefore he invited Ramanujan to move for Trinity College, Cambridge. Luckily while Ramanujan was deciding on the offer, he met E.H. Neville, a student at Trinity College who was in Madras to attend a lecture. The decision was hard-hitting for his family but they finally agreed.

Ramanujan set off to England on the 17th of March, 1914 and stayed at Neville's house on his arrival for the first few weeks. For some reason he moved into Trinity College and remained in his rooms. Unfortunately Ramanujan faced hard times since World War One started in the same year and therefore there were few Cambridge mathematicians, who left for war service, and few students. Ramanujan was a vegetarian and under these serious conditions it was extremely difficult to obtain vegetarian food outside London. It was stressful to live in England during that period yet Ramanujan and Hardy got together almost on a daily basis.

Still with the stressful and pressurising war, Ramanujan graduated from Cambridge (1916) in hold of a Bachelor of Science for Research on Highly Composite Numbers. A year of satisfaction later, Ramanujan was diagnosed with Tuberculosis and remained in a number nursing homes; Cambridge, Wells and in Matlock (Derbyshire). He was then transferred to Fitzroy House in London as it was noticed that his health was slightly progressing. Some argued that he being elected as 'Fellow of the Cambridge Philosophical Society', 'Fellow of the Royal Society of London' and 'Fellow of Trinity College' in 1918 was the key to his health improvements.

Ramanujan returned to home country, India, on 13th of March 1919. He received best health care throughout several places but unfortunately his health was worsening. During Ramanujan's battle with his health he did not give up his passion, instead he continued his work in mathematics. The battle didn't last long, Ramanujan passed away on 26th of April 1920.

One of Ramanujan's famous quotes 'An equation means nothing to me unless it expresses a thought of God'.

During Ramanujan's mathematical journey, he agreed to share his work with the public through journals. However after his death, Berndt and his colleagues took part in making use of Ramanujan's untidy notebooks and therefore it took them a lot of time to ensure that the results they come up with are tested to meet Ramanujan's results.

Ramanujan produced an astonishing 4000 theorems in different topics including number theory, combinatorics and algebra. He focused on several specific areas from hyper geometric & infinite series to

highly composite numbers. However the two main areas were Ramanujan felt he had a relationship with are 'number theory' and 'modular functions'. Although Ramanujan was brilliant at exploring equation, he was not good enough at explaining how to derive them. Even mathematicians nowadays find it difficult to derive Ramanujan's equations using all the different technologies available.

Most of all, Ramanujan had put so much effort into infinite series and he used them to invent equations for 1p, one of the 17 equations he explored is:

Another interesting work of Ramanujan is the number '1729' otherwise known as the 'Hardy - Ramanujan number' is the smallest taxicab number resulted from the sum of two different positive cubes. Hardy was able to come up with this as he was travelling to visit Ramanujan in the hospital in his last few days. Hardy, in his words, stated that 'I thought the number of my taxicab was 1729. It seemed to me rather a dull number.' But Ramanujan looked at the problem at a different angle and so replied: 'No, Hardy! No, Hardy! It is a very interesting number. It is the smallest number expressible as the sum of two cubes in two different ways.

The interesting part is that the number of different combinations is decided upon the position of the term, Ta(n). For example the fifth term, Ta(5), could be obtained by five different combinations of two positive cubes.

As already mentioned Ramanujan had an enormous curiosity when it comes to 'Infinity' and he has been called 'The Man Who Knew Infinity' by author Robert Kanigel. Ramanujan is known for his weakness in proving formulas and he once sent a letter to Hardy specifying that he found a value which basically stands for the 'prime of prime numbers'. Ramanujan theory was that:

At first they didn't believe his theory, but after a long work, Hardy and Littlewood figured out how Ramanujan came up with this. Ramanujan has looked at 'Riemann's zeta landscape' and was able to find the missing part.

Ramanujan did a lot of work on modular equations where an equation is represented in terms of x, and he did further work on f(x2), f(x3) and so on. It was an area where he was very strong and recognised at. Hardy stated that 'It is here that both the profundity and limitations of Ramanujan's knowledge stand out most sharply'. The study of modular equations led Ramanujan to pay attention to modular functions. His interest pushed him to publish a paper on this topic, titled 'Modular Equations and Approximations top' during his study in 1914.

A lot of Ramanujan's work is related to Pi which is used today in many different areas including computers and education. Children today start learning about pi and how it is used to find the area and circumference of a circle starting from secondary schools where it is compulsory and some continue with it in higher education. Pi exists everywhere and in many different subjects. Not only in circles, but pi also occurs in many mathematical equations, also in science to measure ocean waves as well as in statistics of economy.

Ramanujan has contributed so much towards pi through various different formulas. His contributions were very successful and had high levels of accuracy. The formulas and equations he developed are now used in computers to generate the accurate value of pi which includes millions of digits. Pi reached 100 million digits in 1987. But what is the point of generating more and more values of pi? The answer is simply that the more values of pi there are the more reliable and efficient the computers are. Besides, due to the high number of remarkable mathematical softwares, mathematicians today can untangle the mathematics behind pi so that Ramanujan's methods and proofs become understandable and coherent since his notebooks had barely any statements.

In conclusion Ramanujan has been compared to significant names including some of the masters of mathematics such as Newton and Einstein. His intelligence led him to move away from a poor town in India into Cambridge where he became a famous mathematician taking into account his health issues. One of his great stories that is shared with us took place while he had a conversation with a friend named Sandow. Sandow got curious and so asked why Ramanujan had 'rough and black' elbows. Ramanujan replied "My elbow has become rough and black in making a genius of me! Night and day I do my calculations on slate. It is too slow to look for a rag to wipe it with. I wipe the slate almost every few minutes with my elbow". Sandow was amazed but still questioned why he wouldn't use paper instead, Ramanujan answered "When food itself is a problem, how can I find money for paper? I may require four reams of paper every month". Ramanujan revealed the true definition of 'passion' and proved a great theory that no obstacles can stand in the way of somebody's dream.

Ramanujan has been an inspiration for some generations and his work is carried on until this moment throughout several technologies, most importantly, computers. Ramanujan died at the young age of 37 leaving us a great history in mathematics, so the question we should ask ourselves is: What more could he have achieved if he had lived a little longer?

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