



A Brief Account of Computational Vedic and Ancient Indian Mathematics

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ABSTRACT: The Vedas mentioned some rules for mathematical calculations and their operations. The system of mathematics based on these rules is known as Vedic mathematics. Vedic mathematics was written in the Vedic age. In India, the Vedic mathematics was searched by Sri Bharati Krishna Tirtha ji Maharaja between 1911 and 1918 from ancient scriptures. In the present communication, the origin and development of Vedic mathematics are discussed. The applications of Vedic mathematics are illustrated by solving multiplication problems in very short time. Its application in computing multiplication and future plan of its expansion is explained. Ancient Indian mathematics with important discoveries like decimal system, numerals, zeros and infinity are also discussed. The important works of four Indian mathematicians has also been mentioned in the research paper.

Keywords: Vedic mathematics, ancient indian mathematics, computational mathematics, decimal system, history of mathematics, indian mathematical traditions.

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1. Introduction

All of us have heard about the Vedas. Do you know that the Vedas contained some rules which made mathematical calculations simpler? The system of mathematics based on these rules is known as Vedic mathematics. Vedic mathematics was written in the Vedic age. However, due to foreign invasions, these works remained neglected for centuries. Fortunately, towards the beginning of 20th century, Europeans showed interest in Sanskrit texts and they came across certain texts called Ganith Sutras [1]. These texts contained many mathematical deductions which were not realized and studied earlier. Vedic mathematics was searched by Sri Bharati Krishna Tirtha ji Maharaja [2] between 1911 and 1918 from ancient scriptures. He researched for years and constructed a series of mathematical formulae called sutras. He wrote a book called Vedic mathematics and that was considered to be the starting point of all the researches on Vedic mathematics.

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This book [2] was written by him in his final years and was published five years after his death. A copy of this book reached London in late 1960s. Vedic Mathematics was immediately accepted as a new alternative system of mathematics. British mathematicians took interest in this new system and started delivering lectures on it. This renewed the interest on Vedic Mathematics. The scholars and researchers started not only appreciating it, but also started to apply in computer programming as new algorithms based on Vedic mathematics.

2. Development of Vedic Mathematics

In old days, authors had a practice of writing everything in the form of verses or sutras. Even the technical and abstract things were written in the form of sutras. Their belief was that sutras help students and readers to understand things efficiently. Vedic Mathematics is based on sixteen sutras and their corollaries. These sutras were one-line formulae which could be used to solve almost all the types of problems in Mathematics. They were originally written in Sanskrit. For Example, Ekadhikina purvena means 'one more than the previous one'; Nikhilam Navatashcaraman means 'all from 9 and the last from 10'; Uradhava Triyaghyam stands for 'vertically crosswise' and Paraavartya Vojayet means 'transport and adjust' are the first four sutras of Vedic mathematics.

Vedic Mathematics is known for its coherence and simplicity. The use of intuition and innovation is developed by Vedic Sutras. That is why it is enormously popular among educationalist and academicians. It is advantageous and beneficial because of a consolidated metaphysical background in the Veda of the objective sciences including mathematics whose basic concepts cultivate more reasoning and thinking power among the readers.

3. Vedic Mathematics Applications

Various formulas and their applications have been given in Vedic Mathematics, which are applied in carrying out difficult and time-consuming arithmetic operations and mental alertness. Next, we discuss two important sutras and their applications in solving cumbersome arithmetic and computations problems.

3.1. Ekadhikina Purvana(by one more than the previous one)

This sutra deals with square of the numbers ending in 5. To explain this sutra let us consider the example of 25^2 . In this number, the first digit is 2 and the second digit is 5. We add 1 to 2 and get 3 as sum. The result of 25^2 has two parts namely LHS and RHS. LHS of the result is $2 \times 3 = 6$ and RHS of the result is $5^2 = 25$. Thus $25^2 = (2 \times 3)25 = 625$.

In the same way $45^2 = (4 \times 5)25 = 2025$ and $125^2 = (12 \times 13)25 = 15625$.

3.2. The Nikhilam Sutra

Firstly, we consider a simple multiplication of 2 digits. Let us start to multiply together two numbers 97 and 94, a little less than 100 by applying the Nikhilam Sutra method due to Mahara ji [2]:



Figure 1: Illustration by Nikhilam Sutra

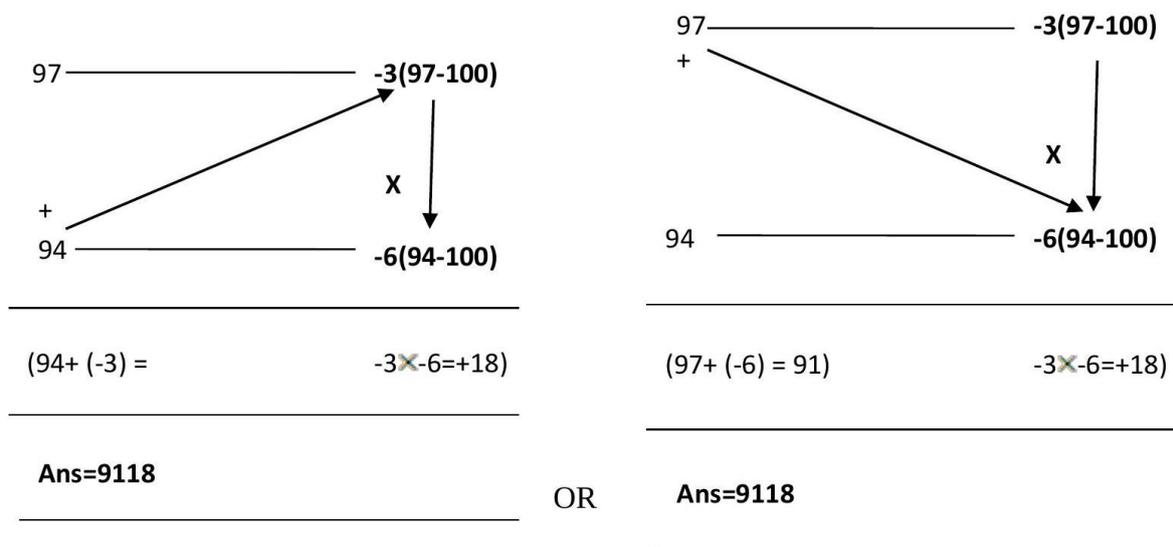


Figure 2: Working Example by Nikhilam Sutra

The process involves the following steps:

Step 1: The deviations of 97 and 94 from 100 are -3 and -6 respectively.

Step 2: Multiplying deviations -3 and -6 we get 18, which is the right part of our answer.

Step 3: To get the left part of the answer, one of deviations is cross added. Thus, we get 91 which is the left part of our answer that is equal in both cases.

It may be noted that the base is 100 in case of two digital numbers. 0 is put if it is less and if it is more, add the excess digit to the left part of the answer. So final answer comes to the 9118, which is same in both cases.

3.3. Another Computational Process

Next, we apply another sutra in digital computing, when we get either the multiplier or multiplication 0's as all. Next, we consider an example in terms of bits.

Example: Let us consider a problem of multiplying 997 and 998. Binary equivalent of 997 is 1111100101 and of 998 is 1111100110 . For this we have to take our base as 1000000000

BASE →	1000000000	1000000000	1000000000	1000000000	1000000000	100
1111100101	111100101	11100101	1100101	100101	00101	01
1111100110	111100110	11100110	1100110	100110	00110	10
10111001011	1011001011	101001011	10001011	101011	00111	10
11110010111	1110011000	110011011	10100000			
11110010111	0	1	0	1	111	10
FINAL RESULT →	11110010111010111110					=995006

Figure 3: Illustration of bits by Nikhilam Stra



Figure 4: Binary illustration of Nikhilam Sutra

3.4. Future Plan

- a. Lesser steps are required in computational Vedic Mathematics to achieve the result. Thus, it is expected to perform better than the existing multiplication algorithms, like Booth's algorithm.
- b. On successful application in multiplication, we can apply computational Vedic Mathematics in division also.
- c. All computational methods in Vedic mathematics are effectively implemented in computers from hardware level to network level; since it reduces the time in computation drastically.
- d. Thus, computation problems in Vedic Mathematics are pattern tools are required to obtain both in theoretical and practical domains.

4. Comments on Sri Bharati Krishna Tirtha Maharaja's Vedic Mathematics

Some academicians, even mathematicians have objected to use of Vedic by Swami Sri Tirthaji Maharaja to his mathematics [2]. They have argued that there are four Vedas and the Arthveda which deals with architecture; engineering and general mathematics does not contain mathematics discovered

by swami ji. Thus, it is intriguing when it is not mentioned in any of Vedas, why Vedic work was used as prefix?

The pupils of Swami Ji have put forth their argument with regard to the question raised. They said that according to Swami ji 'Veda' meant a source of limitless knowledge and any knowledge which led to all round development of humanity was a part of Veda. Moreover, the word comes from the root 'Vid'" which means to know. It was the whole essence of Swami Ji's assessment of Vedic tradition that was not to be approached from a factual standpoint but from the ideal standpoint.

The Vedas were considered in India as repository of all knowledge not necessarily in human possession. Originally the Vedas were handed down in the oral tradition and were not in the form of any text. After many years the Veda in present form were codified and published. Thus, use of Vedic word for analysis of Swami Ji's research in mathematics was proper and justified.

5. Vedic Geometry

Sulbasutras of Baudhayana(3200 BCE) [3-4] is regarded the well-known manual of Vedic Geometry. Sulbasutras of Apastamba, Manav and Katyayana were copied much after the time of Baudhayana. Sulbasutras were developed as manuals for construction of various types of altars for performing Yajnas. These are of special importance as these deal with the rules for measurements and constructions of altars. These also content with many geometrical propositions and problems related to rectilinear and other types of figures.

The well-known Pythagoras theorem was widely used by sulbasutras. Prof. Sidenberg of USA and several others have opined that Indian savants independently knew this theorem before 2500 BCE. There is solid evidence that this popular theorem was very well known to Brahmanas which follow Vedas.

6. Ancient Indian Mathematics

Since the dawn of Vedic civilization on the planet, mathematics has held in the highest esteem among all disciplines. Initially, the three branches were developed in ancient India to sustain Vedic culture and civilization:

- a. Arithmetic for use of in everyday life.
- b. Geometry for the construction of Vedis of various shapes and size to perform Yajnas.
- c. Astronomy to develop a suitable calendar system

Brief There are other mathematicians who lived before swami ji and contributed to significant development of mathematics. A brief account of work of eminent ancient mathematicians has been given in 'Aryabhata, Life and Contributions' written by Hooda and Kapur [5]. Out of these eminent mathematicians here we discuss some important contributions of four mathematicians.

- The algorithm for finding cube roots, sum of squares and cubes of natural numbers was enumerated by Aryabhata (476 AD). He also gave approximation of π by 3.1416, mensuration formulae and tables for the $\sin \theta$. The differential equation of sine function in its finite-difference form and a method of solving linear indeterminate equation were also explained by him.
- Brahmagupta (598 AD) solved the indeterminate equation $Nx^2 + 1 = y^2$ in integers, gave the sum of geometrical progression, determined the right-angled triangles and cyclic quadrilaterals with rational sides, gave interpolation formulae and the formulae for the area of a cyclic quadrilateral. His work is known as Brahma Sphuta Sidhanta and a karana text called Khanda Khadyaka.
- Ganita-Sara Samgraha was written by Mahavircarya in 850 AD. It contains problems in quadratic equations, the general formulae of cube root and unit fractions in arithmetic and construction of cyclic quadrilaterals of any given area and circumference for the ellipse in geometry
- Siddhanta Siromani was written by Bhaskaracarya (1114 AD) at the age of thirty-six and that was in the systematized mathematics known at that time. He discovered formulae for surface area of sphere and its volume, volume of frustums of a pyramid, problems on permutations and combinations, problems on quadratic equations and indeterminate equations. He also formulated some results which showed that he almost had discovered the calculus.

6.1. Decimal System

The most important discoveries made by the ancient mathematicians in mathematics were decimal system, numerals and zero symbols. The usage of nine digits and a symbol of zero to denote all integral numbers by assigning place value to each digit were most important features of the system. However, the decimal systems of numeration can be appreciated profoundly in words of Laplace (1749-1827), the greatest mathematicians of all time. He wrote "the idea of expressing all quantities by nine figures (or digits), whereby is imparted to them both an absolute value and by position, is so simple that this very simplicity is the reason for our not being sufficiently aware how much admiration it deserves".

The decimal system was perhaps the most revolutionary and the greatest scientific achievement in the ancient world. The numbers in the decimal system were called Arabic numerals by the European; but these were called Hindu numerals by the Arabs. Question is whether these numerals Arabic or Hindu. The Numerals are written in Urdu, Persian and Arabic languages are written from right to left, while numbers in Hindi or English language are written from left to right. Since the numbers were taken from a language that was written from left to right, therefore it can be confirmed that these were taken from India. Thus, it was accepted that those numbers came from India and were copied by Arabs.

A new theory was professed by Dr. S. R. Rao, a well-known that the decimal system of measurement to the world and use of gold as medium of exchange was given by the Harappans. He was of the view that Harappans produced gold discs which were made in a particular ratio of weight. Its unit was named Gunja which was conforming with Survana referred as Masaka in Arthasastra. Various sized gold discs were also found at Lothal and hitherto mistakenly assumed as pendants, but these were the ceremonial ornament called rukma, which is described in Vedic text and was worn by priests. Those golden discs weighed exactly 50, 100, 2500, 2750, 2800, 2900, 3000, 3250 milligrams following decimal system.

6.2. Zero and Infinity

The invention of Sunya (zero) as absolute value and as positional value in decimal system of counting numbers is now credited beyond any kind of doubt as great gift to humanity. The two concepts of zero are explained by the fact that in sequence $0, 1, 2, 3, \dots$, where zero is predecessor of 1 and zero in 203 has a position value with absolute value. This is considered as one of the topmost inventions on this earth. As regards the modern symbol for zero, viz., 0 , there are evidences to conclude that this symbol was used by great ancient scholar and mathematician Pingala at least 5000 years ago.

It is very important that the Indian Mathematicians realized the various operations with zero in the mathematical sense earlier than other countries. From Brahmagupta onward, mathematical works systematically give rules of operations with zero as follows:

$$a - a = 0; a \pm 0 = a; 0 \pm a = \pm a; 0 \times (\pm a) = 0; 0 \times 0 = 0; 0/a = 0$$

Mahaviracarya also (9th Century A.D.), a famous mathematician from Jaina School of thoughts, has stated general Rules in regard to zero.

"A number multiplied by Zero is Zero and that (number) remains unchanged when it is divided by combining with (or) diminishing by zero. In the operation of addition, the zero becomes the same as what is added to it. Mahaviracarya obviously thinks that a division by zero is no division at all".

Lilavati [6] contains rules concerning zero are explained as follows:

The sum of all ciphers is equal to zero. It is worth mentioning that square and cube of zero is zero and similarly, the square root and cube root of zero is also zero, while a definite quantity divided by cipher is indeterminate and the product with cipher is naught. Thus, any further operation imposed, cipher having a multiplier can become afterwards a divisor and the definite quantity must be understood to be unchanged. Similarly, any quantity to which cipher is added, or from which it is subtracted also remain unaltered.

According to Ganesha Daivajna (A.D.1507) author of Buddhivilashini and one of the best expositions of Bhaskaracarya's Lilavati [6] "Fraction with its denominator cipher is an infinite quantity. Since it cannot be determined how great it is. Ranganatha (A.D.1603) affirms that it is infinite because the smaller the divisor is the greatest in the quotient: now cipher being in the utmost degree shall give a quotient infinitely great.

7. Conclusions

A new and entirely different approach to mathematics has been provided by Vedic Mathematics which has immensely helped to meet the current and future demands in computing. Vedic mathematics is a fast calculative technique because of its reduced number of operations and its inherent nature of parallelism. Since the current and future trends indicate growing demands of high performance and energy efficient computing, parallelism is the way to go ahead. As inherent of Vedic techniques to implement parallelism, it might be the next big thing to hit the digital world. The algorithm and hardware circuitry are currently under development phase.

The invention of symbol for zero came after the idea of zero became a common property. Thus, the people who devised numerals and a symbol for zero did a great service to civilization. However, the names of neither these people nor the period when they lived are known with identity, because the numerals remained unused for centuries.

Limit is another concept in Indian history of mathematics, which reached the stage of preserving the names of important contributors. Delivering into some of the significant number systems including those of ancient human civilization, a comparative analysis underlines the concept of zero as essential for rapid and natural development.

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