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Mathematical Knowledge System in Ancient India

Dr Ramesh Bhinde
Department of Mathematics, PMCOE KSCSK Govt P. G. College Alirajpur

यथा शिखा मयूराणां नागानां मणयो यथा ।
तद्वद् वेदांगशास्त्राणां गणितं मूर्ध्नि संस्थितम् ॥

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Corresponding Author:
Dr Ramesh Bhinde

ABSTRACT

The Indian knowledge system in mathematics is one of the world's most ancient and profound knowledge systems. In addition to introducing the concept of zero, Indian mathematicians also made significant contributions to the study of other fields, including geometry, arithmetic, binary mathematics, the concept of negative numbers, algebra, trigonometry, and calculus. The decimal place value system used worldwide today was first developed in India. This comprehensive exploration of the Indian knowledge system in mathematics provides a detailed analysis of its historical development, significant contributions, and underlying philosophical principles. The paper aims to highlight the works of ancient Indian mathematicians, methods of knowledge dissemination, and the far-reaching influence of Indian mathematics on global mathematical thought.

KEYWORDS: Indian knowledge system, Mathematics, Zero concept, Infinity, Decimal system, Algebra and Trigonometry, Geometry

INTRODUCTION

Mathematics, often referred to as the "queen of sciences," is a fundamental discipline that explores patterns, structures, and relationships using abstract concepts and logical reasoning. It serves as a universal language of measurement and computation, essential for understanding the natural world and solving complex problems across various fields. At its core, mathematics is about discovering and explaining patterns in numbers, shapes, and quantities.The practical applications of mathematics in ancient India were diverse and far-reaching, demonstrating the versatility and advanced nature of Indian mathematical knowledge. In astronomy, complex calculations were used to predict celestial events and create accurate calendars. Architectural marvels such as temples and stepwells demonstrated the application of geometric principles and precise measurements. In commerce, sophisticated systems of accounting and calculation facilitated trade and economic activities. This interdisciplinary approach to mathematics not only advanced theoretical knowledge but also made significant contributions to various aspects of daily life and social development. Methods of knowledge transmission, especially the guru-shishya tradition and oral traditions, played a crucial role in preserving and transmitting this mathematical knowledge across generations, ensuring its continuity and evolution over time.

Historical Development of Indian Mathematics

- **Vedic Period (1500–500 BCE)**

The earliest evidence of mathematical activity in India can be traced back to the Vedic period. The Vedas, particularly the Śulba Sūtras, contain geometric principles used in the construction of altars and fire pits.

- **Classical Period (500 BCE–1200 CE)**

The classical period saw the emergence of significant mathematical texts and the development of advanced mathematical concepts. This era is marked by the works of mathematicians like Aryabhata, Brahmagupta, Bhaskara II, and others.

- **Medieval Period (1200–1800 CE)**

During the medieval period, Indian mathematics continued to flourish, with contributions from scholars like Madhava of Sangamagrama and Nilakantha Somayaji. This period also saw the transmission of Indian mathematical knowledge to the Islamic world and Europe.

Mathematicians of Ancient India and their contributions: Baudhayana; Katyayana; Acharya Pingala; Aryabhata; Brahmagupta; Bhaskaracharya; Mahaviracharya and Varahamihira were the great mathematicians of ancient India.

BAUDHAYANA: Baudhayana was the first one ever to arrive at several concepts in Mathematics, which were later rediscovered by the western world. The value of 'pi' was first calculated by Baudhayana. 'pi' is useful in calculating the area and circumference of a circle. What is known as Pythagoras Theorem today is already found in Baudhayana's Sulvasutras, which was written several years before the age of Pythagoras.

KATYAYANA: Katyayana born about 200 BC. He was the Mathematician of Vedic period and written Katyayana Sulba Sutra . He was explained the computation of square root of 2 to five correct decimal places. His contribution to Geometry and Pythagorean theory is just remarkable.

ACHARYA PINGALA: Acharya Pingala discovered the immense possibilities of binary numbers quite by accident. He was working on the meter or Chandah of Vedas. He wrote Chandahsastra . Chandahsastra means the Science of meters as used in poetry in which it is recited.

ARYABHATA: Aryabhata was a fifth century Mathematician, Astronomer, Astrologer and Physicist. He was a pioneer in the field of Mathematics. At the age of 23, he wrote Aryabhatiya, which is a summary of Mathematics of his time . There are four sections in this scholarly work. In the first section, he describes the method of denoting big decimal numbers by alphabets. In the second section, we find difficult questions from topics of modern-day Mathematics, such as Number Theory, Geometry, Trigonometry and Algebra (beejganita). The remaining two sections are on Astronomy. Aryabhata showed that zero was not only a numeral but also a symbol and a concept. Discovery of zero enabled Aryabhata to find out the exact distance between the Earth and the Moon. The discovery of zero also opened up a new dimension of negative numerals. In ancient India, the Science of Astronomy was well-advanced. It was called Khagol Shastra. Khagol was the famous astronomical observatory at Nalanda, where Aryabhata studied.

The aim behind the development of the Science of Astronomy was the need to have accurate calendars, a better understanding of climate and rainfall patterns for timely sowing and choice of crops, fixing the dates of seasons and festivals, navigation, calculation of time and casting of horoscopes for use in astrology. Knowledge of Astronomy, particularly of the tides and the stars, was of great importance in trade, because of the requirement of crossing the oceans and deserts during night time. He also correctly stated that the Moon and the planets shined by reflected sunlight. He also gave a scientific explanation for solar and lunar eclipse clarifying that the eclipse were not because of Rahu and/or Ketu or some other rakshasa (demon). In recognition of his great contribution, the first satellite sent into orbit by India has been named after Aryabhata.

BRAHMAGUPTA: In the seventh century, Brahmagupta took Mathematics to heights far beyond others. In his methods of multiplication, he used place value in almost the same way as it is used today. He introduced negative numbers and operations on zero into Mathematics. He wrote Brahmasphutasiddhanta through which the Arabs came to know our mathematical system. This book has twenty five chapters and a total of 1008 stanzas. It covers mean longitudes of the planets, true longitudes of the planets, the three problems of diurnal rotation, lunar eclipses, solar eclipses, the moon's crescent and conjunctions of the planets with the fixed stars.

BHASKARACHARYA: Bhaskaracharya was the leading light of 12th century. He was born at Bijapur, Karnataka. He is famous for his book Siddhanta Shiromani. It is divided into four sections: Lilavati (Arithmetic) ,Beej ganit (Algebra), Goladhyaya (Sphere) and Graha ganit (mathematics of planets). Bhaskara introduced Chakrawat Method or the Cyclic Method to solve algebraic equations. This method was rediscovered six centuries later by European Mathematicians, who called it inverse cycle.

MAHAVIRACHARYA: There is an elaborate description of Mathematics in Jain literature (500–100 BC). Jain gurus knew how to solve quadratic equations. They have also described fractions, algebraic equations, series, set theory, logarithms and exponents in a very interesting manner. Jain Guru Mahaviracharya wrote Ganitasnrasanngraha in 850 BC, which is the first textbook on arithmetic in present day form . The current method of solving Least Common Multiple (LCM) of given numbers was also described by him. Thus, long before John Napier introduced it to the world, it was already known to Indians. He presented general formulas for permutation and combination of numbers, solutions to n-degree equations and published many properties of cyclic quadrilaterals. He gave the empirical formula of the circumference and area of the ellipse. He is highly respected among Indian mathematicians, because of his establishment of terminology for concepts such as equilateral and isosceles triangles, rhombus, circle and semicircle .

VARAHAMIHIRA: Varahamihira made great contributions in the fields of Hydrology, Geology and Ecology. He lived in the Gupta period. He was one of the first scientists to claim that termites and plants could be the indicators of the presence of underground water. He gave a list of 6 animals and 30 plants, which could indicate the presence of water. He gave very important information regarding termites (deemak or insects that destroy wood), that they go very deep to the surface of water level to bring water to keep their houses (bambis) wet. Another theory, which has attracted the world of science is the earthquake cloud theory given by Varahamihira in his Brihat Samhita . The 32nd chapter of this Samhita is devoted to signs of earthquakes. He has tried to relate earthquakes to the influence of planets, undersea activities, underground water, unusual cloud formation and abnormal behaviour of animals. Varahamihira's contribution

is worth mentioning in Jyotish or Astrology. It was presented scientifically in a systematic form by Aryabhata and Varahamihira. Varahamihira was one of the nine gems, who were scholars, in the court of Vikramaditya. Varahamihira's predictions were so accurate that king Vikramaditya gave him the title of 'Varaha'.

CONCLUSION

The Indian knowledge system in mathematics encompasses a vast array of concepts, methodologies, and innovations that span several millennia. From the development of the decimal system and the concept of zero to advanced trigonometry and algebra, Indian mathematicians made groundbreaking discoveries that revolutionized the field. These contributions were not isolated achievements but were deeply intertwined with philosophical, astronomical, and linguistic studies, reflecting the holistic approach to knowledge in ancient Indian tradition. The legacy of Indian mathematics extends far beyond its historical significance. Its influence can be traced in modern mathematical practices, educational approaches, and even in the way we conceptualize numbers and mathematical relationships.

The emphasis on practical applications, alongside theoretical explorations, has shaped mathematical pedagogy worldwide. Moreover, the Indian mathematical tradition's focus on pattern recognition, generalization, and proof techniques continues to be relevant in contemporary mathematical research and problem-solving strategies. As we delve deeper into the intricacies of Indian mathematical knowledge, we uncover not only a rich historical narrative but also a source of inspiration for addressing current mathematical challenges and fostering innovative thinking in the field.

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