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Contributions of mathematics in Indian Knowledge System

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Abstract
Mathematics, the study of numbers, patterns, and relationships, is a key tool for reasoning and understanding the world. It plays a vital role in modern civilization, impacting daily life and technological advancements. Ancient India made remarkable contributions, including the concept of zero, the decimal system, and early advancements in algebra and geometry. These innovations remain foundational to modern mathematics and should be studied with appreciation and respect. The present article discusses some of the outstanding innovations introduced by Indian mathematics in the field of mathematics is immense and it should always be studied from a thoughtful perspective.

Keywords: Mathematics, reasoning, ancient, astrology

Introduction

Mathematics is a fundamental field of study that plays a crucial role in developing various life skills. Beyond enhancing mathematical concepts and skills, it also nurtures attitudes like interest, appreciation, and critical thinking. The study of mathematics encourages the development of one's own reasoning abilities and decision-making processes, contributing to higher-order thinking skills. Starting with basic concepts, mathematics gradually progresses to more complex topics, helping individuals develop both linear and abstract thinking. This progression makes mathematics indispensable in daily life and in understanding the world around us.

Mathematics has a rich and long history in India, where it has significantly contributed to the development of the nation's culture and intellectual traditions. From ancient times, mathematical methods were used for practical purposes in fields such as architecture, astronomy, and astrology. In the Harappan civilization, for example, mathematical principles were applied in construction and urban planning. Similarly, the Jain mathematicians employed mathematics for astronomical calculations, while the Shulba Sutras, composed by Baudhayana and his successors, detailed geometric constructions for Vedic altars.

By the 6th or 5th century BCE, mathematics in India began to be studied not only for practical use but also for its inherent intellectual value. This shift marked the transition of mathematics into a pure science, explored for its own sake. The continuous development of mathematics in India, from ancient to medieval times, highlights its integral role in Indian culture and intellectual life. There was never a period in Indian history when mathematics was not being developed, and this commitment to the discipline can be seen in the Sanskrit verse from the *Vedang Jyotish* (circa 1000 BCE), which states:

"As the crown on the head of a peacock and as the gem on the hood of a snake, so stands Mathematics crowned above all disciplines of knowledge."

This verse underscores the reverence with which mathematics was held in ancient India, symbolizing its supreme importance in the spectrum of human knowledge.

Indian mathematicians made significant contributions to several branches of mathematics, including arithmetic, algebra, geometry, and calculus. The concept of zero and the decimal system, pioneered in India, revolutionized mathematics and had a profound impact on global developments. Indian mathematicians also developed methods for solving quadratic equations, creating early forms of infinite series expansions, and advancing trigonometry. These works, once translated, influenced mathematicians across the world, significantly shaping the course of mathematical thought in Europe and the Middle East. Thus, India's contributions to mathematics were not only critical to its own intellectual development but also had a lasting global impact.

Mathematics in ancient times (3000 to 600 bc)

Indus Valley Civilization is the earliest and the oldest confirmation of Indian mathematical understanding and its application. The metallic seals found in the excavations of Mohan-Jo-Daro and Harrapan indicates that the people of this civilization had the knowledge of numbers. It is also understandable from the pottery and other archaeological leftovers that they had the acquaintance of dimensions and geometry even in crude form. The Indus valley civilization existed around 3000 BC. Two of its most famous cities, Harappa and Mohenjo-Daro, present authentication that construction of buildings followed a standardized measurement which was decimal in nature.

Vedic Mathematics is the most importance era in the development of the Indian mathematical ideas and a lot has been explored and written about it. In particular, the Shatapatha Brahmana, which is a part of the Shukla Yajur Veda, includes comprehensive descriptions of the geometric construction of altars for yajnas. In this period, the brick making technology of Indus Valley civilization extended to new uses. Shulba Sutras are complementary to the Vedas. These texts are considered to date from 800 to 200 BC. Four in numbers, they are named after their authors: Baudhayana (600 BC), Manava (750 BC), Apastamba (600 BC), and Katyayana (200 BC). The sutras hold the famous theorem usually attributed to Pythagoras. The Shulba Sutras initiated the concept of irrational numbers, numbers that are not the ratio of two whole numbers.

Mathematical development of this period was associated with the solution of practical geometric problems,

particularly the construction of religious altars. But, one can found a hint of the development of the series expansion which illustrates towards the development of an algebraic point of view. In later times, we locate a move towards algebra, with simplification of algebraic formulate and summation of series acting as catalysts for mathematical discovery.

Mathematics (600 BC TO 500 AD)

Just as Vedic philosophy and theology encouraged the development of positive aspects of mathematics, so too did the rise of Jainism. Jain cosmology showed the way to ideas of the infinite. This in turn, led to the development of the notion of orders of infinity as a mathematical concept. By orders of infinity, we indicate a theory by which one set could be deemed to be 'more infinite' than another. In modern language, this matches to the concept of cardinality. In Europe, it was not until Cantors effort in the nineteenth century that an appropriate concept of cardinality was recognized.

Besides the investigations into infinity, this period saw developments in several other fields such as number theory, geometry, computing, with fractions. In particular, the recursion formula for binomial coefficients and the 'Pascal's triangle' were already known in this period.

The Classical Era of Indian Mathematics (500 TO 1200 AD)

There was time in the Indian mathematical development which can called the classical era of Indian Mathematics as the most famous and significant names of Indian mathematics are from this period and these mathematicians established India as the source of science and mathematics. This can be seen in the words of Albert Einstein, German scientist and humanist (1879-1955)

"We owe a lot to the Indians, who taught us how to count, without which no worthwhile scientific discovery could have been made."

Aryabhata I (500 AD) Brahmagupta (700 AD), Bhaskara I (900 AD), Mahavira (900 AD), Aryabhatta II (1000 AD) and Bhaskarachrya or Bhaskara II (1200 AD) all belonged to this golden age.

Kusumapura near Pataliputra and Ujjain emerged as the two centers of mathematical research at this time. Aryabhata I was the leading figure at Kusumapura. One of Aryabhata's discoveries was a technique for solving linear equations of the form ax + by = c. Aryabhata devised a general method for solving such type of equations, and he called it the kuttaka (or pulverizer) method. It must be understood that Aryabhata's calculated linear equations because of his interest in astronomy. Amongst other significant contributions of Aryabhata is his approximation of Pie to four decimal places (3.14146) and work on trigonometry.

The other most important centre of mathematical learning during this phase was Ujjain, which was home to Varahamihira, Brahmagupta and Bhaskaracharya. The text Brahma-sphuta-siddhanta by Brahmagupta, published in 628 ADS, dealt with arithmetic involving zero and negative numbers.

As with Aryabhata, Brahmagupta was an astronomer, and he was greatly influence by the astronomy and this interest encouraged him to work in the field of mathematics. He solved the difficulties of astronomy using the mathematical concepts. He presented the well-known formula for a solution to the quadratic equation. Brahmagupta also studied quadratic equation in two variables and sought solutions in whole numbers.

This period closes with Bhaskaracharya (1200 AD). In his original work on arithmetic (titled Lilavati) he advanced the kuttaka method of Aryabhata and Brahmagupta. The Lilavati is remarkable for its originality and diversity of topics.

Brahmagupta put forward a method, which he named samasa, by which; known two solutions of the equation a third solution could be created. Brahmagupta's lemma was acknowledged one thousand years before it was rediscovered in Europe by Fermat, Legendre, and others. This method can now be seen in most standard text books and courses in number theory. The name of the equation is a historical accident.

Mathematics in the Modern Age

Indian mathematical development does not end with the classical era. In fact, it moves ahead with the mathematicians of modern age who were and are equally competent.

Ramanujan (1887- 1920) is perhaps the most renowned of modern Indian mathematicians. His contributions in number theory are very important and useful but his most enduring innovation may be the arithmetic theory of modular forms. In a significant paper published in 1916, he initiated the study of the Pie function. Ramanujan proved some properties of the function and speculated many more. As a result of his work, the modern arithmetic theory of modular forms, which occupies a central place in number theory and algebraic geometry, was developed by Hecke.

Harish-Chandra (1923-83) is perhaps the least known Indian mathematician outside the mathematical circles. He began his career as a physicist, working under Dirac. In his thesis, he worked on the representation theory of the group SL2 (C). This research made him convinced that he was really a mathematician, and he lived the remainder of his academic life working on the representation theory of semi-simple Lie groups and Lie algebra.

D.R. Kaprekar (1905-1988) was fond of numbers. He was well known for "Kaprekar Constant" 6174. Take any four-digit number in which all digits are not alike. Arrange its digits in descending order and subtract from it the number formed by arranging the digits in ascending order. If this process is repeated with reminders, ultimately number 6174 is obtained, which then generates itself. Kaprekar discovered the Kaprekar constant or 6174 in 1949.

Conclusion

The present mathematical knowledge and development is not being achieved as a fruit from the sky, nor is a result of some magical tricks. Actually, these developed and finest facts and theories have been achieved by the continuous and effortless practices and researches of hundreds of mathematicians and historians for the centuries. Lots of people had contributed to the fruits, facilities and luxuries which we benefit from today. In this view the contribution of Indian mathematicians is immense and extra-ordinary. From the concept of zero to the modern concept of computational number theory, their input is noteworthy. It is important to state that the outstanding contributions made by Indian mathematicians over many hundreds of years cannot be explained in few words or understood without

being familiar to the field of mathematics. What is quite surprising is that there has been an unwillingness to identify this by the world and one has to conclude that many well-known historians of mathematics found what they expected to find, or perhaps even what they hoped to find, rather than to realize what was so clear in front of them.

It is the need of the today's time to promote ahead the heritage of great mathematicians so as to encourage and cherish the magnificent tradition of the country in mathematics. The creative method of expressing every possible number using a set of ten symbols (each symbol having a place value and an absolute value) appeared in India. Now, we are so used to of using these symbols that its significance and thoughtful importance is no longer appreciated. Its effortlessness lies in the way it facilitated calculation and placed arithmetic foremost amongst useful inventions. The importance of this invention is more voluntarily appreciated when one believes that it was ahead of the two greatest men of ancient times, Archimedes and Apollonius.

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