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HISTORY OF MATHEMATICS IN INDIA

AANCHAL

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ABSTRACT: Mathematics is the study of numbers, and counting, and measuring, but that is only the beginning. Mathematics involves the study of number patterns and relationships, too. It is also a way to communicate thoughts, and perhaps more than anything, it is a way of reasoning that is distinctive to human beings. Mathematics plays a vital role in the modernization of this civilization as it is everywhere and affects the everyday lives of people. Although it is abstract and theoretical knowledge, it emerges from the real world. It is also a way to correspond and evaluate ideas, a tool for organizing and interpreting data and above all, perhaps a method of logical reasoning unique to man. Mathematics is a necessary part of other science.

Mathematics has played a significant role in the development of Indian culture for millennia. Mathematical ideas that originated in the Indian subcontinent have had a profound impact on the world. Swami Vivekananda said: 'You know how many sciences had their origin in India. Mathematics began there. You are even today counting 1, 2, 3, etc. to zero, after Sanskrit figures, and you all know that algebra also originated in India'.

Mathematics has been existed since the early age of human civilization. But mathematics has achieved immense importance today, since without its application higher technology cannot be mastered and harnessed for increasing production of goods and services and promoting human welfare. Over the centuries there has been spectacular progress in the development of mathematics as a branch of knowledge. And without the application of mathematics on a wide scale no country can march forward in line with the general progress of human knowledge and thought. Therefore learning of mathematics and promoting the horizons of knowledge by advanced researches in mathematics should be over emphasized. Thus, mathematics is an important and inseparable part of human life. It has been existed and developed since the ancient era and the present article discusses some of the outstanding innovations introduced by Indian mathematics from ancient times to modern as India's contribution in the field of mathematics is immense and it should always be studied from a thoughtful perspective.

INTRODUCTION:

"India was the motherland of our race and Sanskrit the mother of Europe's languages. India was the mother of our philosophy, of much of our mathematics, of the ideals embodied in Christianity... of self-government and democracy. In many ways, Mother India is the mother of us all." - Will Durant, American Historian 1885-1981

Mathematics is an important field of study. Mathematics is essential as it helps in developing lots of realistic skills, in fact study of mathematics itself include the concepts related to the routine lives of human. It not only develops mathematical skills and concepts, it also helps in developing the attitudes, interest, and appreciation and provides opportunities to develop one's own thinking. So, mathematics is undoubtedly a discipline which is imperative to know and study. Mathematics starts from simple things and linear thinking that lead towards the more complex things and higher order thinking skills.

Mathematics has taken centuries to develop in its present form and that's why it will be really fruitful to know about its development.

Mathematics has played a very significant role in the progress and expansion of Indian culture for centuries. Mathematical ideas that originated in the Indian subcontinent have had a thoughtful impact on the world. In ancient time, mathematics was primarily used in a supplementary or practical role. Thus mathematical methods were used to solve problems in architecture and construction (as in the public works of the Harappan civilization) in astronomy and astrology (as in the Jain mathematicians) and in the construction of Vedic altars (as in the case of the Shulba Sutras of Baudhayana and his successors). By the sixth or fifth century BC, mathematics was studied for its own sake, as well as for its relevance in other fields of knowledge. In fact there was not the single period in Indian history when mathematics was not being developed and included in the lives of the people. The importance of mathematics in India can be seen by a well-known verse in Sanskrit of "Vedang Jyotish" (written 1000 BC) as:

This verse means that "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."

Indian were very well aware of this fact and it was the prime reason why they gave special and most needed importance to the development and progress of mathematics from the beginning. Indian mathematicians made immense contributions in developing arithmetic, algebra, geometry, infinite series expansions and calculus. Indian contributions in the field of mathematics influenced the world mathematicians when the Indian works got translated.

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 Mohenjo-Daro and Harappa 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. 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. . Here, we see mathematical ideas developed for the purpose of construction. This civilization had an advanced brick-making technology (having invented the kiln). Bricks were used in the construction of buildings and embankments for flood control.

The study of astronomy is considered to be even older, and there must have been mathematical theories on which it was based. Even in later times, we find that astronomy motivated considerable mathematical development, especially in the field of trigonometry.

Much has been written about the mathematical constructions that are to be found in Vedic literature. In particular, the Satapatha Brahmana, which is a part of the Shukla Yajurveda, contains detailed descriptions of the geometric construction of altars for Yajnas. Here, the brick-making technology of the Indus valley civilization was put to a new use. As usual there are different interpretations of the dates of Vedic texts, and in the case of this Brahmana, the range is from 1800 to about 800 BC. Perhaps it is even older.

Supplementary to the Vedas are the Shulba Sutras. These texts are considered to date from 800 to 200 BC. Four in number, they are named after their authors: Baudhayana (600 BC), Manava (750 BC), Apastamba (600 BC), and Katyayana (200 BC). The sutras contain the famous theorem commonly attributed to Pythagoras. Some scholars (such as Seidenberg) feel that this theorem as opposed to the geometric proof that the Greeks, and possibly the Chinese, were aware of.

The Shulba Sutras introduce the concept of irrational numbers, numbers that are not the ratio of two whole numbers. For example, the square root of 2 is one such number. The sutras give a way of approximating the square root of number using rational numbers through a recursive procedure which in modern language would be a 'series expansion'. This predates, by far, the European use of Taylor series.

It is interesting that the mathematics of this period seems to have been developed for solving practical geometric problems, especially the construction of religious altars. However, the study of the series expansion for certain functions already hints at the development of an algebraic perspective. In later times, we find a shift towards algebra, with simplification of algebraic formulate and summation of series acting as catalysts for mathematical discovery.

Jain 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 period 600 AD corresponds with the beginning and supremacy of Buddhism. In the Lalitavistara, a memoir of the Buddha which may have been written around the first century AD, there is an incident about Gautama was asked to name of large powers of 10 starting with 10. He is able to give names to numbers up to 10 (tallaksana). This incident clearly depicts that the mathematicians of that period were capable of telling very large and big numbers. And it is also a reality that these large numbers cannot be calculated without any proper or at least some type of place value system.

Brahmi Numerals, The place-value system and Zero

Indian Mathematical development and contribution will always be incomplete without discussing the Indian numerals, the Place-Value system and the concept of Zero. The numerals or numbers that are in practice today can be marked out to the Brahmi numerals that appear to have made their emergence in 300 BC. But Brahmi numerals were not part of a place value system. They developed into the Gupta numerals around 400 AD and afterward into the Devnagari numerals, which developed gradually between 600 and 1000 AD.

By 600 AD, a place-value decimal system was properly in exercise in India. This means that when a number is written down, each symbol that is used has an absolute value, but also a value relative to its position. For example, the numbers 2 and 6 have a value on their own, but also have a value relative to their position in the number 26. The significance of a place-value system require hardly be emphasized. It would be adequate to mention an often-quoted comment by La-place (1749-1827): "It is India that gave us the ingenious method of expressing all numbers by means of ten symbols, each symbol receiving a value of position as well as an absolute value; a thoughtful and important idea which appears so simple to us now that we ignore its true merit. But it's very simplicity and the great ease which it has lent to computations put our arithmetic in the first rank of useful inventions; and we shall appreciate the magnificence of the achievement the more when we remember that it escaped the genius of Archimedes and Apollonius, two of the greatest men produced by ancient times".

At the same time, other civilizations were also using the place-value system based on numbers; for example, the Babylonians used a sexagesimal place-value system as early as 1700 BC, but the Indian system was the first decimal system. Moreover, until 400 BC, The Babylonian system had an innate vagueness as there was no symbol for zero. Thus it was not a complete place-value system in the manner we assume of it today.

The rise of zero, as the equal position as other numbers (numerals), created problems for the several bright mathematicians and they all struggled with the concept of zero initially. The key dilemma included the formulation of such arithmetic system which include zero. While addition, subtraction, and multiplication with zero were mastered, division was a more restrained question. Today, we know that division by zero is not well-defined and so has to be excluded from the rules of arithmetic. But this perception was not or cannot be achieved at once at that time as it was totally a new idea for the whole world. This problem took the collective efforts of many minds. It is fascinating to note that it was not until the seventeenth century that zero was being used in Europe.

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 AD, 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 South India

Mahavira is a mathematician who belongs to the ninth century who was most likely from modern day Karnataka. He calculated the problem of cubic and biquadratic equations and solved them for some families of equations. His work had a considerable impact on the development of mathematics in South India. His book Ganita- sara- sangraha intensified the discoveries and the researches of Brahmagulpta and proposed a very constructive orientation for the position of mathematics in his days.

Another remarkable mathematician of South India was Madhava from Kerala. Madhava belongs to the fourteenth century. He invented series expansions for some trigonometric functions such as the sine, cosine and arctangent that were not known in Europe until after Newton. In modern terminology, these expansions are the Taylor series of the functions in question.

Madhava gave an approximation to Pie of 3.14159265359, which goes far ahead of the four decimal places calculated by Aryabhata. Madhava's work with series expansions suggests that he either discovered elements of the differential calculus or nearly did so.

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.

It is said that Ramanujan's discoveries are unusually rich and that there is often more to them than initially meets the eye. As a by-product, new directions of research were opened up. Examples of the most

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interesting of these formulae include the intriguing infinite series. One of his remarkable capabilities was the rapid solution for problems. The number 1729 is known as the Hardy-Ramanujan number after a famous tale of the British mathematician G. H. Hardy regarding a visit to the hospital to see Ramanujan. In Hardy's words:

I remember once going to see him when he was ill at Putney. I had ridden in taxi cab number 1729 and remarked that the number seemed to me rather a dull one, and that I hoped it was not an unfavourable sign. "No," he replied, "it is a very interesting number; it is the smallest number expressible as the sum of two cubes in two different ways."

The two different ways are

1729 = 13 + 123 = 93 + 103.

Generalizations of this idea have created the notion of "taxicab numbers". Coincidentally, 1729 is also a Carmichael number. He worked on divergent series. He sent 120 theorems on imply divisibility properties of the partition function. Partition of whole numbers is another similar problem that captured Ramanujan attention. Subsequently Ramanujan developed a formula for the partition of any number, which can be made to yield the necessary result by a series of successive approximation example 3=3+0=1+2=1+1+1.

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. For most of that period, he was a professor at the Institute for Advanced Study in Princeton, New Jersey. His Collected Papers published in four volumes contain more than 2,000 pages. His style is known as meticulous and thorough and his published work is likely to treat the most general case at the very beginning. This is in contrast to many other mathematicians, whose published work tends to develop through special cases. Interestingly, the work of Harish-Chandra formed the basis of Langlands's theory of automorphic forms, which are a vast generalization of the modular forms considered by Ramanujan.

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. Thus, starting with 1234, we have

4321 - 1234 = 3087, then

8730 - 0378 = 8352, and

8532 - 2358 = 6174

Repeating from this point onward leaves the same number (7641 - 1467 = 6174). In general, when the operation converges it does so in at most seven iterations.

Another class of numbers Kaprekar described is the Kaprekar numbers. A Kaprekar number is a positive integer with the property that if it is squared, then its representation can be partitioned into two positive integer parts whose sum is equal to the original number (e.g. 45, since 45^2=2025, and 20+25=45.) However, note the restriction that the two numbers are positive; for example, 100 is not a Kaprekar number even though 100^2=10000, and 100+00 = 100. This operation, of taking the rightmost digits of a square, and adding it to the integer formed by the leftmost digits, is known as the Kaprekar operation.

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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