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CHRONOLOGICAL REVIEW OF INDIAN MATHEMATICIANS (FROM ANCIENT-VEDIC-MODERN) AND THEIR CONTRIBUTIONS

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Abstract : Mathematics, referred to as "ganita," has been an integral part of students' lives since very ancient times. What started as a requirement at an early stage continued through the post-Vedic period as an uninterrupted tradition, and many useful contributions to the field of mathematics were made throughout Indian history. Over the years, the contributions spanned almost all modern areas of mathematics. These include algebra, geometry, trigonometry, indeterminate equations, squares, cubes and their roots, permutations and combinations, numerical methods and approximations, and infinite series, to name a few.

As is known generally, significant contributions have been made by many Indian scholars in different fields over an extended period of time. Ancient India succeeded in providing the mathematics with many interesting ideas well ahead of their appearance elsewhere in the world. The earliest Indian mathematical works go back at least to the Vedas (ca. 2500 - 1700 BCE). The numbers were the first mathematical concept which was mentioned considerably in the Vedic literature. They spread through oral communication in combinations of powers of 10 from a hundred up to a trillion, which helped them to handle large numbers easily.

The purpose of the present paper is to provide an overview of some novel mathematicians with their contributions.

IndexTerms **-** Contribution, Ancient Indian Mathematics, Arithmetic, Algebra, Geometry, Calculus**.**

I. INTRODUCTION

Mathematics on the Indian subcontinent has a rich and long history going back over 5,000 years and thrived for centuries before advances were made in Europe. Its influence spread to China, Southeast Asia, the Middle East, and Europe. Apart from introducing the concept of zero, Indian mathematicians made seminal contributions to the study of geometry, arithmetic, binary mathematics, the notion of negative numbers, algebra, trigonometry, and calculus, among other areas. The decimal place value system that is employed worldwide today was first developed in India [8]. For a large part, European mathematicians were reluctant to accept negative numbers as meaningful. Many took the view that negative numbers were absurd. This reluctance to adopt negative numbers, and indeed zero, held European mathematics back for many years. Although the reputation of Indian mathematics continues to suffer from the Eurocentric bias. Notwithstanding this, the Indian subcontinent has a strong and continuing mathematical heritage, the pinnacle of its expression being the mathematical genius in Ramanujan, who lived in the 20th century CE [6] . Let us look at the genius of the mathematicians in the Vedic age by taking an example. It is a regular feature for the Vedic people to make several offerings to the gods in a sacrifice. The sacrificial altars were not a standard shape, such as a square or a rectangle. There were more than 70 different shapes of altars used in various sacrifices. These include shapes such as tortoises, falcons, and chariot wheels. The construction of these involved several complex shapes, including the isosceles triangle, rhombus, and circle. The construction complexity had certain other dimensions. For example, there was a fixed number of bricks of certain shapes to be used. The number of layers in the altar was also fixed. Furthermore, there were other constraints, such as the area of certain altars being equal to other altars. Among other things, this is a tough mathematical problem to solve[10].

Aspects of Indian mathematics: Indian mathematics is unique, and it vastly differs from the modern approaches. A few of them are worthy of mention:

(a) There is a popular thinking among many that the world is divided into those who know and love mathematics and those who don't. This separation was primarily because we are educated that mathematics works with left-brain functionalities and literature works with

right-brain functionalities. Therefore, the design of the pedagogy and delivery has kept these away in two separate compartments. In contrast, Indian mathematics is a seamless blend of poetry, literature, logic, and mathematical thinking woven into a single work [12]. All great works of mathematics are invariably great literary works too, and they appeal to everyone on account of this natural blend. Therefore, there is no fear or stress in learning mathematics.

(b) Mathematics was considered as a part of life. This is why mathematics could be found in temple inscriptions, literary work addressing issues of life, and in a discussion on religion or spirituality. Bhskarcrya in his Lilvat [7,9], for example, brings interesting mathematical concepts by posing interesting riddles to a student and solving them. Similarly, the Brahmastrabhya of Ankarcrya and the Vysabhya on Patañjali's Yogastras refer to the decimal place value system as an example while discussing a philosophical issue.

(c) The use of stras is characteristic of the Indian tradition to convey ideas and concepts. These improve the retention of complex ideas and details very easily. Indian mathematics uses these mechanisms as much as possible. For example, there is a pre-Sutra for remembering the pattern that constitutes a binary cycle of length ce based on eight groups defined by Pingala in his Chandah-ästra. Aryabhatta's uniqueness lies in his ability to use sutras to bring the utmost simplicity to describing complex information.

(d) There has been an uninterrupted tradition of mathematical thinking, and it has widely spread across the length and breadth of the world.Mathematical concepts were developed by those from Gandhara (modern-day Afghanistan) to those in Bengal, as well as by those from Kashmir to Kerala.[13]

(e) One of the important characteristics of Indian mathematics is its algorithmic approach and the fact that it allows for approximate solutions based on the needs of real-life situations. Indian mathematicians also adopted what is today referred to as the constructive approach, where the emphasis is on finding a procedure to solve a problem rather than merely seeking proofs of the existence of a solution[2].

II. GREAT MATHEMATICIAN SAND THEIR CONTRIBUTION

Before we discuss some key mathematical concepts developed by Indians, it will be interesting to have a bird's-eye view of some of the great mathematicians and their contributions. The number of mathematicians India has produced, and their contributions, are significant. A closer look at the table reveals a continuous stream of mathematical theory building. Several areas of modern mathematics have been addressed [1,3,4]. These include, for example, the Fibonacci series, Pell's equation, and Pascal's triangle. In this chapter, we shall take a few examples from different areas of mathematics and briefly sketch the contributions made by Indians in the past. Indian mathematics dealt with almost all areas of modern mathematics for more than 1000 years. Mathematical concepts found in Vedic texts and Buddhist and Jain works suggest that this culture is several thousand years old. few methods. This is to provide a curtain-raiser view of the Indian mathematical tradition and its contribution to the development of science, engineering, and technology.

III. ARITHMETIC

Arithmetic is the branch of mathematics dealing with computation using numbers and basic mathematical operators such as division. Indian arithmetic was quite sophisticated and is part of the daily life of any society. Commercial operations and trade require handling numbers and basic mathematical operators such as addition, subtraction, multiplication, and division. Indian mathematics is quite sophisticated by the time of Aryabhatta in the 5th century CE [10] . This is primarily a fully developed decimal place value system employing 0 to 9. In the 7th century, Brahmagupta established the use of 0 as a number and gave rules for addition, subtraction, division, and multiplication of zero. The Indian decimal place value system was well known by the middle of the 7th century, as evident from the following observation of the Syriac bishop Severus Sebokht: “Indians possess a method of calculation that no one can praise enough.”Their rational system of mathematics, or their method of calculation. I mean the system using nine symbols [5,7,11].

IV. CRONOLOGICAL REVIEW OF INDIAN MATHEMATICIANS AND THEIR SALIENT CONTRIBUTIONS

Sl. No.	Mathematician	Period, Location, Birth Place	Sallient Contributions
1	Vedic Texts	3000 BCE or earlier	The earliest recorded mathematical knowledge, number system, Pythagorean type triplets; Decimal system of naming numbers, the concept of infinity.
2	Lagadha - Vednga-jyotia	~1300 BCE	Astronomical concepts; a mathematical model for sun-moon movement in time; equinoxes and solstices.
3	Sulba-sutras (Baudhyana, pasthamba, Kätyyana and Mnava Sulba-sutras)	800-600 BCE	Earliest Texts of Geometry; Approximate value of the square root of 2, and . Exact procedures for the construction and transformations of squares, rectangles, trapezia, etc.
4	Panini-Astadhyayi	500 BCE; Salatura (in Khyber province in Pakistan)	Algorithmic approaches; 0riginator of the Backus-Naur Form (BNF), used in programming languages today, Context sensitive rules, Arrays, inheritance, polymorphism.
5	Pingala-Chandah-sastra	300 BCE	Binary sequences; Conversion of Binary to Decimal system and vice versa; Meru Prastara' (Pascal's triangle):

			Optimal Algorithms to calculate powers; Zero as a Symbol.
6	Bauddha Mathematical Works	about 500 BCE to 500CE	Multi-valued logic, Discussion indeterminate and infinite numbers.
7	Jaina Mathematical works: Surya-Prajñapti, Jambdvipa-prajñapti, Bhagavati-sutra, Sthânanga-sütra, Uttardhyayana-sutra, Tiloyapannati, Anuyoga-dvra-sutra	200 BCE to 300 CE	Concepts of logarithm, large number; algorithms for raising a number by a power; the arc of a circle; combinatorics; Decimal system; mensuration; Approximation of π.
8	Äryabhaa-Arryabhatiyam	476-550 CE; Kusumapura, near Pataliputra, Bihar	Concise verses; Algorithm for square root, cube root, Place value system; Sine table; geometry; quadratic equations; Linear indeterminate equations; Sums of squares and cubes of numbers; Planetary astronomy; Plane and spherical trigonometry.
9	Varaha Mihira - Brhat Samhita, Brhat-jataka, Pañca-siddhantika	482-565 CE, Ujain, Madhya Pradesh	Summary of five ancient siddhntas; Sine table, trigonometric identities; $(sin^2 + cos^2)$; combinatorics; Magic squares;
10	Bhskara I-Commentary on Aryabhatiya, Laghu-bhãskariyam and Maha-bhaskariyam	600-680 CE, Vallabhi region, Saurastra, Gujrat	Expanded Aryabhata's work on Integer solution for indeterminate equations; Approximate formula forthesine function, Planetary Astronomy.
11	Brahmagupta - Brahmasphuta siddhnta; Khandakhãdyaka	598-668 CE; Bhillamala in Rajasthan	Rules of arithmetic operations witth zero and negative numbers, (Bijagaita); Algebra linear and indeterminate quadratic equations; Pythagorean triplets, Formula forthe diagonals and area of a cyclic quadrilateral; notion of arithmetic mean.
12	Virahnka- Vrttajtisamuccaya(in Prakrt)	~600 CE	Fibonacci numbers; Moric metres.
13	Šrdharacarya - Trisatika and Pätiganita	870-930 CE; Bhurshut village, Hugli, WB	Arithmatic, algebra, commercial mathematics, approximation os square root of non-square number, Quadratic equation.
14	Mahviracrya -Ganita-sra sangraha	800-870 CE; Gulbarga Karnataka;	A comprehensive, on exclusive textbook mathematics covering arithmetic geometry- algebra. Continuing the ancient Jaina mathematics tradition; permutations and combinations; arithmetic and geometric series; the sum of squares and cubes of numbers in arithmetic progression.
15	Jayadeva	10th Century CE or earlier	Cakraväla (cyclic) method for solution of the second-order indeterminate equation.
16	Shripati-Gaita-tilaka, Siddhânta sekhara,Dhikotidakarana, etc.	1019-1066 CE; Rohikhanda, Maharashtra	Planetary Astronomy
17	Bhskaracrya (Bhaskara-II) Lilvati on arithmetic and geometry; Bijagaita on algebra; Siddhnta-Širomani on astronomy; Vasanabhyasya - on Siddhânta-siromai.	1114-1185 CE,Hailled from Bijjadavida.	Canonical textbooks used all over India, Detailed explanations including Upapatti (demonstration or proot): addition formula for sine function. Surds; permutations, and combinations; Solution of indeterminate equations, Ideas of calculus, including mean value theorem, planetary astronomy: construction several instruments.
18	Narayana Pandita- Gaita kaumudi-atreatise on and Bijaganita arithmetic Vatarma- a treatise on algebra.	1325-1400 CE;	Advanced textbooks taking forward the works of Bhskarcãrya, further properties of cyclical quadrilaterals summation and repeated summations arithmetic series, theory and construction of Magic Squares, further developmentsit combinatorics.
19	Mädhava of Sangamagrama	1340-1425 CE, Sangama Grama in Kerala	Founder of Kerala School of Mathematics -A pioneer in the development of calculus; Infinite series and approximations for, Infinite series and approximations for cosine and sine functions.
20	Paramevesara, - Drgganita, Siddhntadipika; Commentaries on Äryabhatiyam, Maha-bhskariya; Laghu-bhskariya, Llävati, and Süryasiddhnta	1360-1460 CE; Alathiyur, (near Tirur), Kerala	Properties of Cyclic quadrilateral; Iterative techniques.
21	Nilakanha Somayji, Tantra sangraha; Aryabhatiya-bhãsya, Siddhnta-darpana	1444-1544 CE,Near Tirur, Kerala	Irrationality of , basic ideas of calculus; revised planetary theory, which is a close approximation to Kepler's model; Exact results in spherical astronomy.
22	Jyethadeva - Yukti-bhãsa	1500-1575 CE; Kerala	Hailed as the first textbook of Calculus; detailed explanations and proofs of the infinite series given by Mädhava.

23	Šankaravariyar-Kriyakraramakari commentary on Lilvti and commentary on Tantra-sangraha	1500-1569 CE Kerala	Explanations and Proofs ofthe results and procedures given in Lilvati.
24	Ganesa Daivajña - Buddhi-vilasini (commentary on Lilãvati);	1504 CE; Nandi Grama, Nadod, Gujarat	Explanations and Proofs of the results and procedures given in Lilvati.
25	Krsna Daivajña - Bijapallva Commentary on Bijaganita of Bhskaracãrya	1600 CE Delhi	Explanations and Proofs of results and procedures given in Bijaganita.
26	Munivara-Siddhnta-sârvabhauma, commentary on Llãvat; Patisra;	17th Century CE , Varanasi	Explanations and Proofs ofthe results and procedures given in Lilâvat; trigonometric identities.
27	Kamalakara- Siddhnta-tattva vÍveka	1616-1700 CE; Varanasi, Uttara Pradesh	Addition and subtraction theorems for the sine and the cosine; Sines and cosines of double, triple, etc, angles.
28	Radhanath Sikdar	1813–1870, Kolkata	**Trigonometric Calculations:** Sikdar used trigonometric calculations to determine the height of Mount Everest, a feat that earned him recognition in the history of mathematics and geography.
29	Ashutosh Mukherjee	28 June 1864- 25 may 1924	He wrote an article, "New Demonstration of proposition in Euclid". Some of his articles on mathematical problems become popular as Mookharjee's theorems.
30	Syamadas Mukhopadhyaya	1866-1937, Horipal, Hooghly, WB	He introduced the four-vertex theorem and Mukhopadhyaya's theorem in plane geometry.
31	Srinivasa Ramanujan	1887–1920, Erode, in present-day Tamil Nadu	**Ramanujan's Notebooks:** His work, compiled in his notebooks, contains thousands of results, many of which were original and highly advanced. **Partition Function:** Ramanujan developed a highly original approach to the partition function, which has been influential in the study of number theory. **Mock Theta Functions:** His discovery of mock theta functions opened up new areas of research in mathematics.
32	Prasanta Chandra Mahalanobis	1893-1972, Calcutta	His areas of work were mathematics and statistics. He is remarkable for the Mahalanobis distance, a statistical measure.
33	Satyendra Nath Bose	1894- 1974, Calcutta	His work on quantum mechanics in the early 1920s in developing the foundations for Bose statistics and the theory of Bose condensate.
34	Raj Chandra Bose	1901- 1987. Narmadapuram, Madhya Pradesh	His works were design theory, finite geometry and the theory of error-correcting codes.
35	Calyampudi Radhakrishna Rao	1920–2023, Huvvina Hadagalli Karnataka	**Cramer-Rao Bound:** One of his most famous results is the Cramer-Rao bound, which provides a lower bound on the variance of estimators. **Rao-Blackwell Theorem:** This theorem, which Rao developed, is a cornerstone of statistical theory.
36	Harish-Chandra	1923–1983, Kanpur, Allahabad in Uttar Pradesh,	**Harmonic Analysis:** His work in harmonic analysis on semisimple Lie groups is considered foundational and has had a lasting impact on mathematics.

There are also many other Indian mathematicians whose contributions are worldwide. The English equivalent of mathematics comes from the Greek word mathema, meaning "that which is learnt" or "what one gets to know," hence also "study" and "science."

The practice of mathematics, where it originated, and when it started is a historical debate. Some historians believe that Egypt is the birthplace of the practice of mathematics. Some historians say that Babylonian civilization is the birthplace of this practice. Again, many researchers identify India as the origin of the practice of mathematics. The practice of mathematics in India has been advanced and more advanced since ancient times.

V. CONCLUSIONS

The contributions of Indian mathematicians have profoundly influenced both ancient and modern mathematics. From the invention of zero to the development of calculus, their work continues to inspire and challenge mathematicians around the world. The rich legacy of these brilliant minds underscores the importance of mathematics in advancing human knowledge and understanding.

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