IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

Volume 12, Issue 10, October 2023

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.317

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 12, Issue 10, October 2023||

|DOI:10.15662/IJAREEIE.2022.1210006 |

Applications and Importance of Vedic Mathematics in Present Scenario

DR. PAWAN CHANCHAL

Associate Professor, Dept. of Mathematics, Govt. Girls College, Ajmer, Rajasthan, India

ABSTRACT: Vedic Mathematics is a book written by the Indian monk Bharati Krishna Tirtha, and first published in 1965. It contains a list of mathematical techniques, which were falsely claimed to have been retrieved from the Vedas[1] and to contain advanced mathematical knowledge.[2]

Krishna Tirtha failed to produce the sources, and scholars unanimously note it to be a mere compendium of tricks for increasing the speed of elementary mathematical calculations sharing no overlap with historical mathematical developments during the Vedic period. However, there has been a proliferation of publications in this area and multiple attempts to integrate the subject into mainstream education by right-wing Hindu nationalist governments.

KEYWORDS-Vedic, Mathematics, Krishna, Governments, scenario,present

I.INTRODUCTION

The book contains metaphorical aphorisms in the form of sixteen sutras and thirteen sub-sutras, which Krishna Tirtha states allude to significant mathematical tools.[3] The range of their asserted applications spans from topic as diverse as statics and pneumatics to astronomy and financial domains.[3][4] Tirtha stated that no part of advanced mathematics lay beyond the realms of his book and propounded that studying it for a couple of hours every day for a year equated to spending about two decades in any standardized education system to become professionally trained in the discipline of mathematics.[3]

STS scholar S. G. Dani in 'Vedic Mathematics': Myth and Reality[3] states that the book is primarily a compendium of tricks that can be applied in elementary, middle and high school arithmetic and algebra, to gain faster results. [1,2,3]The sutras and sub-sutras are abstract literary expressions (for example, "as much less" or "one less than previous one") prone to creative interpretations; Krishna Tirtha exploited this to the extent of manipulating the same shloka to generate widely different mathematical equivalencies across a multitude of contexts.[3]

Source and relation with The Vedas

According to Krishna Tirtha, the sutras and other accessory content were found after years of solitary study of the Vedas—a set of sacred ancient Hindu scriptures—in a forest. They were supposedly contained in the pariśiṣṭa—a supplementary text/appendix—of the Atharvaveda.[3] He does not provide any more bibliographic clarification on the sourcing.[3] The book's editor, Professor V. S. Agrawala argues that since the Vedas are defined as the traditional repositories of all knowledge, any knowledge can be de facto assumed to be in the Vedas, irrespective of whether it may be physically located in them; he even went to the extent of deeming Krishna Tirtha's work as a pariśiṣṭa in itself.[5]

However, numerous mathematicians and STS scholars (Dani, Kim Plofker, K.S. Shukla, Jan Hogendijk et al) note that the Vedas do not contain any of those sutras and sub-sutras.[3][6][7][4] When challenged by Shukla, a mathematician and a historiographer of ancient Indian mathematics, to locate the sutras in the Parishishta of a standard edition [4,5,6]of the Atharvaveda, Krishna Tirtha stated that they were not included in the standard editions but only in a hitherto-undiscovered version, chanced upon by him; the foreword and introduction of the book also takes a similar stand.[3][5] Sanskrit scholars have also confirmed that the linguistic style did not correspond to the time-spans but rather reflected contemporary Sanskrit.[3]

Dani points out that the contents of the book have "practically nothing in common" with the mathematics of the Vedic period or even with subsequent developments in Indian mathematics.[3] Shukla reiterates the observations, on a per-chapter basis.[5] For example, multiple techniques in the book involve the use of high-precision decimals. These were unknown during the Vedic times and were introduced in India only in the sixteenth century;[4] works of numerous ancient mathematicians such as Aryabhata[7,8,9], Brahmagupta and Bhaskara were entirely based on fractions.[3] Some of the sutras even run parallel to the General Leibniz rule and Taylor's theorem (which, per Krishna Tirtha, were to be yet studied by the western world during the time of his writing) but did ultimately boil down to the sub-elementary

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 12, Issue 10, October 2023||

|DOI:10.15662/IJAREEIE.2022.1210006 |

operations of basic differentiation on polynomials. From a historiographic perspective, India had no minimal knowledge about the conceptual notions of differentiation and integration.[3] Sutras have been further leveraged that analytic geometry of conics occupied an important tier in Vedic mathematics, which runs contrary to all available evidence.[3][4]

Publication history and reprints

First published in 1965, five years after Krishna Tirtha death, the work consisted of forty chapters, originally on 367 pages, and covered techniques he had propagated, through his lectures.[3] A foreword by Tirtha's disciple Manjula Trivedi stated that he had originally written 16 volumes—one on each sutra—but the manuscripts were lost before publication, and that this work was penned in 1957.[6][3][8]: 10

Reprints were published in 1975 and 1978 to accommodate typographical corrections.[9] Several reprints have been published since the 1990s.[8]: 6

Reception

S. G. Dani of the Indian Institute of Technology Bombay (IIT Bombay) notes the book to be of dubious quality. He believes it did a disservice both to the pedagogy of mathematical education by presenting the subject as a bunch of tricks without any conceptual rigor, and to science and technology studies in India (STS) by adhering to dubious standards of historiography.[3][a] He also points out that while Tirtha's system could be used as a teaching aid, there was a need to prevent the use of "public money and energy on its propagation" except in a limited way and that authentic Vedic studies were being neglected in India even as Tirtha's system received support from several government and private agencies.[3] Jayant Narlikar has voiced similar concerns.[10]

Hartosh Singh Bal notes that whilst Krishna Tirtha's attempts might be somewhat acceptable in light of his nationalistic inclinations during colonial rule — he had left his spiritual endeavors to be appointed as the principal of a college to counter Macaulayism —, it provided a fertile ground for further ethno-nationalistic abuse of historiography by Hindu Nationalist parties; [10,11,12]Thomas Trautmann views the development of Vedic Mathematics in a similar manner.[6][11] Meera Nanda has noted hagiographic descriptions of Indian knowledge systems by various right-wing cultural movements (including the BJP), which deemed Krishna Tirtha to be in the same league as Srinivasa Ramanujan.[12]

Some have however praised the methods and commented on its potential to attract school-children to mathematics and increase popular engagement with the subject.[13][14][15] Others have viewed the works as an attempt at harmonizing religion with science.[16]

Originality of methods

Dani believes Krishna Tirtha's methods to be a product of his academic training in mathematics[b] and long recorded habit of experimentation with numbers; nonetheless, he considers the work to be an impressive feat.[3] Similar systems include the Trachtenberg system or the techniques mentioned in Lester Meyers's 1947 book High-speed Mathematics.[3] Alex Bellos points out that several of the calculation tricks can also be found in certain European treatises on calculation from the early Modern period.[17]

Computation algorithms

Some of the algorithms have been tested for efficiency, with positive results.[18][19][20][21] However, most of the algorithms have higher time complexity than conventional ones, which explains the lack of adoption of Vedic mathematics in real life.[22]

Integration into mainstream education

The book had been included in the school syllabus of Madhya Pradesh and Uttar Pradesh, soon after the Bharatiya Janata Party (BJP), a right-wing Hindu nationalist political party came to power and chose to saffronise the education-system.[8]: 6[12][23][24]

Dinanath Batra had conducted a lengthy campaign for the inclusion of Vedic Maths into the National Council of Educational Research and Training (NCERT) curricula.[25] Subsequently, there was a proposal from NCERT to induct Vedic Maths, along with a number of fringe pseudo-scientific subjects (Vedic Astrology et al.), into the standard academic curricula. This was only shelved after a number of academics and mathematicians, led by Dani and sometimes backed by political parties, opposed these attempts based on previously discussed rationales [13,14,15]and

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 12, Issue 10, October 2023||

|DOI:10.15662/IJAREEIE.2022.1210006 |

criticized the move as a politically guided attempt at saffronisation.[4][26][27][28][29][30] Concurrent official reports also advocated for its inclusion in the Madrassah education system to modernize it.[31]

After the BJP's return to power in 2014, three universities began offering courses on the subject while a television channel, catering to the topic, was also launched; generous education and research grants have also been allotted to the subject.

II.DISCUSSION

Indian mathematics emerged in the Indian subcontinent[1] from 1200 BCE[2] until the end of the 18th century. In the classical period of Indian mathematics (400 CE to 1200 CE), important contributions were made by scholars like Aryabhata, Brahmagupta, Bhaskara II, and Varāhamihira. The decimal number system in use today[3] was first recorded in Indian mathematics.[4] Indian mathematicians made early contributions to the study of the concept of zero as a number,[5] negative numbers,[6] arithmetic, and algebra.[7] In addition, trigonometry[8] was further advanced in India, and, in particular, the modern definitions of sine and cosine were developed there.[9] These mathematical concepts were transmitted to the Middle East, China, and Europe[7] and led to further developments that now form the foundations of many areas of mathematics.[16,17,18]

Ancient and medieval Indian mathematical works, all composed in Sanskrit, usually consisted of a section of sutras in which a set of rules or problems were stated with great economy in verse in order to aid memorization by a student. This was followed by a second section consisting of a prose commentary (sometimes multiple commentaries by different scholars) that explained the problem in more detail and provided justification for the solution. In the prose section, the form (and therefore its memorization) was not considered so important as the ideas involved.[1][10] All mathematical works were orally transmitted until approximately 500 BCE; thereafter, they were transmitted both orally and in manuscript form. The oldest extant mathematical document produced on the Indian subcontinent is the birch bark Bakhshali Manuscript, discovered in 1881 in the village of Bakhshali, near Peshawar (modern day Pakistan) and is likely from the 7th century CE.[11][12]

A later landmark in Indian mathematics was the development of the series expansions for trigonometric functions (sine, cosine, and arc tangent) by mathematicians of the Kerala school in the 15th century CE. Their work, completed two centuries before the invention of calculus in Europe, provided what is now considered the first example of a power series (apart from geometric series).[13] However, they did not formulate a systematic theory of differentiation and integration, nor is there any direct evidence of their results being transmitted outside Kerala.[14][15][16][17]

III.RESULTS

Samhitas and Brahmanas

The religious texts of the Vedic Period provide evidence for the use of large numbers. By the time of the Yajurvedasaṃhitā- (1200–900 BCE), numbers as high as 10^{12} were being included in the texts.[2] For example, the mantra (sacred recitation) at the end of the annahoma ("food-oblation rite") performed during the aśvamedha, and uttered just before-, during-, and just after sunrise, invokes powers of ten from a hundred to a trillion:[2]

Hail to śata ("hundred," 10^2), hail to sahasra ("thousand," 10^3), hail to ayuta ("ten thousand," 10^4), hail to niyuta ("hundred thousand," 10^5), hail to prayuta ("million," 10^6), hail to arbuda ("ten million," 10^7), hail to nyarbuda ("hundred million," 10^8), hail to samudra ("billion," 10^9, literally "ocean"), hail to madhya ("ten billion," 10^{10}, literally "middle"), hail to anta ("hundred billion," 10^{11}, lit., "end"), hail to parārdha ("one trillion," 10^{12} lit., "beyond parts"), hail to the uṣas (dawn) , hail to the vyuṣṭi (twilight), hail to udeṣyat (the one which is going to rise), hail to udyat (the one which is rising), hail udita (to the one which has just risen), hail to svarga (the heaven), hail to martya (the world), hail to all.[2]

The Satapatha Brahmana (c. 7th century BCE) contains rules for ritual geometric constructions that are similar to the Sulba Sutras.[22]

Śulba Sūtras[19,20,21]

The Śulba Sūtras (literally, "Aphorisms of the Chords" in Vedic Sanskrit) (c. 700–400 BCE) list rules for the construction of sacrificial fire altars.[23] Most mathematical problems considered in the Śulba Sūtras spring from "a single theological requirement,"[24] that of constructing fire altars which have different shapes but occupy the same area. The altars were required to be constructed of five layers of burnt brick, with the further condition that each layer consist of 200 bricks and that no two adjacent layers have congruent arrangements of bricks.[24]

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 12, Issue 10, October 2023||

|DOI:10.15662/IJAREEIE.2022.1210006 |

According to Hayashi, the Śulba Sūtras contain "the earliest extant verbal expression of the Pythagorean Theorem in the world, although it had already been known to the Old Babylonians."

The diagonal rope (akṣṇayā-rajju) of an oblong (rectangle) produces both which the flank (pārśvamāni) and the horizontal (tiryaṇmānī) <ropes> produce separately."[25]

Since the statement is a sūtra, it is necessarily compressed and what the ropes produce is not elaborated on, but the context clearly implies the square areas constructed on their lengths, and would have been explained so by the teacher to the student.[25]

They contain lists of Pythagorean triples,[26] which are particular cases of Diophantine equations.[27] They also contain statements (that with hindsight we know to be approximate) about squaring the circle and "circling the square."[28]

Baudhayana (c. 8th century BCE) composed the Baudhayana Sulba Sutra, the best-known Sulba Sutra, which contains examples of simple Pythagorean triples, such as: (3, 4, 5), (5, 12, 13), (8, 15, 17), (7, 24, 25), and (12, 35, 37),[29] as well as a statement of the Pythagorean theorem for the sides of a square: "The rope which is stretched across the diagonal of a square produces an area double the size of the original square."[29][30] It also contains the general statement of the Pythagorean theorem (for the sides of a rectangle): "The rope stretched along the length of the diagonal of a rectangle makes an area which the vertical and horizontal sides make together."[29] Baudhayana gives an expression for

the square root of two:[31]

> The expression is accurate up to five decimal places, the true value being 1.41421356...[32] This expression is similar in structure to the expression found on a Mesopotamian tablet[33] from the Old Babylonian period (1900–1600 BCE):[31]

which expresses √2 in the sexagesimal system, and which is also accurate up to 5 decimal places.

According to mathematician S. G. Dani, the Babylonian cuneiform tablet Plimpton 322 written c. 1850 BCE[34] "contains fifteen Pythagorean triples with quite large entries, including (13500, 12709, 18541) which is a primitive triple,[35] indicating, in particular, that there was sophisticated understanding on the topic" in Mesopotamia in 1850 BCE. "Since these tablets predate the Sulbasutras period by several centuries, taking into account the contextual appearance of some of the triples, it is reasonable to expect that similar understanding would have been there in India."[36] Dani goes on to say:[22,23,24]

As the main objective of the Sulvasutras was to describe the constructions of altars and the geometric principles involved in them, the subject of Pythagorean triples, even if it had been well understood may still not have featured in the Sulvasutras. The occurrence of the triples in the Sulvasutras is comparable to mathematics that one may encounter in an introductory book on architecture or another similar applied area, and would not correspond directly to the overall knowledge on the topic at that time. Since, unfortunately, no other contemporaneous sources have been found it may never be possible to settle this issue satisfactorily.[36]

In all, three Sulba Sutras were composed. The remaining two, the Manava Sulba Sutra composed by Manava (fl. 750–650 BCE) and the Apastamba Sulba Sutra, composed by Apastamba (c. 600 BCE), contained results similar to the Baudhayana Sulba Sutra.[25,26,27]

Vyakarana

An important landmark of the Vedic period was the work of Sanskrit grammarian, Pāṇini (c. 520–460 BCE). His grammar includes early use of Boolean logic, of the null operator, and of context free grammars, and includes a precursor of the Backus–Naur form (used in the description programming languages).[37][38]

Pingala (300 BCE – 200 BCE)

Among the scholars of the post-Vedic period who contributed to mathematics, the most notable is Pingala (piṅgalá) (fl. 300–200 BCE), a music theorist who authored the Chhandas Shastra (chandaḥ-śāstra, also Chhandas Sutra chhandaḥ-sūtra), a Sanskrit treatise on prosody. There is evidence that in his work on the enumeration of syllabic combinations, Pingala stumbled upon both Pascal's triangle and binomial coefficients, although he did not have knowledge of the binomial theorem itself.[39][40] Pingala's work also contains the basic ideas of Fibonacci numbers (called maatraameru). Although the Chandah sutra hasn't survived in its entirety, a 10th-century commentary on it by Halāyudha has. Halāyudha, who refers to the Pascal triangle as Meru-prastāra (literally "the staircase to Mount Meru"), has this to say:[28,29,30]

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 12, Issue 10, October 2023||

|DOI:10.15662/IJAREEIE.2022.1210006 |

Draw a square. Beginning at half the square, draw two other similar squares below it; below these two, three other squares, and so on. The marking should be started by putting 1 in the first square. Put 1 in each of the two squares of the second line. In the third line put 1 in the two squares at the ends and, in the middle square, the sum of the digits in the two squares lying above it. In the fourth line put 1 in the two squares at the ends. In the middle ones put the sum of the digits in the two squares above each. Proceed in this way. Of these lines, the second gives the combinations with one syllable, the third the combinations with two syllables, ...[39]

The text also indicates that Pingala was aware of the combinatorial identity:[40]

Kātyāyana

Kātyāyana (c. 3rd century BCE) is notable for being the last of the Vedic mathematicians. He wrote the Katyayana Sulba Sutra, which presented much geometry, including the general Pythagorean theorem and a computation of the square root of 2 correct to five decimal places.

Jain mathematics (400 BCE – 200 CE)

Although Jainism as a religion and philosophy predates its most famous exponent, the great Mahaviraswami (6th century BCE), most Jain texts on mathematical topics were composed after the 6th century BCE. Jain mathematicians are important historically as crucial links between the mathematics of the Vedic period and that of the "classical period."

A significant historical contribution of Jain mathematicians lay in their freeing Indian mathematics from its religious and ritualistic constraints. In particular, their fascination with the enumeration of very large numbers and infinities led them to classify numbers into three classes: enumerable, innumerable and infinite. Not content with a simple notion of infinity, their texts define five different types of infinity: the infinite in one direction, the infinite in two directions, the infinite in area, the infinite everywhere, and the infinite perpetually. In addition, Jain mathematicians devised notations for simple powers (and exponents) of numbers like squares and cubes, which enabled them to define simple algebraic equations (beejganita samikaran). Jain mathematicians were apparently also the first to use the word shunya (literally void in Sanskrit) to refer to zero. More than a millennium later, their appellation became the English word "zero" after a tortuous journey of translations and transliterations from India to Europe. (See Zero: Etymology.)[31,32,33]

In addition to Surya Prajnapti, important Jain works on mathematics included the Sthananga Sutra (c. 300 BCE – 200 CE); the Anuyogadwara Sutra (c. 200 BCE – 100 CE), which includes the earliest known description of factorials in Indian mathematics;[41] and the Satkhandagama (c. 2nd century CE). Important Jain mathematicians included Bhadrabahu (d. 298 BCE), the author of two astronomical works, the Bhadrabahavi-Samhita and a commentary on the Surya Prajinapti; Yativrisham Acharya (c. 176 BCE), who authored a mathematical text called Tiloyapannati; and Umasvati (c. 150 BCE), who, although better known for his influential writings on Jain philosophy and metaphysics, composed a mathematical work called Tattwarthadhigama-Sutra Bhashya.

Oral tradition

Mathematicians of ancient and early medieval India were almost all Sanskrit pandits (paṇḍita "learned man"),[42] who were trained in Sanskrit language and literature, and possessed "a common stock of knowledge in grammar (vyākaraṇa), exegesis (mīmāṃsā) and logic (nyāya)."[42] Memorisation of "what is heard" (śruti in Sanskrit) through recitation played a major role in the transmission of sacred texts in ancient India. Memorisation and recitation was also used to transmit philosophical and literary works, as well as treatises on ritual and grammar. Modern scholars of ancient India have noted the "truly remarkable achievements of the Indian pandits who have preserved enormously bulky texts orally for millennia."[43]

Styles of memorization[34,35]

Prodigious energy was expended by ancient Indian culture in ensuring that these texts were transmitted from generation to generation with inordinate fidelity.[44] For example, memorisation of the sacred Vedas included up to eleven forms of recitation of the same text. The texts were subsequently "proof-read" by comparing the different recited versions. Forms of recitation included the jaṭā-pāṭha (literally "mesh recitation") in which every two adjacent words in the text were first recited in their original order, then repeated in the reverse order, and finally repeated in the original order.[45]

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 12, Issue 10, October 2023||

|DOI:10.15662/IJAREEIE.2022.1210006 |

The Sutra genre

Mathematical activity in ancient India began as a part of a "methodological reflexion" on the sacred Vedas, which took the form of works called Vedāṇgas, or, "Ancillaries of the Veda" (7th–4th century BCE).[47] The need to conserve the sound of sacred text by use of śikṣā (phonetics) and chhandas (metrics); to conserve its meaning by use of vyākaraṇa (grammar) and nirukta (etymology); and to correctly perform the rites at the correct time by the use of kalpa (ritual) and jyotiṣa (astrology), gave rise to the six disciplines of the Vedāṇgas.[47] Mathematics arose as a part of the last two disciplines, ritual and astronomy (which also included astrology). Since the Vedāṇgas immediately preceded the use of writing in ancient India, they formed the last of the exclusively oral literature. They were expressed in a highly compressed mnemonic form, the sūtra (literally, "thread"):

The knowers of the sūtra know it as having few phonemes, being devoid of ambiguity, containing the essence, facing everything, being without pause and unobjectionable.[47]

Extreme brevity was achieved through multiple means, which included using ellipsis "beyond the tolerance of natural language,"[47] using technical names instead of longer descriptive names, abridging lists by only mentioning the first and last entries, and using markers and variables.[47] The sūtras create the impression that communication through the text was "only a part of the whole instruction. The rest of the instruction must have been transmitted by the so-called Guru-shishya parampara, 'uninterrupted succession from teacher (guru) to the student (śisya),' and it was not open to the general public" and perhaps even kept secret.[48] The brevity achieved in a sūtra is demonstrated in the following example from the Baudhāyana Śulba Sūtra (700 BCE).[37

The domestic fire-altar in the Vedic period was required by ritual to have a square base and be constituted of five layers of bricks with 21 bricks in each layer. One method of constructing the altar was to divide one side of the square into three equal parts using a cord or rope, to next divide the transverse (or perpendicular) side into seven equal parts, and thereby sub-divide the square into 21 congruent rectangles. The bricks were then designed to be of the shape of the constituent rectangle and the layer was created. To form the next layer, the same formula was used, but the bricks were arranged transversely.[49] The process was then repeated three more times (with alternating directions) in order to complete the construction. In the Baudhāyana Śulba Sūtra, this procedure is described in the following words:

II.64. After dividing the quadri-lateral in seven, one divides the transverse [cord] in three.
II.65. In another layer one places the [bricks] North-pointing.[49]

According to Filliozat,[50] the officiant constructing the altar has only a few tools and materials at his disposal: a cord (Sanskrit, rajju, f.), two pegs (Sanskrit, śanku, m.), and clay to make the bricks (Sanskrit, iṣṭakā, f.). Concision is achieved in the sūtra, by not explicitly mentioning what the adjective "transverse" qualifies; however, from the feminine form of the (Sanskrit) adjective used, it is easily inferred to qualify "cord." Similarly, in the second stanza, "bricks" are not explicitly mentioned, but inferred again by the feminine plural form of "North-pointing." Finally, the first stanza, never explicitly says that the first layer of bricks are oriented in the east–west direction, but that too is implied by the explicit mention of "North-pointing" in the second stanza; for, if the orientation was meant to be the same in the two layers, it would either not be mentioned at all or be only mentioned in the first stanza. All these inferences are made by the officiant as he recalls the formula from his memory.[49]

The written tradition: prose commentary

With the increasing complexity of mathematics and other exact sciences, both writing and computation were required. Consequently, many mathematical works began to be written down in manuscripts that were then copied and re-copied from generation to generation.

India today is estimated to have about thirty million manuscripts, the largest body of handwritten reading material anywhere in the world. The literate culture of Indian science goes back to at least the fifth century B.C. ... as is shown by the elements of Mesopotamian omen literature and astronomy that entered India at that time and (were) definitely not ... preserved orally.[51]

The earliest mathematical prose commentary was that on the work, Āryabhaṭīya (written 499 CE), a work on astronomy and mathematics. The mathematical portion of the Āryabhaṭīya was composed of 33 sūtras (in verse form) consisting of mathematical statements or rules, but without any proofs.[52] However, according to Hayashi,[53] "this does not necessarily mean that their authors did not prove them. It was probably a matter of style of exposition." From the time of Bhaskara I (600 CE onwards), prose commentaries increasingly began to include some derivations (upapatti). Bhaskara I's commentary on the Āryabhaṭīya, had the following structure:[52]

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 12, Issue 10, October 2023||

|DOI:10.15662/IJAREEIE.2022.1210006 |

- Rule ('sūtra') in verse by Āryabhaṭa
- Commentary by Bhāskara I, consisting of:
  - Elucidation of rule (derivations were still rare then, but became more common later)
  - Example (uddeśaka) usually in verse.
  - Setting (nyāsa/sthāpanā) of the numerical data.
  - Working (karana) of the solution.
  - Verification (pratyayakaraṇa, literally "to make conviction") of the answer. These became rare by the 13th century, derivations or proofs being favoured by then.[52]

Typically, for any mathematical topic, students in ancient India first memorised the sūtras, which, as explained earlier, were "deliberately inadequate"[51] in explanatory details (in order to pithily convey the bare-bone mathematical rules). The students then worked through the topics of the prose commentary by writing (and drawing diagrams) on chalk- and dust-boards (i.e. boards covered with dust). The latter activity, a staple of mathematical work, was to later prompt mathematician-astronomer, Brahmagupta (fl. 7th century CE), to characterise astronomical computations as "dust work" (Sanskrit: dhulikarman).[54]

Numerals and the decimal number system[34,35]

It is well known that the decimal place-value system in use today was first recorded in India, then transmitted to the Islamic world, and eventually to Europe.[55] The Syrian bishop Severus Sebokht wrote in the mid-7th century CE about the "nine signs" of the Indians for expressing numbers.[55] However, how, when, and where the first decimal place value system was invented is not so clear.[56]

The earliest extant script used in India was the Kharoṣṭhī script used in the Gandhara culture of the north-west. It is thought to be of Aramaic origin and it was in use from the 4th century BCE to the 4th century CE. Almost contemporaneously, another script, the Brāhmī script, appeared on much of the sub-continent, and would later become the foundation of many scripts of South Asia and South-east Asia. Both scripts had numeral symbols and numeral systems, which were initially not based on a place-value system.[57]

The earliest surviving evidence of decimal place value numerals in India and southeast Asia is from the middle of the first millennium CE.[58] A copper plate from Gujarat, India mentions the date 595 CE, written in a decimal place value notation, although there is some doubt as to the authenticity of the plate.[58] Decimal numerals recording the years 683 CE have also been found in stone inscriptions in Indonesia and Cambodia, where Indian cultural influence was substantial.[58]

There are older textual sources, although the extant manuscript copies of these texts are from much later dates.[59] Probably the earliest such source is the work of the Buddhist philosopher Vasumitra dated likely to the 1st century CE.[59] Discussing the counting pits of merchants, Vasumitra remarks, "When [the same] clay counting-piece is in the place of units, it is denoted as one, when in hundreds, one hundred."[59] Although such references seem to imply that his readers had knowledge of a decimal place value representation, the "brevity of their allusions and the ambiguity of their dates, however, do not solidly establish the chronology of the development of this concept."[59]

IV.CONCLUSION

A third decimal representation was employed in a verse composition technique, later labelled Bhuta-sankhya (literally, "object numbers") used by early Sanskrit authors of technical books.[60] Since many early technical works were composed in verse, numbers were often represented by objects in the natural or religious world that correspondence to them; this allowed a many-to-one correspondence for each number and made verse composition easier.[60] According to Plofker,[61] the number 4, for example, could be represented by the word "Veda" (since there were four of these religious texts), the number 32 by the word "teeth" (since a full set consists of 32), and the number 1 by "moon" (since there is only one moon).[60] So, Veda/teeth/moon would correspond to the decimal numeral 1324, as the convention for numbers was to enumerate their digits from right to left.[60] The earliest reference employing object numbers is a c. 269 CE Sanskrit text, Yavanajātaka (literally "Greek horoscopy") of Sphujidhvaja, a versification of an earlier (c. 150 CE) Indian prose adaptation of a lost work of Hellenistic astrology.[62] Such use seems to make the case that by the mid-3rd century CE, the decimal place value system was familiar, at least to readers of astronomical and astrological texts in India.[60]

It has been hypothesized that the Indian decimal place value system was based on the symbols used on Chinese counting boards from as early as the middle of the first millennium BCE.[63] According to Plofker,[64]

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 12, Issue 10, October 2023||

|DOI:10.15662/IJAREEIE.2022.1210006 |

These counting boards, like the Indian counting pits, ..., had a decimal place value structure ... Indians may well have learned of these decimal place value "rod numerals" from Chinese Buddhist pilgrims or other travelers, or they may have developed the concept independently from their earlier non-place-value system; no documentary evidence survives to confirm either conclusion."[63]

Bakhshali Manuscript

The oldest extant mathematical manuscript in India is the Bakhshali Manuscript, a birch bark manuscript written in "Buddhist hybrid Sanskrit"[12] in the Śāradā script, which was used in the northwestern region of the Indian subcontinent between the 8th and 12th centuries CE.[65] The manuscript was discovered in 1881 by a farmer while digging in a stone enclosure in the village of Bakhshali, near Peshawar (then in British India and now in Pakistan). Of unknown authorship and now preserved in the Bodleian Library in the University of Oxford, the manuscript has been dated recently as 224 AD- 383 AD.[66]

The surviving manuscript has seventy leaves, some of which are in fragments. Its mathematical content consists of rules and examples, written in verse, together with prose commentaries, which include solutions to the examples.[65] The topics treated include arithmetic (fractions, square roots, profit and loss, simple interest, the rule of three, and regula falsi) and algebra (simultaneous linear equations and quadratic equations), and arithmetic progressions. In addition, there is a handful of geometric problems (including problems about volumes of irregular solids). The Bakhshali manuscript also "employs a decimal place value system with a dot for zero."[65] Many of its problems are of a category known as 'equalisation problems' that lead to systems of linear equations. One example from Fragment III-5-3v is the following:

One merchant has seven asava horses, a second has nine haya horses, and a third has ten camels. They are equally well off in the value of their animals if each gives two animals, one to each of the others. Find the price of each animal and the total value for the animals possessed by each merchant.[67]

The prose commentary accompanying the example solves the problem by converting it to three (under-determined) equations in four unknowns and assuming that the prices are all integers.[67]

In 2017, three samples from the manuscript were shown by radiocarbon dating to come from three different centuries: from 224 to 383 AD, 680-779 AD, and 885-993 AD. It is not known how fragments from different centuries came to be packaged together.[68][69][70]

Classical period (400–1600)

This period is often known as the golden age of Indian Mathematics. This period saw mathematicians such as Aryabhata, Varahamihira, Brahmagupta, Bhaskara I, Mahavira, Bhaskara II, Madhava of Sangamagrama and Nilakantha Somayaji give broader and clearer shape to many branches of mathematics. Their contributions would spread to Asia, the Middle East, and eventually to Europe. Unlike Vedic mathematics, their works included both astronomical and mathematical contributions. In fact, mathematics of that period was included in the 'astral science' (jyotiḥśāstra) and consisted of three sub-disciplines: mathematical sciences (gaṇita or tantra), horoscope astrology (horā or jātaka) and divination (saṃhitā).[54] This tripartite division is seen in Varāhamihira's 6th century compilation—Pancasiddhantika[71] (literally panca, "five," siddhānta, "conclusion of deliberation", dated 575 CE)—of five earlier works, Surya Siddhanta, Romaka Siddhanta, Paulisa Siddhanta, Vasishtha Siddhanta and Paitamaha Siddhanta, which were adaptations of still earlier works of Mesopotamian, Greek, Egyptian, Roman and Indian astronomy. As explained earlier, the main texts were composed in Sanskrit verse, and were followed by prose commentaries.[54]

Fourth to sixth centuries

Surya Siddhanta

Though its authorship is unknown, the Surya Siddhanta (c. 400) contains the roots of modern trigonometry.[Because it contains many words of foreign origin, some authors consider that it was written under the influence of Mesopotamia and Greece.[72][

This ancient text uses the following as trigonometric functions for the first time:[

- Sine (Jya).
- Cosine (Kojya).

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 12, Issue 10, October 2023||

|DOI:10.15662/IJAREEIE.2022.1210006 |

- Inverse sine (Otkram jya).

Later Indian mathematicians such as Aryabhata made references to this text, while later Arabic and Latin translations were very influential in Europe and the Middle East.

Chhedi calendar

This Chhedi calendar (594) contains an early use of the modern place-value Hindu–Arabic numeral system now used universally.

Aryabhata I

Aryabhata (476–550) wrote the Aryabhatiya. He described the important fundamental principles of mathematics in 332 shlokas. The treatise contained:[35]

- Quadratic equations
- Trigonometry
- The value of π, correct to 4 decimal places.

Aryabhata also wrote the Arya Siddhanta, which is now lost. Aryabhata's contributions

REFERENCES

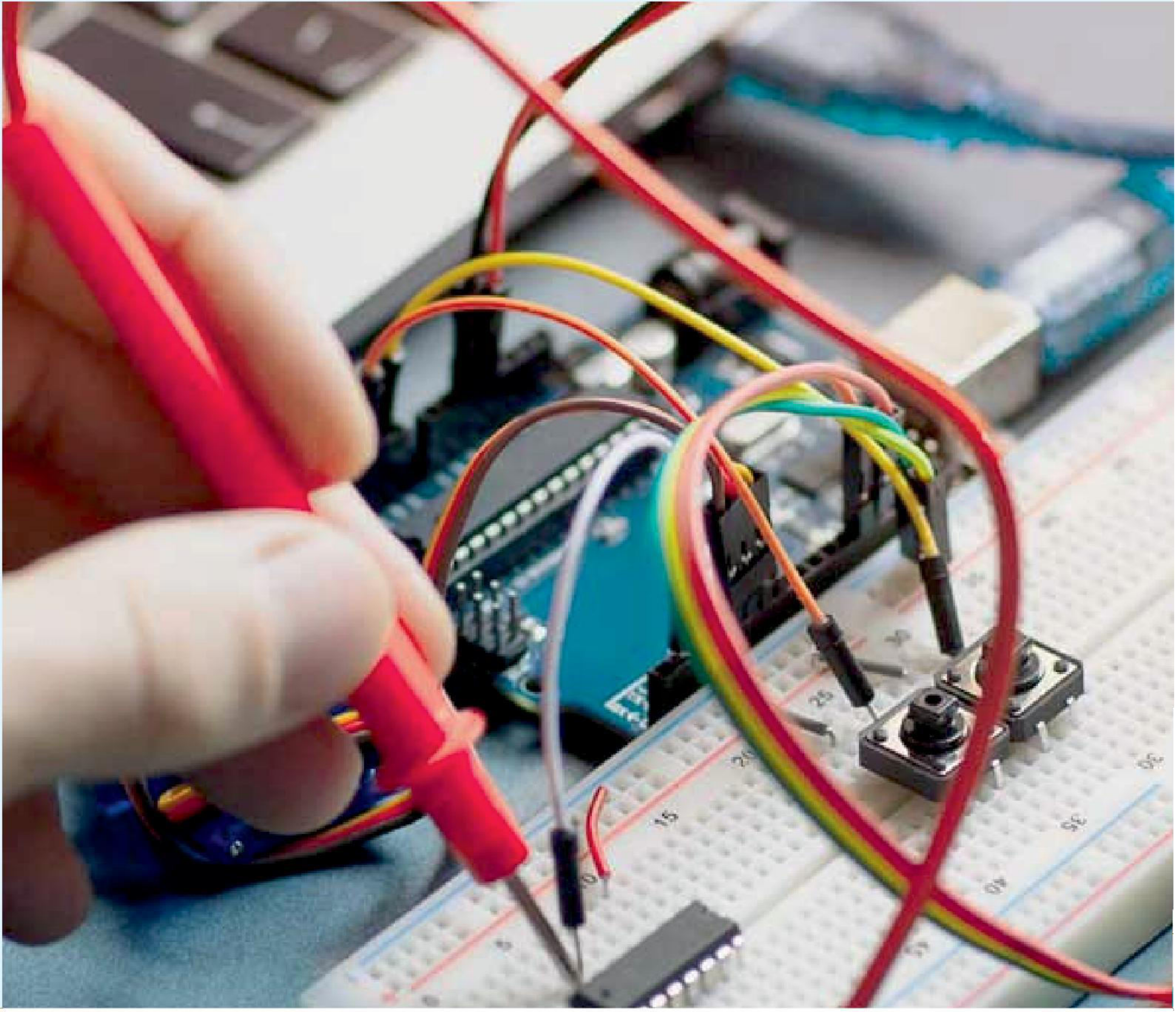
1. Dani, SG (22 November 1993). "Myths and reality : On 'Vedic mathematics'" (PDF). TIFR. Archived (PDF) from the original on 6 January 2022. Retrieved 17 November 2022.
2. ^ Cooke, Roger L. (2013). "Overview of Mathematics in India". The history of mathematics : a brief course. Hoboken, N.J.: Wiley. p. 212. ISBN 978-1-118-46029-0. OCLC 865012817.
3. ^ S. G. Dani (December 2006). "Myths and reality : On 'Vedic mathematics'".
   - Originally published in Dani, S. G. (1993). "'Vedic Mathematics': Myth and Reality". Economic and Political Weekly. 28 (31): 1577–1580. ISSN 0012-9976. JSTOR 4399991.
   - Near-simultaneously, as a 2-part article in Frontline, 22 October and 5 November 1993.
   - An updated version appears in Kandasamy and Smarandache (2006).
4. ^ a b c d e Hogendijk, Jan (March 2004). "De Veda's en de berekeningen van goeroe Tirthaji" (PDF). Nieuwe Wiskrant. 23 (3): 49–52.
5. ^ a b c Shukla, K.S. (2019). "Vedic Mathematics: The deceptive title of Swamiji's book". In Kolachana, Aditya; Mahesh, K.; Ramasubramanian, K. (eds.). Studies in Indian Mathematics and Astronomy: Selected Articles of Kripa Shankar Shukla. Sources and Studies in the History of Mathematics and Physical Sciences. Singapore: Springer Publishing. doi:10.1007/978-981-13-7326-8. ISBN 9789811373251.
6. ^ a b c Bal, Hartosh Singh (12 August 2010). "The Fraud of Vedic Maths". The Open. Retrieved 25 November 2019.
7. ^ Plofker, Kim (18 January 2009). "Mathematical Thought In Vedic India". Mathematics in India. Princeton University Press. p. 16. ISBN 9780691120676.
8. ^ a b c W.B. Vasantha Kanadasamy; Florentin Smarandache (December 2006). Vedic Mathematics: Vedic Or Mathematics: A Fuzzy and Neutrosophic Analysis (PDF). American Research Press. ISBN 978-1-59973-004-2. Retrieved 23 May 2013.
9. ^ Biographical sketch by Manjula Trivedi, 1965 in book Vedic Mathematics, pages x, xi.
10. ^ Narlikar, Jayant V. (4 August 2003). The Scientific Edge: The Indian Scientist from Vedic to Modern Times. Penguin UK. ISBN 9789351189282.
11. ^ Trautmann, Thomas R. (2002). Languages and Nations : Conversations in Colonial South India. University of California Press. p. 45. ISBN 9780520931909. OCLC 476020847.
12. ^ a b Nanda, Meera (2000). "The Science Wars in India". The Sokal Hoax: The Sham that Shook the Academy. University of Nebraska Press. pp. 206–213. ISBN 9780803219243.
13. ^ Pandey, Pushp Deep (2003). "Public engagement with mathematics in India" (DjVu). Current Science. 84 (7): 862–863. ISSN 0011-3891. JSTOR 24108037.
14. ^ Glover, James (17 October 2014). "Everything Vedic in 'Vedic Maths'". The Hindu. Retrieved 4 January 2016.
15. ^ "tecmath". YouTube. Retrieved 14 March 2020.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 12, Issue 10, October 2023||

|DOI:10.15662/IJAREEIE.2022.1210006 |

16. ^ Crisman, Karl-Dieter (9 August 2019). "Reviews". The American Mathematical Monthly. 126 (7): 667–672. doi:10.1080/00029890.2019.1606573. ISSN 0002-9890. S2CID 215770851.
17. ^ Bellos, Alex (2010). "Something about nothing". Alex's Adventures in Numberland. Bloomsbury. ISBN 9781408808863.
18. ^ Kasliwal, Prabha S.; Patil, B. P.; Gautam, D. K. (1 January 2011). "Performance Evaluation of Squaring Operation by Vedic Mathematics". IETE Journal of Research. 57 (1): 39–41. doi:10.4103/0377-2063.78327. ISSN 0377-2063. S2CID 120316446.
19. ^ Huddar, S. R.; Rupanagudi, S. R.; Kalpana, M.; Mohan, S. (2013). "Novel high speed vedic mathematics multiplier using compressors". 2013 International Mutli-Conference on Automation, Computing, Communication, Control and Compressed Sensing (IMac4s). IEEE. pp. 465–469. doi:10.1109/iMac4s.2013.6526456. ISBN 978-1-4673-5090-7. S2CID 11124644.
20. ^ Mehta, Parth; Gawali, Dhanashri (2009). "Conventional versus Vedic Mathematical Method for Hardware Implementation of a Multiplier". 2009 International Conference on Advances in Computing, Control, and Telecommunication Technologies. IEEE. pp. 640–642. doi:10.1109/ACT.2009.162. ISBN 978-1-4244-5321-4. S2CID 6773150.
21. ^ Kunchigi, V.; Kulkarni, L.; Kulkarni, S. (2012). "High speed and area efficient vedic multiplier". 2012 International Conference on Devices, Circuits and Systems (ICDCS). IEEE. pp. 360–364. doi:10.1109/ICDCSyst.2012.6188747. ISBN 978-1-4577-1546-4. S2CID 19077488.
22. ^ Sen, Syamal K.; Agarwal, Ravi P. (1 January 2016), Sen, Syamal K.; Agarwal, Ravi P. (eds.), "5 - Conclusions", Zero, Academic Press, pp. 93–142, ISBN 978-0-08-100774-7, retrieved 23 November 2019
23. ^ Behera, Navnita Chadha (1 July 1996). "Perpetuating the divide: Political abuse of history in South Asia". Contemporary South Asia. 5 (2): 191–205. doi:10.1080/09584939608719789. ISSN 0958-4935.
24. ^ Pijl, Kees Van Der (2010). "Warrior Heroes in the Indo-European Lineage". The Foreign Encounter in Myth and Religion: Modes of Foreign Relations and Political Economy. Vol. 2. Pluto Press. p. 98. doi:10.2307/j.ctt183h05v.7. ISBN 978-0-7453-2316-9. JSTOR j.ctt183h05v.7.
25. ^ Taylor, McComas (2 October 2014). "Hindu Activism and Academic Censorship in India". South Asia: Journal of South Asian Studies. 37 (4): 717–725. doi:10.1080/00856401.2014.956679. ISSN 0085-6401. S2CID 144408510.
26. ^ "Neither Vedic Nor Mathematics A statemant signed by SG Dani and other Indian scientists". www.sacw.net. Retrieved 20 October 2019.
27. ^ "Legitimisation of Vedic mathematics, astrology opposed". The Hindu. 14 August 2001. ISSN 0971-751X. Retrieved 25 November 2019.
28. ^ "Stop this Fraud on our Children". archives.peoplesdemocracy.in. Archived from the original on 14 March 2016. Retrieved 20 October 2019.
29. ^ Hasan, Mushirul (1 December 2002). "The BJP's intellectual agenda: Textbooks and imagined history". South Asia: Journal of South Asian Studies. 25 (3): 187–209. doi:10.1080/00856400208723498. ISSN 0085-6401. S2CID 143341141.
30. ^ Kurien, Prema A. (2007). "Re-visioning Indian History: Internet Hinduism" (PDF). A place at the multicultural table the development of an American Hinduism. Rutgers University Press. p. 164. ISBN 9780813540559. JSTOR j.ctt5hj9tk. OCLC 703221465.
31. ^ Sikand, Yoginder (2009). "Voices for Reform in the Indian Madrasas". In Noor, Farish A.; Sikand, Yoginder; Bruinessen, Martin van (eds.). The madrasa in Asia : political activism and transnational linkages. ISIM Series on Contemporary Muslim Societies. Amsterdam University Press. p. 61. ISBN 978-81-7304-837-1. JSTOR j.ctt46n10w. OCLC 912632940.
32. ^ Nelson, Dean (7 January 2015). "India's next gift to the world could be Vedic mathematics". Daily Telegraph. ISSN 0307-1235. Retrieved 20 October 2019.
33. ^ Nussbaum, Martha Craven (2008). The Clash Within : Democracy, Religious Violence, and India's Future. Harvard University Press. p. 222. ISBN 9780674030596. OCLC 1006798430.
34. ^ Nanda, Meera (2005). "Postmodernism, Hindu Nationalism, and "Vedic Science"". In Koertge, Noretta (ed.). Scientific values and civic virtues. Oxford University Press. p. 224. doi:10.1093/0195172256.001.0001. ISBN 9780198038467. OCLC 62288153.
35. ^ "Vedic maths: Not quite adding up - Times of India". The Times of India. 11 January 2015. Retrieved 22 October 2019.



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 8.317

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

9940 572 462 6381 907 438 ijareeie@gmail.com

Scan to save the contact details