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Jaina literature -A treasure house of unique mathematical concepts

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Abstract: Jaina philosophical texts are rich in mathematical depth, advancing from elementary arithmetic to complex algebraic theories. Beyond the eight standard operations of early Indian mathematics—addition, subtraction, multiplication, division, squares, cubes, and their roots—these works explore sophisticated concepts like *vargita-samvargita* (self-exponentiation), *viralana-deya*, *niruddha*, and different forms of logarithms. The renowned Jaina mathematician Mahāvīra played a pivotal role in this evolution, formalising these philosophical insights into a rigorous, systematic framework.
Keywords: Vargita- Samvargita,Viralana-deya, Nirudha , Arddhaccheda, Trikaccheda

Introduction :

While Indian thought is often defined by the six traditional systems—Sānkhya, Yoga, Nyāya, Vaiśeṣika, Pūrvami¯māmsa, and Uttarami¯māmsa(Vedānta) —the Jaina system stands apart with its own unique specialties. A primary distinction of Jaina philosophy is its dense integration of scientific enquiry, particularly in cosmology and mathematics.

Moving from basic numerical concepts to advanced ideas in arithmetic and algebra, Jaina texts go beyond the eight fundamental operations—addition, subtraction, multiplication, division, squaring, and cubing—typically found in early Indian mathematics. Famous mathematicians like Mahāvīra incorporated these basics alongside sophisticated Jaina operations such as *vargita-samvargita* (exponentiation), *viralanadeyam* (distribution), *niruddha* (LCM), and even early logarithmic concepts. Through this fusion of philosophy and science, the Jainas made lasting contributions to the evolution of mathematical thought.

Numbers: Jaina philosophy categorizes numbers into three primary groups: **Samkhyāta** (countable), **Asamkhyāta** (uncountable), and **Ananta** (infinite). This classification was essential for the quantitative analysis of Karmic events, which required a sophisticated understanding of mathematical infinity. Through iterative processes—including complex multiplication, squaring, and the projection of sets—thinkers like Yativṛṣabha eventually defined 21 distinct types of numerical ranges.[1].

The *Dhavalā* (Vol. 3, p. 249) classifies countable numbers into **Oja-rāśi** (odd) and **Yugma-rāśi** (even), further subdividing them into what modern mathematics calls **residue classes modulo 4**:

- **Odd Numbers:**

o **Tejoja:** Numbers with a remainder of 3 when divided by 4 (e.g., 15).

o **Kalioja:** Numbers with a remainder of 1 when divided by 4 (e.g., 25).

- **Even Numbers:**

o **Kṛtayugma:** Numbers divisible by 4 (remainder 0, e.g., 48).

o **Bādarayugma:** Numbers with a remainder of 2 when divided by 4 (e.g., 34).

This sophisticated system demonstrates an early grasp of modular arithmetic. Additionally, texts like the *Tiloyapaṇṇatti* apply these principles alongside **perfect numbers** (integers equal to the sum of their proper divisors) to describe the dimensions of cosmological structures like Jambu-dvīpa.

Operations: Jaina mathematicians categorized the eight fundamental operations as **parikarma-vyavahāra**, while the study of fractions and their rules was termed **kalāsavarṇa-vyavahāra**. A key contribution by Mahāvīra was the concept of **niruddha**, which represents the Least Common Multiple (LCM). In addition to these standard practices, the Jaina school developed several specialized operations to address more complex mathematical problems.

Vargita-samvargita A very special operation seen in jaina works is 'vargita-samvargita'[2] i.e., raising of numbers to the given number. This is a great contribution of Ācārya Vīrasena. He used this for expressing very big numbers.

The first vargita- samvargita of a number is simply known as vargita-samvargita and can be written as $\overline{x|}^{1}$ and so $\overline{x|}^{1} = x^{x}$.

The second vargita –samvargita of x is defined as the vargita- samvargita of the first vargita- samvargita of x and can be written as $\overline{x|}^{2}$ so $\overline{x|}^{2} = \left(\overline{x|}^{1}\right)^{\overline{x|}^{1}} = \left(x^{x}\right)^{\left(x^{x}\right)}$

Similarly third vargita-samvargita of x is defined as the vargita- samvargita of the second vargita-samvargita of x and can be written as $\overline{x|}^{3} = \left(\overline{x|}^{2}\right)^{\overline{x|}^{2}}$

Eg:- 1st vargita-samvargita of 2 = $\overline{2|}^{1} = 2^{2} = 4$.

2nd vargita-samvargita of

$$2 = \overline{2|}^{2} = \left(\overline{2|}^{1}\right)^{\overline{2|}^{1}} = \left(2^{2}\right)^{\left(2^{2}\right)} = 4^{4} = 256$$

3rd vargita samvargita of 2 = $\overline{2|}^{3} = (4^{4})^{4^{4}} = (256)^{256}$.

By the operation of vargita-samvargita on 2 it becomes 4. By the operation of second vargita-samvargita on 2 or by the operation of vargita-samvargita on 4 the number becomes $4^{4} = 256$. By the operation of third vargita-samvargita on 2 or by the operation of vargita-samvargita on 4^{4} the number becomes $(256)^{256}$

.i.e.,

$$2 \xrightarrow{1^{st}\text{vargita samvargita}} 2^{2} \xrightarrow{2^{nd}\text{vargita samvargita}} 4^{4} \xrightarrow{3^{rd}\text{vargita samvargita}} 256^{256}.$$

So it is clear that the operation vargita samvargita is a very useful tool for obtaining a rapidly increasing divergent sequence.

Viralana-deya

In jaina works we can see another operation called viralana-deya means spread and give.[3] Viralana means the spreading of a number into its unities. Deya means the substitution of 'n' in place of 'l'. So viralana of n is 1 1 1 . . . . up to n times viralana-deya of n is n n n . . . n times. So vargita-samvargita of 'n' is obtained by multiplying the n's obtained by the viralana-deya of n.

Logarithm

The Jaina mathematical tradition also introduced the advanced concept of logarithms using various bases. These ideas were clearly established by **Ācārya Vīrasena** (AD 792–853) in his *Dhavalā* commentaries on the *Ṣaṭkhaṅḍāgama*. Within these texts, distinct terminology was developed to identify logarithms of different bases—specifically base 2, base 3, and base 4—marking a significant milestone in early algebraic thought.[4]

Arddhaccheda

In Dhavalā-3, p. 21 it is given that 'जितनी बार कोई संख्या उत्तरोत्तर आदी - आधी की जा सकती है उतने उस संख्या का अर्थच्छेद कहे जाते है।'.[5]. which means arddhaccheda of a number is equal to the number of times it can be divided by 2 ie., arddhaccheda of a number which can be put in the power form of two is the power to which 2 must be raised. ie., if $k = 2^{m}$ then the arddhaccheda of k is m.

E.g., 32 is divisible by 2 (5 times) or 32= 2^{5}.

Hence arddhaccheda of 32 is 5. But according to modern mathematics, $\log_2 32 = 5$

i.e., $\log_2 x$ and arddhaccheda of x are same.

The concept of arddhaccheda is also seen in Dhavalā-3, p-139-141 and p-342-344.

Trikaccheda

Trikaccheda of a number is equal to the number of times that it can be divided by 3 (Dhavalā 3-p. 56) .[6]. . ie., trikaccheda of a number which can be put in the power form of 3 is the power to which 3 must be raised. ie., if $k = 3^{m}$ then trikaccheda of k is m.

E.g., 81 is divisible by 3, 4 times or 81 = 3^4 Hence trikaccheda of 81 is 4

But $\log_3 81 = 4$. So $\log_3 x$ and trikaccheda of *x* are same.

Similarly caturthaccheda of a number is the number of times that it can be divided by 4 (Dhavalā - 3. P. 56). .[7].

Hence caturthaccheda of 256=4 or $\log_4 256 = 4$.

The common properties of logarithm such as $\log_2 xy = \log_2 x + \log_2 y$ $\log_2 \frac{x}{y} = \log_2 x - \log_2 y$ etc are also seen in Dhavalā.[8]

Eventhough the concepts of $\log_2$, $\log_3$, $\log_4$, $\log_5$ etc. are found in Dhavalā, $\log_e$ or log10 which are commonly used in modern mathematics are nowhere seen

Also $\log_2 \log_2$ of a number is given in Dhavalā - 3 - p. 21, The name used for $\log_2 \log_2 x$ is 'vargaśalaka' of x.[9]

Despite of these facts, the invention of logarithms is credited to John Napier (1550–1617). However, this attribution overlooks the much earlier work of Jaina mathematicians like Ācārya Vīrasena, whose systematic use of *Ardhaccheda* (base 2) and *Trakaccheda* (base 3) demonstrates that the logic of logarithms was well-established in India long before the 16th century

Conclusion: The Jaina mathematical tradition has left an indelible mark on both Indian and global intellectual thought. By exploring the nature of infinity, developing innovative number systems, and pioneering advancements in arithmetic, geometry, and algebra, Jaina scholars established a vital foundation for future mathematical progress.Their unique perspectives and rigorous approach to problem-solving continue to inspire and challenge modern academics. While their contributions may not always receive the same level of mainstream recognition as other traditions, their legacy remains a sophisticated and essential chapter in the history of human knowledge.

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