My Inspiration
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Lecture No. 13: Module 1: Arithmetic, Algebra and Combinatorics

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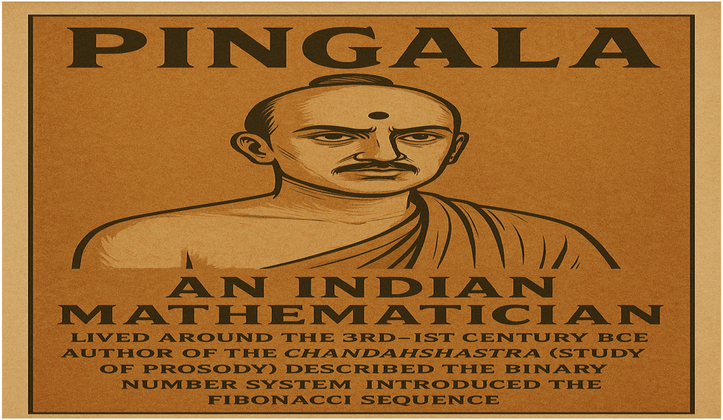

Combinatorics in Ancient Indian Mathematics

Pingala's Chandaḥśāstra (c. 2nd century BCE):

Context:

- Pingala was a scholar of Sanskrit prosody (Chandas).
- His work Chandaḥśāstra (a treatise on poetic meters) is a binary and combinatoric masterpiece.
- He used short (laghu $\downarrow$) and long (guru $\uparrow$) syllables in patterns.

Combinatorics in Ancient Indian Mathematics

Pingala's Chandaḥśāstra (c. 2nd century BCE):

Core Concepts from Pingala:

Binary Representation (like modern 0 and 1):

- Laghu (short) = 1 ($\downarrow$)
- Guru (long) = 0 ($\uparrow$)

So a meter like "laghu-guru-laghu" is represented as 1–0–1 in binary.

Combinatorics in Ancient Indian Mathematics

Pingala's Chandaḥśāstra (c. 2nd century BCE):

Total number of metrical combinations:

For a meter of n syllables, the total number of combinations $= 2^n$
This is the same as in binary strings of length n.

Meru-prastaara (Pascal's Triangle):

- Pingala gave a recursive method to generate **Meru**, which is equivalent to **Pascal's Triangle**.
- Each row shows the number of ways to arrange k laghus in n syllables (i.e., combinations $\binom{n}{k}$)

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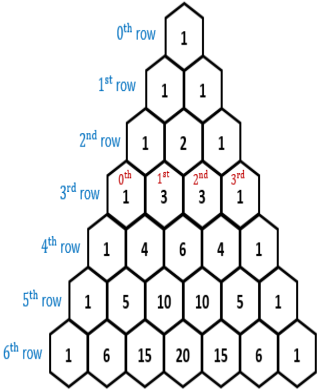
Meru-prastaara (Pascal's Triangle):



Combinatorics in Ancient Indian Mathematics

Pingala's Chandaḥśāstra (c. 2nd century BCE):

Prastāra (Expansion):

- Lists all possible combinations of laghu/guru syllables.
- Equivalent to listing all binary strings of a given length.

Nashta:

- Given a number (say 5), find the binary representation or the corresponding syllable pattern.
- Used in locating the metrical form quickly.

Combinatorics in Ancient Indian Mathematics

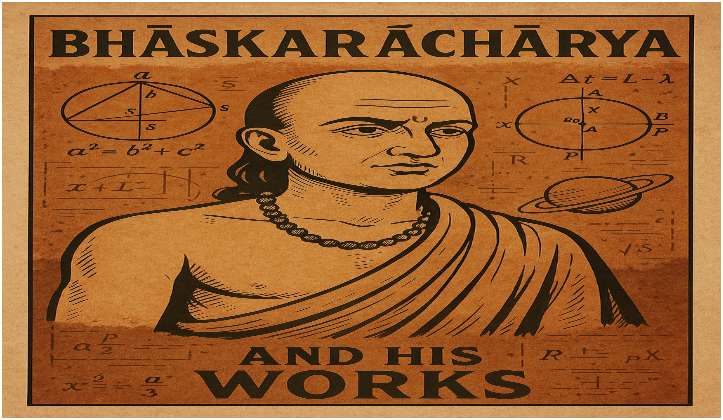
Pingala's Chandaḥśāstra (c. 2nd century BCE):

Uddiṣṭa:

- Given a pattern (e.g., guru-laghu-laghu), find its position in the Prastāra.
- Equivalent to mapping binary strings to integers.

Combinatorics in Ancient Indian Mathematics

Bhaskaracharya's Līlāvatī (c. 1150 CE):



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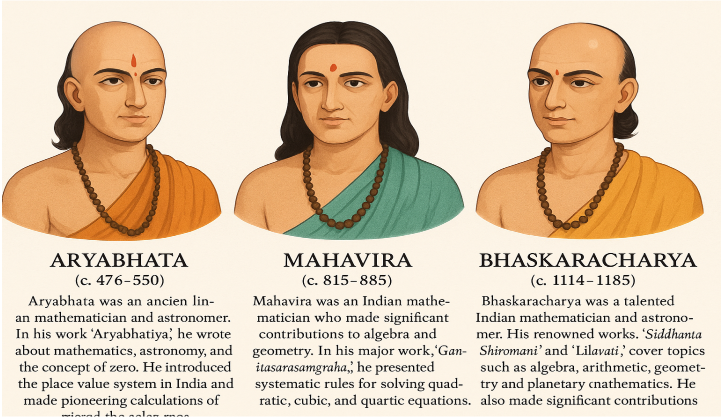
Bhaskaracharya's Līlāvatī (c. 1150 CE):



Combinatorics in Ancient Indian Mathematics

Bhaskaracharya's Ankapāśa (in Līlāvatī, 12th century CE):

Ankapāśa = "Net of Numbers" or Grid of Numbers:

- Found in the Līlāvatī section of Bhāskara II's work.
- It is a method for computing the number of combinations and permutations.

Combinatorics in Ancient Indian Mathematics

Bhaskaracharya's Ankapāśa (in Līlāvatī, 12th century CE):

Topics and Concepts:

Permutation (Vikalpa):

- Bhāskara gives formulae for permutations, using terms like:

$$n! = n(n-1)(n-2)(n-3)\ldots 3.2.1$$

- Problems include: "In how many ways can ornaments be arranged?" or "How many ways to seat people?"

Combinatorics in Ancient Indian Mathematics

Bhaskaracharya's Ankapāśa (in Līlāvatī, 12th century CE):

Topics and Concepts:

Combination (Saṅkhyā):

- Bhāskara discusses choosing r objects from n without regard to order:

$$\binom{n}{r} = \frac{n!}{r!(n-r)!}$$

Combinatorics in Ancient Indian Mathematics

Bhaskaracharya's Ankapāśa (in Līlāvatī, 12th century CE):

Topics and Concepts:

Magic Squares and Number Grids (Ankapāśa proper):

- Constructed magic squares and grid patterns filled with numbers—a type of combinatorial design.
- Used in recreational problems, often with poetic flair.

Combinatorics in Ancient Indian Mathematics

Bhaskaracharya's Ankapāśa (in Līlāvatī, 12th century CE):

Topics and Concepts:

Word Problems in Verse:

Bhāskara included real-world problems using combinations:
"Tell me, clever girl, how many ways can three ornaments be placed on three fingers?"
This is:
$3! = 6$ ways

Combinatorics in Ancient Indian Mathematics

Final Thoughts:

Indian scholars used combinatorics not only for poetry and aesthetics but also in logic, cryptography, and recreational math.

The concept of binary numbers, Pascal's triangle, factorials, and permutations were all present in ancient Indian texts long before they appeared in European mathematics.