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Lecture No. 14: Module 1: Arithmetic, Algebra and Combinatorics

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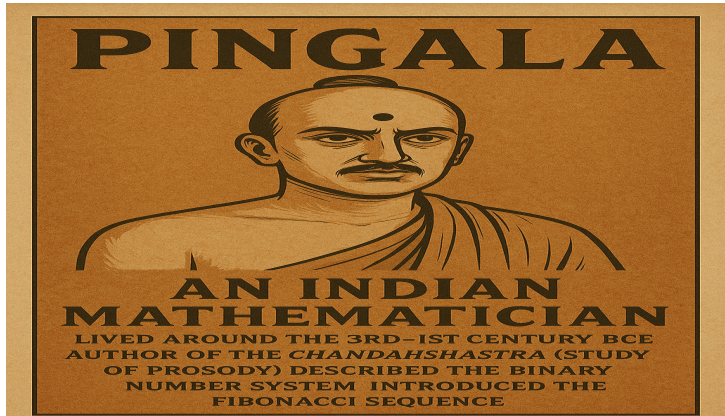
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Some examples from ancient Indian combinatorics with their original Sanskrit verses, followed by modern translations and explanations

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



Some examples from ancient Indian combinatorics with their original Sanskrit verses, followed by modern translations and explanations

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

Sanskrit Verse 1: Prastāra (Expansion of Meters)

"dvau bhāvau laghu-guruḥ — tasmād dvirgunaḥ
prastāraḥ"

Translation:

"There are two types (of syllables): laghu (short) and guru (long); hence, the total number of combinations (Prastāra) is a power of two."

Some examples from ancient Indian combinatorics with their original Sanskrit verses, followed by modern translations and explanations

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

Modern Explanation:

For n syllables, the number of possible combinations of laghu and guru is: 2^n

E.g., For 3 syllables:

LLL, LLG, LGL, GLL, LGG, GLG, GGL, GGG $\rightarrow 8 = 2^3$

Some examples from ancient Indian combinatorics with their original Sanskrit verses, followed by modern translations and explanations

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

Sanskrit Verse 2: Meru (Pascal's Triangle):

"ardhadvayāt upari ardhadvayam, evam urdhvam
samāsataḥ"

Translation:

"Take pairs of numbers from the row below, add them to form the next row above—this builds the triangle step by step."

Some examples from ancient Indian combinatorics with their original Sanskrit verses, followed by modern translations and explanations

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

Modern Explanation:

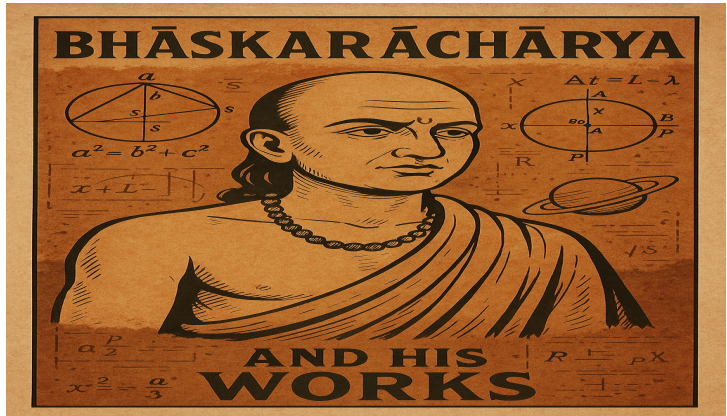
This is a recursive description of Pascal's Triangle (Meru-prastaara), where each entry is the sum of the two directly below it.

Some examples from ancient Indian combinatorics with their original Sanskrit verses, followed by modern translations and explanations

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Bhaskaracharya's Līlāvati (c. 1150 CE):

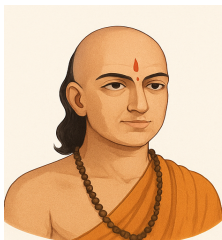


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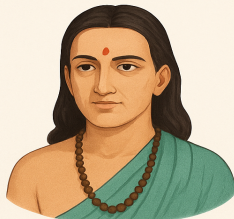
Bhaskaracharya's Līlāvati (c. 1150 CE):



ARYABHATA

(c. 476–550)

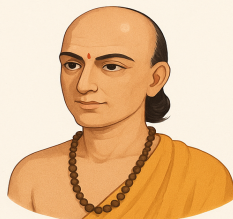
Aryabhata was an ancient Indian mathematician and astronomer. In his work 'Aryabhatiya', he wrote about mathematics, astronomy, and the concept of zero. He introduced the place value system in India and made pioneering calculations of



MAHAVIRA

(c. 815–885)

Mahavira was an Indian mathematician who made significant contributions to algebra and geometry. In his major work, 'Ganitasarasamgraha', he presented systematic rules for solving quadratic, cubic, and quartic equations.



BHASKARACHARYA

(c. 1114–1185)

Bhaskaracharya was a talented Indian mathematician and astronomer. His renowned works, 'Siddhanta Shiromani' and 'Lilavati', cover topics such as algebra, arithmetic, geometry and planetary mathematics. He also made significant contributions

Some examples from ancient Indian combinatorics with their original Sanskrit verses, followed by modern translations and explanations

Bhaskaracharya's Līlāvātī (c. 1150 CE):

Sanskrit Verse 3: Sum of Natural Numbers:

"ekāṅkadhṛte dviguṇitaṃ yutaṃ saṅkhyayā taduttareṇa
bhaktaṃ —
tatsyāt sarvasaṅkhyānāṃ yogo
madhyasthasaṅkhyābhyāṃ vā"

Translation:

"Double the first number minus one, add it to the number of terms, divide by 2 — the result is the sum of the series. Or take the average and multiply by the number of terms."

Some examples from ancient Indian combinatorics with their original Sanskrit verses, followed by modern translations and explanations

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Bhaskaracharya's Līlāvātī (c. 1150 CE):

Modern Formula:

$$S_n = \frac{n}{2}(a + l)$$

or

$$S_n = \frac{n(n + 1)}{2}$$

(when $a = 1$ and $d = 1$)

Some examples from ancient Indian combinatorics with their original Sanskrit verses, followed by modern translations and explanations

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Bhaskaracharya's Līlāvātī (c. 1150 CE):

Sanskrit Verse 4: Permutations of Objects:

"padārthānām ekādhikānām krameṇa gatiḥ syāt"

Translation:

"The number of arrangements (gati) of a number of distinct objects is the factorial of one more than the number."

Some examples from ancient Indian combinatorics with their original Sanskrit verses, followed by modern translations and explanations

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Bhaskaracharya's Līlāvātī (c. 1150 CE):

Modern Formula:

If there are n distinct items:

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

Example:

3 ornaments $\rightarrow 3! = 6$ arrangements.