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## Lecture No. 12: Module 1: Arithmetic, Algebra and Combinatorics

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# Progressions and Series in Indian Mathematics

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## Earliest References – Vedic Period:

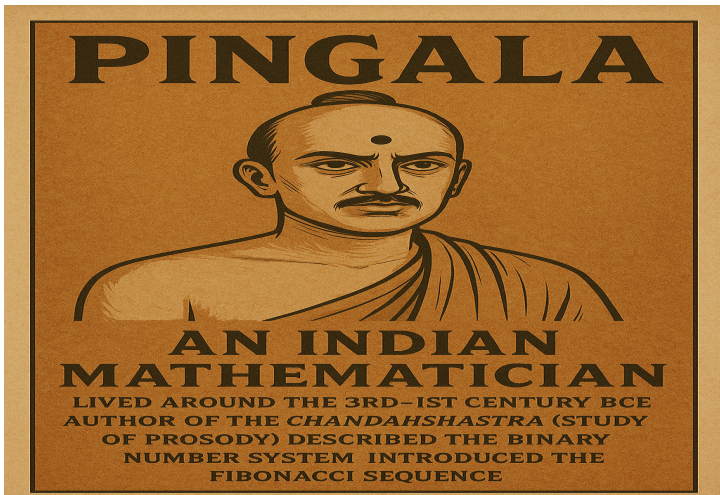
The Sulba Sutras (800 BCE – 200 BCE), associated with ritual geometry, contain implicit knowledge of arithmetical series through their geometric constructions.

Example: Lengths of squares and rectangles for altar construction imply sequences and proportional relationships.

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# Progressions and Series in Indian Mathematics

Pingala's Chandaḥśāstra (c. 200 BCE):

Pingala, in his treatise on Sanskrit prosody, discussed binary combinations of short (laghu) and long (guru) syllables.

This led to combinatorics, Pascal's triangle, and Fibonacci-like sequences, though not in modern notation.

This work implies the sum of geometric series: e.g., total number of patterns =  $2^n$

# Progressions and Series in Indian Mathematics

Aryabhata (476 CE):

In his seminal work *Aryabhatiya*, Aryabhata gives formulas for the sum of arithmetic series:

“The sum of an arithmetic series is half the number of terms multiplied by the sum of the first and last terms.”

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

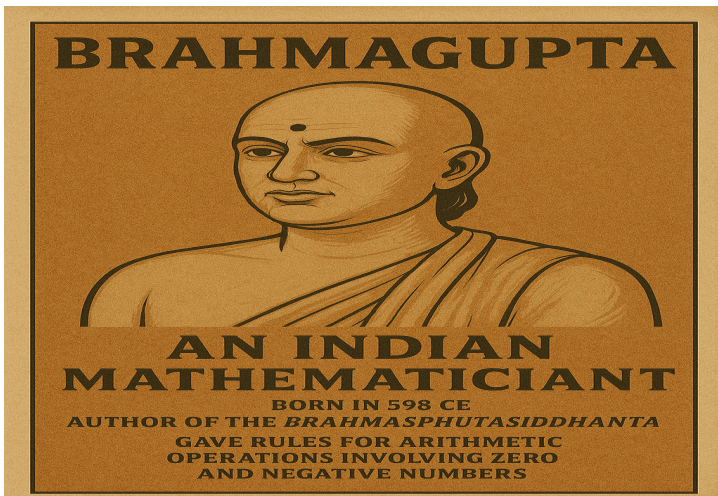
Example verse from *Aryabhatiya*:

“vargānāṃ samāsastryaḥ, ardhamūlam samāsam api”  
(Gives rules for summing squares and cubes).

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# Progressions and Series in Indian Mathematics

Brahmagupta (598–668 CE):

His work Brahmasphuṭasiddhānta gives formulas for:

Sum of the first  $n$  natural numbers.

Sum of squares and cubes:

$$\sum_{k=1}^n k = \frac{n(n+1)}{2}, \quad \sum_{k=1}^n k^2 = \frac{n(n+1)(2n+1)}{6},$$

$$\sum_{k=1}^n k^3 = \left( \frac{n(n+1)}{2} \right)^2$$

# Progressions and Series in Indian Mathematics

**Bhaskara II (1114–1185 CE):**

In Lilavati, Bhaskara II presented problems involving A.P. and G.P., often in poetic form with applications.

Gave explicit problems on series summation, using real-life contexts like distribution of pearls or coins.

**Example (from Lilavati):**

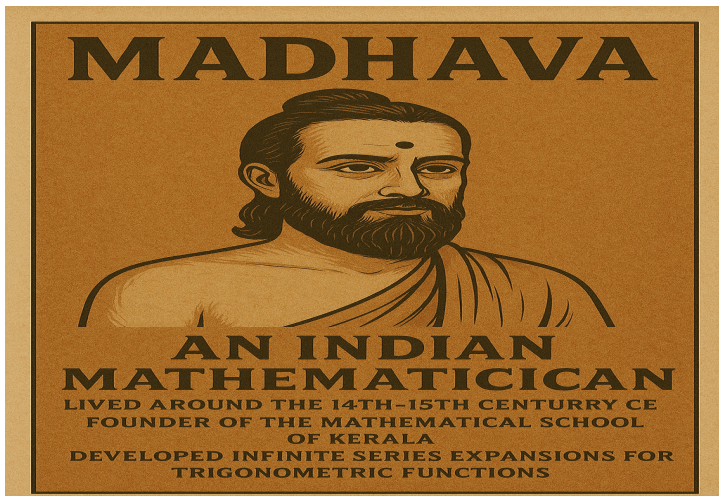
"A merchant gives one coin to the first person, two to the second, three to the third... How many coins in total to 20 people?"

Solved using:  $S_n = \frac{n(n+1)}{2} = \frac{20 \cdot 21}{2} = 210$  coins

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# Progressions and Series in Indian Mathematics

Madhava of Sangamagrama (c. 1350–1425 CE):

Founder of the Kerala School of Mathematics.

Developed infinite series expansions for:

- $\pi(pi)$
- Trigonometric functions like  $\sin x$ ,  $\cos x$ ,  $\arctan x$

Madhava's  $\pi$  series (centuries before Gregory and Leibniz):

$$\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \dots$$

This is the Leibniz series in Europe, but Madhava derived it first!

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## Summary of Key Contributions

Mathematician	Contribution to Progressions and Series
Sulba Sutras	Arithmetic series via geometry
Pingala	Binary series, combinatorics
Aryabhata	Sum of A.P., basic series
Brahmagupta	Sums of natural numbers, squares, cubes
Bhaskara	II Word problems involving A.P., G.P.
Madhava	Infinite series, especially for $\pi$ and sine

# Progressions and Series in Indian Mathematics

## Applications in Indian Context

Calendar calculations

Poetic meter analysis (chandas)

Architecture and temple design

Astronomy and planetary motion (Jyotisha)