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# Science and Technology in Indian Knowledge Systems

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## Abstract

The Indian Knowledge System (IKS) is not merely a collection of ancient traditions; it is a sophisticated framework of scientific inquiry that has guided the Indian subcontinent for millennia. IKS in science and technology comprises ancient Indian contributions—spanning Ayurveda, mathematics, astronomy, and metallurgy—integrated with modern research to foster innovation from the precise movement of celestial bodies to the complex alchemy of medicine. IKS represents a legacy where spirituality and empirical logic coexist. This initiative under the Ministry of Education promotes interdisciplinary studies in areas like sustainable architecture, traditional medicine, and advanced mathematics.

In IKS, astronomy was never just about gazing at stars; it was a rigorous mathematical discipline used for time reckoning. Long before modern calculus, the Sulva Sutras in Vedic mathematics laid the foundational stones for geometry and measurement. The Indian approach to health is holistic, combining Ayurveda (the science of longevity) with Rasa Shastra (ancient chemistry or latrochemistry). The most exciting contemporary development is the integration of IKS within Computer Science. We shall deal with these four aspects of IKS in detail.

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## INTRODUCTION

## KEY ASPECTS OF IKS IN SCIENCE & TECHNOLOGY

**The key aspects of IKS in Science & Technology are:**

- In Medicine & Health: Ayurveda, including Sushruta's advancements in surgery (cataract, plastic surgery) and the use of natural ingredients.
- In Mathematics & Astronomy: Development of the zero, decimal system, and precise calculations of planetary motion by scholars like Aryabhata and Bhaskaracharya.
- In Engineering & Architecture: Sustainable technologies, including traditional water management (stepwells), eco-friendly construction, and metallurgy
- In Modern Integration: The IKS division encourages applying traditional, eco-aware knowledge to contemporary problems, such as in agriculture, robotics, and design.

Even though Indian scientists produced immense works on science and technology, a major part of this knowledge system was orally transmitted through generations. These oral traditions percolated every aspect of Indian communities. However, the scientific reasoning behind a lot of these oral traditions and cultural practices was lost with time. Indian knowledge was branded primitive, simple and static during nineteenth century colonialism to undermine millennia of Indian cultural heritage. Integrating IKS into modern curricula through interdisciplinary research, experiential learning, and community engagement can enhance education by bridging traditional knowledge with contemporary scientific advancements.

## ASTRONOMY

In IKS, astronomy was never just about gazing at stars; it was a rigorous mathematical discipline used for time reckoning. Central to this is the study of nakṣatras (lunar mansions).

- Nakṣatra-based Time: By dividing the sky into 27 segments, ancient astronomers could track the moon's position with incredible precision.
- Calendar Systems: This paved the way for the *Panchang*, a complex calendar system that synchronises solar and lunar cycles, essential for agriculture and seasonal planning.

While Western astronomy eventually settled on the 12 signs of the Zodiac, IKS developed a more granular 27-part lunar mansion system known as Nakṣatras.

- Sidereal Focus: Unlike solar calendars, Nakṣatra-based reckoning tracks the Moon's path against the fixed stars. This allows for a precise measurement of the "Sidereal Month" (approximately 27.3 days).
- Mathematical Precision: Ancient astronomers like Aryabhata calculated the Earth's circumference and the length of a solar year with an error margin of less than 1%.
- Instruments: The *Yantra Mantra* (observatories) utilised massive stone structures to calculate planetary positions, eclipses, and declination without the aid of glass lenses.

In the Indian Knowledge System (IKS), astronomy—known as Jyotisha Vedanga was developed not just for stargazing, but as a precise mathematical tool for timekeeping (*Kala-vidhana*). It transitioned from the ritualistic observations of the Vedic period to the highly sophisticated planetary models of the Siddhantic era (5th century CE onwards).

The Coordinate Systems and Spherical Astronomy

Ancient Indian astronomers understood that the sky is spherical in shape; henceforth, they developed complex coordinate systems to track the different celestial bodies:

- The Celestial Equator (Vishuvad-vrita): They recognised the equator and the ecliptic (the Sun's path).
- The Precession of Equinoxes (Ayanamsha): Unlike many ancient cultures, IKS recognised that the positions of the equinoxes shift slowly over time. The Surya Siddhanta provides a rate for this "wobble" of the Earth's axis, essential for keeping the calendar aligned with the seasons.
- Spherical Trigonometry: To calculate the position of a planet on a curved sky, astronomers like Bhaskara II developed the concept of the Sine (*Jya*) and Cosine (*Kojya*), allowing them to convert spherical positions into linear coordinates.

### Planetary Models and Heliocentrism

While the Western world largely adhered to a static Geocentric (Earth-centred) model until Copernicus, Indian astronomers were experimenting with "Fluid Models":

- Aryabhata's Rotating Earth: In 499 CE, Aryabhata stated that the Earth is spherical and rotates on its own axis. He explained that the stars appear to move westward only because the Earth rotates eastward—an observation far ahead of its time.
- The Nilakantha Model: In the 15th century, Nilakantha Somayaji of the Kerala School proposed a "Semi-Heliocentric" model. In this system, the five planets (Mercury, Venus, Mars, Jupiter, and Saturn) orbit the Sun, while the Sun itself orbits the Earth. Mathematically, this is identical to the model Tycho Brahe proposed in Europe over a century later.

### The 27 Nakṣatras: The Lunar Highway

Instead of the 12-sign solar zodiac used in the West, IKS relies heavily on the 27 Nakṣatras (Lunar Mansions).

- Lunar Movement: Because the Moon takes approximately 27.3 days to orbit the Earth, the sky was divided into 27 segments. Each night, the Moon "rests" in a different Nakṣatra.
- Specific Identifiers: Each Nakṣatra is identified by a "junction star" (*Yoga-tara*). For example, the Nakṣatra *Chitra* is identified by the star Spica. This allowed for an incredibly precise "celestial clock" that farmers and sailors could use without complex tools.

### Instruments of Observation (Yantras)

Before the invention of the telescope, Indian astronomers used massive stone and metal instruments to achieve precision through scale.

- Gnomon (Shanku): A vertical rod used to measure the Sun's shadow. By observing the shadow's length and direction, they could determine the latitude of a place and the exact time of the solstices.
- Armillary Sphere (Gola-yantra): A wooden or metal model of the celestial sphere used to demonstrate the movement of planets and stars.
- Samrat Yantra: Found in observatories like the Jantar Mantar, this is a massive sundial capable of measuring time to an accuracy of two seconds. Its giant triangular gnomon points exactly to the North Pole.

**Concept of Cosmic Time (The Yuga System)**

Indian astronomy deals with "Deep Time." To calculate planetary positions accurately over long periods, they used the Mahayuga cycle (4,320,000 years).

By calculating how many full revolutions a planet makes in one Mahayuga, they could determine its position at any given second. For instance, the *Surya Siddhanta* states that the Moon revolves 57,753,336 times in a Mahayuga. This allows for an orbital period calculation that is accurate to several decimal places by modern standards.

## VEDIC MATHEMATICS

Long before modern calculus, the Sulva Sutras laid the foundational stones for geometry and measurement. These Sutras are ancient Sanskrit texts that form part of the *Kalpa Vedanga*, specifically the *Shrauta Sutras*. These texts were originally designed for the precise construction of sacrificial altars (*Vedi*). The Sulva Sutras (approx. 800–500 BCE) are the oldest known Indian mathematical texts. They weren't just theoretical; they were applied manuals for "stringing" or measuring ritual spaces.

- The Pythagorean Theorem: The Baudhayana Sulva Sutra contains a specific formulation of the theorem: "The areas produced separately by the length and the breadth of a rectangle together equal the area produced by the diagonal."
- Geometric Algebra: These texts provided methods for "squaring the circle" (and vice versa), i.e. constructing a circle with an area equal to a given square and constructing a square with an area equal to a given circle.
- Approximation of the square root of 2: The Baudhayana Sulba Sutra gives a remarkably accurate numerical value for the square root of 2. Baudhāyana gives the length of the diagonal of a square in terms of its sides, which is equivalent to a formula for the square root of 2:

"samasya dvikaraṇī. pramāṇaṃ tṛtīyena vardhayet tac caturthenātma catustriṃśonena saviśeṣaḥ, which means *Sama* – Square; *Dvikarani* – Diagonal (dividing the square into two), or Root of Two, *Pramanam* – Unit measure; *tṛtīyena vardhayet* – increased by a third, *Tat caturtena (vardhayet)* – that itself increased by a fourth, atma – itself; *Caturtrimsah savisesah* – is in excess by $34^{th}$ part

The diagonal of a square of unit measure is given by increasing the unit measure by a third, and that again by a fourth (of the previous amount). This by itself is in excess by a $34^{th}$ part (of the previous amount). That is,

$\sqrt{2} = 1 + 1/3 + ¼ (1/3) = 17/12$

This calculation results in 1.4142156..., which is correct to five decimal places.

- Algorithmic Speed: Modern "Vedic Math" uses 16 Sutras (aphorisms) to perform complex multiplication and division mentally, treating numbers as flexible entities rather than rigid digits.

The "algorithmic speed" of Vedic Mathematics comes from its ability to reduce complex, multi-step arithmetic into single-line answers. Unlike the traditional "long" methods taught in schools, these techniques utilise specific patterns (Sutras) that minimise mental load and the number of intermediate steps.

The 16 Sutras of Vedic Mathematics were reconstructed by Jagadguru Swami Bharati Krishna Tirthaji in the early 20th century. He claimed these word-formulae were derived from the *Atharva Veda*, providing a system that simplifies arithmetic, algebra, and geometry into mental patterns. Each Sutra (aphorism) acts as a mental shortcut or an "algorithm" for solving specific types of mathematical problems.

**The 16 Main Sutras**

| # | Sanskrit Sutra | English Translation | Primary Application |
|---|---|---|---|
| 1 | ***Ekadhikena Purvena*** | By one more than the previous one | Squaring numbers ending in 5; Fractions. |
| 2 | ***Nikhilam Navatashcaramam Dashatah*** | All from 9 and the last from 10 | Subtraction from powers of 10; Multiplication. |
| 3 | ***Urdhva-Tiryakbhyam*** | Vertically and Crosswise | General multiplication; Division. |
| 4 | ***Paravartya Yojayet*** | Transpose and Apply | Solving linear and quadratic equations. |
| 5 | ***Sunyam Samyasamuccaye*** | When the Sum is the same, it is zero | Solving complex algebraic equations. |
| 6 | ***(Anurupye) Shunyamanyat*** | If one is in ratio, the other is zero | Solving simultaneous equations. |
| 7 | ***Sankalana-vyavakalanabhyam*** | By Addition and by Subtraction | Solving simultaneous linear equations. |
| 8 | ***Puranapuranabhyam*** | By the Completion or Non-completion | Cubing; Solving higher-order equations. |
| 9 | ***Chalana-Kalanabhyam*** | Differences and Similarities | Calculus; Factoring quadratics. |
| 10 | ***Yavadunam*** | Whatever the Extent of its Deficiency | Squaring numbers near a base (e.g., $96^2$). |
| 11 | ***Vyashtisamashtih*** | Part and Whole | Factoring polynomials. |
| 12 | ***Shesanyankena Gena*** | The Remainders by the Last Digit | Converting fractions to decimals. |
| 13 | ***Sopantyadvayamantyam*** | The Ultimate and Twice the Penultimate | Solving specific algebraic forms. |
| 14 | ***Ekanyunena Purvena*** | By one less than the previous one | Multiplication by 9, 99, 999, etc. |
| 15 | ***Gunitasamuccayah*** | The Product of the Sum is the Sum of the Product | Verifying answers (Digit Sum method). |
| 16 | ***Gunakasamuccayah*** | The Factors of the Sum are the Sum of the Factors | Factorisation of polynomials. |

Here are some of the most effective algorithms for high-speed calculation:

**1. Urdhva-Tiryakbhyam (Vertically and Crosswise)**
This is the "master algorithm" for multiplication. It works for any number of digits and eliminates the need for large partial products.

- **The Logic:** You multiply digits vertically and then crosswise, adding the results as you go.
- **Speed Advantage:** You can write the answer from right to left (or left to right) in a single row without needing multiple lines of scratch work.

**1. Nikhilam Navatashcaramam Dashatah**
"All from 9 and the Last from 10". This algorithm is incredibly fast when multiplying numbers close to a power of 10 (e.g., 98 x 97 or 103 x 105).

**How it works:**

1. Find the "deficiency" (how far the numbers are from the base, like 100).
2. Subtract the deficiency of one number from the other number crosswise.
3. Multiply the deficiencies together for the second half of the answer.

**Example (97 x 96):**
Deficiencies are 3 and 4.

- 97 - 4 = 93 (First part of answer).
- 3 times 4 = 12 (Second part of answer).
- Result: 9312.

**3. Ekadhikena Purvena** (By One More than the Previous). This is a "special case" algorithm used for squaring numbers ending in 5. It reduces a squaring operation to a simple 2-second mental task.

- **Algorithm:** Multiply the first digit by "itself + 1" and then simply append 25.
- **Example (65 x 25):**
- Take the first digit (6) and multiply by 7 (6 times 7 = 42).
- Append 25.
- Result: 4225.

From a computer science or cognitive load perspective, these methods are much faster and offer the following features:

1. **Reduced Space Complexity:** You don't need much "paper space" to hold intermediate values.
2. **Parallel Processing:** Because many steps are independent, you can often calculate different parts of the answer simultaneously in your head.
3. **Error Checking:** Many Vedic Sutras have built-in "digit sum" checks (Navashesh) that allow you to verify the accuracy of a calculation instantly.

## THE DIGITAL FRONTIER: IKS IN COMPUTER SCIENCE

Perhaps the most exciting contemporary development is the integration of IKS within **Computer Science**. The structured nature of ancient Indian linguistics and logic offers a goldmine for modern technology.

- ***Natural Language Processing (NLP):*** Panini's *Ashtadhyayi* (a Sanskrit grammar treatise) is often cited as the world's first formal language system, sharing a strikingly similar structure to the Backus-Naur Form used in modern programming.
- ***Algorithms*:** Ancient Indian logic (*Nyaya*) and the binary-like patterns found in classical prosody (Pingala's *Chandaśāstra*) are being researched to improve algorithmic efficiency and data structures. Pingala used a system of "Laghu" (light/0) and "Guru" (heavy/1) syllables to classify poetic meters (Matra Meru). His *Matra Meru* is the earliest known version of what we now call Pascal's Triangle, used in probability and computer algorithms today. He developed algorithms to calculate permutations of these syllables, effectively creating a binary representation of numbers.

The intersection of IKS and Computer Science is one of the most active areas of modern research, specifically in

**Linguistics** and **Logic**.

- ***Paninian Grammar*:** Panini's Sanskrit grammar (*Ashtadhyayi*) uses a "meta-language" of 4,000 rules. NASA researcher Rick Briggs famously noted that Sanskrit's structure is so logical and unambiguous that it is an ideal "natural language" for **Artificial Intelligence** and machine translation.
- ***Binary and Combinatorics*:** The mathematician **Pingala** (c. 3rd century BCE), while analysing Sanskrit poetry meters, stumbled upon the structures of **Binary Numbers** and what we now call **Pascal's Triangle** (*Meru Prastara*).
- ***Knowledge Representation*:** The *Navya-Nyaya* school of logic developed a technical language to express complex conceptual relations. Today, this is being mapped to **Semantic Web** technologies and knowledge graphs to help computers "understand" relationships between data points.

Today, IKS is being revived not as a replacement for modern science, but as a "validation layer." Whether it's using Ayurvedic compounds for modern drug discovery or applying Vedic algorithms to optimise data encryption, the integration is about efficiency and holistic thinking.

## CONCLUSION

The study of Indian Knowledge Systems (IKS) reveals that ancient Indian science was not merely a collection of s piritual beliefs, but a rigorous, empirical and highly structured approach to understanding the physical world. By integrating these four key domains, we can draw the following conclusions:

The **Sulva Sutras** and **Vedic Mathematics** prove that India had a sophisticated understanding of geometry and arithmetic long before the European Renaissance. These texts provided the foundational logic—such as the Pythagorean theorem and binary systems—that underpins modern mathematical thought.

The study of **Astronomy and Nakshatra-based time reckoning** highlights incredible precision in observing celestial bodies. This was not just for ritual, but for developing accurate calendars, agricultural cycles, and navigational tools, showing a deep connection between human life and the rhythms of the universe.

Perhaps most importantly, the **Integration of IKS in Computer Science** shows that this knowledge is not "primitive." From Panini's formal grammar (NLP) to Pingala's binary patterns, IKS provides the logical architecture required for modern artificial intelligence and computational linguistics.

In summary, IKS serves as a bridge between the ancient and the modern. It encourages a **holistic scientific temper**—one that seeks to advance technology without losing sight of biological balance and natural harmony. For a modern learner, IKS offers a unique perspective: it proves that the roots of our digital and medical future are deeply embedded in our historical past.

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