A Brief Account of Pre-Twentieth Century Science in India

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A List of Topics

- Medical Sciences.
- Science in the Vedic Period.
- Jaina Mathematics.
- Classical Period.
- Kerala Mathematics.

- Early Indian contribution to astronomy has been briefly mentioned earlier.
- Source: Wikipedia.



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Ayurveda: Medical Sciences

- Originates from Atharvaveda.
  - Contains 114 hymns for the treatment of diseases.
  - Legend: Dhanvantari obtained this knowledge from Brahma.
- Fundamental and applied principles were organised around 1500 BC.
- Texts.
  - Sushruta Samhita attributed to Sushruta.
  - Charaka Samhita attributed to Charaka.



Sushruta Samhita of Sushruta

- The book as it survives dates to 3rd or 4th century AD. It was composed sometime in the first millennium BC.
- 184 chapters, descriptions of 1120 illnesses, 700 medicinal plants, 64 preparations from mineral sources and 57 preparations based on animal sources.
- Plastic and cataract surgery and other surgical procedures.
- Anaesthetic methods.
- Other specialities: medicine; pediatrics; geriatrics; diseases of the ear, nose, throat and eye; toxicology; aphrodisiacs; and psychiatry.



Charaka Samhita of Charaka

- Maurya period (3rd to 2nd century BCE).
  - Work of several authors.
  - Charaka: wandering religious student or ascetic.
- 8 sections and 120 chapters.
- Scientific contributions.
  - A rational approach to the causation and cure of disease.
  - Introduction of objective methods of clinical examination.



Science in the Vedic Period

- Use of large numbers: numbers as high as 10^{12} appear in Yajurveda (1200-900 BCE).
- Sulba sutras.
  - Rules for the construction of sacrificial fire altars.
  - Altar: five layers of burnt brick; each layer consists of 200 bricks; no two adjacent layers have congruent arrangements of bricks.
- Baudhayana Sulba Sutra (c. 8th century BC).
  - Statements of the Pythgorean theorem and examples of simple pythagorean triplets.
  - A formula for the square root of two (accurate up to 5 decimal places).

$$\sqrt{2} = 1 + \frac{1}{3} + \frac{1}{3 \cdot 4} - \frac{1}{3 \cdot 4 \cdot 34}.$$

  - Statements suggesting procedures for 'squaring the circle' and 'circling the square'.
- Manava Sulba Sutra (c. 750-650 BC) and the Apastamba Sulba Sutra (c. 600 BC).
  - Contains results similar to those in Baudhayana Sulba Sutra.



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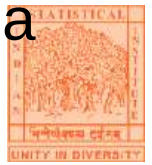


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Science in the Vedic Period

Panini (c. 4th century BC).

- Ashtadhyayi: 3959 rules (and 8 chapters) of Sanskrit morphology, syntax and semantics.
  - Comprehensive and scientific theory of grammar.
  - Earliest known work on descriptive linguistics and generative linguistics.
  - Describes algorithms to be applied to lexical lists (Dhatupatha, Ganapatha) to form well-formed words.
  - Generative approach: concepts of the phoneme, the morpheme and the root.
  - Focus on brevity gives a highly unintuitive structure.
  - Use of sophisticated logical rules and techniques.



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Science in the Vedic Period: Panini

- Relation to modern linguistics.
  - Influenced works of many eminent modern linguistics.
  - Panini's grammar can be considered to be the world's first formal system.
  - Notion of context-sensitive grammars and the ability to solve complex generative processes.
  - Use of auxiliary symbols to mark syntactic categories and control grammatical derivations.
    - Used in formal grammar to describe computer languages.

"The first generative grammar in the modern sense was Panini's grammar."

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Jaina Mathematics (400-200 BC)

- Freed Indian mathematics from religious and ritualistic constraints.
- Enumeration and classification of very large numbers.
  - Enumerable, innumerable and infinite.
- Five different types of infinity:
  - infinite in one direction, infinite in two directions, infinite in area, infinite everywhere, and the infinite perpetually.
- Notations for simple powers (and exponents) of numbers like squares and cubes.



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- Were the first to use the word shunya.
- Pingala (c. 300-200 BC) composed Chandah-shastra:
  - A treatise on prosody.
  - Developed mathematical concepts for describing prosody.
  - Credited with developing the first known description of a binary number system.
  - Evidence of Binomial coefficients and Pascal's triangle in his work.
  - Basic ideas of Fibonacci numbers.



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Classical Period (400-1200 AD)

- Golden age of Indian mathematics.
- Major mathematicians: Aryabhata, Varahamihira, Brahmagupta, Bhaskara-I, Mahavira, and Bhaskara-II.
- Broader and clearer shape to many branches of mathematics.
- Contributions spread to Asia, the Middle East, and eventually to Europe.
- Tripartite division of astronomy: mathematics, horoscope and divination.
- Mathematics was included as part of astronomy.
  - Unlike Vedic times.



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Classical Period: Fifth and Sixth Centuries

- Surya Siddhanta (c. 400 AD): authorship unknown.
  - Roots of modern trigonometry: Sine (Jya), Cosine (Kojya), Inverse Sine (Otkram jya); earliest uses of Tangent and Secant.
- Earliest known use of the *modern, i.e., base 10,* place-value numeral system.
  - In a legal document dated 594 AD (Chhedi calendar: 346).
  - Arose due to fascination of Indians with large numbers.
  - Transmitted to the Arabs and thence to Europe.
  - (Babylonians (19th century BC) had a place-value system (in base 60).)

"The ingenious method of expressing every possible number using a set of ten symbols (each symbol having a place value and an absolute value) emerged in India. The idea seems so simple nowadays that its significance and profound importance is no longer appreciated.

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  - Continued fractions; simultaneous quadratic equations; solutions of linear equations; formula for sum of cubes.
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Classical Period: Seventh and Eighth Centuries

- Pati-ganit and Bija-ganit: separation of mathematics into two branches.
- Brahmagupta: Brahma Sphuta Siddhanta (628 AD).
  - Two chapters (12 and 18) on mathematics.
  - Basic operations: cube roots, fractions, ratio and proportion.
  - Theorem on cyclic quadrilaterals; formula for area of a cyclic quadrilateral (generalization of Heron's formula); complete description of rational triangles, i.e., triangles with rational sides and areas.
  - Rules for arithmetic operations involving zero and negative numbers.
    - Considered to be the first systematic treatment of the subject.
  - Solution of quadratic equation.
  - Progress on finding integral solution to Pell's equation: $x^2 - Ny^2 = 1$.
- Bhaskara I (c. 600-680): indeterminate equations, trigonometry.



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- Virasena (9th century): Jain mathematician – composed Dhavala.
  - Ardhaccheda: number of times a number can be halved – log to base 2 – and related rules.
  - Trakacheda, Caturthacheda: log to bases 3 and 4.
- Mahavira Acharya (c. 800-870 AD): Ganit Saar Sangraha.
  - Numerical mathematics, area of ellipse and quadrilateral inside a circle; empirical rules for area and perimeter of an ellipse.
  - Algebra: non-existence of the square-root of a negative number; solution of cubic and quartic equations; solutions of some quintic equations and higher-order polynomials.
- Shridhara Acharya (c. 870-930 AD): wrote Nav Shatika, Tri Shatika and Pati Ganita.
  - Volume of a sphere; solution of quadratic equations.
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- Manjula (10th century).
  - Elaboration of Aryabhata's differential equations.
- Aryabhata-II (c. 920-1000 AD): Maha-Siddhanta which discusses numerical mathematics, algebra and solutions of indeterminate equations.
- Shripati Mishra (1019-1066 AD): Siddhanta Shekhara, Ganit Tilaka
  - Permutations and combinations; general solution of the simultaneous indeterminate linear equation.
  - Wrote other works on astronomy: solar and lunar eclipse; planetary longitudes; planetary transits.



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  - Interest computation; arithmetical and geometrical progressions; plane geometry; solid geometry; a proof for division by zero being infinity.
  - The recognition of a positive number having two square roots; surds; solutions of multi-variate quadratic equations; chakravala method for solving general form of Pell's equations;
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  - Discovered the derivative; derived the differential of the sine function; stated Rolle's theorem; computed π, correct to 5 decimal places; calculated length of Earth's revolution to 9 decimal places.
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Kerala Astronomy and Mathematics (1300-1600 AD)

- History.
  - Founded by Madhava of Sangamagrama.
  - ‘Tantrasangraha’ by Neelakanta and a commentary on it of unknown authorship.
- Most important discoveries: series expansion of certain trigonometric functions.
  - Several centuries before calculus was developed.
  - Cannot be said to have invented calculus; did not develop a theory of differentiation or integration.
- An intuitive notion of limit.
- Intuitive use of mathematical induction.
  - No proper use of the inductive hypothesis in proofs.
- Theorems were stated without proofs.
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