# Mathematics In Ancient India

**by Manjil Saikia - Sunday, April 17, 2011**

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The development of human civilization is accompanied by the development of mathematics. For civilization to flourish, stability in society and in thoughts of people is most essential. Stability in thoughts comes only with the knowledge of mathematics. At the dawn of civilization, stable thoughts express themselves in the form of mathematics. Later as the civilization prosper; the knowledge of mathematics is used in the daily life of the people. The earliest mathematical concepts developed are ***(i) the concept of form and shape, (ii) the concept of counting and numbers and (iii) the concept of measure or magnitude***. Some of the marvelous architectures of ancient world can be considered as the gifts of mathematics and geometry. The Pyramids of Egypt, Hanging garden of Babylon, the Colosseum of Rome are some examples of ancient architecture built with the aid of mathematical calculation and geometrical diagrams.

Tracing back to history, we find earliest human civilization flourish along the river valley of **Nile**, the river valley of **Tigris and Euphetris**, the river valley of **Hwang Ho and Yangtze** and the river valleys of **Indus and Ganges**. The history of mathematics in India takes us back to the days of **Indus valley Civilization** which existed around 3000 BCE to 1500 BCE. The Indus Valley Civilization with its prominent centre's in **Harrapa** and **Mohenjadaro** provides archeological evidence of well planed towns and cities with proper drainage system, public bath, buildings made of bricks and wide roads. Excavation in Harappa and Mohenjo-Daro, provide evidence that construction of buildings followed a standardized measurement which was decimal in nature. This civilization had an advanced brick-making technology and the mathematical ideas were developed for the purpose of construction.

After the decline of Indus Valley Civilization, the **Aryans** came to India around 1500 BCE. The religious texts of Aryans prominently the four Vedas provides evidence of use of large numbers. Many Slokas related to mathematics can be found in the religious texts of vedic period. From these text books one can know that the people of that time posses a high level of knowledge in the field of astronomy. In **Rig Veda** it is mentioned that the priest from the house of **Aatri Rishi** could successfully predict the date of Solar Eclipse. In **Yajur Veda** it is mentioned that the duration of a year is more than 365 days but is less than 366 days. From astronomical point, it was an important discovery and shows how the knowledge of mathematics was used in the field of astronomy in early Vedic period.

Another major source of mathematics in Vedic periods are the **Shulba Sutras**. Literally it means "***Aphorisms of the Chords***" in Vedic Sanskrit. These texts dated around 800 BCE to 200 BCE. The four major Shulba Sutras are composed by **Baudhayana** (600 BCE), **Manava** (750 BCE), **Apastamba** (600 BCE), and **Katyayana** (200 BCE). The Shulba Sutras are Sutra texts belonging to the Srauta ritual and containing geometry related to fire altar constructions, which have different shapes but occupy the same area. The Shulba Sutras provides evidence that the Indian mathematicians of that time were aware of **Pythagorean theorem** and **Pythagorean Triples**. The Shulba Sutras introduce the concept of irrational numbers, numbers that are not the ratio of two whole numbers. For example, the square root of 2 is one such number. The sutras give a way of approximating the square root of number using rational numbers through a recursive procedure. Around 500 BCE, the work of Sanskrit grammarian, **Panini** includes early use of **Boolean logic**, of null operator, and of context free grammars and also includes precursor of the **Backus-Naur form** which is used to describe the syntax of language used in computing, such as computer programming languages, document formats, instruction sets and communication protocol.

During this period **jaina** mathematicians also developed many mathematical ideas. The jaina mathematicians classified the numbers into three classes namely **enumerable, innumerable** and **infinite**. This in turn, led to the development of the notion of ***orders of infinity*** as a mathematical concept. By orders of infinity, we mean a theory by which one set could be deemed to be 'more infinite' than another. The even define five different types of infinity***: the infinite in one direction, the infinite in two directions, the infinite in area, the infinite everywhere and the infinite perpetualy***. Jaina mathematicians were also the first to use the word **Shunya** to refer to Zero.

In 326 BCE **Alexander of Macedonia** invaded India. Apart from its political consequences, during this period Greek mathematicians came in contact with Indian mathematicians which resulted in transfer of knowledge between both sides. Two books on astronomy named **Jyotish Vedanga** and **Surya prajnapti** composed during the rule of **Mauryan Dynasty** throw some lights on this interchange of mathematical knowledge between Indian and Greek mathematicians. Though the books are written in Sanskrit, some of the mathematical terms are imported from Greek language. During this era, another notable scholar who contributed to mathematics is **Pingala**. Pingala was a musical theorist who authored **Chandas Shastra**, a Sanskrit treatise on Prosody. He developed advanced mathematical concepts for describing prosody and in that process, he presented the first known description of binary numeral system. Pingala's work contains basic knowledge of ***Pascal Triangle*** and ***binomial coefficients***. His works also contains the basic ideas of ***Fibonacci numbers*** and it seems Pingala was aware of ***combinatorial identity***.

After the decline of Mauryan Empire, India witnessed major political instability. No major works on mathematics are found until the rise of **Gupta Empire** in 320 CE. The period between 400 CE to 1200 CE is considered as the classical period of Indian mathematics. The period saw mathematicians such as **Aryabhata, Varahmihira, Brahmagupta, Bhaskara I, Mahavira** and **Bhaskara Acharaya** or **Bhaskara II**. During this period, the decimal place value system and the invention of zero took place in India. Indian mathematicians' biggest invention was the use of zero as a placeholder, to make it easier to add and multiply numbers. Our word "zero" comes from the Sanskrit word meaning "nothing". During this period, two centers of mathematical research emerged, one at **Kusumapura** near Pataliputra and the other at **Ujjain**. **Aryabhata** was the dominant figure at Kusumapura. His fundamental work, the Aryabhatiya, set the agenda for research in mathematics and astronomy in India for many centuries. In his book **Aryabhatiya**, he proposed many mathematical theorems and methods. The linear equations mentioned in Aryabhatiya are of interest in computational number theory and are of fundamental importance in cryptography, in modern times. He also approximated the value of **Pie to four decimal places (3.14146)**. Aryabhatiya also contain Aryabhata's work on trigonometry, including his tables of values of the sine function as well as algebraic formulate for computing the sine of multiples of an angle.

The other major centre of mathematical learning during this period was **Ujjain**, which was home to Varahamihira, Brahmagupta and Bhaskaracharya. **Varahamihira** (505–587 CE) produced the **Pancha Siddhanta** (The Five Astronomical Canons or Principles) namely **Surya Siddhanta, Poulisha**

**Siddhanta, Bashishista Siddhanta, Poitamaha Siddhanta** and **Rumanka Siddhanta**. He made important contributions to trigonometry, including sine and cosine tables to 4 decimal places of accuracy.

In 628 CE, **Brahmagupta** wrote a book on astronomy**, Brahma-sphuta-siddhanta** explaining how zero worked, with rules like "*The sum of zero and zero is zero*" and "*The sum of a positive and a negative is their difference; or, if they are equal, zero*". He also stated his famous theorem on the diagonals of a cyclic quadrilateral that "***If a cyclic quadrilateral has diagonals that are perpendicular to each other, then the perpendicular line drawn from the point of intersection of the diagonals to any side of the quadrilateral always bisects the opposite side".***

**Bhaskara I** (600–680 CE) expanded the work of Aryabhata in his books titled **Mahabhaskariya, Aryabhatiya-bhashya** and **Laghu-bhaskariya**. He produced solutions of indeterminate equations and formula for calculating the sine of an acute angle without the use of a table, correct to two decimal places.

**Mahavira Acharya** (800–870 CE) a notable mathematician from Mysore in Karnataka, wrote a book titled **Ganit Saar Sangraha** on numerical mathematics, and also wrote treatises about a wide range of mathematical topics.

The Classical period of Indian mathematics came to an end with **Bhaskara Acharya** or **Bhaskara II**, who was an mathematician- astronomer from Ujjain around 1114 CE to 1185 CE. His works on mathematics are known as **Siddhanta Shiromani**. Siddhanta Shiromani is divided into four parts named as **Lilavati, Bijaganita, Gola Addhaya and Graha Ganita**. He named one of the treatises after his daughter **Lilavati** whom he loved very much. His contributions include computed **Pie(?) correct to 5 decimal places**, calculated **the length of the Earth's revolution around the Sun to 9 decimal places**, the solutions of the **general form of Pell's equation** using the chakravala method, **gave a proof for division by zero being infinity** and numerous another mathematical and geometrical formulas and solutions which earned him a place of great respect in the world of mathematics till this day.

After the Arabs and Turkish invaded India, these knowledge of ancient Indian mathematics specially the **knowledge of Zero** spread quickly from India to West Asia and Africa and then later during the wars of Crusades, these knowledge finally reached the Christian Europe around 1200 CE. It will be not wrong to claim that it is the mathematicians of ancient India who taught the world how to count properly and laid the foundation of all the scientific inventions of the modern world.

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