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The History of Mathematics: A Special Focus on 7th Century CE. - 12th Century CE.

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Article History

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Abstract

This document delves into the extensive history of mathematics, particularly emphasizing developments from the 7th to the 12th centuries CE. It explores the contributions of prominent Indian mathematicians such as Aryabhata, Bhaskaracharya, and Brahmagupta, highlighting their advancements in arithmetic, algebra, trigonometry, and mathematical astronomy. The text also examines the evolution of mathematical concepts like the decimal number system and the concept of zero. Additionally, it provides an overview of mathematical traditions from prehistory, Vedic, and Jaina traditions, and discusses the significant impact of the Bakhshali Manuscript on the development of number systems. Through these historical narratives, the document illustrates the profound influence of Indian mathematics on both regional and global mathematical thought.

Keywords: Mathematics, Decimal, Number System, Algebra, Arithmetic

Introduction

Mathematics is the discipline that investigates concepts like quantity (numbers), organization, spatial relationships, and transformation. The Baudhayana, Katyayana, Pingala, Aryabhatta, Varahamihira, Yativrsabha, Brahmagupta, Bhaskaracharya I, Shridhara, Mahavira, Pavuluri Mallana, and Bhaskaracharya II are Indian mathematicians whose contributions have achieved immortality. Examples of mathematical concepts include the decimal number system, the concept of zero as a number, negative numbers, arithmetic, algebra, trigonometry, and so on. Mathematical works in ancient and Medieval India were primarily created in Sanskrit, namely consisting of sutras that described a series of rules or problems.

1. Prehistory Mathematics
2. Vedic Mathematics
3. Mathematics from the Jaina tradition
4. Development of the number system and numeral
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Pre-history Mathematics

Certain early cultures have a limited vocabulary consisting only of terms for “one”, “two”, and “many”. Aside from fingers, sticks and stones were commonly used as implements for counting. Archaeological artifacts dating back to 20,000-35,000 BC, were used for counting and consisted of bones with incisions [1].

Numeral Systems

The earliest civilizations, including Sumer in Mesopotamia, Egypt, and Minoan in Crete, may be traced back to the period between 3500 and 4000 BC. A uniform system was necessary to facilitate calculations and depict the results for trade, city management, and the measurement of size, weight, and time. The Sumerian Systems of Measures and Calendars may be traced back to around 4000BC [2]. Ancient civilizations developed specialized clay tokens to tally the number of sheep, days, and various other objects. Each type of object was counted using distinct tokens, frequently employing separate counting methods.

During the year 3000 BC, the city of Uruk utilized over twelve distinct counting methods. The Abacus, an instrument for computation, was invented. Subsequently, with the advent of a writing method that included impressing cuneiform symbols onto clay tablets using a reed stylus, the Sumerians also developed a numbering system known as sexagesimal, which is based on the number 60 (not to be confused with the hexadecimal system, which is based on 16). Currently, the Sumerian system is employed to measure time (hours, minutes, and seconds) as well as geographic coordinates. The sign value system was eventually converted into a place-value system. In place value systems, symbols are assigned varying magnitudes based on their position within the number.

Babylonian Numerals

Originally, a system based on the value of signs underwent a gradual transformation into a system based on the value of positions. In positional systems, the symbols used remain the same but their value varies depending on their position within the number.

Egyptian Numerals (2000 BC)

The Egyptian number system, which emerged around 2500-3000 BC, is decimal in nature as it is based on powers of 10. However, since it is a sign-value system, distinct symbols are employed for numbers such as 10, 100, 1000, and so on.

Vedic Mathematics

The Sulvasutras, essential texts from the Vedic period, encapsulate a wealth of mathematical knowledge. These works were designed to provide precise guidance on the principles and methods of constructing vedis (altars) and agnis (fireplaces) essential for performing yojnas, integral rituals in Vedic civilization [3].The fireplaces were constructed in various forms, including falcons, tortoises, chariot wheels, circular troughs with handles, and pyres, tailored to the specific yojna's context and purpose. Typically, these fireplaces measured around 20 to 25 feet in length and width.

Additionally, the Sulvasutras contain detailed instructions on building platforms for these fireplaces using tiles of moderate sizes and straightforward shapes like squares and triangles, occasionally incorporating special shapes such as pentagons. Some vedis, particularly those used during special events, had dimensions ranging from 50 to 100 feet. Creating these structures required the ability to draw perpendicular lines, a skill achieved through methods still taught in schools today. This involved ensuring the perpendicularity of the line connecting the centers of two intersecting circles with the initial line connecting the two points of intersection, as well as utilizing the converse of the Pythagorean theorem. An explicit statement of the Pythagorean theorem is present in all four major Sulvasutras, indicating the individuals' familiarity with this principle.[4]

The Sulvasutras also explain several geometric principles and constructs, such as methods for transforming a square into a circle with the same area and vice versa, along with a close approximation of the square root of two. Notably, the Sulvasutras, like other Vedic knowledge, were conveyed exclusively through oral tradition over an extended period, ensuring their preservation and transmission across generations.

Mathematics from the Jainism Tradition

Within Jainism, there is a longstanding tradition of engaging deeply with mathematics. Unlike other traditions where mathematical inquiry was inspired by ritualistic needs, Jain scholars were driven by profound reflection on the cosmos. They developed a sophisticated understanding of cosmography [5], envisioning the universe as a flat plane composed of concentric annular regions. At the center of this cosmography lies Jambudvipa, a circular area with a diameter of 100,000 yojanas. Surrounding Jambudvipa are alternating rings of water and land, with each successive ring doubling in width.

This Jain cosmographic model, which also appears in the Puranas, emphasizes the geometry of circles, significantly influencing philosophical and mathematical discussions. The discussions often included the philosophical implications of these geometric forms, underscoring the interconnectedness of their worldview and mathematical concepts. Even though the primary participants in these debates were philosophers, their engagement with the geometry of circles reveals the profound impact of mathematical thinking on Jain cosmography.One significant characteristic of the Jainism tradition is its rejection of the old notion that the ratio of the circumference to the diameter is 3. The text Suryaprajnapti acknowledges the conventional value of 3 but rejects it in favor of a different value. From ancient times, the Jainas were cognizant of the fact that the ratio of the area of a circle to the square of its radius is equal to the ratio of the circumference to the diameter. In addition, they possessed intriguing approximation equations for calculating the lengths of circular arcs and the areas they include, together with the accompanying chord. The process by which they derived this formula remains unknown. Jainism literature contains detailed discussions on mathematical themes such as permutations and combinations, sequences, and categorization of infinities. The practice of mathematics in the Jainism tradition resurfaced in the 8th century and likely persisted until the mid-14th century. The Ganitasara sangraha, authored by Mahavira in 850, is a renowned piece of literature in this domain. Virasena, Sridhara, Nemicandra, and T. hakkura Pheru are notable figures in the development of mathematics in the Jaina canon. Virasena lived in the 8th century, Sridhara between 850 and 950, Nemicandra around 980 CE, and T. hakkura Pheru in the 14th century. Virasena provided an estimate for the value of ? by multiplying the diameter by sixteen, adding 16, and then dividing the result by 113. He also stated that multiplying the diameter by three gives a good approximation for the circumference. The formula's inclusion of 16 is peculiar, as the author should have been aware that the circumference is directly proportionate to the diameter. Adding 16, regardless of the diameter's magnitude, contradicts this principle. By disregarding that aspect (based on what rationale?), the value of ? can be determined as 3 + 113 16 = 355 113, which is a highly satisfactory approximation, as emphasized by the author's description of it as a precise value with seven significant figures. Chong Zhi, a Chinese mathematician, established the identical formula during the 5th century. We are elucidating the Indian mathematicians from the ancient era of India and their significant contributions.

Baudhayana, born around 800 BCE, is renowned for his work in mathematics, particularly his approximation of the square root of 2 and his formulation of an early version of the Pythagorean Theorem. Moving forward in time, Katyayana, who lived around 300 BCE, made significant contributions through his work on the Varttika, Vyakarana, and the later Sulba Sutras. Pingala, born around 500 BCE, is credited with the development of the Matrameru, the binary numeral system, and the arithmetical triangle.

Aryabhata, who flourished between 476-550 CE, made groundbreaking contributions in astronomy and mathematics, including his works the Aryabhatiya and Arya-siddhanta. He offered explanations for lunar and solar eclipses, proposed that the Earth rotates on its axis, and made accurate calculations of the value of π and the circumference of the Earth. Varahamihira, living between 505-587 CE, is notable for his influential texts, the Pancha-Siddhāntikā, Brihat-Samhita, and Brihat Jataka.

In the 6th century CE, Yativrsabha authored the Tiloyapannatti, which introduced various units for measuring distances and time and explored concepts of infinity. Brahmagupta, born between 598-670 CE, made seminal contributions to mathematics, including the introduction of zero and advancements in the modern number system, as well as several theorems and identities bearing his name.

Bhaskaracharya I, who lived between 600-680 CE, is known for his sine approximation formula.

Shridhara, active between 650-850 CE, provided a rule for calculating the volume of a sphere. In the 9th century CE, Mahavira's work on algebra was highly syncopated, emphasizing the development of techniques for solving algebraic problems.

In the 11th century CE, Pavuluri Mallana translated the mathematical treatise Ganitasara Samgraham by Mahivaracharya into Telugu as Sara Sangraha Ganitamu. Finally, Bhaskaracharya II, who lived from 1114-1185 CE, is celebrated for discovering the principles of differential calculus and applying them to solve astronomical problems and computations.

Development of the Number System and Numerals

The investigation of the evolution of the numerical system in India encompasses the Vedic, Jaina, and Buddhist traditions. India has had a long-standing obsession with high numbers, as evidenced by the Vedic and Jaina traditions discussed in previous sections [6]. In the Buddhist tradition, there are significant numerical values, and Buddha himself was known for his exceptional mathematical abilities. One such example is the term "Tallaks.han.a," which represents the number 1053. The designations for powers of 10 varied across different traditions and time periods. For example, the term "Parardha," which originally denoted "halfway to heaven," represented 10^12 in early literature but was later used to represent 10^17 in works by Bhaskara II. The utilization of various powers of 10 in oral tradition likely had a significant impact on the development of decimal representation in written form, particularly during the early centuries of the Common Era.

The Mathematical Astronomy Tradition

The Siddhanta, also known as the mathematical astronomy tradition, has been the prevailing branch of mathematics in India. It has maintained a continuous and prosperous tradition for nearly a millennium, commencing around the third or fourth centuries. Aryabhatta (476 - 550) is considered the pioneer of scientific astronomy in India and is widely recognized as the first prominent figure in this field. The Siddhanta tradition persisted until the time of Bhaskara II (1114 - 1185), who is widely regarded as the final prominent figure in its lineage. The earliest fully preserved composition among the Siddhanta works is Arya Bhatt's written in 499. It is fundamental to the tradition and contains procedures for determining square roots and cube roots, an approximate value for π, formulas for calculating areas and volumes of different geometric shapes, as well as formulas for calculating sums of consecutive integers and sums of squares.

Nature of Mathematics

Initially, our approach to nature is focused on describing its characteristics. However, as our understanding deepens and we recognize the connections between different elements, we start to develop a Mathematical Model to represent nature. This is a profoundly innovative approach towards gaining understanding and motivation. By engaging in this process, we establish the definitions of the words and construct fundamental principles that serve as the basis of mathematical theory. Subsequently, we need to infer the implications of our set of axioms. Theorems are derived by employing logical deduction methods. These theorems are simply logical deductions derived from our axioms and should not be regarded as definitive statements about relationships that are inherently true in nature. To establish these theorems, it is imperative to possess a comprehensive understanding of the principles of logic and the techniques employed in constructing mathematical proofs.

Development of Mathematics

The inception of mathematics originated with Arithmetic, which emerged from the necessity of people to quantify items in the context of trade and daily transactions. This development was ultimately accompanied by the emergence of Geometry, which arose from humanity's innate desire to quantify and measure land. Approximately 2500 years ago, the works of Greek Geometer established a strong basis for Geometry by defining a set of axioms [7]. Over time, these axioms evolved into significant theorems through the deductive process, which continue to be applied across various scientific disciplines. The foundations have remained unaltered due to the faultless and perfect nature of the subject. The intricate challenges in trade and industry necessitated the resolution of equations, which led to the development of number theory and the theory of equations. Collectively, these advancements constituted the field of algebra [8].

History of Some Branches of Mathematics

Search for the solution of the equations that significantly impact the development of number theory can be summarized as follows: Starting from the set of natural numbers, we progress to the set of integers, then to the set of rational numbers, followed by the set of real numbers, and finally to the set of complex numbers. Every stage is driven by the aspiration to resolve a specific type of equations. Arithmetic can be seen as a direct result of the basic act of counting. Counting is essentially the process of creating a series of positive whole numbers, where each number is defined by the one that comes before it. The simplest act in counting is moving from one already formed number to the next one to be formed. The sequence of these numbers serves as an extremely valuable tool for the human intellect, offering an endless abundance of remarkable principles derived from the application of the four fundamental arithmetic operations. Addition is the process of combining any number of repeated instances of the aforementioned simplest action into a single action. Similarly, multiplication arises from this process. While addition and multiplication can always be performed, the operations of subtraction and division are found to have limitations. Undoubtedly, the creation of negative and fractional numbers by the human mind has been driven by the same limitation that has prompted the need for new creations.

History of Bhaskaracharya II (1114 - 1185)

In Indian history, there is a mention of two scholars named Bhaskaracharya, distinguished as Bhaskaracharya I and Bhaskaracharya II. Bhaskaracharya was primarily a scholar of philosophy and Vedanta. He was born during the 7th century Common Era (CE). Bhaskaracharya II was an Indian mathematician and astronomer [9]. Here, the biography of Bhaskaracharya II is discussed in detail.

Birth of Bhaskaracharya

Similar to other ancient Indian scholars, there is a scarcity of information regarding the mathematician Bhaskaracharya. In his prominent work 'Siddhanti Shiromani', he states that he was born in Saka-Samvat 1036 and completed the composition of this book when he was 36 years old. Saka Samvat is a calendar system that is 78 years ahead of the Gregorian calendar. By adding 78 years to the year 1036, we can determine that his birth year is 1114 AD. Bhaskaracharya stated that he was born in a village named Vizh David, located within the 6 Sahyadri mountain regions. The Sahyadri Mountains are situated in Maharashtra; however, the specific district in Maharashtra where the village of Wijjidvid is located remains unknown.

Bhaskaracharya's father, Maheshvaracharya, was a highly skilled mathematician. Bhaskaracharya became interested in mathematics due to the influence of the person. Based on the received information, Ujjain is regarded as the work area of Bhaskaracharya. In this location in Madhya Pradesh, he engaged in the pursuit of knowledge and resided there while creating his literary works [10]. According to certain scholars, Bhaskaracharya held the position of the chief at the astrological observatory in Ujjain. During his time there, he dedicated himself to studying and applying his written works.

Historically, it was common for scholars in ancient times to create their works with the support and sponsorship of a royal court. Consequently, he openly commended his benefactors in his literary creations. However, Bhaskaracharya's texts do not contain any such description. It can be inferred that Bhaskaracharya was a self-reliant scholar who was inclined towards conducting his research independently, without relying on the support of a monarch.

Bhaskaracharya's Works

His work 'Siddhant Shiromani' has a special significance in the biography of Bhaskaracharya II. Bhaskaracharya discusses the principles of mathematics and astronomy in 'Siddhant Shiromani'. He composed this book at the age of 36 in the year 1150. This book is composed in the Sanskrit language and written in form of verse. By that time, the provincial languages had been born in the country and Sanskrit was used only in the learned society but still Bhaskaracharya composed his book in Sanskrit. Being in Sanskrit, this book was considered so esoteric that it was difficult for everyone to understand it. That is why some scholars in his time started saying that 'Siddhant Shiromani' can be considered either Bhaskaracharya himself or Saraswati. When Bhaskaracharya realized this too, he himself prepared an easy commentary of his book and named it 'Vasnaa Bhasya'.

Siddhant Shiromani

Siddhant Shiromani is a voluminous tome authored by mathematician Bhaskaracharya, consisting of four distinct books. The titles of these books are Patiganit or Lilavati, Algebra, Goladhyay, and Grahagnith. Bhaskaracharya's work in Patiganit focuses on various mathematical concepts such as the number system, zero, fractions, and mensuration. These sutras are included in the curriculum of high school courses. The Patiganit book is alternatively referred to as 'Lilavati'. The subject matter of this book revolves around a female protagonist named Lilavati.

The second segment of the book 'Siddhant Shiromani' is referred to as Beej Mathematics. Bhaskaracharya has described algebra as 'latent mathematics'. Algebra, being a branch of mathematics that deals with unknown or hidden quantities, was referred to as latent mathematics in ancient times. In algebra, variables such as K and Y are employed to represent unknown quantities. In antiquity, these entities were known as 'Yavat-Tawat' and the letter 'Y' was employed to represent them in written form. In his book, Bhaskaracharya has examined both positive and negative zodiac signs. Initially, he asserted that the multiplication of two negative numbers yields a positive result. He stated that the result obtained from dividing one negative number by another negative number will be positive. He clarified that the product of a positive number and a negative number would be negative, and similarly, the result of dividing a positive number by a negative number would also be negative [11].

Bhaskaracharya discusses zero and eternal in this section. According to him, dividing a number by zero will make the quotient value infinite. He named it 'Kh-har', referring to the eternal. Here 'b' means zero. He told that the number in every place where there is zero, that number will be infinite ie 'b-ha'.

In the section titled Goladhyay, Bhaskaracharya discusses the movements of planets and the mechanism of astronomy [12]. In this chapter, he has also provided a description of the instruments he used to conduct astronomical observations. In addition, he has provided numerous regulations pertaining to astronomy within this section.

The topic of gravity is addressed by Bhaskaracharya in this section. Lilavati inquires, "Upon whom does this terrestrial sphere, upon which we reside, find its foundation?" Bhaskaracharya responded to Lilavati's question by stating, "Some individuals claim that this earth is represented by Sheshnag, tortoise, elephant, or any other object." Their pronunciation is incorrect. If we assume that the Earth is supported by an object, then the question arises as to what that object is resting on. Therefore, the cause of reason and subsequently its justification...This sequence is infinite [13].

Upon hearing this, Lilavati inquired, "However, the question persists: upon what does the earth find support?" Bhaskaracharya questioned the possibility of the earth being unsupported. ... if we assert that the Earth remains stationary due to its inherent force and refer to it as the faculty of perception, what would be the flaw in this argument? Bhaskaracharya provided justification for this by elucidating the potency of objects.

मरुचलो भूरचला स्वभावतो यतो, वचित्रिावतवस्तु शक्तय%।।
¼सद्धिाँत शरोमणा गोलाध्याय-भुवनकोश & 5½
आकृष्टशिक्तश्चि मही तया यत् खस्थं, गुरुस्वाभमिुखं स्वशक्तत्या।
आकृष्यते तत्पततीव भाता, समेसमन्तात् क्व पतत्वयिं खे।।
¼सद्धिाँत शरोमणा गोलाध्याय-भुवनकोश & 6½

(In other words, the Earth possesses its own inherent allure). It exerts gravitational force to pull matter towards itself. As a result of this gravitational force, it descends towards the surface of the earth. What is the process of falling? Essentially, the planets in the sky appear to be stationary due to the gravitational forces exerted by all the planets in the sky, which maintain a state of equilibrium.

Evidently, Bhaskaracharya had expounded on the concept of gravity five and a half centuries prior to Newton. If his theory was accurately understood and widely disseminated, it would be recognized as Bhaskaracharya.

In the section called Siddhanta Shiromani, Bhaskaracharya examines both the relative motion between the planets and the absolute motion of the planets [14]. In addition, he has also emphasized the aspects pertaining to time, direction, and location in this book. In addition, he has also addressed subjects such as solar eclipses, lunar eclipses, and so on.

Bhaskaracharya and Lilavati

The Patiganit book of Bhaskaracharya is alternatively referred to as 'Lilavati'. The subject matter of this book revolves around a female protagonist named Lilavati. In his book, Bhaskaracharya refers to Lilavati as 'Sakhi' at one point, and as 'Dear' and 'Bale' at other points. Nowhere does it disclose the nature of his association with Lilavati.

Was Lilavati his daughter or his romantic partner in the relationship? Furthermore, there is a lack of information on this matter in other ancient Sanskrit texts. However, subsequent scholars have depicted Lilavati as the offspring of Bhaskaracharya. Upon reading the introduction to Bhaskaracharya's life, it is discovered that when Akbar's court poet Faizi translated 'Lilavati' into Persian, he referred to Lilavati as his daughter. In addition to this, he included a captivating anecdote about Lilavati in his book. Here is the anecdote:

Upon Lilavati's birth, Bhaskaracharya became aware that her married life would be vexatious. They grew concerned about this. Based on his calculations, he deduced that this situation can be altered if Lalavati is married during a specific Muhurta. In order to commemorate that propitious moment, he constructed a waterfall. Once a specific quantity of water has been added, place it in a secure location. Unexpectedly, Bhaskaracharya had to abruptly leave in the midst of the situation. Lilavati's inquisitiveness was aroused by the sight of the waterfall. Simultaneously, a precious gem inadvertently slipped from her grasp and descended into the watershed. As a result, the water outlet in the waterway became blocked, preventing Lilavati from getting married at the specific auspicious time determined by Bhaskaracharya. Bhaskarachary was deeply saddened by this. Simultaneously, he resolved to impart to his daughter the knowledge required to comprehend the movements of the planetary constellation. He imparted Lilavati with the knowledge of that arcane wisdom and consolidated all those elements to create the Lilavati text [15].

Lilavati gained widespread recognition as Faizi's daughter following his authorship of this story. Although the book of Bhaskaracharya does not make any reference to this. This demonstrates that the narrative is entirely imaginative and lacks any connection to actuality.

Mahabhaskariya

Another major work of Bhaskaracharya is the Mahabhaskariya, in which he presents a detailed explanation of the chapters of Aryabhatiya's astronomy. Sen According to Sen's book A Conscience History of Science in India, this book has a total of eight chapters. Bhaskaracharya discusses mainly the following topics in this book:

1. Line and indeterminate analysis between planets.
2. Line Modification.
3. Time, place, direction, spherical trigonometry, body, and lunar eclipse.
4. Actual lines of planets.

5. Sun and lunar eclipse.
6. The rise and fall of planets.
7. Astronomical constant.
8. Date and Miscellaneous Examples.

While Aryabhata laid down the rules of non-essential analysis related to astronomy, Bhaskaracharya detailed them and applied them to astronomy applications [16]. Bhaskar also produced an abbreviated version of his major works, which are popularly known as 'Laghubhaskariya'.

Karan-Kahutuhal

Although Bhaskaracharya's Siddhanta Shiromani does not specifically discuss astrology, many people still use the Bhaskara Horoscope associated with his name. During the final stage of his life, at the age of 68, he authored a book titled 'Karan Kutuhal'. This book provides a detailed explanation of the process for creating an almanac. It is alternatively referred to as the cause book. Due to the inclusion of astrology in the Panchang, he is held in high regard in the field of astrology for his book.

Bhaskaracharya received global acclaim for his profound foundations and principles. Akbar's courtier Faizi was responsible for the first translation of his works. In 1587, he rendered the text 'Lilavati' into Persian. The translation of Lalavati greatly pleased the Mughal emperor Shah Jahan. In 1634, he had his courtier Ataullah Rasidi translate Bhaskaracharya's 'Algebra' into Persian. In 1816, Edward Strachey, a member of the East India Company, obtained a Persian translation of the book 'Algebra' and was greatly impressed by it. As a result, he proceeded to translate the book into English. In 1817, Henry Thomas Colebrook, an Englishman, translated the Sanskrit texts 'Lilavati' and 'Algebra' into English.

Lakshmidhar, the son of Bhaskaracharya, was a proficient scholar of mathematics and astronomy, just like his father. However, like his father, he lacked the ability to make significant contributions and did not gain a notable reputation. Indeed, during that period, no scholar of Bhaskaracharya's caliber emerged in India. He is remembered as the final scientist of ancient India for this reason [17].

Lilavati

Due to the tragic events in Lilavati's early life, she chose to reside in her father's house. Bhaskaracharya began teaching his daughter mathematics as a way to ease her emotional distress. He also recognized the importance of dedicating one's life to the study of mathematics. Within a short period, she gained extensive knowledge and expertise in the aforementioned subject. Bhaskaracharya wrote a comprehensive treatise covering the fields of Patiganit, Algebra, and Astrology. Most of the mathematics in this work is attributed to Lilavati. Bhaskaracharya named a section of Patiganit as Lilavati to honor his daughter for eternity.

Bhaskaracharya used poetic mathematical formulas to teach his daughter Lilavati. It was necessary to commit those sutras to memory. The mathematical questions were subsequently resolved by employing those formulas. Bhaskaracharya initially elucidated Lilavati using a gradual and uncomplicated approach prior to mastering it. He affectionately addressed the girl as "Lilavati," describing her as a beloved young girl with eyes resembling those of a deer. He then proceeded to introduce the sutras. Please enter the title "Lilavati". In contemporary times, mathematics is often perceived as a dull and uninteresting subject. However, Bhaskaracharya's work 'Lilavati' serves as an exemplar of how mathematics can be taught by incorporating elements of entertainment, enjoyment, and curiosity [18].

An example of Lilavati -

> *".... Worshiped Shiva, Vishnu and Surya from Tritiyamsa, Panchamamsha and Shatamamsha of a group of normal lotuses, Parvati from quartiles and Guru Charanas from the remaining six lotuses..."*

Come, Bale Lilavati, quickly tell how many flowers were there in that lotus group..?

Answer - 120 lotus flowers.

Bhaskaracharya explains that the square and its area are referred to as "the square." The mathematical operation of multiplying two identical numbers is mostly referred to as "squaring." Likewise, when three numbers are multiplied together and, they are all the same, the result is a cube. This cube has twelve cells, and all of its sides are of equal length. In Sanskrit, the term 'mool' is employed to denote the fundamental part of a tree or plant or to signify the origin of something. In ancient mathematics, the term "class root" referred to the square arm that served as the cause or origin of a class.

Likewise, the significance of Ghanmool can also be comprehended. Various techniques for extracting square and cube roots were commonly used. A book called "Siddhanta Shiromani" was written to address Lilavati's questions. This extensive book is divided into four parts: (1) Lilavati, (2) Algebra, (3) Planets Ganitadhyaya, and (4) Goladhyaya. 'Lilavati' elucidates the origins of mathematics and astronomy in a remarkably uncomplicated and lyrical manner. In 1587, Faizi, who served as the court scholar of Emperor Akbar, translated the book "Lilavati" into Persian. J.K. Weller was the first to translate "Lilavati" into English in 1716. Until recently, several teachers in India instructed mathematics using couplets. There are a total of fifteen tables. The numbers assigned to the tables are: thirty-five, forty-four, sixty-six, ninety-eight, twenty-eight, and nine-thirty-five.

Similarly, the Padmayya Sutra also contained a method for memorizing the calendar, which goes as follows: "Si up juno thirty ki, the thirty one thirty-eight, twenty-eight of February fourth of twenty eight." After receiving instruction in mathematics from his father, Lilavati gained recognition as a distinguished mathematician and astronome.

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