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# History of pi and Indian contribution

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**ABSTRACT**

In this present paper I have tried to introduce the early history of pi, the concept and equation of pi .also represent the devotion of Indian scholar mathematicians or astrologers to find the value of pi .Pi has a very long history so much that many great thinkers in the not only in India but also in ancient world were attachment to try and counting pi.
The calculation of pi (π) was revolutionized by the development of infinite series techniques in the sixteenth and seventeenth centuries .An infinite series allowed mathematicians to compute pi(π) with much greater precision than Archimedes and other who used geometrical technique. pi has been more ponder, examined and calculated than any other number. The most basic properties of pi(π)where understood in the period of classical Greek mathematical by the time of the death of mathematicians Archimedes in 212 BC.
pi (π) has a great importance in mathematics for not only to the measurement of the circle but also in the more advanced mathematics in connection with such topics as continued function ,logarithms of imaginary numbers, and periodic function. Also the concept of Pi is found in many formulae in trigonometry and geometry. It is also found in formulae from other branches of science, such as cosmology number theory statistics, fractals, thermodynamics, mechanics, and electromagnetism.

## 1. Introduction

The first use of mathematics in the Indian subcontinent was in the Indus valleyand dates as far back as 3000BC.

Pi is the 16 th letter of the Greekalphabetand symbolically represented as π and has been introduced to our universe near About 4000 year ago. But even if we calculate the number of second in those 4000 years and calculate pi (π) to that number of places. Up till now we still are approximating actual value of pi. Inmathematics, the definition of is pi means the ratio of the circumferences of a circle to its diameter .The symbol for pi is π. The ratio is the same for all circles and is approximately 3.1416.

Pi is a irrational number it means that its value cannot be expressed exactly as a function.m/n, where m and n are integers.(such as 22/7or other functions that are commonly used to approximate pi ( π ); consequently ,its decimal representation never ends and never settles into a permanent repeating pattern.is atranscendentalnumber(a number that is not the root of a non-zero polynomial having rational coefficient ). Many mathematicians and Mathematics fans are interested in calculating pi to as many digits as possible.

The notation pi (π) can be mathematically generally expressed asit is the ratio of circumference of a circle to diameter .The interesting thing about this is that ratio is the same for all circles, where it as small as a small circle or as big as the sum. Although this fact was probably recognized by all the ancient civilization like Indian,Babylonians,Egyptians,Chinese, Arabic, and many more.

Pi's rigorous statement and proof was probably first written by Euclid in his seminal work Element.SoEuclid marks the stage in human civilization by which we able to prove the existence of pi.

The value of pi ( π ) is the ratio of any circle's circumference to its diameter this is the same value is as the ratio of a circle's area to the square of its radius and it is approximately equal to 3.14159.π is one of the most important mathematical, and physical constant:many formulae from mathematics, science and engineering involve π.it is also appears in many different formulas that have nothing to do with circles.In daytoday'salgebraic notation this implied the formula

$\pi = \text{Circumference}/\text{Diameter}$

Where the value of pi(π) is constant.

## 2. The Research of Indian mathematician to find Numerical value of pi(π)

Generally the use of mathematics in India subcontinent was in the Indus valley and dates as far back as 3000BC. In the history of Indian Mathematics generally begin with the geometry.So many different values of pi appear in the sulabasutras, even several different ones used in one text. Generally three value of pi from the Brahmans and BudhyanaSulbasutra are discussed. Above values emerge whensquare are transformed in to circles of equal area, a commonly occurring operation in vaidic altar construction. The value of pi(π) implicit in the organization of the Rig-Veda and this should be earlier than the age of Brahmans literature.

Some of Indian Mathematician as well as astronomer have tried to solve or discussed the value of pi. In the book

SatapathaBrahmama and Baudhyayanasulbasutrathe value of pi are discussed.

***Arybhata:***

Insixteenth century BCE we find its mention in the old Sanskrit text BaudhyanaSulbaSutrathat indicate this ratioAryabhata work on the approximation for pi (π) and may have come to the conclusion that π is an irrational number. In the 2nd part of Aryabhatiya, he writes the ratio of circumference to diameter is 3.1416. First in the line of great Mathematician and Astronomersfrom the classical age of Indian mathematics and Indian astronomy .His most famous works are the Aryabhatia (499CE, when he was 23 year old) andArya –siddhanta.Arayabhata worked on the approximation for pi (π), and many have conclusion that pi (π) is irrational. In the second part of Aryabhatiyam,he writes in his varse,

Caturadhikamsatanamatagunamdvasastistathasahasranam

Ayutadavayaviskambhasyasannovrttaprinahah.

It means

“Add four to 100 multiply by eight and then add 62,000.By this rule the circumference of a circlewith a diameter of 20,000can be approached.”

$$\frac{((4+100)\times 8+62000}{20000}=\frac{62832}{20000}=3.1416$$

Which is accurate to five significant figures,generally it means that Aryabhata used the word asanana (approaching)to meanthat not only is this an approximation but that the value is incommensurable.(or irrational).if this is correct it is quite a sophisticated insight ,because the irrationality of pi was proved in Europe only in 1767 by Johann Heinrich Lambert.After Aryabhatiya was translated into Arabic (ca.820CE) this approximation was mentioned in Al-Kkhawarizmi”s book ontopic algebra .centuries later in 825 CEfamous Arab mathematicians Mohammed Ibna Musa says “the value has been given by the Hindus (Indians)

***Brahmagupta(598-668):***

Brahmaguptawas a great Indian mathematician and astronomer hewrote Brahmasphutasiddhanataininin 628,in verse ,he gave the value of pi .Brahmaguptacalculated the perimeters of inscribed polygons with 12,24,48,and 96 sides as (9.65,(9.81,and( 9.87 respectively . and then armed with this information, he made the 1 eap of faith that as the polygons approached the circle, the perimeter and therefor pi , would approach the square root of 10 (this is equal to3.162….).this is about0.66 percent higher than the true value of pi.Brahmagupta dedicated a substantial portion of his work to geometry and trigonometry. He established √10 (3.162277) as a good practical approximation for π (3.141593), and gave a formula, now known as Brahmagupta's Formula, for the area of a cyclic quadrilateral, as well as a celebrated theorem on the diagonals of a cyclic quadrilateral, usually referred to as Brahmagupta'sTheorem.Brahmagupta uses 3 as a ‘practical’ value of pi (π) and square root of 10 as an accurate value of pi (π).

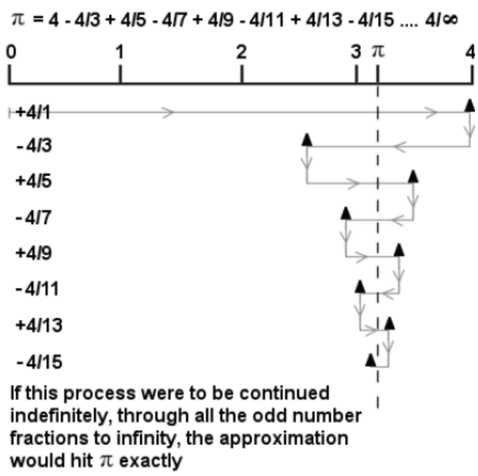
***Bhasakara(1114-1185)***

He is also known as Bhasakara II and Bhaskara Achara wasan Indian mathematicians and astronomer.he is born in bijpur in Karnataka.he wrote Siddhantashriomani(Sanskrit for “Crown of Treaties’’)at the age of 36 in 1150 AD.This colossal work is divided into four parts; Llilawati, Beejganit , Ganitadhyaya,and Goladhya and consist of about 1450 verses . He even gave an approximate value of pi (π) as 22/7, whichis 3.1414. Bhasakara was even failure with the concept of infinity and called it as Kaharrashi which mean ‘anant’.

***Madhava of Sangamagramma (ca1350-ca1425)***

Great Indian mathematician-astronomer of medieval Indian.Madhava born around 1350 in Sangamagramma in the state of Kerala,near the southern tip of India .and founded the Kerala school of astronomy and mathematics in the 14 th centurythe almost original work of Madhava is lost .he is referred to in the work of later Kerala mathematicians as the sources for several infinite series expansions including the sine, cosine tangent and arctangent functions and the value of pi (π) Madhavas pi,sine and cosine power series was rediscovered about 250years later in Europe by scholars-Wilhelm Leibniz(1673),Newton (1675),De Lagny(1682),

Madhava applied these series to trigonometry, developing highly accurate tables for trigonometric values .in developing the infinite series for the arcsine function, madhava was able to produce an excellent approximate for pi, He also analyzed the reminder terms when the exact infinite series is truncated to a finite sum. Scholar believe that madhava used the method of continued fraction to drive these reminder terms




Madhava went further and linked the idea an infinite series with geometry and trigonometry .he realized that by successively adding and subtracting different odd numbers fractions to infinity , he could home in on an exact formula for π(this was two centuries before Lebniz was to come the same conclusions in Europe)through this applications of this series, Madhava obtained a value for π correct to an astonishing 13 decimal places .many historians believe that madhava,s discovery of infinite series expansion is akin to a term by term integration technique of calculus a few hundred years before the official discovery of calculus

Sankara in four verses said (atraha madhava)which suggests that madhava had actually suggested a method for finding the circumference of a circle by means of the circle constructing a number of regular polygons for the sum of the sides of the polygons would almost be equal to the length of the circumference of the circle.Steep by steep procedure was adopted to compute the side of the squarepolygon for a circle, then half side of the square polygon (octagon), then half side of the octagon (hex decagon)then half side of the hex decagon (32-gon)and so on indicating that the number of the regular polygons had to be large for considerably accurate value.

The historically first exact formula for π, based on infinite series, was not available until a millennium later, when in the 14th century the Madhava–Leibniz series was discovered in Indian mathematics.

Madhava give the value of pi = 3.1416…..

***ShrinivasaRamanujan(1897-1920):***

was one of the India's greatest mathematical geniuses. he made substantial contributions to the analytical theory of numbers and worked on elliptic functions,continued fractions and infinite series .He found several rapidly converging infinite series of pi(π),which can compute 8 decimal places of pi(π) with each term in the series Since the 1980s, his series have become the basis for the fastest algorithms, currently used by Yasumasa Kanada and the chudnovsky brother to compute pi(π).

In 1914Ramanuhan come to Trinity college in England at Hardy'sinvitation, and in the next fiveyear's would produce 21 research paper on avariety of topics:approximation to pi, highly composite (that is, not prime) numbers,and the average numberof prime divisor. These publications were remarkable for their elegance, mathematical depth, and rapid convergence. One of these formula, based on modularequation; Bill Gosper was the first to use it for advances in the calculation of pi πsetting a record of 17 million digits in 1985.Ramanujans formulae anticipated the modern algorithms developed by the Browniebrothers.

***Ramanujan and his goddess:***

The ingredients for the multi-million digit calculations of pi are a combination ofiterative algorithms and some truly ingenious infinite series. Shrinivasa Ramanujan was self-taught mathematical prodigy who comes up with several such as

$$\frac{1}{\pi} = \frac{2\sqrt{2}}{9801}\sum_{k=0}^{\infty}\frac{(4k)!(1103+26390k)}{(k!)^4 396^{4k}}$$

This is an infinite series and which converges to 1/π

Ramanujan produced several diaries of formulae of this kind, which he simply stated formulae of this kind; he simply stated formulae with no proof or even hits of their justification. These diaries have kept generations of subsequent mathematicians busy in a quest to prove the unproven formulae .They are remarkable for their mathematical depth. Ramanujan, s insight is indeed hard to explain, his own explanationof the source of his formulae is that his family goddess Namagiri revealed them to him.

AlsoShrinivasaRamanujan published dozens of innovative new formulae for pi ,remarkable for their elegance ,mathematical depth and rapid convergence.one of is formula based on modular equation Bill Gosper was the first use it for advance in the calculation of pi,setting a record of 17 million digits in 1985.Ramanujans formulae for anticipated the modern algorithms developed by the Borwin brothersand Chundnovsky brothers.

In 1918 he was elected as fellow to the Royal Society of London, the first Indian to receive that honor. Mathematicians recognized Ramanujan as one of the greatest geniuses of all time.

Pi is everywhere in nature: the disk of the moon and the sun, the double helix of DNA (they are revolved around the pi)it is hidden in rainbow also spreading rings when a raindrop in to water, even that pi is number that came directly from god, we will never know for sure ,but one this is real, universe is round-shaped within every round ,pi is there.

Pi occurs in various mathematical problems involving the length of acre or other curves ,the area of ellipses, sectors,and the other curved surfaces,and the volumes of many solids.. it is also used in various formulas, of physics and mathematics and engineering to describe such periodic phenomena as the motion of pendulums, the vibration of string, and alternating electric current.

Many mathematicians have played with it and have improved the approximation that we have .some examples are:

Babylonian (1800-16000 BC): pi = 3
Hebrew(1 King 7:23): pi = 3
Egypt (RhindPapyrus):pi =3 1/7
Chinese (1200 BC):pi =3
Archimedes (3000 BC):prove pi = 3.14163

All of those are approximation, as they are measures of real near circular object (a large metal blow in the Hebrew case, the volume of a cylindrical grain silo for the Egyptian reference) which would never be perfectly circular due to manufacturing consideration, measure techniques, etc., but they served as useful approximations to do the necessary work. From that ancient period to up till now many mathematicians and computer have till solving the value of pi

Some Selected Formulae for PI by some mathematicians:

**I}Archimeads: (ca250 BC)**

Let

Set $\sqrt[2]{3}$ and b=3which are the value for circumscribed and inscribed 6-gons. If

$a_{n+1=\frac{2a_nb_n}{a_nb_n}}$ (H) and $b_{n+1=\sqrt{a_nb_n}}$ (H)

Then an andbn converges linearly to π (with an error 0 (4-n).)

II} Madhava, James Gregory, Gottfried Wilelm Leibniz: (1450-1671)

$$\frac{\Pi}{4}=1-\frac{1}{3}+\frac{1}{5}-\frac{1}{7}+\frac{1}{9}-..........$$

III} IsaacNewton: Newton and Leibnitz (late 17th century) :When Newton and Leibnitz developed calculus in the late 17th century, more formulas were discovered that could be used to compute pi. for example, there is a formula for the arctangent function:

$$\arctan x = x-\frac{x}{3}+\frac{x^5}{5}+\frac{x^7}{7}+......+(-1\le x\le 1)$$

If you substitute $x$ = 1 and notice that arc tan(1) is $\pi$ 4 , you get a formula for pi

**IV}Srinivasa Ramanujan:(1914)**

The 20th Century › In the 20th century, there have been two important developments: – the invention of electronic computers – the discovery of much more powerful formulas for pi › In 1910, the great Indian mathematician Ramanujan discovered the following formula for pi:

$$\frac{1}{\pi}=\frac{2\sqrt{2}}{9801}\sum_{k=0}^{\infty}\frac{(4k)!(1103+26390k)}{(k!\ )^4 396^{4k}}$$

This series converges much more rapidly than most arc tan series, including Machin's formula. Bill Gosper was the first to use it for advances in the calculation of π, setting a record of 17 million digits in 1985.Ramanujan's formulae anticipated the modern algorithms developed by the Borwein brothers and the Chudnovsky brothers. The Chudnovsky formula developed in 1987 is

$$\frac{1}{\pi}=\frac{12}{640320^{3/2}}\sum_{k=0}^{\infty}\frac{6k!(13591409+545140134k)}{(3k)(k!)^3(-640320)^{3k}}$$

It produces about 14 digits of π per term,[ and has been used for several record-setting π calculations, including the first to surpass 1 billion ($10^9$) digits in 1989 by the Chudnovsky brothers, 2.7 trillion ($2.7\times10^{12}$) digits by Fabrice Bellard in 2009, and 10 trillion ($10^{13}$) digits in 2011 by Alexander Yee and Shigeru Kondo. For similar formulas. In the year 1985, William Gosper used this formula to calculate the first 17 million digits of pi.

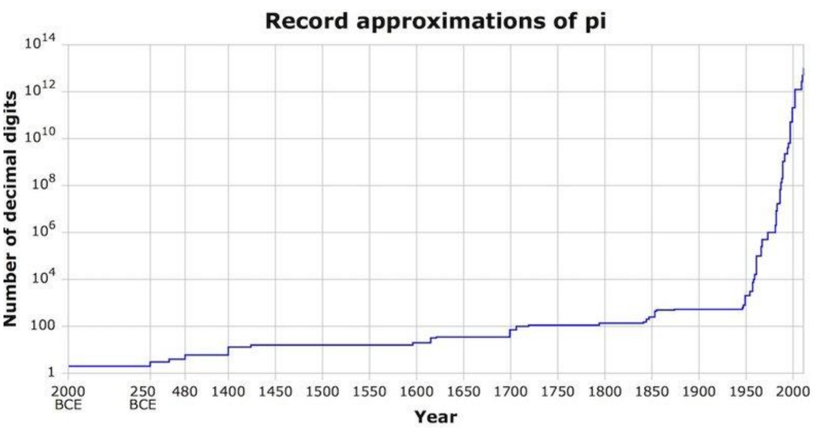
Not only in ancient Indian mathematicians but also in ancient Egyptian, Chinese, Babylonians, Italian and many more countries mathematicians and astronomers have tried to find or to solve the actual value of pi or near about approximation.

### 3. Applications

Pi in Real Life: Pi is used in areas ranging from geometry to probability to navigation. Common real-world application problems involve finding measurements of circles, cylinders, or spheres, such as circumference (one-dimensional), area (two-dimensional), or volume (three-dimensional),also need to calculate areas of the skin of the aircraft or arc length, for everything from fitting equipment in ,to line of sight calculations.additionally ,pi comes up in machining parts for aircraft.it is also use in circular slot for mounting a camera that has a certain radius and a certain arc length.Pi is also used in signals like radio ,tv,radar,telephone, etc.it is also used in the all area of engineering to simulate unknown factors and loading conditions. For example “white noise “which is a normally distributed random variable used in estimation to predict such things as a wild gusts on a plane or the worst case vibrational loading on a beam (this is really big use in pi).white noise is also used to give a certain amount of apparent “bumpiness” in many software simulations such as games. Also used in navigation like global paths, global positioning

In Aeronautical science when plane flies great distance they are actually flying onan arc of a circle. The path must be calculated as such in order to accurately gauge fuel use etc.for all those pi comes into the calculation in most methods.

In the above graph it shows the historical evolution of the record precision of numerical approximation to pi(π)measured in decimal places.



## 4. Conclusion

Pi is a fundamental mathematical building block in fact it is so fundamental that it produces human existence as intelligent being; the number pi is plays very important role in many of the major scientific advances of mankind.

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