JANATA SHIKSHAN SANSTHA'S

KISAN VEER MAHAVIDYALAYA, WAI

Deparment of Mathematics

Class: B.Sc. III (2022-23)

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CERTIFICATE OF COMPLETION

Date :

This is to certify that the project work entitled, **"FIBONACCI SEQUENCE AND IT'S APPLICATIONS"** is work done by, **"Miss. ADSUL MANASI RAJENDRA"** of **B.Sc.III** for the practical Course prescribed by **SHIVAJI UNIVERSITY, KOLHAPUR,** during the academic year **2022-2023.**

20/05/23

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Date :

This is to certify that the project work entitled, **"ARYABHATA AND ITS WORK "** is work done by, **"Mr. Shinde Anil Krushna"** of **B.Sc.III** for the practical Course prescribed by **SHIVAJI UNIVERSITY, KOLHAPUR,** during the academic year **2022-2023.**

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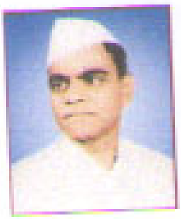

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This is to certify that project entitled "Pi and its Application" is a work done by Mr. Shaikh Bilal Salauddin for the practical course prescribed by Shivaji University, Kolhapur at the final year of Bachelor of Science in Mathematics during the academic year 2022-2023.

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Roll No: 61

Exam Seat No: 38931

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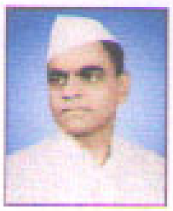

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This is to certify that project entitled "Magic square" is a work done by Miss. **THOMBARE MADHAVI DIPAK** for the practical course prescribed by Shivaji University, Kolhapur at the final year of Bachelor of Science in Mathematics during the academic year 2022-2023.

NAME: MISS. THOMBARE MADHAVI DIPAK

Roll No: 66 | *Exam Seat No:* 38945

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Date:-15/05/ 2022-23

This is to certify that the project work entitled, **"PYTHON AND ITS APPLICATION"** is work done by, **"Miss. Wakale Sarita Shivaji** "of **B.Sc. III** for the practical course prescribed by **SHIVAJI UNIVERSITY, KOLHAPUR,** during the academic year **2022-2023.**

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Date-

This is to certify that the project work entitled, "Inequality" is work done by, Miss. Rajpure Manasi Balkrushna of B. Sc. III for the practical course prescribed by SHIVAJI UNIVERSITY KOLHAPUR, during the academic year 2022-23.

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This is to certify that project entitled "Ancient Ionian Greek mathematician & philosopher Pythagoras" is a work done by Mr. Rapure Prem Jitendra for the practical course prescribed by Shivaji University, Kolhapur at the final year of Bachelor of Science in Mathematics during the academic year 2022-2023.

Name: Mr. Rajpure Prem jitendra

Roll No: 79 **Exam Seat No:** 38341

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This is to certify that the project work entitled, "CRYPTOGRAPHY AND NETWORK SECURITY" is work done by, Miss. DHANAWDE ANKITA MAHADEV of **B.Sc.III** for the practical Course prescribed by SHIVAJI UNIVERSITY, KOLHAPUR, during the academic year **2022-2023.**

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This is to certify that project entitled "Optimization Model" is a work done by Miss. Sutar Aboli Arun for the practical course prescribed by Shivaji University, Kolhapur at the final year of Bachelor of Science in Mathematics during the academic year 2022-2023.

Name: Miss. Aboli Arun Sutar

Roll No:81 **Exam Seat No:** 38944

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This is to certify that the project work entitled, "Game Theory and it's Applications" is work done by, Miss. Jathar Mansee Pravin of B. Sc. III for the practical course prescribed by SHIVAJI UNIVERSITY KOLHAPUR, during the academic year 2022-23.

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Date :

This is to certify that the project work entitled, "ARYABHATA AND ITS WORK" is work done by,"**Mr.Tejas Rajendra Mahamuni**" of B.Sc.III for the practical Course prescribed by SHIVAJI UNIVERSITY, KOLHAPUR, during the academic year 2022-2023.

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DEPARTMENT OF MATHEMATICS

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This is to certify that the project work entitled, "Application of Differential Equations" is work done by, Mr. Hogade Shashikant Dattatray of B. Sc. III for the practical course prescribed by SHIVAJI UNIVERSITY KOLHAPUR, during the academic year 2022-23.

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This is to certify that the project work entitled **"FUN IN MATHEMATICS"** is work done by, **"Mr. DINESH ANANDA PISAL"** of **B.Sc. III** for the practical Course prescribed by **Shivaji University, Kolhapur,** during the academic year **2022-2023.**

Date : /05/2023
Place: Wai

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This is to certify that the project work entitled, "LEONHARD EULER" is work done by,"**Mr.Bhoite Arjun Rajendra**" of B.Sc.III for the practical Course prescribed by SHIVAJI UNIVERSITY, KOLHAPUR, during the academic year 2022-2023.

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Date: 20 - 5 - 2023

This is to certify that the project work entitled, **"GRAPH THEORY AND its APPLICATIONS"** is work done by, **"Miss. BHOSALE DHANSHREE SUBODH"** of **BSc III** for the practical Course prescribed by **SHIVAJI UNIVERSITY, KOLHAPUR,** during the academic year **2022-2023.**

20/05/23

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Roll No. - 134 **Exam Seat No.-** 38952

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DEPARTMENT OF MATHEMATICS

CERTIFICATE OF COMPLETION

Date-

This is to certify that the project work entitled, "The Study of Laplace Transform and it's Applications" is work done by, Mr. Rajpure Sahil Somnath of B. Sc. III for the practical course prescribed by SHIVAJI UNIVERSITY KOLHAPUR, during the academic year 2022-23.

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Sample Project

JANATA SHIKSHAN SANSTHA'S

KISAN VEER MAHAVIDYALAYA, WAI

TITLE OF PROJECT

“ARYABHATA AND ITS WORK”

A Project Submitted to

DEPARTMENT OF MATHEMATICS

Submitted by

Mr. Anil krushna shinde

UNDER THE GUIDANCE OF

Prof. Dr.S.R. Tate

2022-2023

Roll No.:- 58 Exam seat No.:- 38943

JANATA SHIKSHAN SANSTHA'S

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DEPARTMENT OF MATHEMATICS

CERTIFICATE OF COMPLETION

Date :

This is to certify that the project work entitled, **"ARYABHATA AND ITS WORK "** is work done by, **"Mr. Shinde Anil Krushna"** of **B.Sc.III** for the practical Course prescribed by **SHIVAJI UNIVERSITY, KOLHAPUR,** during the academic year **2022-2023.**

Project Guide	External Examiner	Head of Department

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KISAN VEER MAHAVIDYALAYA * Wai, Dist. Satara *

PREFACE

I am gratefully thankful to Shivaji University to include this project work in our practical syllabus. This project work which increase both my skills & Knowledge also. Form this project I get the valuable information about the aryabhata and its work.

I am gratefully thankful to Prof.Dr. S. R. Tate for the valuable support & great sacrifice about this project. I also thankful to Prof V.A. Suryawanshi and Prof.S.R.Malawade For the very valuable suggestion to improve this project work.

I am also thankful to Mr. Kamble & Librarian for the valuable support to complete this project work.

Shinde Anil

B.S.C. III

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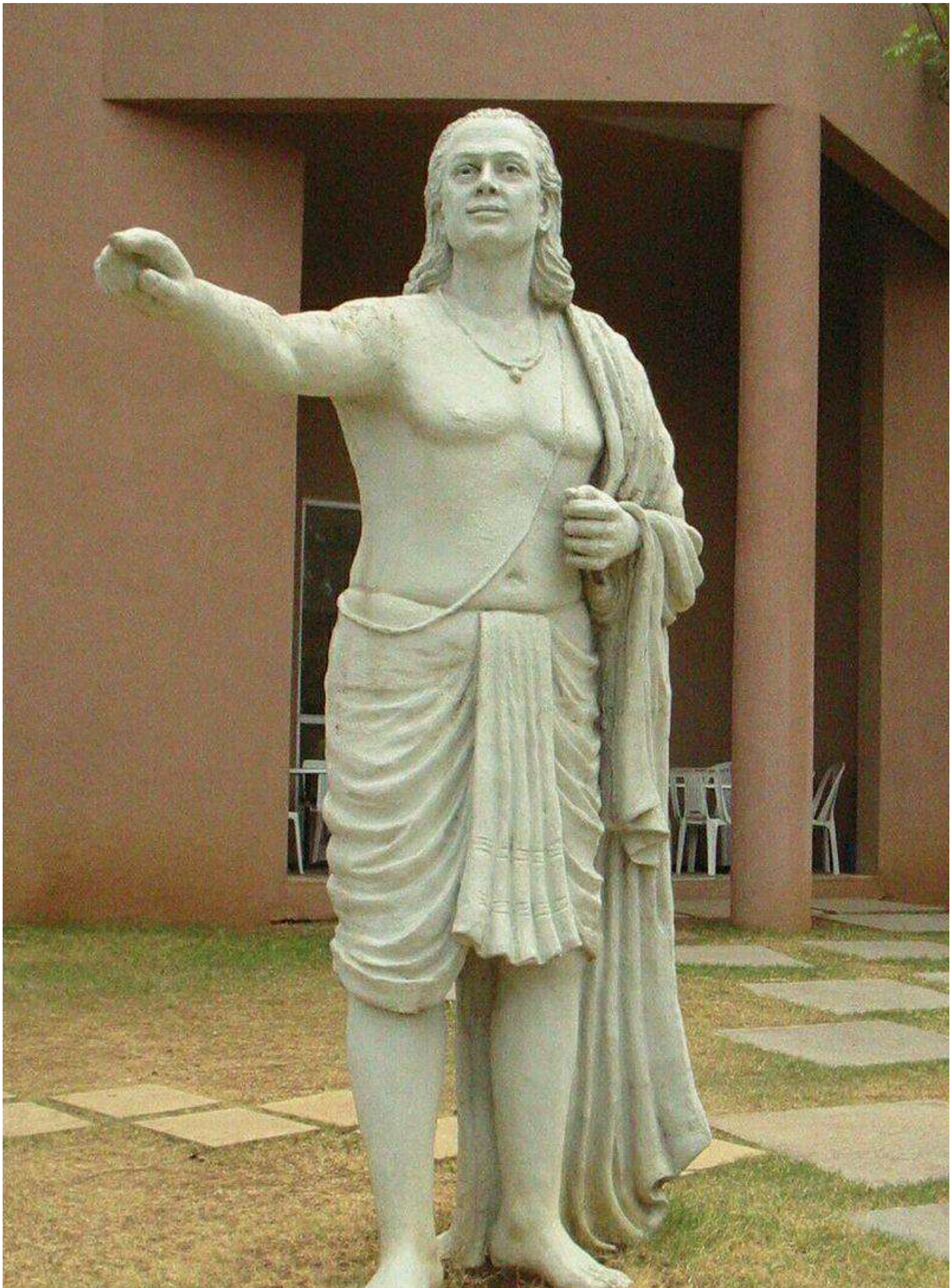

INTRODUCTION

In this project work I shortly introduce the great Swiss mathematician Aryabhata. This project work is very little part out of the great work is done him.

This project consist of almost all information of the aryabhata. I tried giving silent future of this project is “THE WORK OF ARYABHATA”. Which give the introduction of his work. Zero discovered by the Aryabhata, also giving information about pi.

This project work is not a research work, it is just collection of reference books.

BIOGRAPHY

Name

While there is a tendency to misspell his name as "Aryabhatta" by analogy with other names having the "bhatta" suffix, his name is properly spelled Aryabhata: every astronomical text spells his name thus, including Brahmagupta's references to him "in more than a hundred places by name". Furthermore, in most instances "Aryabhatta" would not fit the metre either.

Time and place of birth

Aryabhata mentions in the Aryabhatiya that he was 23 years old 3,600 years into the Kali Yuga, but this is not to mean that the text was composed at that time. This mentioned year corresponds to 499 CE, and implies that he was born in 476.[6] Aryabhata called himself a native of Kusumapura or Pataliputra (present day Patna, Bihar).

OTHER HYPOTHESIS

Bhaskara I describes Aryabhata as *asmakīya*, "one belonging to the *Asmaka* country." During the Buddha's time, a branch of the Asmaka people settled in the region between the Narmada and Godavari rivers in central India.

It has been claimed that the *asmaka* (Sanskrit for "stone") where Aryabhata originated may be the present day Kodungallur which was the historical capital city of *Thiruvanchikkulam* of ancient Kerala. This is based on the belief that Koṭuṅṅallur was earlier known as Koṭum-Kal-l-ur ("city of hard stones"); however, old records show that the city was actually Koṭum-kol-ur ("city of strict governance"). Similarly, the fact that several commentaries on the Aryabhatiya have come from Kerala has been used to suggest that it was Aryabhata's main place of life and activity; however, many commentaries have come from outside Kerala, and the Aryasiddhanta was completely unknown in Kerala. K. Chandra Hari has argued for the Kerala hypothesis on the basis of astronomical evidence.

Aryabhata mentions "Lanka" on several occasions in the *Aryabhatiya*, but his "Lanka" is an abstraction, standing for a point on the equator at the same longitude as his Ujjayini.

EDUCATION

It is fairly certain that, at some point, he went to Kusumapura for advanced studies and lived there for some time. Both Hindu and Buddhist tradition, as well as Bhaskara I (CE 629), identify Kusumapura as Paṭaliputra, modern Patna. A verse mentions that Aryabhata was the head of an institution (*kulapa*) at Kusumapura, and, because the university of Nalanda was in Pataliputra at the time and had an astronomical observatory, it is speculated that Aryabhata might have been the head of the Nalanda university as well. Aryabhata is also reputed to have set up an observatory at the Sun temple in Taregana, Bihar.

WORKS

Aryabhata is the author of several treatises on mathematics and astronomy, some of which are lost.

He was student of Nalanda university, latter he even became head of one department of it. Many researches were made at Nalanda in astronomy, mathematics, physics, biology, medicine and other fields. So Arybhat got his major source of knowledge from Nalanda and his major work was based on previous inventions by Greeks, Mesapotamians and Nalanda university itself. *Aryabhatiya*, a compendium of mathematics and astronomy, was referred to in the Indian mathematical literature and has survived to modern times. The mathematical part of the *Aryabhatiya* covers arithmetic, algebra, plane trigonometry, and spherical trigonometry. It also contains continued fractions, quadratic equations, sums-of-power series, and a table of sines.

The *Arya-siddhanta*, a lost work on astronomical computations, is known through the writings of Aryabhata's contemporary, Varahamihira, and later mathematicians and commentators, including Brahmagupta and Bhaskara I. This work appears to be based on the older Surya Siddhanta which was a Sanskrit summary of Greek and mesapotamian theories in astronomy and mathematics and uses the midnight-day reckoning, as opposed to sunrise in *Aryabhatiya*. It also contained a description of several astronomical instruments: the gnomon (*shanku-yantra*), a shadow instrument , possibly angle-measuring devices, semicircular and circular (*dhanur-yantra* / *chakra-yantra*), a cylindrical stick *yasti-yantra*, an umbrella-shaped device called the *chhatra-yantra*, and water clocks of at least two types, bow-shaped and cylindrical.

A third text, which may have survived in the Arabic translation, is *Al ntf* or *Al-nanf*. It claims that it is a translation by Aryabhata, but the Sanskrit name of this work is not known. Probably dating from the 9th century, it is mentioned by the Persian scholar and chronicler of India, Abu Rayhan al-Biruni

WORKS IN MATHEMATICS

1. PLACE VALUE SYSTEM OF ZERO

The place-value system, first seen in the 3rd-century Bakhshali Manuscript, was clearly in place in his work. While he did not use a symbol for zero, the French mathematician Georges Ifrah argues that knowledge of zero was implicit in Aryabhata's place-value system as a place holder for the powers of ten with null coefficients.

However, Aryabhata did not use the Brahmi numerals. Continuing the Sanskritic tradition from Vedic times, he used letters of the alphabet to denote numbers, expressing quantities, such as the table of sines in a mnemonic form.

2. APROXIMATION OF PI

Aryabhata worked on the approximation for pi (π), and may have come to the conclusion that π is irrational. In the second part of the *Aryabhatiyam* (*gaṇitapada* 10), he writes:

चतुराधिकं शतमष्टगुणं द्वाषष्टिस्तथा सहस्त्राणाम्।

अयुतद्वयस्य विष्कम्भस्य आसन्नौ वृत्तपरिणाहः ॥

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

This implies that for a circle whose diameter is 20000, the circumference will be 62832

i.e, $\pi = 62832/20000 = 3.1416$, which is accurate to three decimal places.

It is speculated that Aryabhata used the word *asanna* (approaching), to mean that 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 (π) was proved in Europe only in 1761 by Lambert.

After Aryabhatiya was translated into Arabic (c. 820 CE) this approximation was mentioned in Al-Khwarizmi's book on algebra.

TRIGONOMETRY

In Ganitapada 6, Aryabhata gives the area of a triangle as

tribhujasya phalasariraṃ samadalakoṭi bhujardhasaṃvargaḥ

that translates to: "for a triangle, the result of a perpendicular with the half-side is the area."

Aryabhata discussed the concept of *sine* in his work by the name of *ardha-jya*, which literally means "half-chord". For simplicity, people started calling it *jya*. When Arabic writers translated his works from Sanskrit into Arabic, they referred it as *jiba*. However, in Arabic writings, vowels are omitted, and it was abbreviated as *jb*. Later writers substituted it with *jaib*, meaning "pocket" or "fold (in a garment)". (In Arabic, *jiba* is a meaningless word.) Later in the 12th century, when Gherardo of Cremona translated these writings from Arabic into Latin, he replaced the Arabic *jaib* with its Latin counterpart, *sinus*, which means "cove" or "bay"; thence comes the English word sine.

INDETERMINANT EQUATION

A problem of great interest to Indian mathematicians since ancient times has been to find integer solutions to Diophantine equations that have the form ax + by = c. (This problem was also studied in ancient Chinese mathematics, and its solution is usually referred to as the Chinese remainder theorem.) This is an example from Bhaskara's commentary on Aryabhatiya:

Find the number which gives 5 as the remainder when divided by 8, 4 as the remainder when divided by 9, and 1 as the remainder when divided by 7

That is, find N = 8x+5 = 9y+4 = 7z+1. It turns out that the smallest value for N is 85. In general, diophantine equations, such as this, can be notoriously difficult. They were discussed extensively in ancient Vedic text Sulba Sutras, whose more ancient parts might date to 800 BCE. Aryabhata's method of solving such problems, elaborated by Bhaskara in 621 CE, is called the *kuṭṭaka* (कुट्टक) method. *Kuṭṭaka* means "pulverizing" or "breaking into small pieces", and the method involves a recursive algorithm for writing the original factors in smaller numbers. This algorithm became the standard method for solving first-order diophantine equations in Indian mathematics, and initially the whole subject of algebra was called *kuṭṭaka-gaṇita* or simply *kuṭṭaka*.

ASTRONOMY

Aryabhata's system of astronomy was called the *audAyaka system*, in which days are reckoned from *uday*, dawn at *lanka* or "equator". Some of his later writings on astronomy, which apparently proposed a second model (or *ardha-rAtrikA*, midnight) are lost but can be partly reconstructed from the discussion in Brahmagupta's *Khandakhadyaka*. In some texts, he seems to ascribe the apparent motions of the heavens to the Earth's rotation. He may have believed that the planet's orbits as elliptical rather than circular.

MOTIONS OF THE SOLAR SYSTEM

Aryabhata correctly insisted that the earth rotates about its axis daily, and that the apparent movement of the stars is a relative motion caused by the rotation of the earth, contrary to the then-prevailing view, that the sky rotated. This is indicated in the first chapter of the *Aryabhatiya*, where he gives the number of rotations of the earth in a *yuga*, and made more explicit in his *gola* chapter:

In the same way that someone in a boat going forward sees an unmoving [object] going backward, so on the equator sees the unmoving stars going uniformly westward. The cause of rising and setting the sphere of the stars together with the planets turns due west at the equator, constantly pushed by the cosmic wind.

Aryabhata described a geocentric model of the solar system, in which the Sun and Moon are each carried by epicycles. They in turn revolve around the Earth. In this model, which is also found in the *Paitamahasiddhanta* , the motions of the planets are each governed by two epicycles, a smaller *manda* (slow) and a larger *sighra* (fast). The order of the planets in terms of distance from earth is taken as: the Moon, Mercury, Venus, the Sun, Mars, Jupiter, Saturn, and the asterisms.

The positions and periods of the planets was calculated relative to uniformly moving points. In the case of Mercury and Venus, they move around the Earth at the same mean speed as the Sun. In the case of Mars, Jupiter, and Saturn, they move around the Earth at specific speeds, representing each planet's motion through the zodiac. Most historians of astronomy consider that this two-epicycle model reflects elements of pre-Ptolemaic Greek astronomy. Another element in Aryabhata's model, the *sighrocca*, the basic planetary period in relation to the Sun, is seen by some historians as a sign of an underlying heliocentric model.

ECLIPSES

Solar and lunar eclipses were scientifically explained by Aryabhata. He states that the Moon and planets shine by reflected sunlight. Instead of the prevailing cosmogony in which eclipses were caused by Rahu and Ketu (identified as the pseudo-planetary lunar nodes), he explains eclipses in terms of shadows cast by and falling on Earth. Thus, the lunar eclipse occurs when the Moon enters into the Earth's shadow (verse gola.37). He discusses at length the size and extent of the Earth's shadow (verses gola.38–48) and then provides the computation and the size of the eclipsed part during an eclipse. Later Indian astronomers improved on the calculations, but Aryabhata's methods provided the core. His computational paradigm was so accurate that 18th-century scientist Guillaume Le Gentil, during a visit to Pondicherry, India, found the Indian computations of the duration of the lunar eclipse of 30 August 1765 to be short by 41 seconds, whereas his charts (by Tobias Mayer, 1752) were long by 68 seconds.

SIDEREAL PERIODS

Considered in modern English units of time, Aryabhata calculated the sidereal rotation (the rotation of the earth referencing the fixed stars) as 23 hours, 56 minutes, and 4.1 seconds; the modern value is 23:56:4.091. Similarly, his value for the length of the sidereal year at 365 days, 6 hours, 12 minutes, and 30 seconds (365.25858 days) is an error of 3 minutes and 20 seconds over the length of a year (365.25636 days).

HELIOCENTRISM

As mentioned, Aryabhata advocated an astronomical model in which the Earth turns on its own axis. His model also gave corrections for the speeds of the planets in the sky in terms of the mean speed of the Sun. Thus, it has been suggested that Aryabhata's calculations were based on an underlying heliocentric model, in which the planets orbit the Sun, though this has been rebutted. It has also been suggested that aspects of Aryabhata's system may have been derived from an earlier, likely pre-Ptolemaic Greek, heliocentric model of which Indian astronomers were unaware, though the evidence is scant. The general consensus is that a synodic anomaly (depending on the position of the Sun) does not imply a physically heliocentric orbit (such corrections being also present in late Babylonian astronomical texts), and that Aryabhata's system was not explicitly heliocentric.

CONCLUSION

- **Era** : Gupta era
- **Main interests** : Mathematics, astronomy
- **Notable works** : Aryabhaṭiya, Arya-siddhanta
- **Notable ideas** : Explanation of lunar eclipse and solar eclipse, rotation of Earth on its axis, reflection of light by moon, sinusoidal functions, solution of single variable quadratic equation, value of π correct to 4 decimal places, diameter of Earth, calculation of the length of sidereal year
- **Influenced** : Lalla, Bhaskara I, Brahmagupta, Varahamihira

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