Unit-1 : Indian knowledge system of Mathematics :
1.1 Ancient Indian Arithmetic from Lilavati Samhita by Bhaskarachary-I:
1.1.1 Arithmetic rule : Sutra (Verse 1)
1.1.2 Multiplication of Large Numbers: Sutra (Verse 5)
1.1.3 Division: Sutra (Verse 8):

Unit-1: Indian Knowledge System of Mathematics

1.1 Ancient Indian Arithmetic from *Lilavati* by Bhāskara II

Lilavati is a famous mathematical treatise written around **1150 CE** by Bhāskara II. It presents mathematical concepts in the form of Sanskrit verses (sutras), making them easy to remember and apply.

1.1.1 Arithmetic Rule – Sutra (Verse 1)

Meaning

The opening verse introduces the basic arithmetic operations that every student should master.

These operations are:

- Addition (योग)
- Subtraction (व्यवकलन)
- Multiplication (गुणन)
- Division (भाग)
- Square (वर्ग)
- Square Root (वर्गमूल)
- Cube (घन)
- Cube Root (घनमूल)

Importance

- Forms the foundation of mathematics.
- Encourages systematic calculation.
- Demonstrates that arithmetic was well developed in ancient India.

Key Point

Bhāskara emphasizes learning these operations before studying higher mathematics.

1.1.2 Multiplication of Large Numbers – Sutra (Verse 5)

Method

Bhāskara describes multiplying large numbers by:

- Writing numbers in place-value form.
- Multiplying each digit systematically.
- Adding the partial products.

This is essentially the same principle used in the modern long multiplication method.

Example

Multiply **345 × 27**

```
   345
 ×  27
--------
  2415   (345 × 7)
 6900    (345 × 20)
--------
  9315
```

Therefore,

345 × 27 = 9315

Features

- Uses the decimal place-value system.
- Suitable for very large numbers.
- Efficient and systematic.

1.1.3 Division – Sutra (Verse 8)

Method

Bhāskara explains division by:

1. Comparing the dividend and divisor.
2. Finding each quotient digit.
3. Multiplying the divisor by the quotient digit.
4. Subtracting the product.
5. Bringing down the next digit.
6. Repeating until completion.

This closely resembles the modern long division algorithm.

Example

Divide **756 by 12**

```
12 ) 756
   72
  ----
    36
    36
  ----
     0
```

Quotient = **63**

Remainder = **0**

Features

- Step-by-step process.
- Accurate for large numbers.
- Forms the basis of today's long division.

Importance of *Lilavati*

- One of the greatest mathematical texts of ancient India.

- Demonstrates the advanced state of Indian arithmetic in the 12th century.
- Introduces mathematical ideas through poetic Sanskrit verses.
- Influenced mathematics in India and neighboring regions for centuries.

Unit-2 : Ancient Algebra and its implementation
2.1 Ancient Algebra and Geometry operations from Lilavati Samhita:
2.1.1 Algebra : Sutra (Verse 13)
2.1.2 Geometric Relationships: Sutra (Verse 17)
2.1.3 Understanding Lilavati Samhita theorem later taught as Pythagorean theorem (Geometry): Sutra (Verse 23)
[Implementation of all sutras in computer Lab. Using C / Python / Any other Prog.Language.]

Unit-2: Ancient Algebra and its Implementation

Based on **Lilavati Samhita** by **Bhāskara II**

2.1 Ancient Algebra and Geometry Operations from *Lilavati*

2.1.1 Algebra – Sutra (Verse 13)

Meaning

Bhāskara II introduced algebra (Beejaganita) as the science of solving unknown quantities using symbols and equations.

The verse explains:

- Unknown quantities (variables)
- Simple algebraic equations
- Finding unknown values

Example

Find **x** if:

$x + 25 = 80$

Solution

$x = 80 - 25$

x = **55**

Python Code

```
# Algebra Example

# Equation: x + 25 = 80

x = 80 - 25

print("Value of x =", x)
```

Output

Value of x = 55

2.1.2 Geometric Relationships – Sutra (Verse 17)

Meaning

Bhāskara explained relationships among:

- Length
- Breadth
- Area
- Diagonal
- Triangles

These relationships became the foundation of later geometry.

Example

Area of Rectangle

Length = 12

Breadth = 8

Area = Length × Breadth

Area = 96 square units

Python Code

```
length = 12
breadth = 8

area = length * breadth

print("Area =", area)
```

Output

```
Area = 96
```

2.1.3 Lilavati Theorem (Later Known as the Pythagorean Theorem)

Long before the theorem became widely associated with **Pythagoras**, Indian mathematical traditions described the relationship between the sides of a right triangle.

For a right triangle:

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Where

- a = Base
- b = Height
- c = Hypotenuse

Example

Base = 3

Height = 4

Hypotenuse

$= \sqrt{(3^2 + 4^2)}$

$= \sqrt{25}$

$= \mathbf{5}$

Python Program

```
import math

base = 3
height = 4

hypotenuse = math.sqrt(base**2 + height**2)

print("Base =", base)
print("Height =", height)
print("Hypotenuse =", hypotenuse)
```

Output

```
Base = 3
Height = 4
Hypotenuse = 5.0
```

Python Program (User Input)

```
import math

base = float(input("Enter Base: "))
height = float(input("Enter Height: "))

hypotenuse = math.sqrt(base**2 + height**2)

print("\nRight Triangle")
print("Base =", base)
print("Height =", height)
```

```
print("Hypotenuse =", hypotenuse)
```

Sample Output

```
Enter Base: 6
Enter Height: 8

Right Triangle
Base = 6.0
Height = 8.0
Hypotenuse = 10.0
```

Summary

Topic	Formula	Python Concept
Algebra (Verse 13)	x = Total − Known	Variables and arithmetic
Geometry (Verse 17)	Area = Length × Breadth	Multiplication
Lilavati/Pythagorean Theorem	$a^2 + b^2 = c^2$	math.sqrt() and exponent (**)

These examples connect the mathematical ideas in *Lilavati* with simple Python implementations, making the concepts easier to understand and apply.

Unit-3 : Indian knowledge system on Astronomy :

3.1 Ancient Indian Astronomy from Suryasidhdhanta by Aryabhatt:
3.1.1 Motion of the Earth: Sutra (Verse 3.9)
3.1.2 Length of the Year : Sutra (Verse 3.10)
3.1.3 Lunar and Solar Eclipses: Sutra (Verse 4.5)
3.1.4 The Motion of Planets : Sutra (Verse 1.13)
3.1.5 The Influence of the Sun on Planetary Motion: Sutra (Verse 2.12)
3.1.6 Zodiac and Signs: Sutra (Verse 1.5)
3.1.7 Solar System: Sutra (Verse 1.15)
3.1.8 Speed of Planets: Sutra (Verse 6.5)
3.1.9 Planetary Distances from earth to moon: Sutra (Verse 7.8)
3.1.10 Latitude and Longitude of Planets : Sutra (Verse 8.12)

Unit-3: Indian Knowledge System on Astronomy

Ancient Indian Astronomy is described in the **Surya Siddhanta**, one of the oldest Indian astronomical texts. While your syllabus attributes it to **Aryabhata**, it's worth noting that **Surya Siddhanta** is traditionally treated as a separate classical work, although both it and Aryabhata's writings are foundational to Indian astronomy.

3.1 Ancient Indian Astronomy from Surya Siddhanta

3.1.1 Motion of the Earth – Sutra (Verse 3.9)

Concept

The Earth rotates on its own axis from **west to east**.

This rotation causes:

- Day and night
- The apparent movement of the Sun across the sky

Python Example

```
# Rotation of Earth

rotation_time = 24   # hours

print("Earth completes one rotation in", rotation_time, "hours.")
```

Output

Earth completes one rotation in 24 hours.

3.1.2 Length of the Year – Sutra (Verse 3.10)

Concept

One solar year is approximately

365.25 days

This value is very close to the modern value of about **365.2422 days**.

Python Example

```
days = 365.25

print("Length of a solar year =", days, "days")
```

Output

Length of a solar year = 365.25 days

3.1.3 Lunar and Solar Eclipses – Sutra (Verse 4.5)

Concept

Ancient Indian astronomers explained eclipses scientifically.

- **Solar Eclipse:** Moon comes between Earth and the Sun.

- **Lunar Eclipse:** Earth comes between the Sun and the Moon.

Python Program

```
eclipse = input("Enter eclipse type (solar/lunar): ")

if eclipse.lower() == "solar":
    print("Moon is between Earth and Sun.")
elif eclipse.lower() == "lunar":
    print("Earth is between Sun and Moon.")
else:
    print("Invalid input")
```

3.1.4 Motion of Planets – Sutra (Verse 1.13)

Concept

Planets revolve in regular orbits around the Sun (in the modern heliocentric understanding). Ancient Indian astronomers developed mathematical models to predict planetary positions.

Python Example

```
planets = ["Mercury","Venus","Earth","Mars","Jupiter","Saturn"]

for planet in planets:
    print(planet)
```

3.1.5 Influence of the Sun on Planetary Motion – Sutra (Verse 2.12)

Concept

The Sun plays the central role in determining planetary motion within the Solar System.

Python Example

```
sun = "Center of Solar System"
```

```
print(sun)
```

3.1.6 Zodiac and Signs – Sutra (Verse 1.5)

Concept

The zodiac consists of **12 signs**.

Python Program

```
zodiac = [
"Aries","Taurus","Gemini","Cancer",
"Leo","Virgo","Libra","Scorpio",
"Sagittarius","Capricorn","Aquarius","Pisces"
]

for sign in zodiac:
    print(sign)
```

3.1.7 Solar System – Sutra (Verse 1.15)

Concept

The Solar System consists of:

- Sun
- Eight planets
- Moons
- Asteroids
- Comets

Python Example

```
solar_system = {
    "Star":"Sun",
    "Planets":8
}
```

```
print(solar_system)
```

Output

```
{'Star': 'Sun', 'Planets': 8}
```

3.1.8 Speed of Planets – Sutra (Verse 6.5)

Concept

Each planet moves with its own orbital speed.

Python Example

```
planet_speed = {
   "Mercury":47.87,
   "Earth":29.78,
   "Mars":24.07
}

for planet, speed in planet_speed.items():
   print(planet, ":", speed, "km/s")
```

3.1.9 Planetary Distances (Earth to Moon) – Sutra (Verse 7.8)

Concept

Average distance from Earth to the Moon:

384,400 km

Python Program

```
distance = 384400

print("Earth to Moon distance =", distance, "km")
```

Output

Earth to Moon distance = 384400 km

3.1.10 Latitude and Longitude of Planets – Sutra (Verse 8.12)

Concept

Planetary positions can be expressed using celestial latitude and longitude.

Python Program

```
planet = "Mars"

latitude = 1.85
longitude = 120.45

print("Planet :", planet)
print("Latitude :", latitude)
print("Longitude :", longitude)
```

Output

```
Planet : Mars
Latitude : 1.85
Longitude : 120.45
```

Summary Table

Topic	Main Idea	Python Concept
Motion of Earth	Earth rotates on its axis	Variables
Length of Year	Approximately 365.25 days	Numeric values
Eclipses	Scientific explanation of solar and lunar eclipses	if-else

Topic	Main Idea	Python Concept
Motion of Planets	Planetary movement	Lists and loops
Sun's Influence	Central role of the Sun in the Solar System	Variables
Zodiac	Twelve zodiac signs	Lists
Solar System	Sun and planets	Dictionary
Speed of Planets	Different orbital speeds	Dictionary and loop
Earth–Moon Distance	Average distance ≈ 384,400 km	Variables
Planetary Latitude & Longitude	Coordinates used to locate planets	Variables and printing

Unit-4: Ancient Indian Astronomy and its Application:

Unit-4: Ancient Indian Astronomy and its Application

This unit is based on the contributions of **Varāhamihira**, a renowned Indian astronomer, mathematician, and astrologer. His famous work, **Panchasiddhantika**, summarizes important astronomical knowledge from earlier Indian traditions.

4.1 Ancient Indian Astronomy by Varāhamihira

4.1.1 On Lunar Phases – Sutra (Verse 2.10)

Concept

The Moon appears to change shape because it reflects sunlight while revolving around the Earth. Different portions of its illuminated half become visible from Earth, producing the familiar lunar phases.

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Main Lunar Phases

- New Moon
- Waxing Crescent
- First Quarter
- Waxing Gibbous
- Full Moon
- Waning Gibbous

- Last Quarter
- Waning Crescent

Python Program

```
phases = [
    "New Moon",
    "Waxing Crescent",
    "First Quarter",
    "Waxing Gibbous",
    "Full Moon",
    "Waning Gibbous",
    "Last Quarter",
    "Waning Crescent"
]

print("Lunar Phases:")
for phase in phases:
    print(phase)
```

Output

```
Lunar Phases:
New Moon
Waxing Crescent
First Quarter
Waxing Gibbous
Full Moon
Waning Gibbous
Last Quarter
Waning Crescent
```


4.1.2 On the Movements of the Stars – Sutra (Verse 2.18)

Concept

- Stars appear to move from east to west.
- This apparent motion is mainly due to the Earth's rotation.

- Some stars are visible throughout the year, while others appear only during certain seasons.

Python Program

```
stars = [
    "Sirius",
    "Polaris",
    "Betelgeuse",
    "Rigel"
]

print("Important Stars:")

for star in stars:
    print(star)
```

Output

```
Important Stars:
Sirius
Polaris
Betelgeuse
Rigel
```

4.1.3 Ecliptic Latitude and Longitude

Concept

Astronomers use celestial coordinates to specify the position of planets.

- **Ecliptic Longitude:** Position measured along the ecliptic.
- **Ecliptic Latitude:** Position measured north or south of the ecliptic.

Python Program

```
planet = "Mars"

longitude = 145.8
```

```
latitude = 1.9

print("Planet :", planet)
print("Longitude :", longitude)
print("Latitude :", latitude)
```

Output

```
Planet : Mars
Longitude : 145.8
Latitude : 1.9
```

4.1.4 Sidereal and Tropical Years

Concept

A **sidereal year** is the time Earth takes to complete one orbit relative to the distant stars.

A **tropical year** is the time between two successive vernal equinoxes and is the basis of the modern calendar.

Year Type	Approximate Length
Sidereal Year	365.256 days
Tropical Year	365.242 days

Python Program

```
sidereal = 365.256
tropical = 365.242

difference = sidereal - tropical

print("Sidereal Year :", sidereal)
print("Tropical Year :", tropical)
print("Difference :", round(difference, 3), "days")
```

Output

Sidereal Year : 365.256
Tropical Year : 365.242
Difference : 0.014 days

4.1.5 Planetary Conjunctions and Aspects

Concept

A **planetary conjunction** occurs when two or more planets appear close together in the sky as viewed from Earth.

An **aspect** refers to the angular relationship between celestial bodies. Ancient astronomers and astrologers studied these angular separations for observation and prediction.

Python Program

```
planet1 = "Jupiter"
planet2 = "Venus"

print(planet1, "and", planet2, "are in conjunction.")
```

Output

Jupiter and Venus are in conjunction.

Summary Table

Topic	Main Idea	Python Concept
Lunar Phases	The Moon's appearance changes as it orbits Earth	Lists and loops
Movement of Stars	Apparent motion is mainly due to Earth's rotation	Lists

Topic	Main Idea	Python Concept
Ecliptic Latitude & Longitude	Coordinates used to locate planets	Variables
Sidereal & Tropical Years	Two ways of measuring Earth's orbital period	Arithmetic operations
Planetary Conjunctions & Aspects	Apparent alignment and angular relationships of planets	Variables and printing