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ARYABHATA MATHEMATICAL METHODS: EXPLORING COMPUTATION AND GEOMETRY THROUGH SANSKRIT

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Abstract

Aryabhata occupies an important place in the history of Indian mathematics, and his mathematical ideas were expressed through concise Sanskrit verses. This paper explores Aryabhata's approach to mathematical computation, with particular focus on selected methods presented in the *Gaṇita* section of the *Aryabhatiya*. The study examines both numerical and geometrical procedures, including methods of squaring, cubing, finding square roots and cube roots, as well as the calculation of the area of a triangle, the area of a circle, and the volume of a sphere.

Selected Sanskrit verses are examined to understand how mathematical rules and procedures were expressed through Sanskrit and how they can be interpreted through mathematical examples. Particular attention is given to the systematic nature of these methods and the sequence of operations involved in carrying out the calculations. The procedures for extracting square roots and cube roots provide examples of systematic numerical computation, while the geometrical rules demonstrate Aryabhata's treatment of measurement and mathematical relationships involving plane and solid figures.

The paper also considers the relationship between Sanskrit expression and mathematical reasoning. Rather than viewing the verses merely as formulas, the study attempts to understand how mathematical knowledge was organized and communicated through concise Sanskrit formulations. Selected procedures will be explained through numerical and geometrical examples to make their mathematical structure and significance clear. The study seeks to show how different branches of mathematics can be brought together through the study of a single mathematical tradition. This approach helps connect numerical operations with geometrical measurement and provides a broader understanding of the range of mathematical ideas represented in the text. It also highlights the importance of interpreting

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mathematical verses carefully, since their concise form requires attention to both language and mathematical meaning.

Through this study, the paper aims to highlight the systematic and innovative nature of Aryabhata's mathematical methods and the role of Sanskrit in expressing and communicating mathematical ideas. By bringing together numerical computation and geometry, the study seeks to provide an integrated view of the mathematical knowledge represented in the *Ganita* tradition and to illustrate the richness of the interaction between Sanskrit and mathematics.

Keywords: Aryabhata, Sanskrit Mathematics, Mathematical Computation, *Ganita*, Geometry

1. Introduction

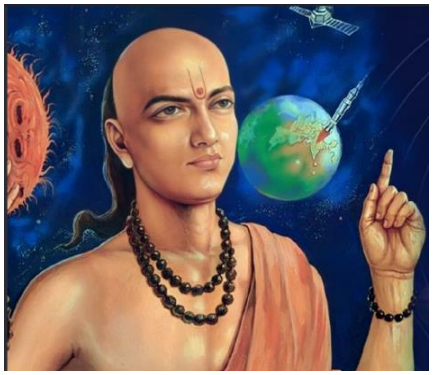
The Aryabhatiya of Aryabhata presents mathematical knowledge through concise Sanskrit verses. The mathematical portion of the work, the Gaṇita section, contains rules dealing with numerical operations, roots, geometrical measurement and other mathematical procedures.

The edition used for the present study is the 1976 critical edition of the Aryabhatiya, critically edited by Kripa Shankar Shukla with the collaboration of K. V. Sarma. The edition provides the Sanskrit text together with English translation, notes and comments.

The Gaṇita section is particularly valuable for studying the relationship between Sanskrit and mathematical computation. Instead of presenting mathematical procedures in modern symbolic notation, the work expresses them through compact verbal formulations. Understanding these verses therefore requires attention to both their Sanskrit terminology and the mathematical procedures implied by them.

The present paper focuses on selected mathematical methods found in this section. The study begins with the ideas of square and cube and then examines the procedures for extracting square roots and cube roots. It then turns to geometrical computation, particularly the area of a triangle, the area of a circle and the volume of a sphere.

The purpose is not merely to translate the verses. It is to understand the mathematical procedure represented by them and to show how numerical computation and geometry are connected within the Gaṇita section.



2. The Gaṇita Section of the Aryabhatiya

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The Gaṇita section begins with numerical notation and the arrangement of numerical places. The edition explains the numerical places through successive positions, with each place being ten times the preceding place. The units, tens, hundreds and higher places are represented according to this positional arrangement.

After discussing numerical places, the text proceeds to mathematical operations.

The sequence examined in the present study is significant:

- square and squaring,
- cube and cubing,
- square root,
- cube root,
- area of a triangle,
- volume of right pyramids,
- area of a circle,
- volume of a sphere.

This arrangement allows numerical operations to lead naturally into geometrical measurement.

The mathematical procedures are presented very concisely. The English explanations and worked examples in the edition help reveal the sequence of operations contained in the Sanskrit verses.

3. Numerical Computation:

3.1 Square and Squaring

The first mathematical topic considered here is the square.

वर्गः समचतुरश्रः फलं च सदृशद्वयस्य संवर्गः ।

वर्गः समचतुरश्रः फलं च सदृशद्वयस्य संवर्गः ।

(Aryabhatiya 2.3)

It explains that a square is an equilateral quadrilateral with equal diagonals, and that the product of two equal quantities is also called a square.

The mathematical idea can be expressed in modern notation as:

$$a \times a = a^2$$

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Thus, if the number is 5:

$$5 \times 5 = 25$$

Therefore:

$$5^2 = 25$$

The important point is that the text connects the geometrical square with the numerical operation of squaring.

A square is a geometrical figure, while the product of two equal quantities represents the corresponding numerical operation. Thus, one concept operates in both geometry and arithmetic.

The commentary included in the edition also discusses terminology associated with square and squaring, including varga, karaṇa, kṛti, vargaṇa and yāvatkāraṇa.

This shows that mathematical terminology itself forms an important part of the Sanskrit mathematical tradition.

3.2 Cube and Cubing

The Sanskrit verse describes the cube as a solid figure having twelve equal edges. It explains that the product of three equal quantities is associated with cubing.

In modern notation:

$$a^3 = a \times a \times a$$

For example:

$$4^3 = 4 \times 4 \times 4 = 64$$

The connection between the numerical cube and the geometrical solid is similar to the relationship between the square and the square operation.

The discussion in the edition also records the terminology used by Bhāskara I for multiplication and powers. The terms associated with repeated multiplication provide a conceptual framework for describing squares, cubes and higher powers.

The treatment of square and cube therefore demonstrates how mathematical operations were described through a combination of geometrical and numerical ideas.

3.3 Extraction of Square Roots

The extraction of square roots is one of the most detailed computational procedures in the Gaṇita section.

भागं हरेदवर्गान्नित्यं द्विगुणेन वर्गमूलेन ।
वर्गाद्वर्गे शुद्धे लब्धं स्थानान्तरे मूलम् ॥

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(Aryabhatiya 2.4)

It explains the procedure in a sequence of operations. After subtracting the greatest possible square from the appropriate place, the square root already obtained is used to determine the next divisor. The process is repeated when further digits remain.

Consider the following example:

$$\sqrt{55{,}225} = 235$$

The calculation begins by separating the appropriate odd and even places. The greatest possible square is first subtracted. The root obtained is then used in the next division. The process continues until the complete root is obtained.

The important feature of this method is that it is procedural.

It can be summarized as follows:

1. Identify the appropriate place of the number.
2. Subtract the greatest possible square.
3. Write the first part of the square root.
4. Double the root already obtained.
5. Use this quantity in the next division.
6. Subtract the square of the new quotient.
7. Repeat the process for the remaining places.

The worked example ends with:

$$235^2 = 55{,}225$$

Thus the remainder is zero and 235 is the exact square root.

This example is particularly useful for the present study because it shows that the Sanskrit verse represents not merely a mathematical result but a method of calculation.

3.4 Extraction of Cube Roots

The Gaṇita section also presents a procedure for finding cube roots.

The verse is:

अघनाद् भजेद् द्वितीयात् त्रिगुणेन घनस्य मूलवर्गेण ।
वर्गस्त्रिपूर्वगुणितः शोध्यः प्रथमाद् घनश्च घनात् ॥

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(Aryabhatiya 2.5)

It explains the arrangement of numerical places for cube-root extraction and then gives a complete numerical example.

Consider the following example,

$$\sqrt[3]{17,71,561} = 121$$

The number is arranged according to cube and non-cube places. The first part of the cube root is obtained, after which successive subtraction and division procedures are performed.

The calculation finally gives:

$$121^3 = 17,71,561$$

The remainder is zero, and therefore 121 is the exact cube root.

The square-root and cube-root procedures have a similar structural feature: both are step-by-step algorithms.

The difference is that the cube-root procedure involves cubic quantities and a different arrangement of numerical places.

These examples demonstrate the importance of systematic computation in the Gaṇita section.

4. Geometrical Computation

4.1 Area of a Triangle

After the treatment of numerical roots, the text moves into geometry. The Sanskrit verse on the area of a triangle states:

त्रिभुजस्य फलशरीरं समदलकोटीभुजार्धसंवर्गः ।

त्रिभुजस्य फलशरीरं समदलकोटीभुजार्धसंवर्गः ।

(Aryabhatiya 2.6)

It means,

The product of the perpendicular dropped from the vertex on the base and half the base gives the measure of the area of a triangle.

In modern notation:

$$A = \frac{1}{2}bh$$

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where:

- b= base
- h= perpendicular height.

For example, if:

$$b = 10$$

and

$$h = 6$$

then:

$$A = \frac{1}{2}(10)(6) = 30$$

Thus, the area is 30 square units.

The important aspect of this rule is the connection between the base, perpendicular and area. The procedure expresses the area through multiplication, showing once again how numerical computation operates within geometrical measurement.

The section also discusses the case where the three sides of a triangle are known but the altitude is not given. The edition provides formulas for determining the relevant segments and altitude.

Here the earlier discussion of square roots becomes important because finding an altitude from given sides requires a square-root operation.

Therefore, the numerical and geometrical sections are interconnected.

4.2 Area of a Circle

The next geometrical topic is the area of a circle.

समपरिणाहस्यार्धं विष्कम्भार्धहतमेव वृत्तफलम् ।

समपरिणाहस्यार्धं विष्कम्भार्धहतमेव वृत्तफलम् ।

(Aryabhatiya 2.7)

It explains the rule as:

Half of the circumference, multiplied by the semi-diameter, gives the area of a circle.

In modern notation:

$$A = \frac{1}{2}C \times r$$

where:

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- C= circumference
- r= radius.

Since:

$$C = 2\pi r$$

the expression becomes:

$$A = \frac{1}{2}(2\pi r)r$$

and therefore:

$$A = \pi r^2$$

It also gives the same result in another form:

$$A = \frac{C \times d}{4}$$

where $d$is the diameter.

This is significant because the rule expresses circular area through measurable quantities—circumference and radius or circumference and diameter.

Thus, the treatment of the circle demonstrates how geometrical measurement and numerical computation work together.

4.3 Circumference and Diameter

The Gaṇita section also gives a specific numerical value for the ratio of circumference to diameter.

The Sanskrit rule is followed by the statement that:

100 plus 4, multiplied by 8, and added to 62,000

gives the nearly approximate circumference of a circle whose diameter is 20,000.

The calculation is:

$$62{,}000 + (104 \times 8) = 62{,}000 + 832 = 62{,}832$$

Therefore:

$$\frac{\square\square\square\square\square\square\square\square\square\square\square\square\square\square\square\square}{\square\square\square\square\square\square\square\square} = \frac{62{,}832}{20{,}000} = 3.1416$$

This explicitly describes this value as approximate.

This is an important example because it shows the use of a numerical approximation in geometrical computation.

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The value is then available for calculations involving the circumference and area of a circle.

4.4 Volume of a Sphere

The treatment of the sphere is one of the most interesting parts of the Gaṇita section.

तद्विषमूलेन हतं घनगोलफलं निरवशेषम् ॥

तद्विषमूलेन हतं घनगोलफलं निरवशेषम् ॥

(Aryabhatiya 2.7)

It means stating that the area of the diametral section multiplied by its own square root gives the volume of a sphere.

If the radius is r, the area of the diametral section is:

$$\pi r^2$$

The section explains Aryabhata's reasoning by treating this area as the area of a square whose side is:

$$\sqrt{\pi r^2}$$

Following this analogy, the volume of the sphere is obtained by treating it as the volume of a cube whose edge is:

$$\sqrt{\pi r^2}$$

Thus the formula represented in the edition is:

$$V = \pi r^2 \sqrt{\pi r^2}$$

The important point here is that the edition does not present this formula as mathematically accurate. It explicitly states that the formula is based on speculation and calls it inaccurate, although the Sanskrit statement itself describes it as exact.

This is an important part of studying the source carefully.

Rather than changing the historical statement to agree with a modern formula, the present study preserves what the edition actually says. The book itself discusses the mathematical reasoning behind the formula and its later assessment.

For this paper, the significance of the passage is therefore not simply whether the formula agrees with the modern formula. Its importance lies in showing how Aryabhata attempted to derive the volume of a sphere by analogy with the area of a circle and the volume of a cube.

5. Relationship Between Numerical Computation and Geometry

The selected examples reveal a strong relationship between numerical computation and geometry in the Gaṇita section. The square is both a geometrical figure and the product of

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two equal quantities. The cube is both a solid figure and the product of three equal quantities. Square-root extraction is a numerical procedure, but square roots also occur when determining geometrical quantities such as the altitude of a triangle. The area of a circle depends upon the circumference and radius, and the circumference itself depends upon the numerical ratio between circumference and diameter. The volume of a sphere similarly uses the area of its diametral section and its square root. Therefore, numerical operations do not appear independently from geometry. They become tools for carrying out geometrical measurement. This integration is one of the main features revealed by the selected passages.

6. Sanskrit and Mathematical Expression

Another important aspect of the Aryabhatiya is its use of Sanskrit to express mathematical procedures.

The mathematical statements are extremely concise. A complete procedure may be expressed in a small number of words.

For example, the square-root rule does not use modern symbols such as:

$$\sqrt{x}$$

Instead, the Sanskrit verse describes the operations to be performed.

Similarly, the triangle rule expresses the relationship between the perpendicular and half the base rather than presenting the modern symbolic formula:

$$A = \frac{1}{2}bh$$

Modern mathematical notation can therefore be used to interpret the historical rule, but it should not be confused with the form in which Aryabhata originally expressed it.

This distinction is important when studying historical mathematics.

The Sanskrit language in the Gaṇita section functions as a technical language. Mathematical terms such as varga, ghana and mūla allow mathematical operations and quantities to be described concisely.

The commentaries included in the edition are particularly useful because they explain the meanings and procedures contained in the compact verses.

7. Discussion

The selected passages from the Gaṇita section reveal three closely connected aspects of mathematical knowledge.

First is computation. The procedures for squaring, cubing and extracting roots show how numerical quantities can be manipulated through systematic operations.

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Second is geometry. The rules for triangles, circles and spheres demonstrate the application of numerical operations to measurement.

Third is language. Sanskrit provides the medium through which the rules are expressed and transmitted.

These three aspects cannot be completely separated.

For example, the square-root procedure is numerical, but it becomes useful in geometry. The circle formula is geometrical, but it depends on numerical computation. The sphere formula combines area, square root and volume.

The selected examples therefore provide an integrated picture of the mathematical material found in the Gaṇita section.

The discussion of the sphere also demonstrates why historical mathematical texts should be read carefully. The edition records Aryabhata's rule, explains its probable reasoning and explicitly discusses its mathematical limitation. This allows the historical mathematical idea to be studied without replacing it with a modern formula.

Thus, the source provides not merely mathematical results but also material for understanding how mathematical reasoning was expressed and interpreted.

8. Conclusion

The study of selected mathematical procedures from the Gaṇita section of the Aryabhatiya demonstrates the close relationship between Sanskrit expression, numerical computation and geometrical measurement.

The discussion of square and cube connects numerical multiplication with geometrical figures. The procedures for square-root and cube-root extraction show systematic methods of numerical computation. The examples given in the text—particularly the extraction of the square root of 55,225 and the cube root of 17,71,561—demonstrate that the mathematical rules were presented as practical procedures rather than merely as statements of results.

The geometrical rules further extend this computational tradition. The area of a triangle is obtained through the perpendicular and half the base. The area of a circle is expressed through half the circumference and the radius. The circumference-diameter calculation provides an approximate value of 3.1416. The discussion of the sphere shows how Aryabhata attempted to obtain a volume through an analogy involving the area of the diametral section and its square root.

An important conclusion from the study is that the mathematics of the Gaṇita section is interconnected. Numerical procedures support geometrical calculations, while geometrical concepts provide interpretations for numerical operations.

The study also demonstrates the importance of Sanskrit as a medium of mathematical expression. The concise verses contain technical mathematical instructions that require

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careful linguistic and mathematical interpretation. The English translation and commentary in the 1976 edition help reveal the procedures contained within these compact Sanskrit formulations.

The Aryabhatiya therefore provides an important example of how mathematical knowledge can be expressed through language in a concise and systematic manner. Studying its mathematical verses allows numerical computation and geometry to be considered together and provides a clearer understanding of the mathematical ideas represented in the Gaṇita tradition.

Reference:

Aryabhata. Aryabhatiya of Aryabhata: Critically Edited with Introduction, English Translation, Notes, Comments and Indexes. Edited by Kripa Shankar Shukla, in collaboration with K. V. Sarma. Indian National Science Academy, New Delhi, 1976.