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The Mathematics Secrets of the Vedas: A Study of Vedic Sutras

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ABSTRACT

Vedic mathematics, an ancient system of mathematical techniques originating from the Vedas, offers a unique approach to numerical computations and problem-solving. Developed in ancient India and formalized by mathematician Bharati Krishna Tirtha in the early 20th century, Vedic mathematics is distinguished by its concise sutras (aphorisms) that encapsulate fundamental mathematical principles. These sutras provide methods for performing arithmetic, algebraic, and geometric operations swiftly and efficiently, often enabling mental calculations faster than conventional methods. By reviewing primary sources and scholarly interpretations, Vedic mathematics elucidates the system's relevance in modern mathematics education and computational methodologies. Furthermore, it investigates potential benefits such as enhanced cognitive skills, improved mathematical proficiency, and broader implications for educational practices. Through this exploration, the abstract aims to contribute to ongoing discussions on the integration of traditional knowledge systems into contemporary educational frameworks and their impact on mathematical learning and problem-solving abilities.

Keywords : Cognitive, Multiplier, Pedagogy, Sutras

INTRODUCTION

Vedic mathematics, an ancient system of mathematical principles and techniques, originates from the Vedas, the oldest scriptures of Hindu philosophy and spirituality. Developed in ancient India between the Vedic period (1500 - 500 BCE) and the early centuries CE, Vedic mathematics presents a unique approach to mathematical computations and problem-solving. It is characterized by its concise and efficient methods, designed to simplify complex arithmetic and algebraic operations. The foundation of Vedic mathematics lies in sixteen sutras (aphorisms) and thirteen sub-sutras, attributed to ancient mathematicians such as Bharati Krishna Tirtha, who revived and systematized these techniques in the early 20th century. These sutras encapsulate profound mathematical insights and offer systematic approaches to perform a wide range of calculations mentally, often faster than conventional methods. Despite its historical roots, Vedic mathematics gained modern prominence due to its potential applications in education, cognitive development, and computational efficiency. Its simplicity and intuitive nature appeal to educators and learners alike, aiming to enhance numerical proficiency and problem-solving skills among students. This research article explores the principles, techniques, and applications of Vedic mathematics, examining its theoretical foundations, practical utility in contemporary settings, and implications for mathematical education. By delving into its historical context and modern relevance, this study aims to contribute to a deeper understanding of Vedic mathematics and its potential impact on mathematical pedagogy and computational methodologies in the 21st century.

These are the 16-basic sutra of Vedic mathematic:

Ekadhikina Purvena:

It means one more than previous one we relate this sutra to multiplication of numbers (suppose a with digit $[a_1, a_0]$ and b with digit $[b_1, b_0]$), whose last digit addition

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(b_0+a_0) comes out to be 10 and previous digit both number $(a_1=b_1)$ is same, but along with this condition number of digit in two number should be same[9]. This sutra, gives the procedure as follows:

a) Last digit a_0 x b_0 = x_1x_0 (2 digit number)
b) Previous digit $(a_1=b_1)$ = $_{a1x}$ (a_1+1) = $y_2y_1y_0$
c) Concatenate result of equations mentioned in point no. 2 and 1 gives $y_2y_1y_0x_1x_0$

(*i.e.* equal to numeric value of a x b).

Examples:

1) Square of 15

[Addition of last digit 5+5 =10]

a) Last digit is 5: 5 x 5=25
b) Previous digit 1: 1x (1+1) = 1 x 2 = 2
c) Concatenate result of equations mentioned in point no. b and a. We get square of 15 *i.e.* 225

2) Square of 165

[Addition of last digit 5+5 =10]

a) Last digit 5: 5 x5 =25
b) Previous digit 16: 16 x (16+1) = 16 x17= 272
c) Concatenate result of equations mentioned in point no. b and a we get square of 185 *i.e.* 27225

3) 22 x 28

[Addition of last digit 2+8 =10]

a) Last digit is 2 and 8: 2x8 =16[2-digit number]
b) Previous digit 2: 2x (2+1) = 2 x3 = 6
c) Concatenate result of equations mentioned in point no. b and a. We get square of 22 x 28 *i.e.* 616.

4) 111 x 119

[Addition of last digit 1+9 =10]

a) Last digit is 1 and 9: 1 x9 =09[2-digitnumber]
b) Previous digit 11: 11 x (11+1) = 11 x12 = 132
c) Concatenate result of equations mentioned in point no. b and a. We get square of 111 x 119 *i.e.* 13209.

Ekanyunena Purvena:

It means one less than previous one or one less than one before, it is considered as a sub-sutra of "nikhilam navatashcaramam dashatoh"[6]. This sutra applicable for multiplication of two numbers where multiplicand is any integer and multiplier are 9 or array of 9.

Examples:

1) 5 x 9

– Step 1: 5-1 = 4
  [Subtract the result from multiplier *i.e.* 9 or array of 9]
– Step 2: 9-4 = 5
  Answer: 5 x 9=45.

2) 45 x 99

– Step 1: 45-1 = 44
  [Subtract the result from multiplier *i.e.* 9 or array of 9]
– Step 2: 99-44 = 55
  Answer: 45x99= 4455.

Now consider examples for application of sutra on multiplication of two numbers with different number of three digits. When array of 9 has more number of digits than other multiplicand.

3) 18 x 999

– Step 1: 18-1 = 17
– Step 2: 999-17 = 982
  Answer: 17 x999=17982.

When multiplicand has a greater number of digit than multiplier (array of 9)[6].

4) 136 x 99

Separate 136 into two parts, this separation depends upon number of digits in array of 9, here array of 9 consist of 2 digits therefore separation will be 1|36.

– Step 1: 1+1=2
  136-2 = 134.
– Step 2: 99-36 = 63.
  63+1=64.
– Step 3: Concatenate result of step 1 and step 2 gives final result of multiplication *i.e.* 136 x99 = 13464.

5) 10462 x 999

Separate 10462 into two parts, this separation depends upon number of digits in array of 9, here array of 9 consist of 3 digit therefore separation will be 10|462.

– Step 1: 10+1=11
  10462-11 = 10451.
– Step 2: 999-462 = 537.
  537+1=538.
– Step 3: Concatenate result of step 2 and step 1 gives final result of multiplication 10462 x999 = 10451538.

(Anurupye) Shunyamanyat:

The Sutra Anurupye Sunyamanyat says if one is in ratio, the other one is zero[8]. We use this Sutra in solving a special type of simultaneous simple equations in which the coefficients of 'one' variable are in the same ratio to each other as the independent terms are to each other. In such a context the Sutra says the 'other' variable is zero from which we get two simple equations in the first variable (already considered) and of course give the same value for the variable.

Examples:

1) $10x + 18y = 8$
The y-coefficients are in the ratio 18:72 = 1:4, the ratio of the constants is 8:32 = 1:4. Hence putting other variable x = 0 in any one of the above equations, we get 18y = 8 or 72y = 32 which gives y= 4/9[8].

2) $18x + 12y = 3$
$12x + 36y = 9$
The ratio of y-coefficients is 12:36 = 1:3, which is same as the ratio of independent terms or constants *i.e.* 1:3.
Hence putting other variable x = 0 in any one of the above equations, we get 12y = 3 or 36y = 9 which gives y = 1/4.

Chalana Kalanabyham:

Differences and similarities. The Sutra means 'Sequential motion' or "By calculus".

Example:

It is used to find the roots of a quadratic equation $(x^2 - 2x + 1) = 0$.

Now by calculus formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$2ax + b = \pm\sqrt{b^2 - 4ac}$$

$$2x - 2 = 0$$

$$x = 1$$

Every Quadratic can thus be broken down into two binomial factors.

Sankalana- vyavakalanabhyam:

Sankalana-Vyavakalanabhyam Sutra is same as Anurupye- Shunyamanyat and is used for solving simultaneous equations. This sutra is used when the coefficients and interchanged[10].

Example:

$45x - 23y = 113$ (1)

$23x - 45y = 91$ (2)

The x-coefficients and the y-coefficients (45 and 23) are interchanged in equation (1) and (2). The procedure to solve for variable x and y is as follows[10]:

- **Step 1**: Addition of equation (1) and (2)
  $(45x-23y) + (23x-45y) = 113+ 91$ $68x-68y=68$
  By simplifying the equation, we get
  $x - y = 3$ (3)
- **Step2**: Subtraction: of equation (1) and (2)
  $(45x-23y)-(45x-23y) = 113-91$ $22x + 22y = 22$
  By simplifying the equation, we get
  $x + y = 1$ (4)
- **Step 3**: Solving equations (3) and (4) simultaneously
  $x - y = 3$
  $x + y = 1$
  $2x = 4$
  We get x=2.

Put the value of x in equation (1) we get the value of y.

Shesanyankena Charamena:

Shesanyankena Charamena means remainder by last digit. This sutra can be used to express a fraction as a decimal, up to required decimal places.

Example: Express 1/7 as a decimal.

- Step 1:
  i) Concatenate zero to the numerator 10 if this numerator is less than the denominator7, Concatenate another zero. If numerator is greater than the denominator, then divide numerator by the denominator, we get the quotient:
  ii) 10 / 7 = 1 and remainder 3.
  iii) Concatenate zero to remainder 3 and divide it by the denominator 7, we get quotient 30 / 7 = 4 and remainder 2.
  iv) Concatenate zero to remainder 2 and divide it by the denominator 7, we get quotient 20 / 7 = 2 and remainder 6.
  v) Concatenate zero to remainder 6 and divide it by the denominator 7, we get quotient 60 / 7 = 8 and remainder 4.
  vi) Concatenate zero to remainder 4 and divide it by the denominator 7, we get quotient 40 / 7 = 5 and remainder5.
  vii) Concatenate zero to remainder 5 and divide it by the denominator 7, we get quotient 50 / 7 = 7 and remainder 1.
  viii) At this point, the remainder 1 is the same number as the original numerator 1. The

answer is going to repeat hence, we will stop divide.

ix) The remainders, are written in order, will be used for step two: 3, 2, 6, 4, 5, and 1.

– Step 2 :

i) Multiply the denominator by the first remainder in the above sequence 7x3=21. Write down the left most digit of this product (1) and drop all the other digits.

ii) Multiply the denominator by the second remainder in the sequence above 7x2 =14. Write down the left most digit of this product (4) and drop all the other digits.

iii) Multiply the denominator by the third remainder in the sequence above 7x6 = 42. Write down the left most digit of this product (2) and drop all the other digits.

iv) Multiply the denominator by the fourth remainder in the sequence above7 x 4 = 28. Write down the left most digit of this product (8) and drop all the other digits.

v) Multiply the denominator by the fifth remainder in the sequence above: 7 x 5 = 35, write down the left most digit of this product (5) and drop all the other digits.

vi) Multiply the denominator by the sixth and last remainder in the sequence above 7 x 1 = 7, write down the left most digit of this product (7) and drop all the other digits.

vii) We get these products in sequence: 1 4 2 8 5 7

Thus, we get, 1/7 = 0.142857142857…

Puranapuranabyham:

By the completion - non - completion. Puranapuranabyham is used to simplify or solve algebra problems.

Example:

$x^3+6x^2+11x+6=0(5)$

– Case 1: $(x + 1)^3$ we don't even have to work out the answer to know this is going to be too low 1 cubed is still just 1.

– Case 2: $(x+2)^3=x^3+6x^2+12x+8(6)$

We'll stop here, because case 2 is very close to the equation (5).

i. Subtract equation (5) and (6) we get $(x^3 + 6x^2 + 12x + 8) - (x^3 + 6x^2 + 11x + 6) = x +2$.

ii. Add (x + 2) to both sides of the equation (5), we get $x^3 + 6x^2 + 11x + 6+x+2= x + 2$ $x^3 + 6x^2 + 12x + 8= x + 2$ $(x+2)^3=(x+2)$.

iii. Now we have a common term, (x + 2), on both sides of the equation. Put y = (x +2) (7) we get $y^3=y$.

iv. Only y= 0 or 1 or -1 satisfy the equation y3=y, if we put y=2 it does not satisfy equation $y^3=y$.

v. Now substitute the values of y in equation (7)

If y = 0 then x + 2 = 0 we get x = -2

If y = 1 then x + 2 = 1 we get x = -1 If y = -1 then x + 2 = -1 we get x = -3 Thus, x = -1, -2, -3.

Urdhva-tiryakbhyam:

Vertically and crosswise. The word "Urdhva-Tiryakbhyam" resources vertical and crosswise multiplication[1]. This multiplication formula is equally applicable to all cases of algorithm for N bit numbers. Conventionally this sutra is used for the multiplication of two numbers in decimal number system. The same concept can be applicable to binary number system. Advantage of using this type of multiplier is that as the number of bits increases, delay and area increases very slowly as compared to other conventional multipliers[1].

Example: Multiplying 123 by 321

– Step 1: Multiply the units place digits vertically. (3 \times 1 = 3).

– Step 2: Multiply crosswise and add the results. ((2 \times 1) + (3 \times 2) = 2 + 6 = 8).

– Step 3: Multiply crosswise and add the results. ((1 \times 1) + (2 \times 2) + (3 \times 3) = 1 + 4 + 9 = 14). Write 4 and carry over 1.

– Step 4: Multiply crosswise and add the results. ((1 \times 2) + (2 \times 3) = 2 + 6 = 8). Add the carryover 1 from step 3: (8 + 1 = 9).

– Step 5: Multiply the tens place digits vertically. (1 \times 3 = 3).

So, (123\times 321) = 39483).

Nikhilam Navatashcaramam Dashatah:

All from 9 and last from 10. Nikhilam Sutra means "all from 9 and last from 10"[7]. Nikhilam Sutra stipulates subtraction of a number from the nearest power of 10 *i.e.* 10, 100, 1000, etc. The power of 10 from which the difference is calculated is called the Base. These numbers are considered to be references to find out whether given number is less or more than the Base. If the given number is 104, the nearest power of 10 is 100 and is the base. Hence the difference between the base and the number is 4, which is Positive and it is called nikhilam. The value of Nikhilam may be reference base, the Nikhilam of 87 is -13 and that of 113 is +13, respectively[7]. Nikhilam Sutra in Vedic Mathematics can be used as shortcuts to multiply numbers, divide numbers in faster approach. In English, it is translated as All from 9 and last from 10[7]. *i.e.* subtract last digit from 10 and rest of digits from 9.

Multiplication using Nikhilam Sutra is used when numbers are closer to power of 10 *i.e.* 10, 100, 1000, etc.

The procedure are as follows:

a. Numbers are below the base number.
b. Numbers are above the base number.
c. One number is above the base and the other number is below it.
d. Numbers are not near the base number, but are near a multiple of the base number, like 20, 30, 50, 250, 600 etc.
e. Numbers near different bases like multiplier is near to different base and multiplicand is near to different base.

Example:

Calculate 98×97 using the Nikhilam Sutra from Vedic mathematics.

– **Identify Base and Calculation Setup**:
  The numbers 98 and 97 are close to 100, which is 10^2.
– **Apply Nikhilam Sutra**:
  - Express 98 and 97 in terms of their complements to 100:
  o 98=100-2
  o 97=100-3
– **Calculate the Product Using Complements**:
  o 98×97= (100-2) × (100-3)
  o Use distributive property: 98×97=100×100x2× 100x3×100+2×3
  = 10000x200x300+6
  = 9604

Therefore, 98×97=9604

Paraavartya Yojayet:

'Paravartya– Yojayet' means 'transpose and apply. In transpose and apply divisors are slightly greater than power of 10[2]. In division method (From left to right) write the Divisor leaving the first digit, write the other digit or digits using negative (-) sign and place them[2]. Consider the division by divisors of more than one digit, and when the divisors are slightly greater than powers of 10.

Example:

Divide 1225 by 12.

– Step 1: (From left to right) write the Divisor leaving the first digit, write the other digit or digits using negative (-) sign and place them below the divisor as shown.

12
-2
––

– Step 2: Write down the dividend to the right. Set apart the last digit for the remainder.

i.e. 12 122 5
- 2

– Step 3: Write the 1st digit below the horizontal line drawn under the dividend. Multiply the digit by –2, write the product below the 2nd digit and add.

i.e., 12 122 5
-2 -2
––– –––
10

Since 1 x –2 = -2 and 2 + (-2) = 0

– Step 4: We get second digits sum as „ 0 . Multiply the second digits sum thus obtained by –2 and writes the product under 3rd digit and adds.

12 122 5
- 2 -20
––– –––
102 5

– Step 5: Continue the process to the last digit.

i.e., 12 122 5
- 2 -20 -4
––– ––– –––
102 1

– Step 6: The sum of last digit is the remainder and the result to its left is quotient thus q=102 and r=1

Shunyam Saamyasamuccaye:

When the sum is same then sum is zero. The sutra sunyamsamyasamuccaye says that „Samuccaya is the same, then Samuccaya is Zero[11].

There are six cases in this sutra as follows: -

1. Samuccaye terms occur as a common factor and equate that common factor to zero.
   Ex: *-5(x+1) =3(x+1),* by sutra *x+1=0*
2. Applicable for same numerator (sum of

denominator=0).

Ex: *-1/(3x-2) =1/(2x-1)*, by sutra *5x-3=0*

3. Samuccaya =the sum of the numerator and the sum of denominator is same then sum equals to zero.

   Ex : *3x+4)/ (3x+5) = (3x+5)/ (3x+4)*,

By sutra *6x+9=0*

1. For any constant factor k

   Ex :-*(2x+3)/(4x+5) =(x+1)/(2x+3),*

   Bysutra *3x+4=2(3x+4), 3x+4=0*
2. For same denominator

   Ex: *-1/(x-4) +1/(x-6) =1/(x-2) +1/(x-8),*

   2x-10=0
3. In the context of a quadratic equation (Numerator=*N*, Denominator=*D*)

   Ex: *-3x+2/2x+5=2x+5/3x+2*

   a) if $N_1+N_2=D_1+D_2$, then $N_1+N_2=0$ or $D_1+D_2=0$, by sutra *5x+7=0*

   b) if $N_1-D_1=N_2-D_2$, then $N_1-D_1=0$ or $N_2-D_2=0$, by sutra *x-3=0*

Yaavadunam:

Whatever the extent of its deficiency. This sutra means that whatever the extent of its deficiency, it is use for Calculating square of numbers near (or lesser) to power of 10[3].

Example:

1. Square of 98

a) nearest power of 10 to 98 is 100

b) 100 as base

c) 100-98=2, here 2 is deficiency

d) 98-2=96, here 96 is left side of answer

e) Square of deficiency =right side of answer (square of *2=04*), 04 in spite of 4 because number of digits in square number is equal to number of zeros in base

f) Answer is <u>*9604*</u>

Vyashtisamanstih:

This sutra is use for finding the part-whole ratio[5]. It gives us the amount of a content from the overall mixture as shown in below.

A bag contains 4 Apple, 8 Mangoes, and 12 Bananas

Total quantity	=24
Now, part-whole ratio of apple	= 4/24
Part-whole ratio of mango	= 8/24
Part-whole ratio of banana	= 12/24

Gunakasamuchyah:

Factors of the sum is equal to the sum of factors. This sutra means that factor of sum is equal to the sum of factor

$Ax^2 + bx + c = (x + d)(x + e)$

where d and e are factors of c and addition of d and e is equal to b.

Now by calculus formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$2ax + b = \pm \sqrt{b^2 - 4ac}$$

Sutra says $2ax + b = (x + d) + (x + e)$

Example: $x^2 + 5x + 4 = (x+4)(x+1)$

$(2x + 5) = (x+4) + (x+1)$

Sopaantyadvayamantyam:

This sutra means the ultimate and twice the penultimate of given multiplication[4].

Example:

1. For single digit value (132 x 12)

a) Zero sandwich for 132(01320)

b) Last digit + 2(second last digit) *=0+2(2) =4*

c) Second last digit + 2(third last digit) *=2+2(3) =8*

d) Third last digit + 2(fourth last digit)*=3+2(1) =5*

e) Fourth last digit + 2(fifth last digit) *=1+2(0) =1* Answer take value from bottom to top=<u>*1584*</u>, from b) to e) 4,8,5 and 1 are single digit values.

2. For double digit value (187 x 12)

a) Zero sandwich for 187(01870)

b) Last digit + 2(second last digit) = 0*+2(7) =14*, double digit value

c) Second last digit + 2(third last digit) *=7+2(8) =23*, double digit value

d) Third last digit + 2(fourth last digit) *=8+2(1) =10*, double digit value

e) Fourth last digit + 2(fifth last digit) *=1+2(0) =1* Answer take value from bottom to top*=1|10|23|14=1+1|0+2|3+1|4=2244*

Gunitasamuchyah:

This sutra means the product of sum is equal to sum. of product[11]. This sutra is for checking the correctness of any given equation.

Example:

$(x+3)(x+2) = x^2 + 5x + 6$

Coefficient of x in x+3 is 1, coefficient of x in x+2 is 1, coefficient of x in x^2 is 1, coefficient of x in 5x is 5 For correctness of any given equation, product of sum of coefficients=sum of coefficients in product.

(1+3) (1+2) =12,

1+5+6=12……. correct

Conclusion :

Vedic mathematics, rooted in ancient Indian scriptures, offers a unique and efficient approach to mathematical calculations. Its techniques simplify complex arithmetic, algebra, geometry, and calculus, making them accessible and easier to understand. The use of sutras, such as the Nikhilam Sutra, enables rapid mental calculations, promoting both speed and accuracy.Empirical studies and practical applications have demonstrated that Vedic mathematics can significantly enhance problem-solving skills and cognitive abilities. Its integration into modern educational frameworks has shown promising results in improving students' mathematical proficiency and interest.

Future Scope:

1. **Educational Integration and Curriculum Development:**
   - Research Focus: Further research should investigate the impact of integrating Vedic mathematics into primary and secondary education curriculums on students' overall mathematical performance.
   - Expected Outcome: Enhanced computational skills and a deeper conceptual understanding of mathematics among students.
2. **Advanced Computational Applications:**
   - Research Focus: Exploration of Vedic mathematics techniques for developing efficient algorithms in computer science and engineering.
   - Expected Outcome: Innovations in cryptography, data compression, and error detection/correction algorithms.
3. **Teacher Training and Resource Development:**
   - Research Focus: Development and evaluation of training programs for educators to effectively teach Vedic mathematics.
   - Expected Outcome: Increased teacher competency in Vedic methods, leading to better student outcomes.
4. **Competitive Examination Preparation:**
   - Research Focus: Analyzing the effectiveness of Vedic mathematics in preparing students for competitive exams where time efficiency is crucial.
   - Expected Outcome: Improved performance in standardized tests such as SAT, GRE, and GMAT.
5. **Global Dissemination and Cross-Cultural Studies:**
   - Research Focus: Investigating the adaptability and effectiveness of Vedic mathematics in diverse educational systems worldwide.
   - Expected Outcome: Broader adoption and recognition of Vedic mathematics as a universal tool for enhancing mathematical education.
6. **Cognitive and Psychological Benefits:**
   - Research Focus: Studying the cognitive and psychological benefits of practicing Vedic mathematics, such as enhanced memory, concentration, and problem-solving abilities.
   - Expected Outcome: Validation of Vedic mathematics as a means to improve cognitive health and intellectual development.

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