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The Vedic Sūtras for binary division

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Abstract

The use of Sūtras in computer arithmetic and several disciplines of mathematics to solve problems is investigated in the paper. You may find examples of binary arithmetic in Vedic mathematics, including addition, subtraction, multiplication, division, squaring, and cubing. By applying the Sūtras to a range of novel situations and places, the researcher has sought to clarify their usefulness. Word formulas are used to recall the Sūtras and Sub-Sūtras. Once we grasp their meaning and pattern, we may apply the relevant Sūtras to solve the issue in a matter of seconds, unlike traditional mathematics where numerous steps are written in between. There is little effort needed to wean students off the calculators, and the procedure is unaffected by the students' ages or qualifications. To summaries, Algebra from the Vedas is a tool for better computation abilities. The consistency mathematics found in the Vedas the most significant trait, according to researchers. This property makes mathematics fun and simple to understand. It encourages new ideas as well.

Keywords: Vedic mathematics, theorems, formalism, proofs, algebraic

Introduction

Vedic Sūtras and Comparison of Vedic Methods with Algebraic Algorithms: Thirteen Sub-Sūtras and sixteen Sūtras form the basis of Vedic mathematics in ancient India. Mathematical computation of Sūtra applications has never been approached in a more efficient and systematic way. The researcher has made an effort to demonstrate the methodologies' connections to Algebra, Arithmetic, and Calculus, and to explain them using Sōtras and Sub-Sūtras.

Ekādhikena Pūrve a Sūtra

Meaning: By a greater margin than before.
For finding Square of numbers having unit digit 5:
Traditional methods for finding the square of a number 95 include multiplying 95 by 95.
A one-line solution may be obtained by squaring a number that contains the unit digit 5 using the Vedic Ekādhikena Pūrve a Sūtra.

E.g. [1]
Find square of 95 i.e. $(95)^2$.
Five is the value that is used in the Vedic Ekādhikena Pūrve a Sūtra, which is the unit of measurement.

Procedure

To get the L.H.S. of the final result, multiply the first digit, 9, by 10 (one more than 9). The last solution's L.H.S. is $9 \times 10 = 90$ and to get the right-hand side's final result, square the last index digit, which is 5 i.e. $5^2 = 25$. To reach the final solution, combine the left and right sides of the portion.

The final answer is $(95)^2 = 90 \mid 25 = 9025$ [2].
Find the square of 125. $(125)^2 = 12 \times (12 + 1) \mid 5^2 = 12 \times 13 \mid 25 = 156 \mid 25 = 15625$

For conversion of vulgar fraction into Recurring Decimal: One step for special divisions whose divisors finish in 1 (e.g., 1/21, 1/41..., 1/29) and another for special divisions whose divisors end in 9 (e.g., 1 divided by 19, 29, 39..., etc.).

Denominator ending in 1: To decrease the dividend by one, remove the unit digit from the divisor if it is 1. In this process, we prefix the remainder to the complement of the quotient digit from nine instead of to each quotient digit, and then we continue dividing in the same way as when dealing with divisors ending in 9.

Materilas and Methods
Convert 1/19 into recurring Decimal.
To solve the above issue using the multiplication technique, follow the steps outlined in the Ekādhikena Pūrve a Sūtra. Begin by multiplying 1 by 2, and then write the result to the left of 1. Repeat this procedure until you reach step 18.

1. Start with 1 (Therefore, the relevant multiplicand and multiplier product must conclude in 9)
2. $1 \times 2 = 2$. Write 2 to the left side of 1 i.e. 21
3. $2 \times 2 = 4$. Write 4 to the left side of 21 i.e. 421 $4 \times 2 = 8$. Write 8 to the left side of 421 i.e. 8421
4. $8 \times 2 = 16$. Write 6 to the left of 8421 and 1 carried over. i.e. ${}_1 68421$
5. $6 \times 2 = 12 + 1$ carried over $= 13$. Write 3 to the left side of 68421 and 1 carried over.i.e.${}_1 368421$
6. $3 \times 2 = 6 + 1$(carried over) $= 7$ i.e.7368421
7. $7 \times 2 = 14$. i.e.${}_1 47368421$
8. $4 \times 2 = 8 + 1$(carried over) $= 9$ i.e. 947368421
9. $9 \times 2 = 18$ i.e. ${}_1 8947368421$…………….

Proceed with this procedure until you reach step 18. Once you've completed 18 steps, just write each number on the left side in the same sequence to keep going. Another scenario is when we deduct the first step's outcome. When we subtract 1 from 9, we obtain 8, the outcome of the tenth step. You may find the first nine digits after the decimal point by subtracting the answer of the last nine digits from 9. This process works if you know the answer of the last nine digits after the decimal point. This means that the final result, which is 18 digits after the decimal point, can be gotten in one line after we know the technique by executing mental steps.

$\therefore 1/19 = 0.{}_1 0\ {}_0 5\ {}_1 2\ {}_0 6\ {}_0 3 {}_1 1\ {}_1 5\ {}_1 7\ {}_1 8\ {}_0 9\ {}_1 4\ {}_0 7\ {}_1 3\ {}_1 6\ {}_0 8\ {}_0 4\ {}_0 2\ {}_0 1$

The answer is validated using the Division technique, and the alternative process outlined above achieves correct results.

E.g.
1/41 Here, the auxiliary fraction of 1/41 is

$$\therefore \frac{1}{41} = .00_1 2_1 4_3 3_0 9_0 0_1 2_1 4_1 3_0 9 = 0.02439$$

$$\therefore \frac{1}{39} = 0_{.1} 0_2 2_2 5_1 6_0 4_0 1_1 0_2 2_2 5_1 6_0 4_0 1$$

$$\therefore \frac{1}{39} = 0.02564125641 \ldots \ldots \ldots \ldots = 0.025641$$

Literature review
"Vedic Mathematics Made Easy" simplifies fundamental Vedic mathematics concepts and distinguishes between two categories: quick and reliable for specific numbers, and theoretically infinite applications. The author includes a chapter on "Mental Magic" to provide methods for predicting things like a person's date of birth and pocket money. The book is useful for students preparing for national and international admission exams, such as the Graduate Management Aptitude Test, and for students applying to schools abroad. The author presents engaging examples to help students understand Vedic mathematics methods for quickly solving mathematical problems, ensuring they excel on these tests.
Is it possible for The scholar examines the Nikhila's performance, including the multiplication algorithm, which is crucial in binary systems, image processing, convolution, and frequency analysis. The Vedic Nikhilaṁ method is used for multiplication, which is carried out using a multiplicand and a multiplier of equal length. The performance of the Nikhilaṁ Algorithm is examined for integers including multiplication, with predicted processing time and performance evaluation shown graphically. The study concludes that operational processing time increases as bit length increases, and the Nikhilaṁ Multiplication Algorithm outperforms the usual technique in terms of processing time and proliferation. The study provides a detailed explanation of the Nikhilaṁ multiplication method.
In his research work "Extension Method of Computing a Guide to Solving Squares of Two-Digit Numbers, published in May 2015, Chandra Rohan delineates a less complicated approach to calculating the two-digit pieces that are similar to $10x + y$, where $0 \le x \le 9$ and $5 \le \le 9$, as long as x and y are integers. In this article, we show how to square two-digit integers using a

quick and straightforward technique originally from the Vedas. The procedure is shown by (a) author's ability to swiftly square a two-digit number, which is crucial for the task at hand. Vedic math's shortcuts are well acknowledged.
Chaudhary Ila, Kularia Deepika (2016), The study "Design of 64-bit High-Speed Vedic Multiplier" discusses the design of a 64-bit Vedic multiplier, which uses a half adder for partial products. The Vedic multiplier is the optimal structural design, using a half adder for partial products. The article provides a visual explanation of the partial product with preceding carry. The 64-bit Vedic multiplier's VHDL code was generated, and results of comparing 8-bit and 64-bit array multipliers, booth multipliers, and multipliers using the Vedic method are presented in a tabular format. The 64 × 64-bit Vedic multiplier was found to be superior in terms of speed and area.

Vertically & Crosswise Sūtra in solving Successive Differentiation

Derivative of multiplication of 2 functions by Crosswise Sūtra: Consider u and w to be two variables. $x, and\ if\ y = u$. w then

$$\frac{dy}{dx} = u.\frac{dw}{dx} + w.\frac{du}{dx} \dots\dots\dots\dots [P]$$

If one is familiar with the standard formula, they may use the Vedic Crosswise Sūtra to determine the differentiation of multiplication in this sort of connection.

Example: 9

Find $\frac{dy}{dx}\ if y = x^2.2^x$

By current method,
The following formula was used [P],

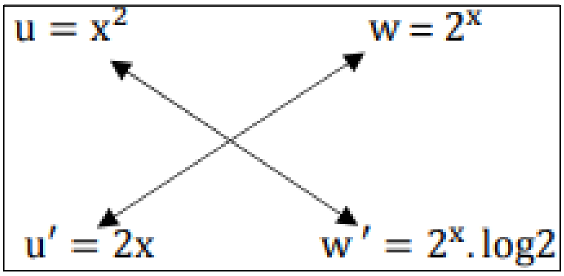
$$u = x^2 \ \&\ w = 2^x;$$

$$u' = \frac{du}{dx} = 2x \ \&\ w' = \frac{dw}{dx} = 2^x.log2$$

$$\therefore \frac{dy}{dx} = x^2(2^x\ log2) + 2^x.(2x)$$

$$\therefore \frac{dy}{dx} = x^2.2^x log2 + 2x.2^x$$

By Vedic Method,
The Vedic Crosswise Sūtra is used to get the derivative of u and w using the conventional formula.,



Looking at the figure above,

$$\therefore \frac{dy}{dx} = x^2(2^x log2) + 2x\ (2^x)$$

Procedure for finding 2nd order and 3rd order derivative by Crosswise Sūtra
Assuming f(x)' is provided. Determine the first order derivative, denoted as f'(x), using the Crosswise Sūtra method. By retaining the first column and repeating the process in the second column using the aforementioned Sūtra and the binomial expansion (Pascal's Triangle), the value of fx may be determined.

For finding $f'''x$ proceeds in the same way as before, which is the same as Leibnitz theorem.
Through the use of the binomial theorem and the vertically and crosswise SŪtra,

Let $f(x) = u.w$

$f'x = (u.w)' = 1C0\, u\, w' + 1C\, u'\, w$

$f''x = u.w'' = 2C0\, u\, w'' + 2C1\, u'\, w' + 2C2\, u''\, w$

$f'''x = u.w''' = 3C0 u\, w''' + 3C1 u'\, w'' + 3C2 u''\, w' + 3C3 u'''\, w$

$f''''(x) = u.w'''' = 4C0\, u\, w'''' + 4C1\, u'\, w''' + 4C2\, u''\, w'' + 4C3\, u'''\, w' + 4C4\, u''''\, w$

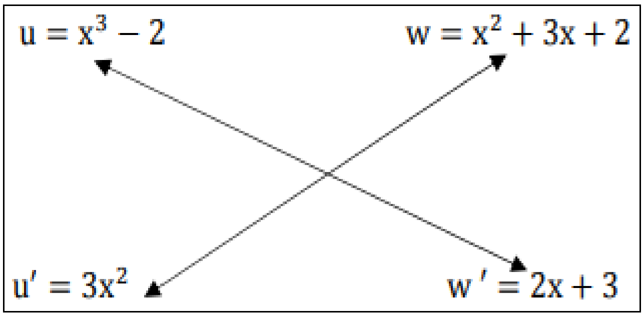
Example: 11

Determine the first and second derivatives of for $y = (x^3, -2)(x^2 + 3x + 2)$
Conventional Method:
Let $u = (x^3 - 2)\ and\ w = (x^2 + 3x + 2)$

$\therefore u' = 3x^2\ \&\ w' = 2x + 3$

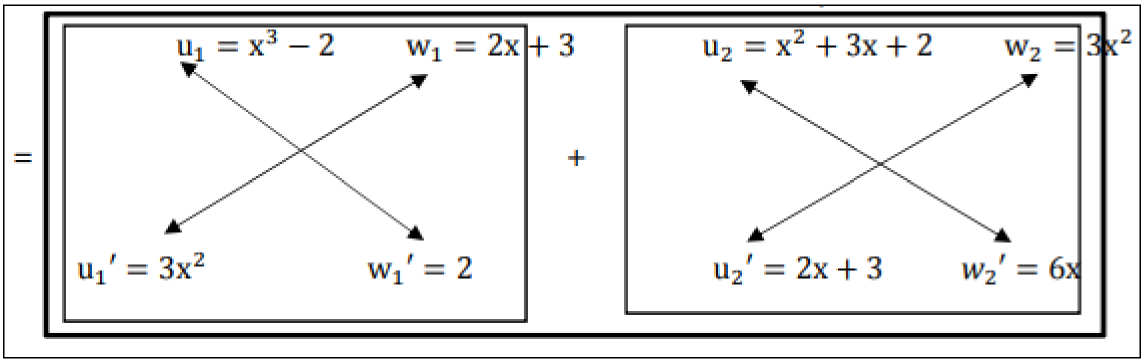
$$\therefore \frac{dy}{dx} = \frac{d}{dx}(u.w) = (x^3 - 2)(2x + 3) + (x^2 + 3x + 2)(3x^2)$$

By using the Vedic Crosswise Sūtra,



$$\frac{dy}{dx} = (x^3 - 2)(2x + 3) + (x^2 + 3x + 2)(3x^2)$$

By applying the Crosswise Sūtra to the 1st order derivative, we may determine the 2nd order derivative.



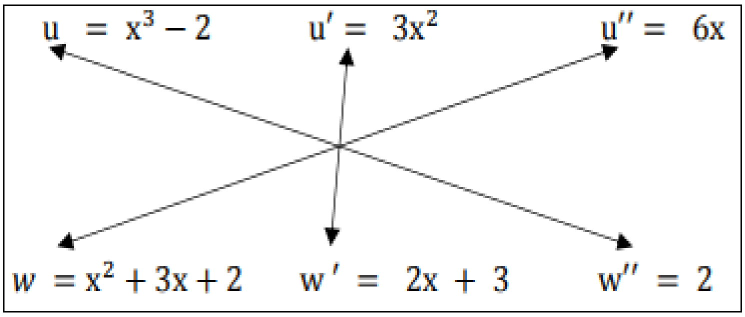
$$\frac{d^2y}{dx^2} = \frac{d}{dx}[(x^3 - 2)(2x + 3) + (x^2 + 3x + 2)(3x^2)]$$

$$= \frac{d}{dx}[(x^3 - 2)(2x + 3)] + \frac{d}{dx}[(x^2 + 3x + 2)(3x^2)]$$

$$2\,(x^3 - 2) + 3x^2\,(2x + 3) + (x^2 + 3x + 2)\,(6x) + 3x2(2x + 3)$$

$$2\,(x^3 - 3) + 2[3x^2(2x + 3)] + (x^2 + 3x + 2)\,(6x)$$

Finding $f''(x)$ by Vertically & Crosswise Sūtra and Binomial expansion:



$$\therefore \frac{d^2y}{dx^2} = 1[2(x^3 - 2)] + 2[3x^2(2x + 3)] + 1[(x^2 + 3x + 2)(6x)]$$

Digression: Differentiation of the ratio of the polynomials
Derivative of the division of two polynomials
If both u and we are polynomials, then finding the derivative of the division of two polynomial functions may be done quickly using the Vertically and Crosswise Sūtra method.

Example: 15
Differentiate

$$\boldsymbol{y = \frac{2 + 4x}{2x + 2x^2}}$$

With the use of the division rule,

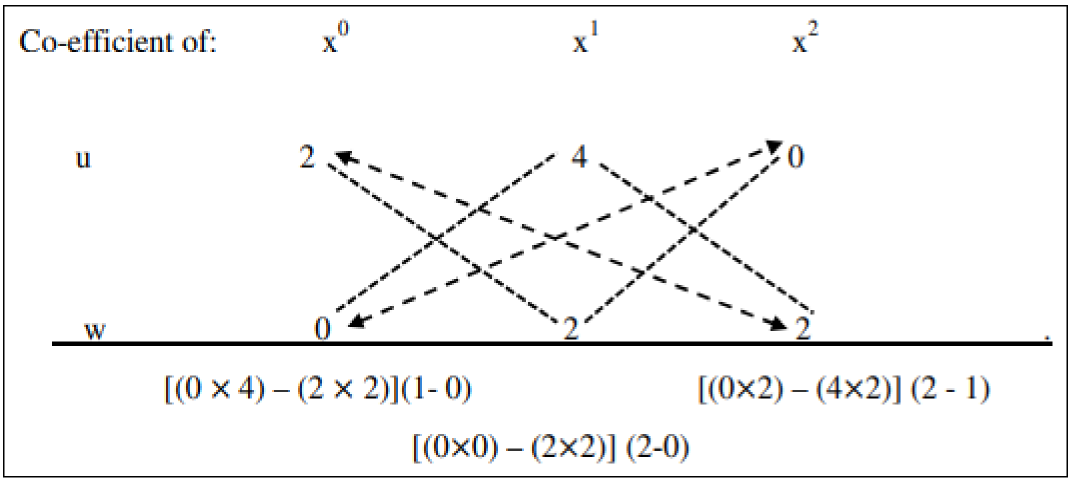
$$\boldsymbol{\frac{(2x + 2x^2)4 - (2 + 4x)(2 + 4x)}{[2x + 2x^2]^2}}$$

$$\boldsymbol{\frac{(8x + 8x^2) - (4 + 16x + 16x^2)}{[2x + 2x^2]^2}}$$

$$\boldsymbol{= \frac{8x + 8x^2 - 4 - 16x + 16x^2}{[2x + 2x^2]^2}}$$

$$\boldsymbol{\therefore \frac{dy}{dx} = \frac{-4 - 8x + 8x^2}{[2x + 2x^2]^2}}$$

To find the derivative of the division of two polynomials using crosswise sūtra, the lengthy method described above can be simplified as follows: the denominator is the square of the term in the denominator of the given problem, and the numerator part of the answer can be easily obtained, as shown in the figure below.



Let $y=\frac{2+4x}{2x+2x^2}=\frac{2x^0+4x+0x^2}{0x^0+2x+2x^2}$

$$\frac{dy}{dx}=\frac{(0\times 4-2\times 2)(1-0)+(0-2\times 2)(2-0)x+(2\times 0-4\times 2)(2-1)x^2}{[2x+2x^2]^2}$$

$$=\frac{(-4)+(-4)2x+(-8)x^2}{[2x+2x^2]^2}$$

$$\therefore \frac{dy}{dx}=\frac{-4-8x-8x^2}{[2x+2x^2]^2}$$

Binary Division by using Vedic Sūtras

Binary Division Algorithm by using Nikhilaṁ Sūtra

Dividend (numerator) A, divisor (denominator) B, and number of bits in divisor (N) are defined. After deducting 10N from the divisor, locate the bits that are missing. Make sure that the remainder bits are equal to the divisor bits and that the number of quotient bits is equal to the number of dividend bits - number of divisor bits by dividing the dividend bits into two parts: one for the quotient bits and another for the remainder bits.

Head over to the top row and write down the bits for the dividend and remainder. Then, write down the first bit of the dividend part under the first bit below the last row in the first column which is the first bit Q_1 of the final answer of the quotient. Then find product of deficit bits D_1 D_2 and Q_1 which is P_1 P_2 write it below the second and third bits of dividend.

Add the second bit of dividend to P_1 and write it below the last row as Q_2.

Till the last bit continue this process. The last quotient bit considered for finding remainder R_1, R_2…….

Example of binary division by Nikhilaṁ Sūtra

1100110 ÷ 1001

A deficit of bits equals 10,000 minus 1001 equals 0111.

OR Deficit Bits = 2's complement of 1001 = 0111

Table 1: Divisor bits

Divisor bits 1 0 0 1	Dividend bits 1 1 0 0 1 1 0	
Deficit Bits: 0 1 1 1	Bits allotted for finding quotient bits	Bits allotted for finding remainder bits
	1 1 0	0 1 1 0
	0 1	1 1
	0	1 1 1
		0 1 1 1
	1 1 1	10 100 11 1
		10 1
	1 1 1	100 1 1 1
Therefore, Q = 1 1 1		R = 100 111

Here, Remainder is greater than Divisor. So, considering Remainder as dividend divide it by the divisor same process as above.

Table 2: Dividend bits and Previous Remainder

<table>
<tr><th>Divisor bits 1001</th><th colspan="6">Dividend bits = Previous Remainder 100111</th></tr>
<tr><th>Deficit Bits</th><th colspan="2">Bits allotted for finding quotient bits</th><th colspan="4">Bits allotted for finding remainder bits</th></tr>
<tr><td rowspan="6">0111</td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>0</td><td></td><td>1</td><td>1</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>10</td><td>10</td><td>1</td></tr>
<tr><td></td><td></td><td>1</td><td>1</td><td></td><td></td></tr>
<tr><td>1</td><td>0</td><td>10</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td colspan="7">Therefore, Q = 111 + 10 = 1101 R = 10101</td></tr>
</table>

Conclusion

Recruiters have also adjusted their methods of recruiting to reflect the modern era's cutthroat competitors and the need for total perfection. Aptitude tests are often used as the first step in the hiring process for prestigious jobs in both academia and business. The freedom to choose one's own method encourages pupils to rely on their instincts and inventiveness. Within this quickly changing world, flexibility and adaptability are absolutely essential for success.

By using Vedic Sūtras complicated and lengthy computations can be solved with greater precision and reduced computation time as compared with traditional mathematical methods. VM also improves memory and creates greater mental alertness. Consistency is the most important aspect of Vedic mathematics. This trait makes it easy to relax and appreciate one's surroundings. Innovations are sparked by it. The exquisite harmony between arithmetic and algebra is clearly visible in the Vedic system. Vedic algorithms based on Ūrdhva-Tiryagbhyām Sūtra, Nikhilaṁ Sūtra & Ānurūpyeṇa Sub- Sūtra etc. may be used to create very quick designs Holistic Enhancers & reconfigurable Fast Fourier Transform (FFT) in DSP.

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