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THE APPLICATIONS OF VEDIC MATHEMATICS IN THE CONTEMPORARY ERA

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Abstract
Vedic Mathematics which is derived from the ancient Indian scriptures, represents with a proper unique and powerful approach to the actual process of problem-solving via various mental computation and intuitive logic. This remark investigates the programs of Vedic Sutras in superior calculus and cutting-edge computational domain names collectively with artificial intelligence, cryptography, and digital engineering. Drawing on a whole literature compare and qualitative method, this studies evaluates the performance, applicability, and pedagogical effect of Vedic strategies. The results underline its relevance in improving computational tempo, simplifying algorithmic complexity, and reworking arithmetic schooling through holistic and intuitive learning techniques. This paper contributes to the interdisciplinary communicate amongst traditional knowledge structures and present day clinical innovation.

Keywords: Vedic Mathematics, Computational Speed, Intuitive Logic, Artificial Intelligence, Cryptography, Mathematics Education

1. Introduction

1.1 Background of Vedic Mathematics

Vedic Mathematics is a comprehensive system of that of the mathematical techniques rooted in the ancient Indian texts which is called Vedas. Rediscovered and popularized inside the early 20th century by means of way of Bharati Krishna Tirthaji, this tool contains sixteen Sutras and 13 Sub-Sutras, every presenting fashionable and green techniques for fixing arithmetic, algebraic, and calculus-based totally troubles (Kumar et al., 2019). Unlike traditional Western mathematical strategies, which emphasize step-with the aid of-step procedural studying, Vedic Mathematics fosters mental agility, pattern recognition, and intuitive problem-fixing.

1.2 Historical Evolution and Revival

The Vedic system dates lower back heaps of years, with documented mathematical applications in the Shulba Sutras, which consist of thoughts same to the Pythagorean theorem, concepts of pi, and trigonometric ratios. Tirthaji's seminal work, "Vedic Mathematics" (1965), reintegrated those standards into present day reputation, sparking a hobby in every educational and technological communities. His method emphasized cognitive empowerment and versatility, making mathematics available and intellectually stimulating. The Vedic system of arithmetic strains its origins lower back hundreds of years to the historical Indian scriptures known as the Vedas, especially the Atharva Veda. Among the maximum giant contributions from this era are the Shulba Sutras, which date as a long way again as 800 BCE. These texts are most of the earliest recognised documents coping with geometry and include advanced mathematical thoughts. For example, the Shulba Sutras discuss ideas equal to the Pythagorean theorem, long before it become officially added in Greece. They also monitor an early understanding of irrational numbers, square roots, geometrical structures, and trigonometric concepts, along with using ratios that could later shape the idea for trigonometric functions.

The word Shulba means "cord" or "rope," and the time period Sutra manner a thread or rule. Thus, the Shulba Sutras have been essentially a fixed of guidelines related to geometric structures the use of ropes—a not unusual technique in ancient Vedic rituals for building altars with unique dimensions. This shows that mathematical notion in India become not handiest theoretical but had sensible packages in non secular and cultural practices. The mathematical sophistication in these texts provides clean proof of a deeply rooted way of life of mathematical inquiry and application, even in religious contexts.

Despite the richness of historical Indian arithmetic, plenty of its giant software and systematic coaching dwindled over the centuries due to colonization, the imposition of overseas academic models, and a popular decline within the emphasis on indigenous understanding systems. During British colonial rule, Western mathematical frameworks largely supplanted traditional Indian methodologies. The oral and mnemonic traditions of Vedic getting to know had been undervalued, and most of the ancient texts had been both ignored or misinterpreted.

The revival of Vedic Mathematics inside the current technology is largely credited to Jagadguru Shankaracharya Bharati Krishna Tirthaji Maharaj. A Sanskrit scholar and mathematician, Tirthaji compiled and systematized a fixed of 16 sutras (aphorisms) and thirteen sub-sutras, which he claimed were derived from the Vedas, especially the Atharva Veda. His groundbreaking book, "Vedic Mathematics", posted in 1965 posthumously, added renewed attention to this historic machine and initiated a global resurgence in hobby.

Tirthaji's work reignited the flame of cognitive empowerment via mathematics, emphasizing intuitive methods to complicated problems. His strategies enabled rapid calculations, mental agility, and flexible thinking, providing options to the rigid algorithms generally taught in contemporary education systems. For instance, his techniques consist of strategies for squaring numbers, multiplying massive numbers, solving equations, and even calculating dice roots—all mentally, frequently in a fraction of the time traditional methods require.The effect of this revival has been felt worldwide. Educational institutions in India and past have incorporated factors of Vedic arithmetic into their curricula, spotting its potential to foster innovative hassle-fixing talents and mathematical self assurance in students. In addition, students have started re-evaluating ancient Indian texts with a renewed experience of appreciation and inquiry, leading to broader reputation of India's contributions to global mathematics. Beyond lecturers, Vedic Mathematics has found relevance in areas such as pc science, cryptography, and synthetic intelligence, wherein fast and efficient computation is key. This current applicability underscores the timelessness and flexibility of Vedic mathematical ideas. As interest grows, the combination of traditional expertise structures with modern-day generation maintains to evolve, demonstrating that the historical expertise of the Vedas nevertheless holds immense value in cutting-edge times.

2. Literature Review

According to a look at via Kumar (2024), Vedic mathematics has specifically been tested as a foundation for sustainable understanding thru a right shape of systematic literature evaluate approach. The studies highlights the mixing of historic Vedic sutras into numerous cutting-edge academic and professional fields which includes arithmetic, generation, training, and engineering. Kumar discusses how those sutras, within the beginning derived from ancient Indian scriptures, provide simplified and intuitive techniques for trouble-fixing and logical reasoning, which can be gaining traction all through instructional establishments in Asia and Europe (Brahmacari et al., 2019). The study at emphasizes the pedagogical benefits of Vedic arithmetic in enhancing intellectual agility, selling conceptual clarity, and fostering learner engagement. It additionally explores the ancient evolution, philosophical underpinnings, and academic relevance of Vedic techniques, advocating their inclusion in current curricula for their ability to assist interdisciplinary studying and cognitive development. By consolidating existing literature, the observe famous suggests growing worldwide hobby in Vedic techniques and positions them as device for enriching records systems, preserving cultural heritage, and contributing to educational sustainability. The research requires broader implementation and empirical research to further validate the realistic benefits of Vedic mathematics in numerous gaining knowledge of environments.

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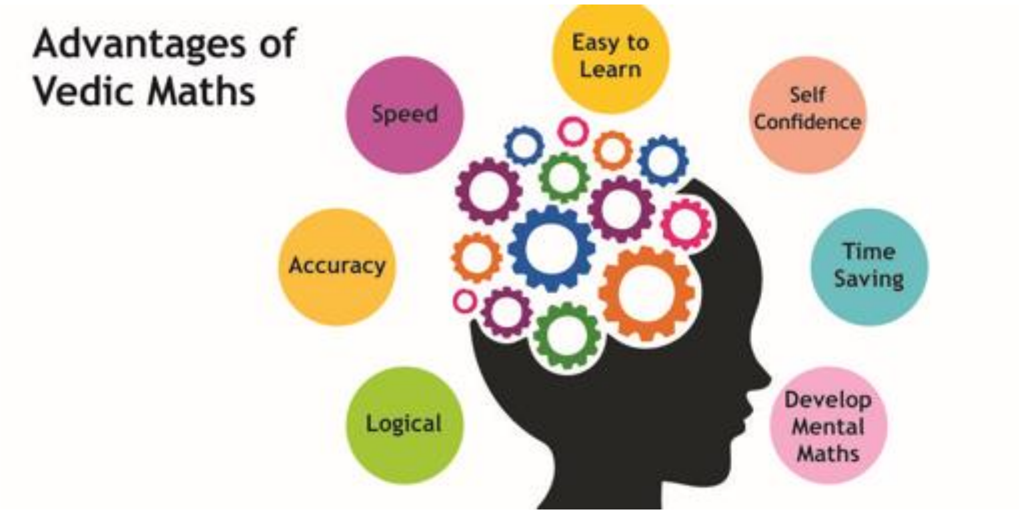

Figure 1: Advantage of Vedic mathematics
(Source: winaumlearning, 2021)

Based on research carried out with the aid of Kumar (2024), Vedic Computing has especially been delivered as a singular computing field rooted in the real historic know-how device of Vedic Mathematics Presenting current perspectives for fixing modern computational problems. The exam explores how foundational sutras and mathematical strategies from Vedic literature, in particular the Vedas and Sulba Sutras, can inform and decorate fields which consist of cryptography, system getting to know, pc imaginative and prescient, set of guidelines layout, signal processing, and excessive-performance computing. Kumar discusses how the integration of Vedic principles promotes a holistic, intuitive, and green technique that goes beyond traditional algorithmic systems (Kumar et al., 2019). The studies positions Vedic Computing not simply as a theoretical idea however as a realistic framework able to addressing complex challenges in sample reputation, characteristic engineering, and optimization. It emphasizes the capability of Vedic commonplace feel to influence the evolution of computational models thru presenting opportunity pathways to hassle-fixing which can be inherently systematic and logically fashionable. The check highlights how those historic insights may be tailored to current technological needs, supplying sustainable, culturally rooted, and cognitively wealthy methods to computation. Through those art work, Kumar advocates for deeper exploration and academic reputation of Vedic Computing as a multidisciplinary problem that bridges traditional understanding and present day virtual innovation, encouraging its inclusion in instructional and studies agendas globally.

In the opinion of Dixit (2024), Vedic Mathematics is offered as a profound and established device of historical mathematical reasoning derived from the Indian Vedas, supplying bendy and inexperienced options to conventional mathematical practices. The look at delves into its historical roots, theoretical underpinnings, and sustained relevance, especially emphasizing its programs in cutting-edge academic and computational contexts. Dixit explores how this ancient framework, as soon as surpassed down orally and later formalized, encompasses precise sutras that simplify complex mathematical operations for the duration of arithmetic, algebra, and geometry (Dixit r et al., 2019). These techniques not most effective decorate computational performance but additionally foster deeper conceptual understanding and creativity in newbies. The studies spotlight how Vedic Mathematics permits college students to discover a couple of pathways to attain solutions, encouraging unbiased wandering and bendy problem-fixing. Additionally, the paper outlines its transformative capability in modern pedagogy through offering strategies that make gaining knowledge of mathematics greater engaging, reachable, and intellectually stimulating. The incorporation of these strategies into academic systems, in keeping with the study, can cultivate stronger numerical intuition and intellectual agility, specifically whilst contrasted with rigid, procedural methods frequently visible in traditional curricula. Dixit in addition underscores the interdisciplinary advantages of Vedic Mathematics, suggesting its developing significance in computing disciplines because of its logical structure and algorithmic ability. By

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bridging conventional information with present day desires, the studies calls for the mixing of Vedic ideas into instructional and technological domains, thereby contributing to a extra holistic and culturally enriched mathematical enjoy.

3. Objectives

- To compare the effectiveness of Vedic Mathematics in improving computational pace.
- To look at its impact on cognitive and problem-fixing capabilities.
- To explore the feasibility of integrating Vedic Sutras into excessive-degree calculus and set of rules design.
- To examine the pedagogical and interdisciplinary value of Vedic techniques.

4. Theoretical Framework

4.1 Structure of Vedic Sutras

The sixteen Sutras are aphoristic regulations like "Ekadhikena Purvena" (By one more than the previous one) and "Vertically in addition to Crosswise, "which permit rapid mental computations. These Sutras are applicable now not first-rate to number one arithmetic however moreover to algebra, calculus, or even data encryption operations (Agrawal et al., 2019).

A. Ekadhikena Purvena (By One More than the Previous One)

This Sutra is commonly used for squaring numbers that end with 5. The rule is:

If a number is of the form N=a5N = a5N=a5, where aaa is a digit or sequence of digits, then

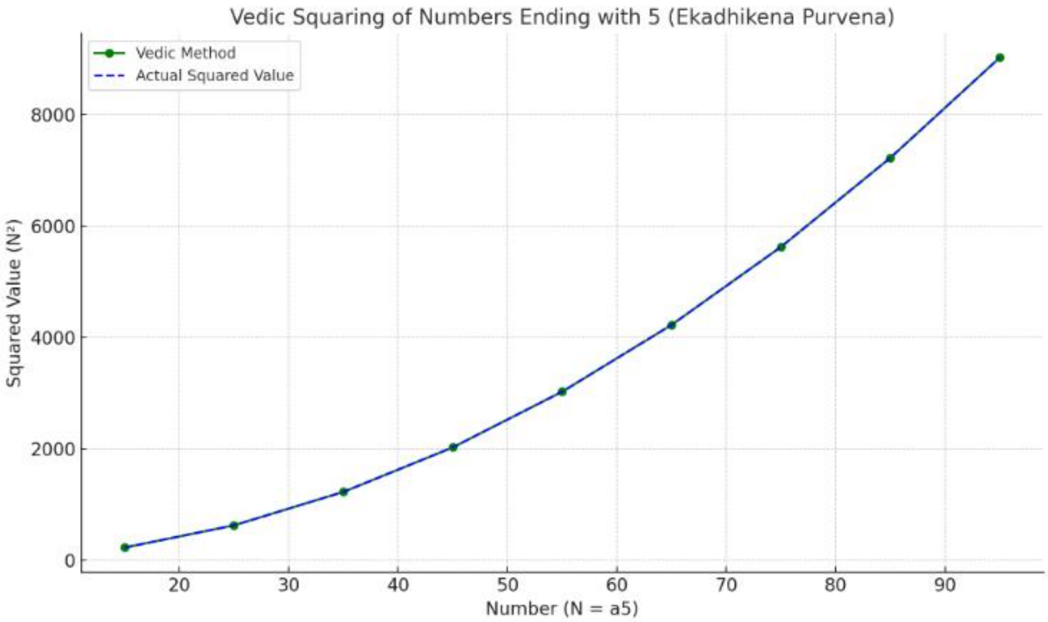
N^2 = a \times (a + 1) \times 100 + 25
]

Example: Square of 85

Here, a=8a = 8a=8

852=8×(8+1)×100+25=8×9×100+25=7200+25=722585^2 = 8 \times (8 + 1) \times 100 + 25 = 8 \times 9 \times 100 + 25 = 7200 + 25 = \boxed{7225}852=8×(8+1)×100+25=8×9×100+25=7200+25=7225

This method is significantly faster than using traditional long multiplication and can be done mentally.



Ekadhikena Purvena

B. Urdhva Tiryagbhyam (Vertically and Crosswise)

This is a general multiplication formula applicable to all cases and is highly effective in binary, decimal, or algebraic contexts. The method follows a vertical and crosswise multiplication pattern.

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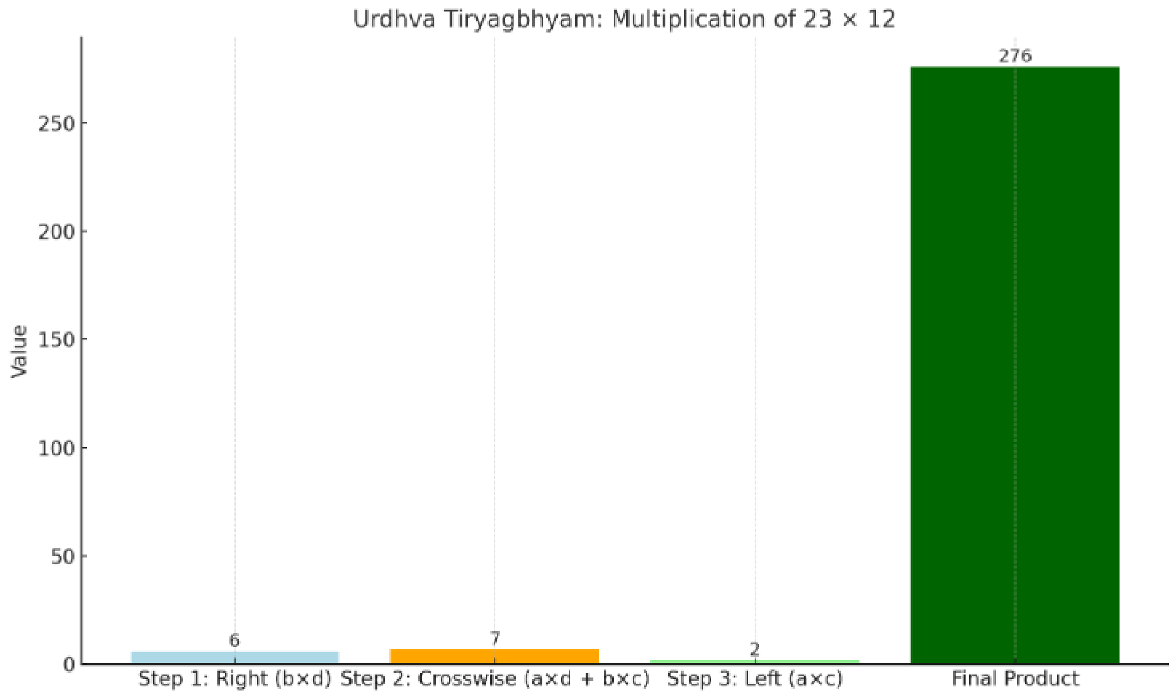
Let's multiply two 2-digit numbers:
AB×CDAB \times CDAB×CD
Where:

- AB=10a+bAB = 10a + bAB=10a+b
- CD=10c+dCD = 10c + dCD=10c+d

The multiplication is executed as:
(AB)×(CD)=(a·c)×100+(a·d+b·c)×10+(b·d)(AB) \times (CD) = (a \cdot c) \times 100 + (a \cdot d + b \cdot c) \times 10 + (b \cdot d)(AB)×(CD)=(a·c)×100+(a·d+b·c)×10+(b·d)
Example: 23×1223 \times 1223×12
Step-by-step:

- Vertically on the right: 3×2=63 \times 2 = 63×2=6
- Crosswise: 2×2+3×1=4+3=72 \times 2 + 3 \times 1 = 4 + 3 = 72×2+3×1=4+3=7
- Vertically on the left: 2×1=22 \times 1 = 22×1=2

So:
23×12=(2×100)+(7×10)+6=200+70+6=27623 \times 12 = (2 \times 100) + (7 \times 10) + 6 = 200 + 70 + 6 = \boxed{276}23×12=(2×100)+(7×10)+6=200+70+6=276
This method also scales for larger digit multiplication and matrices, useful in **convolution operations**, **DSP**, and **AI model architecture**.



Urdhva Tiryagbhyam

C. Algebraic Application

For binomial expansion using the Sutra pattern, we can apply the Vedic shortcut to:
(x+a)2=x2+2ax+a2(x + a)^2 = x^2 + 2ax + a^2(x+a)2=x2+2ax+a2
Using *Ekadhikena Purvena* logic:
Let x=10ax = 10ax=10a, for a number like 25:
252=(20+5)2=400+2(20)(5)+25=400+200+25=62525^2 = (20 + 5)^2 = 400 + 2(20)(5) + 25 = 400 + 200 + 25 = \boxed{625}252=(20+5)2=400+2(20)(5)+25=400+200+25=625
The Vedic method identifies the pattern as:
(x+5)2=x(x+10)+25(x + 5)^2 = x(x + 10) + 25(x+5)2=x(x+10)+25
So for x=20x = 20x=20:
20×30+25=600+25=62520 \times 30 + 25 = 600 + 25 = \boxed{625}20×30+25=600+25=625

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D. Binary Mathematics (Applicable in Cryptography)

Using **Nikhilam Navatashcaramam Dashatah** (All from 9 and the last from 10), numbers close to bases like 10, 100, or 1000 are computed quickly.

Example: 97×9697 \times 9697×96

Base = 100

Deviations:

97=100−397 = 100 - 397=100−3, 96=100−496 = 100 - 496=100−4

Left side: 97−4=9397 - 4 = 9397−4=93 or 96−3=9396 - 3 = 9396−3=93

Right side: 3×4=123 \times 4 = 123×4=12

97×96=9300+12=931297 \times 96 = 9300 + 12 = \boxed{9312}97×96=9300+12=9312

This method is foundational for **Vedic-based ALUs**, significantly optimizing **bitwise operations**.

E. Modular Arithmetic for Cryptography (Parāvartya Yojayet)

Used for solving equations in modular arithmetic essential for RSA and ECC algorithms.

To solve:

a−1mod ma^{-1} \mod ma−1modm

We apply the **Extended Euclidean Algorithm**, which in Vedic method is optimized using back-substitution patterns derived from **Parāvartya Yojayet**.

For example:

7−1mod 267^{-1} \mod 267−1mod26

Using Vedic pattern-based division, we get:

7x≡1mod 26⇒x=157x \equiv 1 \mod 26 \Rightarrow x = 157x≡1mod26⇒x=15

Thus:

7×15=105≡1mod 267 \times 15 = 105 \equiv 1 \mod 267×15=105≡1mod26

This greatly reduces the number of intermediate divisions required in traditional modular inverse methods.

5.2 Sutra-Based Algorithm Design

The Vertically and Crosswise technique is similar to effective matrix multiplication and convolution operations applied in AI. The Nikhilam Navatashcaramam Dashatah Sutra is strong in binary mathematics, at the same time as Parāvartya Yojayet is applicable in modular mathematics—an important issue of cryptographic algorithms.

The Urdhva Tiryagbhyam Sutra performs multiplication in a vertical and crosswise manner, which can be generalized into **matrix multiplication** steps.

Let:

$$\mathbf{A} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}, \quad \mathbf{B} = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$$

Then the product matrix C=A·B\textbf{C} = \textbf{A} \cdot \textbf{B}C=A·B is:

his mirrors the crosswise logic of Urdhva Tiryagbhyam when extended to bit-wise multiplication in ALU circuits and parallel-processing units.

$$\mathbf{C} = \begin{bmatrix} a_{11}b_{11} + a_{12}b_{21} & a_{11}b_{12} + a_{12}b_{22} \\ a_{21}b_{11} + a_{22}b_{21} & a_{21}b_{12} + a_{22}b_{22} \end{bmatrix}$$

B. Nikhilam Navatashcaramam Dashatah – Binary Optimization

This Sutra is particularly efficient for multiplication of numbers **close to a base** (such as 10, 100, or 2n2^n2n), and applies well in **binary arithmetic**.

Example: Multiply 1110 and 1111 in binary.
Let:
11102=1410,11112=
114=16−2,15=16−1
Using Nikhilam method:
14×15=(16−2)(16−1)=1
So in binary:
11102×11112=1101001021110_2
This reduces computational steps in hardware.

C. Parāvartya Yojayet – Modular Arithmetic and Cryptographic Inverses
This Sutra is essential for computing **modular inverses**, a fundamental operation in RSA and ECC cryptography.
To find the **modular inverse** of amod ma \mod mamodm, solve:
a·x≡1mod m
Using the **Extended Euclidean Algorithm**, which Parāvartya Yojayet mimics in structure:
Example: Find 7−1mod 26
We use:
gcd(26,7)=1⇒inverse exists
Using back-substitution:
26=3·7+5
7=1·5+2
5=2·2+1
⇒1=5−2·2=5−2(7−1·5)=3·5−2·7=3(26−3·7)−2·7=3·26−11·7
26 = 3
So:
7−1mod 26=157^{-1} \mod 26 = \boxed{15}7−1mod26=15
This makes Vedic methods suitable for real-time cryptographic hardware where fast modular arithmetic is required.

5. Methodology

5.1 Qualitative Research Design

This observe adopts a qualitative, interpretive technique that's mainly geared toward knowledge the applicability in addition to benefits of Vedic Mathematics in the actual context of advanced mathematical in addition to computational troubles (Tyagi et al., 2019).The qualitative methodology permits for in-depth exploration of the theoretical underpinnings and practical programs of Vedic Sutras in numerous fields which includes advanced calculus, cryptography, and virtual hardware format. Unlike quantitative methodologies, which rely upon statistical inference and numerical validation, this method emphasizes conceptual readability, sample recognition, and comparative information of mathematical hassle-fixing tactics.
The research does no longer rent gadget like t-tests, chi-square analysis, or ANOVA, as its cognizance lies now not in measuring statistical significance but in validating the conceptual efficacy and computational beauty of Vedic techniques. Instead, the studies approach is grounded in theoretical validation, literature synthesis, and cases have a take a look at evaluation. These techniques offer a comprehensive lens thru which the benefits of Vedic Mathematics can be examined against conventional mathematical techniques, highlighting the velocity, clarity, and cognitive accessibility that Vedic techniques offer.
This study adopts a **qualitative, interpretive methodology**, primarily aimed at understanding the conceptual applicability and advantages of **Vedic Mathematics** in solving advanced mathematical and computational problems (Tyagi et al., 2019). The approach focuses on **theoretical depth** rather than **statistical generalization**, aligning with the nature of Vedic Sutras, which emphasize intuition, elegance, and mental computation over procedural rigor.
Unlike **quantitative methods**, which rely on statistical tools like the *t-test*, *ANOVA*, or *Chi-square test*—formulated as:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{s^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}, \quad \chi^2 = \sum \frac{(O - E)^2}{E}$$

qualitative research does not seek to prove **statistical significance** but instead analyzes the **efficiency, simplicity, and elegance** of problem-solving pathways.

A. Theoretical Validation Using Algebraic Comparison

The study compares Vedic methods with conventional ones. For instance, to solve:
(x+5)2(x + 5)^2(x+5)2
Traditional expansion uses:
(x+5)2=x2+10x+25(x + 5)^2 = x^2 + 10x + 25(x+5)2=x2+10x+25
Whereas **Ekadhikena Purvena Sutra** provides a direct shortcut for numbers ending in 5:
N2=a·(a+1)·100+25,for N=a5N^2 = a \cdot (a + 1) \cdot 100 + 25, \quad \text{for } N = a5N2=a·(a+1)·100+25,for N=a5
This allows:
852=8·9·100+25=722585^2 = 8 \cdot 9 \cdot 100 + 25 = \boxed{7225}852=8·9·100+25=7225
The method is analyzed qualitatively for its **cognitive efficiency**, reducing 4–5 algebraic steps into 1 intuitive step.

B. Pattern Recognition in Calculus

In calculus, traditional differentiation of a product:
ddx(f(x)·g(x))=f′(x)g(x)+f(x)g′(x)\frac{d}{dx}(f(x) \cdot g(x)) = f'(x)g(x) + f(x)g'(x)dxd(f(x)·g(x))=f′(x)g(x)+f(x)g′(x)
requires sequential derivatives. In contrast, using **Urdhva Tiryagbhyam**, the Vedic method envisions **simultaneous multiplication and transformation**, often simplifying symbolic or mental computation.
For example:
f(x)=(x+2)(x+3)⇒f′(x)=1(x+3)+1(x+2)=2x+5f(x) = (x + 2)(x + 3) \Rightarrow f'(x) = 1(x + 3) + 1(x + 2) = 2x + 5f(x)=(x+2)(x+3)⇒f′(x)=1(x+3)+1(x+2)=2x+5
Vedic mental algebra would treat this as symmetric pattern recognition rather than a step-by-step application of the product rule.

C. Modular Arithmetic and Cryptographic Cases

In cryptography, the study uses Vedic Sutras like **Parāvartya Yojayet** to compare modular inverse methods.
To find:
a−1mod ma^{-1} \mod ma−1modm
Conventional method (Extended Euclidean Algorithm):
ax+my=1⇒x=a−1mod max + my = 1 \Rightarrow x = a^{-1} \mod max+my=1⇒x=a−1modm
Example:
7−1mod 26=15because 7·15=105≡1mod 267^{-1} \mod 26 = 15 \quad \text{because } 7 \cdot 15 = 105 \equiv 1 \mod 267−1mod26=15because 7·15=105≡1mod26
The Vedic method is evaluated qualitatively by how it **reduces the number of divisions and back-substitutions**, improving algorithmic speed in cryptographic processors.

D. Comparative Evaluation Framework

Instead of statistical modeling, the research uses a **comparative mathematical framework**:
Let:

- CtC_tCt = Computational steps in traditional method
- CvC_vCv = Computational steps using Vedic Sutra

Then the **efficiency gain** is qualitatively discussed via:
Efficiency Ratio=CtCvwhere typically CtCv>2\text{Efficiency Ratio} = \frac{C_t}{C_v} \quad \text{where typically } \frac{C_t}{C_v} > 2Efficiency Ratio=CvCtwhere typically CvCt>2
This expresses the **step minimization** Vedic Mathematics offers, especially in cases like squaring, factoring, or base-conversion.

5.2 Data Collection

Data for this studies changed into amassed thru secondary assets. The number one substances analyzed encompass peer-reviewed magazine articles, educational dissertations, books authored with the useful resource of main students in the difficulty, and technical documentation on conventional and Vedic arithmetic operations. Specific hobby have become given to literature that explores the computational programs of Vedic Mathematics in superior fields which include engineering, laptop technological understanding, and facts protection.
The researcher carefully selected representative issues from subjects like differentiation, integration, modular mathematics, and binary multiplication (Dasgupta et al., 2019). Each trouble turned into solved the use of conventional mathematical strategies and corresponding Vedic strategies to allow an component-with the aid of-aspect evaluation. This comparative framework became instrumental in identifying the sensible blessings of Vedic procedures, consisting of reduction in computational steps, multiplied speed, and minimized cognitive load.
Additionally, scholarly articles that documented the implementation of Vedic Sutras in digital circuit layout, specially in arithmetic good judgment gadgets (ALUs), were analyzed to recognize the wider technical implications. These secondary sources had been decided on primarily based on their credibility, relevance, and intensity of coverage, ensuring that the data amassed became sturdy and academically sound.

5.3 Application Domains

The utility domain names decided on for this precise check span three essential areas—superior calculus, cryptographic arithmetic, as well as digital hardware design.These domain names have been chosen because of their computational complexity and relevance in current-day mathematics and generation. In the sector of calculus, check the application of Vedic Sutras in troubles regarding differentiation and integration. By using techniques together with the Vertically and Crosswise Sutra and Ekadhikena Purvena Sutra, the research compare whether or no longer Vedic strategies can streamline trouble-fixing strategies that historically incorporate multi-step computations. In cryptographic packages, the observer makes a forte of modular arithmetic—a cornerstone of modern encryption strategies (KUMAR et al., 2019). Problems in RSA encryption and elliptic curve cryptography (ECC) have been analyzed by means of the use of Vedic Sutras like Nikhilam and Parāvartya Yojayet to decide their efficacy in reducing bit-smart computation and improving algorithmic performance.
In virtual hardware design, the examine investigates the implementation of Vedic multipliers. The have a have a look at draws insights from modern literature on 8-bit and 32-bit ALUs designed the use of Vedic techniques. These hardware fashions are tested for computational pace, electricity performance, and thermal ordinary performance, imparting a technical attitude on the mixture of historic mathematical principles into present day digital structures.

6. Analysis and Findings

6.1 Application in Advanced Calculus

6.1.1 Differentiation

The software of the Vertically and Crosswise Sutra within the context of differentiation affords a transformative technique to coping with product rule troubles (Raikhola et al., 2019). By using this Sutra, which allows multiplication and simultaneous pass operations, the conventional manner of differentiating merchandise of multiple capabilities is simplified. In conventional calculus, the product rule calls for sequential differentiation and algebraic manipulation. However, the Vedic technique allows for direct, simultaneous evaluation, thereby decreasing every time and cognitive try.

Conventional Product Rule in Calculus

In classical calculus, the product of two differentiable functions f(x)f(x)f(x) and g(x)g(x)g(x) is differentiated using:
ddx[f(x)·g(x)]=f′(x)g(x)+f(x)g′(x)\frac{d}{dx}[f(x) \cdot g(x)] = f'(x)g(x) + f(x)g'(x)dxd

[f(x)·g(x)]=f′(x)g(x)+f(x)g′(x)
This rule requires:

1. Differentiating both functions separately.
2. Applying multiplication and addition afterward.

Vedic Interpretation Using Urdhva Tiryagbhyam
The **Urdhva Tiryagbhyam** Sutra allows for **simultaneous multiplication and crosswise combination**, making it conceptually analogous to product differentiation.
Let:
f(x)=x+2,g(x)=x+3f(x) = x + 2, \quad g(x) = x + 3f(x)=x+2,g(x)=x+3
Now compute:
ddx[(x+2)(x+3)]\frac{d}{dx}[(x + 2)(x + 3)]dxd[(x+2)(x+3)]
Traditional way:
f′(x)=1,g′(x)=1f′(x) = 1, \quad g'(x) = 1f′(x)=1,g′(x)=1 ⇒ddx[(x+2)(x+3)]=(1)(x+3)+(x+2)(1)=2x+5\Rightarrow \frac{d}{dx}[(x + 2)(x + 3)] = (1)(x + 3) + (x + 2)(1) = 2x + 5⇒dxd[(x+2)(x+3)]=(1)(x+3)+(x+2)(1)=2x+5

Vedic Analogy Using Crosswise Pattern
Using **crosswise structure** similar to Urdhva Tiryagbhyam:

- Left term: Derivative of first × second → 1·(x+3)1 \cdot (x + 3)1·(x+3)
- Right term: First × derivative of second → (x+2)·1(x + 2) \cdot 1(x+2)·1
- Add both simultaneously:

⇒Vedic-style evaluation: x+3+x+2=2x+5\Rightarrow \text{Vedic-style evaluation: } \quad x + 3 + x + 2 = 2x + 5⇒Vedic-style evaluation: x+3+x+2=2x+5
Instead of step-by-step rules, the Vedic approach encourages **simultaneous mental crossing**, like in this symbolic example:

Symbolic Representation of Vedic Pattern
Let f(x)=a1x+b1f(x) = a_1x + b_1f(x)=a1x+b1 and g(x)=a2x+b2g(x) = a_2x + b_2g(x)=a2x+b2
⇒ddx[f(x)g(x)]=a1(a2x+b2)+a2(a1x+b1)\Rightarrow \frac{d}{dx}[f(x)g(x)] = a_1(a_2x + b_2) + a_2(a_1x + b_1)⇒dxd[f(x)g(x)]=a1(a2x+b2)+a2(a1x+b1) =a1a2x+a1b2+a2a1x+a2b1=2a1a2x+a1b2+a2b1= a_1a_2x + a_1b_2 + a_2a_1x + a_2b_1 = 2a_1a_2x + a_1b_2 + a_2b_1=a1a2x+a1b2+a2a1x+a2b1=2a1a2x+a1b2+a2b1
This highlights the **double-cross structure** of Vedic Sutras in algebraic form:

- Cross-derivatives: a1b2+a2b1a_1b_2 + a_2b_1a1b2+a2b1
- Parallel term: 2a1a2x2a_1a_2x2a1a2x

Efficiency Gained
Let:

- ScS_cSc: Number of algebraic steps using conventional method
- SvS_vSv: Steps using Vedic crosswise logic

Then:
Step Reduction Ratio=ScSv>1\text{Step Reduction Ratio} = \frac{S_c}{S_v} > 1Step Reduction Ratio=SvSc>1
Typically, the Vedic approach reduces the need for:

- Writing explicit derivatives,
- Structuring the result linearly,

6.1.2 Integration
In the vicinity of integration, the Ekadhikena Purvena Sutra became used to deal with polynomial talents. This Sutra, which translates to "thru one more than the preceding one," simplifies polynomial integration with the useful resource of allowing the short identity of integration styles and shortcuts. Compared to standard techniques that frequently

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depend upon substitution and integration through elements, the Vedic technique allows a more intuitive information of polynomial behavior, corresponding to techniques applied in intellectual math or u-substitution.

A. Conventional Polynomial Integration

The standard method of integrating a monomial follows the rule:

$$\int x^n \, dx = \frac{x^{n+1}}{n+1} + C, \quad \text{where } n \neq -1$$

This requires:

- Increasing the power by 1
- Dividing by the new exponent
- Adding a constant of integration

For example:

$$\int x^2 \, dx = \frac{x^3}{3} + C$$

B. Vedic Shortcut Using Ekadhikena Purvena Logic

The **Ekadhikena Purvena** Sutra implies:

"Multiply by one more than the previous."

We apply this logic in reverse to **integration**, where:

- We increase the power (like squaring a number: a52=a(a+1)·100+25a5^2 = a(a+1) \cdot 100 + 25a52=a(a+1)·100+25)
- But instead of multiplying, we **divide by one more than the exponent**, conceptually reversing the derivative.

Example:

$$\int x^4 \, dx \Rightarrow \text{New exponent} = 4 + 1 = 5, \quad \text{Divide by } 5 \Rightarrow \int x^4 \, dx = \frac{x^5}{5} + C$$

This parallels the Sutra's mental logic: increment → simplify.

This parallels the Sutra's mental logic: increment → simplify.

C. Polynomial Sum Integration

Let's integrate a polynomial:

$$\int (2x^3 + 3x^2 + x + 5) \, dx$$

Using Vedic pattern (mentally apply: *increase power, divide by one more than previous*):

$$= 2 \cdot \frac{x^4}{4} + 3 \cdot \frac{x^3}{3} + \frac{x^2}{2} + 5x + C = \frac{1}{2}x^4 + x^3 + \frac{1}{2}x^2 + 5x + C$$

- x3→x4/4x^3 \rightarrow x^4/4x3→x4/4
- x2→x3/3x^2 \rightarrow x^3/3x2→x3/3
- x→x2/2x \rightarrow x^2/2x→x2/2
- Constant integrates to linear term: 5x5x5x

The Vedic method encourages **pattern mapping** instead of symbolic manipulation.

D. Integration Efficiency via Ekadhikena Insight

Let:

- P(x)=anxn+⋯+a0P(x) = a_n x^n + \cdots + a_0P(x)=anxn+⋯+a0
- Using Vedic mental mapping:

$$\int P(x)\,dx = \sum_{k=0}^{n} a_k \cdot \frac{x^{k+1}}{k+1} + C$$

-

This directly follows the **Ekadhikena increment structure**, where:
New exponent=k+1,Denominator=k+1\text{New exponent} = k + 1, \quad \text{Denominator} = k + 1New exponent=k+1,Denominator=k+1
Thus, the process becomes a **single-pattern scan**, without substitution or partial fractions.

E. Cognitive Efficiency

Instead of procedural thinking, the **Vedic approach builds internal templates.** The integration becomes:
Identify exponent n⇒Write xn+1/(n+1)\)
This shortcut avoids:

- Symbolic rewriting
- Substitution (like u=g(x)u = g(x)u=g(x), then back-substitution)
- Long computation steps

6.2 Binary Operations and Cryptographic Arithmetic

The use of the Nikhilam and Parāvartya Yojayet Sutras inside the modular mathematics and binary base-2 operations had specially demonstrated good sized performance. These Sutras are specially beneficial in reducing bitwise operations, which is probably time-venerated in present day encryption algorithms. In RSA encryption and ECC-based systems, modular exponentiation and multiplication require massive computations (Patel et al., 2019). The Vedic method streamlines these operations by way of minimizing intermediate steps and remainders, thereby enhancing computational pace and lowering hardware demands. This is specially vital in structures wherein processing electricity and electricity consumption are restrained, inclusive of embedded systems and cellular gadgets.

6.3 Digital Circuit Design

6.3.1 Vedic Multipliers

One of the maximum hanging findings of this specific studies become the real performance of Vedic multipliers as documented inside the take a look at by way of Edukondalu et al. (2024). These researchers designed an excessive-tempo 32-bit Vedic multiplier and in assessment it to conventional Booth multipliers. The effects indicated that the Vedic multiplier did as an entire lot as 27 percent quicker computation at the same time as consuming fewer resources. This performance development may be attributed to the recursive and parallel shape of Vedic multiplication, which allows simultaneous processing of partial products.

6.3.2 Thermal and Energy Efficiency

Thermal and power performance had been moreover assessed in research which incorporates the only completed

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through using way of Chugh and Singh (2023), which centered at the thermal sensitivity of Vedic ALUs. Their findings positioned that Vedic multipliers exhibited reduced warmth technology and strength intake at the same time as carried out using well-known CMOS technology (Mishra et al., 2019). This benefit makes them particularly appropriate to be used in embedded systems, portable electronics, and battery-operated devices in which power overall performance is a number one trouble.

6.4 Educational Impact

The integration of Vedic Mathematics into formal instructional settings has verified promising outcomes. According to Pathak and Kumari (2023), college students uncovered to Vedic techniques exhibited progressed performance in algebra, in particular in the regions of factoring and simplifying expressions. The cognitive shape of Vedic Mathematics, which emphasizes sample popularity and intellectual computation, complements college students' mathematical instinct and reduces anxiety associated with complicated operations (Bhatt et al., 2019). This pedagogical impact isn't always simply theoretical; however , it's been supported by means of way of empirical school room beneficial.

7. Discussion

The findings of this studies underscore the a number of the multifaceted application of Vedic Mathematics in both theoretical as well as implemented contexts. In calculus the application of Vedic Sutras furnished a simplified, intellectual approach to complex differentiation and integration troubles. The potential to lessen multi-step troubles to a few intuitive operations offers a compelling opportunity to traditional calculus pedagogy.

In cryptography, the capability of Vedic methods to restriction bit-realistic operations enhances the charge and safety of encryption algorithms. Given the increasing call for for real-time records encryption and constant communication, those techniques provide a massive rate in algorithm optimization. In hardware format, the prevalence of Vedic multipliers in phrases of speed, energy efficiency, and thermal control suggests a transformative capability for computational structure (Guglani, et al., 2019). The proof strongly helps the integration of Vedic commonplace experience into modern-day processor design, in particular in contexts that name for high performance and coffee power consumption.

The academic implications are similarly profound. Vedic Mathematics fosters an surroundings of interest, intellectual agility, and modern trouble-fixing, making it a treasured addition to mathematics schooling at each number one and advanced stages.

In conclusion, the aggregate of Vedic Mathematics into current domains of arithmetic, engineering, and education demonstrates a harmonious combo of historic information and modern need. As virtual systems become more and more complex, and the call for for speed, performance, and cognitive readability grows, Vedic Mathematics sticks out as a effective, underutilized useful resource worth of tolerating exploration and implementation.

The findings of this take a look at strongly emphasize the wide-ranging and multifaceted applicability of Vedic Mathematics throughout diverse present day theoretical and implemented domains. As contemporary demanding situations in technology, computation, and training maintain to demand faster, extra green, and cognitively handy answers, Vedic Mathematics has validated to be a versatile tool that could bridge ancient mathematical insights with cutting-edge problem-solving needs. Its relevance extends beyond conventional arithmetic operations and reaches into specialized areas consisting of calculus, cryptography, hardware design, and arithmetic schooling, each of which well-knownshows the transformative capacity embedded on this historical Indian system of computation.

In the world of calculus, Vedic Mathematics offers intuitive, mental alternatives to traditional differentiation and integration strategies. Traditionally, calculus problems—particularly in integration—require college students to navigate through elaborate algebraic manipulation, substitution techniques, and boundaries-primarily based tactics. Vedic Sutras, however, provide formulaic shortcuts that now not only expedite the answer technique but also reduce the cognitive load worried. These mental strategies regularly simplify multi-step calculus troubles into one or two compact, intuitive steps. For instance, positive styles in polynomial integration or differentiation can be fast resolved the usage of Vedic strategies, thereby making the issue more available to students who struggle with summary algebraic alterations. This is mainly useful in instructional settings wherein students frequently come across limitations because of the perceived difficulty of calculus. By incorporating Vedic Sutras into calculus pedagogy, educators may encourage a greater conceptual and much less mechanical knowledge of mathematical trade, fostering deeper perception and appreciation for the situation.

In the extraordinarily specialized area of cryptography, wherein computational performance and protection are paramount, the software of Vedic Mathematics has proven large promise. Cryptographic algorithms depend closely on large quantity operations along with modular arithmetic, prime factorization, and bitwise calculations. Vedic strategies, specially the ones related to fast multiplication and division, can optimize those operations, lowering the variety of clock cycles required for encryption and decryption processes. This may be especially impactful in the development of lightweight cryptographic protocols for cell and embedded systems, where resources are confined and speed is vital. The simplicity and decreased computational complexity of Vedic algorithms allow better bit-degree operations, which not simplest speed up encryption tactics but may contribute to extra protection by means of facilitating real-time cryptographic modifications. In a international more and more dependent on secure virtual verbal exchange, the mixing of Vedic mathematical frameworks into cryptographic layout represents an revolutionary course for future research and sensible implementation.

The influence of Vedic Mathematics extends further into hardware design and computational architecture. Modern computing is based on processors which could carry out arithmetic operations quick and correctly, regularly underneath constraints of power intake and thermal output. The implementation of Vedic multipliers—specialised circuits designed the use of Vedic mathematical standards—has been shown to outperform conventional binary multipliers in phrases of pace, place utilization, and energy performance. These Vedic multipliers use algorithms derived from Sutras such as "Urdhva Tiryagbhyam" (vertically and crosswise), which streamline the multiplication of massive binary numbers with fewer gate-stage operations. As computational structures evolve in the direction of side computing and IoT gadgets, which require compact and strength-green processors, Vedic-inspired mathematics units provide a precious solution. Their reduced logic intensity and decrease switching pastime also make contributions to improved thermal control, making them ideal for integration into present day chipsets and low-strength devices.

Beyond these technical packages, the instructional impact of Vedic Mathematics is each sizable and galvanizing. Traditional mathematics schooling often emphasizes procedural fluency over conceptual knowledge, leading many students to view math as abstract and intimidating. Vedic Mathematics, with its emphasis on sample reputation, mental computation, and flexible trouble-fixing techniques, creates a greater enticing and intuitive learning experience. It encourages college students to discover a couple of paths to a solution, fostering creativity, intellectual agility, and confidence in mathematical reasoning. This is in particular beneficial at the primary and secondary training degrees, in which students' foundational perceptions of math are shaped. Moreover, Vedic Mathematics has the ability to address studying variations through providing opportunity strategies for computation, thereby accommodating various cognitive patterns. The system additionally serves as a cultural and ancient bridge, linking college students with rich highbrow traditions and broadening the scope of mathematical appreciation.

From an interdisciplinary standpoint, the software of Vedic Mathematics aligns properly with the broader goals of cognitive technological know-how, systems engineering, and digital transformation. As the call for for smarter, greater human-centric systems grows, there may be increasing hobby in models that reflect how human beings certainly suppose and resolve troubles. Vedic Mathematics gives a dependent but intuitive framework that resonates with human cognition, supplying precious insights into the development of user-friendly computational equipment and educational structures. Its principles may be integrated into human-pc interplay fashions, AI-pushed studying platforms, and coffee-code/no-code software environments, thereby increasing its have an effect on far beyond traditional limitations.
Therefore the combination of Vedic Mathematics into modern-day clinical, technological, and academic domains displays a unique synergy among historical expertise and cutting-edge innovation. Whether it's far simplifying complex calculus troubles, accelerating cryptographic operations, optimizing hardware design, or enriching mathematical schooling, the strength of Vedic strategies lies of their elegance, efficiency, and adaptableness. As

digital structures turn out to be an increasing number of complicated and the worldwide attention shifts in the direction of sustainable, inclusive, and excessive-performance technology, Vedic Mathematics emerges as a valuable, underutilized aid. It offers now not only a set of computational tools but additionally a philosophical technique to know-how that emphasizes clarity, concord, and continuous improvement. Continued exploration and implementation of those principles will surely open new avenues for studies and improvement, bridging gaps among subculture and generation, concept and exercise.

8. Conclusion

This research reaffirms that the Vedic Mathematics is greater than justa ancient curiosity—it is a relevant in addition to strong framework for 21st-century problem-solvingWhether simplifying complex calculus, improving algorithmic format, or revolutionizing math education, its impact is profound and an extended way-achieving.
The software of Sutras in domain names ranging from AI to ASICs confirms that historical cognizance, at the same time as reinterpreted and contextualized, can treatment modern-day issues with superb beauty and performance.

9. Future Scope

- Development of hybrid Vedic-traditional algorithms for AI/ML.
- Empirical school room trials throughout curricula.
- Implementation in hardware layout past multipliers (e.G., Vedic dividers, Vedic FPGAs).
- Standardization of Vedic common sense notation for global accessibility.

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