

Comparative Evaluation of Conventional Calculus Methods and Vedic Approaches in Solving Differential Equations

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Abstract

The present paper focuses on the structural applicability of some computational principles of Vedic Mathematics by Bharati Krishna Tirthaji [8] to the algebraic transformation techniques used in solving ordinary differential equations. The present work does not aim to replace the traditional calculus techniques used for solving differential equations by proposing an alternative approach based on Vedic Mathematics. It aims to establish the conceptual correspondence between the traditional solution techniques and the principles of Vedic Mathematics while solving ordinary differential equations. Some typical first-order ordinary differential equations, which are separable, homogeneous, linear, and exact types of equations, are solved by traditional calculus techniques and Vedic Mathematics principles of algebraic transformation logic. The findings of the present work reveal that although the results are identical from an analytical point of view, there exist some structural similarities between the algebraic transformation techniques used by Vedic Mathematics and the traditional calculus techniques while solving the mentioned types of equations by applying the principles of Parāvartya Yojayet [5], Anurūpyena [4], Vilokanam [9], Sankalana-Vyavakalanabhyam [1], and Urdhva-Tiryagbhyam [2]. It is concluded that Vedic computational philosophy may act as an alternative theoretical approach to higher-level mathematical analysis.

Keywords: Vedic Mathematics, Differential Equations, Algebraic Transformation Technique, Structural Correspondence.

1. Introduction

Differential equations are at the core of dynamic system modeling in mathematics, physics, engineering, and other applied sciences. Despite the fact that the theory of differential equations is based on the principles of calculus, the actual process of solving differential equations follows a series of steps involving algebraic manipulations. These steps involve rearranging terms, using the method of separation of variables, using the substitution method, simplifying ratios, recognizing structural forms, and using polynomial manipulations.

Vedic Mathematics, revived by Bharati Krishna Tirthaji [8] in 1965, consists of sixteen sutras that emphasize the principles of structured computation, proportional reasoning, and structural patterns. Although Vedic mathematics is primarily used to solve problems involving arithmetic and simple algebra, the nature of the sutras, which emphasize the process of transformation, provides a basis for conceptual applications to higher symbolic manipulations.

This study aims to determine the structural similarity between the Vedic sutras and the process of solving first-order differential equations.

2. Review of Related Work

Recent research has sought to expand the applicability of Vedic concepts into higher mathematics. Sharma et al. [6] have attempted the application of some sutras for simplification in ordinary and integro-differential equations, which led to easier solutions for intermediate steps. Jyoti [3] has explored the simplification of algebraic expressions in the process of finding an integrating factor with the help of Vedic logic. Sharma [7] has presented a discussion on the structural analogy between the process of polynomial equations in calculus and Vedic multiplicative processes.

The focus of earlier research has largely been on computational efficiency. Very little research has explored the structural analogy between Vedic sutras and traditional differential equations. This identified gap forms the motivation for the present study.

3. Theoretical Framework

A general first-order differential equation is expressed as:

$$\frac{dy}{dx} = f(x, y)$$

Its solution typically involves:

- Variable separation
- Algebraic rearrangement
- Substitution
- Recognition of structural form (linear, homogeneous, exact)
- Symbolic simplification

These steps are inherently transformation-based and rely heavily on algebraic manipulation.

The following Vedic sutras are considered for structural comparison:

- **Parāvartya Yojayet** [5] (Transpose and apply)
- **Anurūpyena** [4] (Proportionately)
- **Vilokanam** [9] (By observation)
- **Sankalana–Vyavakalanabhyam** [1] (Addition and subtraction)
- **Urdhva–Tiryagbhyam** [2] (Vertically and crosswise)

Each represents a transformation principle rather than a subject-specific formula.

4. Comparative Structural Analysis

4.1 Separable Equation

Consider:

$$\frac{dy}{dx} = \frac{y}{x}$$

Conventional Method:

Separate variables and integrate:

$$\frac{1}{y} dy = \frac{1}{x} dx$$

Solution:

$$y = Cx$$

Vedic Interpretation:

The transposition of variables reflects the structural logic of *Parāvartya Yojayet*. The calculus operation remains unchanged; only the interpretative framework differs.

4.2 Homogeneous Equation

For a homogeneous equation:

$$\frac{dy}{dx} = \frac{x + y}{x}$$

Substitution $y = vx$ reduces it to separable form.

This proportional substitution corresponds structurally to *Anurūpyena*, emphasizing ratio-based transformation.

4.3 Exact Equation

An equation of the form:

$$M(x, y)dx + N(x, y)dy = 0$$

is exact if:

$$\frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$$

Recognition of this structural equality reflects *Vilokanam*, or identification by observation.

4.4 Linear Differential Equation

For:

$$\frac{dy}{dx} + P(x)y = Q(x)$$

Construction of the integrating factor requires systematic combination and simplification of expressions. This step demonstrates conceptual similarity with *Sankalana–Vyavakalanabhyam*, involving structured addition and subtraction.

4.5 Polynomial Manipulation

During expansion or simplification of nonlinear expressions in differential equations, multiplication steps resemble the vertical-crosswise structure of *Urdhva–Tiryagbhyam*.

5. Discussion

The analysis of the similarities and differences between the two approaches reveals that:

- The analytical solutions developed by the two approaches are the same.
- There are structural similarities between the principles of transformation used in Vedic mathematics and algebraic techniques used for solving differential equations.
- The similarity between the two is conceptual rather than algorithmic.
- The use of Vedic sutras may improve the interpretation of the results of symbolic computation.

It needs to be emphasized here that this paper is not intended to show that one method is computationally better than the other or that one method replaces the other. It is intended to show the philosophical similarity between algebraic structural transformation and Vedic computational logic.

6. Conclusion

The study establishes that selected sutras from Vedic Mathematics exhibit structural correspondence with algebraic transformation steps involved in solving first-order differential equations. While classical calculus remains the formal analytical foundation, Vedic computational philosophy provides an alternative interpretative lens for understanding procedural algebraic operations. The contribution of this study lies in conceptual mapping rather than algorithmic innovation.

Future research may extend this structural analysis to higher-order and partial differential equations or evaluate measurable computational efficiency.

7. References

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