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Analytical and Numerical Approaches for Solving Ordinary Differential Equations: A Comparative Analysis

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Abstract: *This research explores the analytical and numerical approaches employed to solve ordinary differential equations (ODEs), emphasizing their applications, advantages, and limitations. Analytical methods, such as separation of variables, integrating factor, and Laplace transforms, provide exact solutions for linear and nonlinear ODEs. However, for complex and high-dimensional problems, numerical approaches such as Euler's method, Runge-Kutta methods, and finite difference methods become indispensable. The study conducts a comparative evaluation by analyzing computational efficiency, error propagation, and stability in various contexts. The results highlight that while analytical solutions offer precision, numerical methods provide flexibility for solving real-world problems where exact solutions are unattainable. The paper also discusses the hybridization of analytical and numerical methods to optimize the efficiency and accuracy of solving ODEs in practical applications.*

Keywords: Ordinary Differential Equations, Analytical Solutions, Numerical Methods, Error Analysis, Stability, Runge-Kutta, Laplace Transform

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