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A Study of Numerical Methods for Solving Nonlinear Differential Equations

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Abstract: *Nonlinear differential equations are very important in representation of complex phenomena in a wide range of areas including engineering, physics, biology, and economics. The equations frequently model real world systems which have nonlinear interactions, feedback processes and dynamical behavior. Nonlinear differential equations are however not easy to get exact solutions to analytically or in most cases impossible. Consequently, numerical methods have evolved to be essential tools, to finding acceptable solutions to the problems, and with great efficiency in terms of calculation.*

This paper is a comparative study of popular methods of solving nonlinear ODEs (ordinary differential equations) with numbers. The techniques considered are the Euler method, the modified Euler (that of Heun) method, the Runge Kutta methods, and the predictor-corrector schemes. The methods are evaluated on the basis of the main key performance parameters, including accuracy, stability, convergence behaviour, and computational cost. To test the efficiency and constraints of these numerical methods, benchmark nonlinear problems are used to test these methods in different step sizes and conditions.

The comparative analysis is sustainable with tabulated numerical results and schematic diagrams demonstrating the algorithmic processes and behavior of solutions. Its results show the trade-offs between ease and precision of various numerical algorithms and offer a practical guideline to the choice of suitable techniques in scientific and engineering problems of nonlinear differential equations..

Keywords*:* Nonlinear differential equations, Numerical methods, Runge–Kutta, Euler method, Stability, Convergence