National Conference on Latest Innovations in Engineering, Science, Management and Humanities (NCLIESMH – 2024)

26th May, 2024, Raipur, Chhattisgarh, India.

CERTIFICATE NO : NCLIESMH /2024/C0524546

A Study of Linear Delay Differential Equations Using Differential Transform

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ABSTRACT

Delay Differential Equations (DDEs) play a crucial role in modeling real-world systems where the future state depends not only on the present but also on past states, such as in engineering, biology, and economics. Solving these equations analytically poses challenges due to the presence of time delays. The Differential Transform Method (DTM) offers a semi-analytical technique for solving such equations with greater simplicity and efficiency. This method transforms differential equations into a recurrence relation by converting functions into a series of transformed components, much like a modified Taylor series. When applied to linear Delay Differential Equations, DTM allows the inclusion of delayed terms in the transform domain through specific shifting techniques. The method avoids the need for discretization, linearization, or perturbation, making it computationally efficient and accurate for initial value problems. This paper presents the application of DTM to linear DDEs, discusses the algorithmic structure, and provides examples to demonstrate its effectiveness. The results obtained are compared with exact solutions and show excellent agreement. The study concludes that DTM is a powerful and reliable tool for the approximate solution of linear DDEs, offering fast convergence and high accuracy, especially suitable for problems involving small to moderate delays.