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Exploring Boundary Layer Flow Dynamics on a Semi-Infinite Plate: A Numerical Study of Transpiration Effects and Dual Solutions

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Abstract: This paper explores the flow of a uniform stream with no pressure gradient on a parallel semi-infinite plate. This study unveils a novel perspective on the significant influence of the mass transfer parameter and the velocity parameter on the behavior of self-similar boundary layer flows over moving surfaces, governed by the Prandtl boundary layer equations. The analysis reveals that these parameters are pivotal in determining the existence and multiplicity of solutions, which may include no solution, a unique solution, or dual solutions, depending on their specific values. The modified operational matrix method was employed to reduce the complex nonlinear system to a manageable linear third-order boundary value problem, facilitating a more thorough investigation. The numerical validations conducted, including the calculation of L_2-truncation errors, comparison with exact boundary conditions, and consistency checks against established results in the literature, not only affirm the robustness and accuracy of the proposed method but also instill confidence in its reliability. This work contributes to understanding boundary layer flows over moving surfaces by elucidating the critical roles of mass transfer and velocity parameters. It offers a reliable numerical method for solving these complex fluid dynamics problems and provides valuable insights into the physical phenomena governing such flows.

Keywords: *Prandtl boundary layer equations; heat and mass transfer, boundary layer; dual solutions; semi-infinite plate.*

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