Foreword

The book aims to include several substantial research topics in mathematical fluid mechanics that have enormous applications in engineering and applied sciences. This book should be a valuable resource for graduate students, academic researchers, and educators associated with areas of research or teaching, such as computational mathematics, mathematical modeling, fluid mechanics, nanofluid mechanics, and various branches of applied science. The book should also be of interest to general readers interested in gaining knowledge of recent trends in the applied mathematical sciences. The book consists of ten chapters, as follows.

Chapter 1 aims to use the single-term Galerkin approximation to study primary and secondary instabilities in the Rayleigh-Benard-Taylor convection in the case of rigid isothermal boundaries using Newtonian viscous fluid. The mathematical formulation of the model is presented using the conservation laws of mass, momentum and energy. The critical Rayleigh number and the number of critical waves are estimated for the primary instability. The Taylor critical number and the critical angle between the intersecting rolls are obtained for the secondary Kuppers-Lortz instability. A comparative analysis is also presented between the results of rigid isothermal limits with those of free isothermal limits.

Chapter 2 proposes a novel Rosseland quadratic approximation to study the radiative heat transport when the quadratic variation of the density temperature (QDT) is significant. For the first time, it proposes a quadratic Rosseland approximation. Mathematical modeling is performed with the help of the conservation laws of mass, momentum and energy. It uses the shooting method to examine the heat transfer characteristics of a hybrid nanoliquid over a vertical plate using a single-phase nanoliquid model. Hybrid nanoliquids are essential for reducing manufacturing and operating costs of microelectronics, nano electronics, pharmaceuticals, hybrid engines and fuel cells. It uses the response surface methodology to statistically analyze and optimize the heat transfer rate of hybrid nanoliquid. In addition, sensitivity analysis based on the multivariate quadratic regression model is also performed.

Chapter 3 deals with the magnetohydrodynamic (MHD) free convection of a hybrid nanofluid in the porous cavity using the control volume finite element method. MHD flow and heat transfer have various industrial and manufacturing applications, such as cooling underground power cables, nuclear reactors, geothermal energy extraction, plastic foil, and man-made fibers. Hybrid nanoparticles volume fraction, Hartmann number, Rayleigh number, Darcy number and porosity are the parameters **used** to control and visualize fluid flow through isotherms, flow lines,

and Nusselt mean number. It ends with extensive applications of hybrid nanoliquids.

Chapter 4 simulates the magnetohydrodynamic flow of a thixotropic nanoliquid that has mobile microorganisms with the aid of the Buongiorno model which leads to consider Brownian motion and thermophoretic diffusion. This chapter also deals with various external physical effects such as thermal radiation, heat generation and Joule dissipation. Similarity theory and the MATLAB solver were used to solve the nonlinear differential equations that model the problem. Numerical and graphical results are presented using various estimates of physical parameters.

Chapter 5 provides the numerical solution for the flow of magnetized bioconvected nanofluids induced by the movement of the slippery moving sheet with Stefan's blowing. The dominant expressions of the physical phenomenon are converted into dimensionless forms using the methodology of the Lie group. The Runge-Kutta-Fehlberg fourth and fifth order numerical scheme is used to present solutions of dimensionless expressions. The results of skin friction, heat transfer rate, temperature and velocity are discussed in detail.

Chapter 6 aims to solve the boundary layer problem describing the fully developed Darcy-Forchheimer-Brinkman (DFB) flow through the freely compressed porous medium using the computer-aided successive linearization (SLM) method. The proposed method in this chapter, in general, has a quadratic convergence rate and is not sensitive to the initial solution unlike other numerical methods such as the shooting method. It concludes that the governing parameters have the least effect on the method, which means that the method converges even for large parameter values. This chapter also presents the applications of the Darcy-Forchheimer-Brinkman (DFB) model in frontier areas such as petroleum engineering, hydrogeology, reactor engineering, biology, medicine, etc.

The objective of Chapter 7 is to perform the linear and non-linear stability analysis of the Rayleigh-Benard convection for the couple-stress fluid with a thermorheological effect in the presence of an applied magnetic field. This chapter discusses the three important aspects of the convection control mechanism, namely, suspended particles, applied magnetic field, and variable viscosity. The Runge-Kutta method is used to solve the generalized Lorenz model.

Chapter 8 proposes to present the analytical solution of two-component convection in a micropolar fluid subjected to an imposed boundary concentration modulation. Two-component convection equations and associated mathematics are presented. The perturbation method is used to estimate the expression of the Rayleigh number and the correction Rayleigh number as a function of the parameters, frequency and

amplitude of the micropolar fluid. The effect of various parameters on heat and mass transport is studied by deriving the Ginzburg Landau equation from the sixth order Lorenz equations.

Chapter 9 proposes a comprehensive three-dimensional numerical model accounting for reaction kinetics and, heat and mass transfer for hydrogen charging and discharging in a LaNi5 based MH reactor. The model is compared with the experimental data, and the simulation results agree closely with the experimental data. In this chapter a detailed parametric study is carried out to optimize the operating conditions of the reactor and the geometry of the Helical Coil Heat Exchanger (HCHX) to improve the hydrogen charging and discharging rates. The effect of essential parameters such as supply/exit pressures, Heat Transfer Fluid (HTF) temperature, and helical coil pitch/turns on the thermal performance and sorption rate of the MH bed are analyzed systematically. It shows that increasing the inlet hydrogen pressure and reducing the HTF temperature significantly improves the charging rate.

Chapter 10 adopts the Response Surface Methodology to optimize the heat transfer rate of non-Newtonian Jeffrey nanoliquid flow driven by a flexible surface exposed to quadratic thermal radiation and Boussinesq's quadratic approximation. The Brownian motion and thermophoretic characteristics are also discussed here. The dimensionless distributions of velocity, temperature, nanoparticle concentration and heat transfer rate are simulated by solving the system of nonlinear differential equations using the finite difference-based routine. The importance of the different physical parameters of the problem was explored. In addition, a sensitivity analysis is also performed using the quadratic polynomial for the Nusselt number obtained from the central composite design.

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