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METHODS FOR DIFFERENTIAL EQUATIONS AND SYSTEMS: NUMERICAL AND ANALYTICAL APPROACHES

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Differential equation theory and applications have been crucial to the advancement of mathematics as well as the discovery of new frontiers in the applied sciences. From a theoretical perspective, numerous novel mathematical concepts and methods for resolving ordinary and partial differential equations as well as systems of differential equations have been developed as a result of the qualitative theory of differential equations and analytical procedures. Differential equations are essential and required for describing a wide variety of dynamical systems or processes in real life, according to applications. Numerical methods are also essential in the study of differential equations and the approximation of their solutions because many problems are too complicated to be solved analytically [1].

For decades, there has been a significant growth in the theoretical and numerical aspects of differential equations. Numerous contributions to the theory and development of differential equations can be made with ease since there are so many distinct types of differential equations and their applications in so many different domains. Since fractional differential equations were not frequently studied until the last few decades, there is still room for a lot of important advancements in this area of study [2].

Using both analytical and numerical techniques, this volume compiles some current research contributions to the study of differential equations and systems. The contributions described here included a variety of new developments, but as differential equations research is such a broad topic, many issues are undoubtedly still unresolved and further developments are anticipated.

Twenty of the 61 submissions that were made for the special issue were ultimately included in this edition. From June 2021 to June 2022, submissions were accepted. In this page, we summarise each published item individually, combining some that are highly connected to one another.

The Riccati transformation is used by Kumar et al. (contribution 1) and Almutairi et al. (contribution 3) to obtain results on oscillation that are demonstrated with examples. They investigate the oscillation of solutions for specific neutral differential equations, respectively third-order and fourth-order with delay.

Asjad et al. (contribution 2) simulate a non-Newtonian fluid with nanoparticles between two parallel plates by using the method of Laplace transforms to give analytical solutions for certain Prabhakar fractional differential equations.

Abdelhakem et al. (contribution 4) find approximate solutions to several linear and nonlinear boundary value problems using a pseudo-Galerkin approach with a basis of derivatives of

Chebyshev polynomials. To confirm the method's mathematical validity, they additionally incorporate error analysis.

In their study of Caputo fractional stochastic multi-term differential equations, Ahmadova and Mahmudov (contribution 5) obtain asymptotic separation of solutions generally and global well-posedness results.

Caputo fractional delay differential equations are studied numerically by Avci (contribution 6) and Hashim et al. (contribution 8). They construct operational matrices for fractional integration using bases of shifted Chebyshev polynomials (contribution 8) or bases of Taylor polynomials (contribution 6). Hashim et al. give a uniform convergence theorem, while Avci includes pseudocode for the computer software he utilised.

Branga (contribution 7) uses ideas from fixed point theory to demonstrate existence-uniqueness conclusions for a fractional integral equation and other integral equations in metric spaces over topological modules.

Two investigations on the dynamics of the COVID-19 pandemic are Pan et al. (contribution 9) and Pan et al. (contributor 16). The first one used sensitivity analysis to demonstrate that asymptomatic infections are a significant factor and have a significant impact on the endemic equilibrium; as a result, controlling asymptomatic infections is crucial to halting the pandemic. The second one conducts a compartmentalised analysis, classifying areas into high-, medium-, and low-risk categories and coming to the conclusion that both the endemic and disease-free equilibria are asymptotically stable.

In contribution 10, Fernandez and Fahad examine general classes of fractional-calculus operators, both weighted and weighted with respect to functions. They highlight how these classes relate to the classical fractional calculus and how they contain well-known operators like Erdélyi–Kober fractional calculus and Hadamard-type.

Zhang et al. (contribution 11) use the spectral local linearisation method to numerically solve a nonlinear differential equation that results from simulating the mixed convection boundary layer flow of a viscous fluid over an elastic surface. Assuming the non-canonical scenario, Moaaz et al. (contribution 12) expand certain known results from the second-order case to establish oscillation conditions for neutral differential equations of arbitrary even order.

Using Riemann–Liouville fractional calculus, Lu et al. (contribution 13) examine a fractional variant of the Fokas equation in 4 + 1 dimensions. For comparison, they solve the equation analytically and numerically and derive symmetry properties and conservation laws.

The variable step hybrid block approach is a computation technique that Sunday et al. (contribution 14) modify for the differential equation resulting from the Kepler issue. They examine the algorithm's stability and convergence while describing it with a flow chart. An incommensurate Caputo fractional differential equation is examined by Duan et al. (contribution 15), who use quadratic splines as part of their numerical method to solve it. They include instructive instances to compare this with other approaches.

Fokas et al. (contribution 17) investigate an integrable extension of the well-known Kadomtsev–Petviashvili equation to three spatial dimensions in order to tackle a significant open problem in integrable systems. For this new equation, they build rational solutions, multi-solitons, and high-order breathers.

A Caputo time-fractional variant of the nonlinear foam drainage equation is examined by Liu et al. (contribution 18), who use the homotopy perturbation method in conjunction with Laplace transforms to solve it numerically.

The Klein-Gordon equation with a cubic nonlinear term is examined by Alzaleq and Manoranjan (contribution 19), who use an energy-conserving numerical approach to solve it. The stability and convergence of this system are also mathematically confirmed.

Some nonlinear fractional partial differential equations are solved by Sultana et al. (contribution 20) using a so-called "fractional novel analytic method," which is essentially a numerical method. In order to compare these numerical answers with precise solutions for a few well-known equations, they offer examples.

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