



Notice for the PhD Viva Voce Examination

Ms Deepika S (Registration Number: 2190051), PhD scholar at the Department of Mathematics, School of Sciences, CHRIST (Deemed to be University), Bangalore will defend her PhD thesis at the public viva-voce examination on Tuesday, 1 July 2025 at 2.00 pm in Room No. 044, Ground Floor, R & D Block, CHRIST (Deemed to be University), Bengaluru - 560029.

Title of the Thesis	:	Studies on Properties of Chaotic Dynamical Systems within the Frame of Fractional Calculus Using Numerical Approaches
Discipline	:	Mathematics
External Examiner - I	:	Dr Waleed Adel Abdelsalam Ouf Associate Professor Department of Applied Mathematics French University Cairo Governorate - 4923116, Egypt
External Examiner – II	:	Dr Chandrali Baishya Associate Professor and Head Department of Studies and Research in Mathematics Tumkur University, Jnanasiri Campus Tumakuru - 572118 Karnataka
Supervisor	:	Dr Pundikala Veerasha Assistant Professor Department of Mathematics School of Sciences CHRIST (Deemed to be University) Bengaluru - 560029 Karnataka

The members of the Research Advisory Committee of the Scholar, the faculty members of the Department and the School, interested experts and research scholars of all the branches of research are cordially invited to attend this open viva-voce examination.

Place: Bengaluru
Date: 24 June 2025

Registrar (Academics)

ABSTRACT

A mechanical system that exhibits chaotic behavior and aids in the comprehension of the Lorenz system is the Malkus waterwheel model, alternatively referred to as the chaotic waterwheel model. Malkus waterwheel model has been enhanced by incorporating asymmetric water inflow. An analysis of the hereditary properties of the modified system is conducted to assess its stability, identify key parameters that contribute to stability, and explore various bifurcation behaviors. The system's chaotic behavior with respect to fractional orders is shown by examining the bifurcation parameter and Lyapunov exponent. A numerical technique called the Adams-Bashforth-Moulton method approach is used to capture the system's dynamics. This approach shows that behavior can change from chaotic to unstable and stabilize by choosing suitable parameter values. Furthermore, the study presents a novel fractional-order Genesio-Tesi system, wherein the boundedness and stability of the equilibrium point are examined, a thorough investigation is conducted into bifurcation analysis, the existence and uniqueness of the solution, and Lyapunov stability. The existence of torus and chaotic attractors in distinct fractional-order systems is demonstrated by analyzing this system using an effective predictor-corrector method. As the order decreases from integer to fractional, the point attractors give way to steady-state attractors. The Brusselator chemical reaction influenced by an Amplitude-Modulated force is investigated with the help of the Caputo Fractional operator. This study highlights how different frequencies have a substantial impact on the reaction's dynamics by revealing chaotic behavior under fractional and integer order.

The study also explores a modified Chua's circuit featuring a higher-degree polynomial resistor, investigating its stability, hereditary properties, bifurcation, and chaotic behavior. Through the computation of Lyapunov exponents, the chaotic character of this system is confirmed. At the same time, numerical simulations demonstrate a transition from chaotic to asymptotically stable behavior with changes in parameter values. Upon reducing the system order to fractional, the behavior evolves from a double-scroll attractor to an unstable state, eventually progressing to asymptotic stability. This outcome underscores the complexity of Chua's circuit dynamics across varying polynomial degrees. The dynamics and stability of a time-dependent mass double pendulum system are investigated. The second mass of the system is represented by a spherical shell filled with sand, which experiences a gradual loss of mass at an exponential rate over time. The first mass is securely anchored at a fixed point, while the second mass is suspended and connected by a string of constant length. To model this system, we use generalized coordinates to express the potential and kinetic energy. We derive a set of coupled second-order differential equations that precisely characterize the motion of the double pendulum as the second mass changes using the Lagrangian formulation. This study explores the system's Lyapunov stability for integer and fractional order. We investigate the existence and uniqueness of the solution and also validate the chaotic behavior of the system through a comprehensive numerical investigation. In conclusion, this study provides a solid foundation for future research into fractional-order dynamics-based modified chaotic systems.

Keywords: Malkus waterwheel model, Asymmetric water inflow, Bifurcation parameter, Lyapunov exponent, Adams-Bashforth-Moulton method, Stability of the equilibrium point, Lyapunov stability, Asymptotic stability, Existence and uniqueness of the solution, Genesio-Tesi system, Brusselator chemical reaction, Amplitude-Modulated force, Caputo Fractional operator, Chua's circuit, Time-dependent mass double pendulum, Lagrangian formulation

Publications:

1. **S. Deepika** and P. Veerasha, "Dynamics of chaotic waterwheel model with the asymmetric flow within the frame of Caputo fractional operator", *Chaos, Solitons & Fractals*, vol.169, p.113298, 2023.
2. **S. Deepika** and P. Veerasha, "Modified Genesio-Tesi systems with trigonometric functions and the Caputo fractional derivative", *Mathematics in Engineering, Science & Aerospace*, vol.15, no.1, p.115, 2024.
3. **S. Deepika**, Hari Baskar Ranganathan, and P. Veerasha, "A computational approach for the generalised Genesio-Tesi systems using a novel fractional operator", *Pramana*, vol.98, no. 1, p.18,2024.