Report on the Compact Course

"Modelling Change: An Application-Oriented Introduction to Ordinary Differential Equations"
Dates: 14–16 October 2025
Organized by: Department of Mathematics, Miranda House
Funded by: Professor R. Balakrishnan Endowment Trust (RBET), Tiruchirappalli, and the (Indian) Mathematics Consortium (TMC), Pune
Speaker: Prof. Shobha Bagai, Professor and Director, Cluster Innovation Centre, University of Delhi

Introduction

The three-day compact course aimed to provide participants with a practical understanding of the Ordinary Differential Equations (ODEs) and their applications across various domains. The course was designed to bridge theoretical knowledge with real-world scenarios, emphasizing the versatility and importance of ODEs in modeling dynamic systems.

Day 1: ODEs as Laws of Change

The course commenced with an introduction to ODEs as mathematical models representing the rate of change in real-world systems. Dr. Shobha Bagai emphasized the logistic growth model, illustrating its application in various scenarios, including the spread and eventual saturation of information in meme and rumor virality, analyzing customer flow and waiting times in coffee shops, and understanding how small disturbances can lead to congestion without physical obstacles in traffic flow and phantom traffic jams.
To aid comprehension, participants engaged with slope fields and graphical simulations, allowing them to visualize the qualitative behavior of solutions and the impact of initial conditions on system dynamics.

Day 2: Nonlinear Systems and Human Behavior

The second day delved into nonlinear systems, focusing on their qualitative behavior, including stability, oscillations, and chaotic dynamics. Key topics included opinion dynamics, exploring models that describe how individuals' opinions converge to consensus or diverge into polarization, and the Van der Pol oscillator, studying this nonlinear oscillator to understand biological rhythms, such as heartbeat patterns.
These discussions highlighted the applicability of ODEs in modeling complex human behaviors and interactions. Participants engaged in group brainstorming sessions to identify other potential applications, such as modeling stress, decision-making, and productivity.

Day 3: Interdisciplinary Applications and Advanced Techniques

The final day expanded the scope of ODEs applications to various fields, demonstrating their versatility in modeling diverse phenomena. Topics included marathon pacing models, analyzing the energy-performance tradeoff during long-distance running; bouncing ball with energy loss; box office dynamics, modeling the rise and fall of movie revenues, akin to epidemic spread models; and chemical oscillations, studying reactions.
Advanced mathematical techniques were also introduced, such as phase plane analysis, examining system behavior through nullclines and trajectories; stability analysis, utilizing Jacobian matrices to assess equilibrium points; and discussions on current studies related to SIR models, predator-prey systems, and to connect theory with real-world applications.

Conclusion

The workshop successfully demonstrated the applicability of Ordinary Differential Equations in modeling and understanding dynamic systems across diverse fields. By integrating theoretical concepts with practical applications, participants gained a comprehensive understanding of how ODEs can be utilized to analyze and predict behaviors in various scenarios. The course emphasized the importance of interdisciplinary approaches in mathematical modeling and provided participants with the tools to explore complex systems through the lens of ODEs.

Acknowledgments

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