National Institute of Technology Rourkela

Defence Seminar

Seminar Title	: Analytical and Numerical Solutions of Water Wave Equations in Crisp and Uncertain Environments
Speaker	: Mrutyunjaya Sahoo (Rollno : 520ma2006)
Supervisor	: Snehashish Chakraverty
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Abstract	: Partial differential equations (PDEs) are foundational tools in mathematics used to describe the behavior of systems where variables depend on multiple independent factors, such as time and space. While linear PDEs are simpler and straightforward to analyze, nonlinear partial differential equations (NLPDEs) serve as a powerful mathematical framework for describing complex systems governed by nonlinear interactions, capturing phenomena such as turbulence, soliton dynamics, wave breaking, and chaotic behavior. Among their diverse applications, water wave models are particularly prominent, providing insights into fluid interactions under gravitational and other forces. The shallow water equations (SWE), derived from the Navier-Stokes equations, exemplify the practical use of NLPDEs, offering robust tools for studying tidal flows, storm surges, and tsunamis. Generally, parameters associated with traditional mathematical models are regarded as deterministic entities. However, these parameters may contain imprecision or uncertainty due to observational or experimental errors or a lack of information, which can significantly affect the accuracy and reliability of the models. To handle such uncertainties, alternative methods like interval analysis and fuzzy set theory approaches emerge as valuable tools. Accordingly, this thesis focuses on investigating a range of water wave models in both crisp and uncertain environments, addressing imprecision through interval and fuzzy set representations. Specifically, geophysical shallow water models are studied under crisp conditions, employing various analytical approaches to derive new traveling wave solutions. Stability and bifurcation analyses are conducted near equilibrium points of the dynamical systems associated with these models. Additionally, the behavior of groundwater has been analyzed in detail. Furthermore, several numerical and semi-analytical methods are adapted to operate in fuzzy environments. These methods are employed to address models with interval-based initial conditions and those featuring fuzzy initial conditions and parameter uncertainties. The thesis encompasses both integer-order and fractional-order models, providing a comprehensive framework for understanding the dynamics of water waves having different types of uncertainties.