DIRECTED STUDY ON NUMERICAL SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATIONS
SYMPLECTIC, SECOND-ORDER ACCURATE, TIME-ADAPTIVE METHODS

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Prerequisites: Good undergraduate background in linear algebra and ordinary differential equations.

Content: This focus study falls into the area of modern methods for the numerical solution of initial and boundary value problems for systems of ordinary differential equations, and stochastic differential equations. We will discuss the principal classes of numerical methods and their theory, including convergence and stability considerations, consistency order, step size selection and adaptivity, the effects of stiffness, geometric integration, invariant and Hamiltonian dynamics. The focus will be on time-adaptive, second-order accurate, symplectic methods.

Textbook: *Numerical Methods for Ordinary Differential Equations: Initial Value Problems*, by David F. Griffiths and Desmond J. Higham.

Topics to be covered:

- Euler's method and Taylor series method
- Linear multistep methods: consistency, construction, zero-stability, absolute stability, root locus curve, stiff and oscillatory systems, predictor corrector methods
- Runge-Kutta methods
- Adaptive step size selection
- Long-term dynamics
- Geometric integration: linear and quadratic invariants, symplectic methods, Hamiltonian systems
- Stochastic differential equations, convergence of a numerical method

Additional references:

- 'Solving Ordinary Differential Equations I, Nonstiff Problems', by Ernst Hairer, Syvert P. Nørsett, Gerhard Wanner. Springer.
- 'Solving Ordinary Differential Equations II, Stiff and Differential-Algebraic Problems', by Ernst Hairer, Gerhard Wanner. Springer.
- 'Geometric Numerical Integration Structure-Preserving Algorithms for Ordinary Differential Equations', by Ernst Hairer, Christian Lubich, Gerhard Wanner. Springer.
- 'Numerical Methods for Ordinary Differential Equations', Second Edition, by J. C. Butcher. John Wiley & Sons.
- 'Numerical Methods for Ordinary Differential Equations: The Initial Value Problem', by J. D. Lambert. John Wiley & Sons.
- 'Computer Methods for Ordinary Differential Equations and Differential-Algebraic Equations', by Uri M. Ascher and Linda R. Petzold. SIAM.