Math 571 Comprehensive Exam

Numerical Analysis of Ordinary Differential Equations

Course Description

Theory and implementation of numerical methods for initial and boundary value problems in ordinary differential equations. One-step, linear multi-step (including BDF), Runge-Kutta, and extrapolation methods; convergence, stability, error estimates, and practical implementation. Study and analysis of shooting, finite difference, and projection methods for boundary value problems for ordinary differential equations. Stability concepts including A-stability and A(α)-stability for stiff problems.

Topics

- **One-step methods**
  Scalar problems and systems, implicit and explicit methods, consistency and convergence, error estimates.
- **Runge-Kutta methods**
  General formula, implicit and explicit methods, Butcher tableaux, truncation error.
- **Linear multi-step methods**
  Implicit and explicit methods, construction, initiation, consistency, stability, convergence, absolute stability, predictor-corrector methods, Backward Differentiation Formula (BDF) methods, A-stability, and A(α)-stability for stiff problems.
- **Boundary value problems**
  Difference and shooting methods for linear and nonlinear BVPs.

References

1. *Numerical Methods for Ordinary Differential Equations*, Butcher, 2016.

2. *Numerical Solution of ODEs*, Süli, 2022.

3. *Numerical Methods for ODEs*, Griffiths & Higham, 2010.

4. *Numerical Solution of ODEs*, Atkinson, 2009.

5. *Numerical Analysis: Mathematics of Scientific Computing*, Kincaid and Cheney, 2002.