**Fundamentals of Numerical Analysis**

**Course description:**

This is the first course in numerical analysis for graduate students. The main objectives of this course include:

1. Development and applications of numerical methods when analytical techniques are not available;
2. Development of a conceptual framework for analysis of methods to fix the problem;
3. Discrete calculus and approximations;
4. Tradeoffs between accuracy and computational cost;

**Course outline:**

1. Interpolation (3 hrs)
2. Lagrange Polynomials
3. Polynomial interpolations; Splines
4. Numerical Differentiation (4 hrs)
5. Construction of finite difference scheme, order of accuracy
6. Modified wavenumber as a measure of accuracy
7. Pade approximation
8. Matrix representation of finite difference schemes
9. Numerical Integration (8 hrs)
10. Trapezoidal rule; Simpson’s rule; error analysis and mid-point rule
11. Romberg integration and Richardson’s extrapolation
12. Adaptive quadrature; Gauss quadrature
13. Numerical Solution of Ordinary Differential Equations (10 hrs)
14. Initial value problems; numerical stability analysis, model equation
15. Accuracy; phase and amplitude errors
16. Runge-Kutta type formulas, multi-step methods; implicit methods
17. System of differential equations; stiffness
18. Linearization for implicit solution of non-linear differential equations
19. Boundary value problems, shooting, direct methods, non-uniform grids, eigenvalue problems
20. Partial Differential Equations (10 hrs)
21. Finite-difference solution of partial differential equations
22. Modified wavenumber and Von Neumann stability analysis, modified equations analysis
23. Alternating direction implicit methods; non-linear equations; iterative methods for elliptic PDE’s
24. Fourier Series (6 hrs)
25. Trigonometric Interpolation;
26. FFT Algorithm;
27. Applications of DFT;

**Textbook**:

Parviz Moin “Fundamentals of Engineering Numerical Analysis”, Cambridge University press

Michael T. Heath “Scientific Computing: An Introductory Survey”, McGraw Hill

**Grading**:

Homeworks (55%); Midterm exam (%15); Final exam (%30)