Department of Mathematics
Faculty of Mathematics & Computer Science
PhD, Mathematics

Course Code	AM 503
Course Title	Advanced Numerical Techniques for Differential Equations
Course Credits	02

Course objectives:

To give understanding of numerical methods and their theoretical background to approximate the solution of differential equations. To provide students with the technical tools enabling them to simulate real life phenomena which are mathematically modeled by differential equations.

Minimum Pre-requisites:

Theory of ordinary and partial differential equations.

Course structure:

Numerical methods for ordinary differential equation: Single step method, the general linear multistep method: Derivation through Taylor series expansion, numerical integration, interpolation and their convergence analysis.

Numerical methods for partial differential equations: A model problem, series approximation, an explicit scheme for model problem, difference notation and truncation error, convergence of the explicit scheme, Fourier analysis of error, an implicit method, Thomas algorithm, the weighted average method.

Numerical method for singularly perturbed differential equations: Introduction and Motivation for the singular perturbation problems, regular and singular perturbation, some examples of singular perturbation problems, Analytical behavior of solutions of the singular perturbation problems, Asymptotic expansions (brief description),

Turning point problems.

Basic notions for Numerical methods for the problems with boundary layers: location and width of a boundary layer, norms for boundary layer functions, parameter uniform methods for singular perturbation problems.

Robust numerical methods: Fitted operator methods on uniform, fitted mesh methods on non-uniform meshes, theoretical estimates and their convergence analysis.

Reading suggestions:

- J.D. Lambert, Numerical Methods for Ordinary Differential, Equations**,** John Wiley & Sons (1991).
- K.W. Morton and D.F. Mayers, Numerical Solution of Partial Differential Equations, Cambridge University Press (2005).
- P. A. Farrell, A. F. Hegarty, J. J. H. Miller, E O'Riordon, G. I. Shishkin, Robust Computational Techniques for Boundary Layers, Chapman and Hall, CRC Press, Boca Raton, USA (2000).
- H. Nayfeh, Perturbation Methods, Wiley, 1973.
- H. G. Roos, M. Stynes, L. Tobiska, Robust Numerical Methods for Singularly Perturbed Differential equations, Convection-Diffusion-Reaction and Flow problems, Springer, (1996).
- R. E. O'Malley Jr. Singular Perturbation Methods for Ordinary Differential Equations, Springer Verlag, 1991.
- M. H. Holmes, Introduction to Perturbation Methods, Springer, 1998.
- J.C. Strikwerda, Finite difference Schemes and Partial Differential Equations, Second Edition, SIAM, Philadelphia, 2004.
- R.J. Leveque, Finite Difference Methods for Ordinary and Partial Differential Equation: Steady-State and Time-Dependent Problems, SIAM, Philadelphia, 2007.

Evaluation and Weightage:

- Surprise Quiz / test – 10 Marks
- Computer Practical– 30 Marks
- Mid Semester Examination – 20 Marks
- End Semester Examination – 40 Marks