Course Type	Course Code	Name of Course	L	T	P	Credit
DC	NGPC508	**Advanced Numerical Methods**	3	1	0	4

Course Objective
The primary objective of the course is to apply numerical methods to obtain approximate solutions to mathematical problems and to derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations.

Learning Outcomes

Upon successful completion of this course, students will be able to

- derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration etc.
- find numerical solutions to linear and nonlinear algebraic equations, and differential equations.
- develop understanding of the elements of error *analysis* for *numerical methods* and certain proofs
- develop problem solving skills.

Unit No.	Topics to be Covered	Lecture Hours (L + T)	Learning Outcome
1	Ordinary Differential Equations (ODEs), Numerical Integration of ODEs, Approximating Time Derivative	**7L + 2T**	Understanding differential equations and techniques to solve them numerically.
2	Partial differential equations (PDEs) and their mathematical properties. Numerical methods for PDEs: Finite-difference (FD), Finite- element (FE) and Spectral (SP) Methods, Advantages and disadvantages of these methods,	**6L + 2T**	Understanding Partial differential equations and introduction to numerical methods to solve them
3	Philosophy of computational modeling, Physical problems, Equations of geophysical fluid dynamics, Computational approaches & solutions, Geophysical applications	**5L + 2T**	Getting introduced to geophysical problems and applications that require numerical analysis

4	Introduction to FD methods: Mathematical model, grid, FD approximations, Consistency, stability, convergence, Space-differencing, First, second, & mixed derivatives, Implementation of boundary conditions, Time differencing, Methods for initial-value problems, Implementation of initial conditions, Application to the generic transport equation	**8L + 2T**	Learning the finite difference method and its implementation
5	Introduction to FE methods: Derivation of weak form of equations, Discretization, interpolation functions, Imposition of boundary conditions, Simple examples	**6L + 2T**	Learning the finite element method and its implementation
6	Introduction to SP methods: Polynomial approximation, Collocation methods, True Spectral methods	**6L + 2T**	Learning spectral methods and their implementation
7.	Parallel computing: Overview, Architecture, Distributed memory, Parallel programming	**5L + 2T**	Introducing techniques for faster and high performance computing
	Total Classes	**42L+14T**	

Text books

1. Fletcher, C. A. J. *Computational Techniques for Fluid Dynamics. Fundamental and General Techniques Volume I.* Springer series in computational physics. New York, NY: SpringerVerlag, 1996. ISBN: 9783540530589.

Reference books

1. Trefethen, Lloyd N. *Spectral Methods in MATLAB (Software, Environments, Tools).* Philadelphia, PA: Society for Industrial and Applied Mathematics, 2001. ISBN: 9780898714654.
2. Bathe, K.-J., Finite Element Procedures, Prentice-Hall, 1996. ISBN 0-13-301458-4.
3. Ferziger, J. H., and Peric, M., Computational Methods for Fluid Dynamics, Springer, Berlin, 1996
4. Durran, D.R., Numerical Methods for Wave Equations in Geophysical Fluid Dynamics, Vol. 32 of Texts in Applied Mathematics, Springer, New York, 1999.
5. C. Canuto, A. Quarteroni, M. Y.Hussaini, T. A. Zang, Spectral Methods, Springer2006.