BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI-Hyderabad Campus
SECOND SEMESTER 2021-2022

Course Handout Part II

Date: 15/01/2022

In addition to part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

Course No. : ***MATH F422***
Course Title : **Numerical Methods for Partial Differential Equations**
Instructor-in-Charge : **N. Anil**

1. Scope and Objective of the Course:

The study of differential equations is a fundamental subject area of Mathematics which links important strands of Pure Mathematics to Applied and Computational Mathematics. This course enables one to analyze a number of numerical algorithms for approximating the solution of a variety of generic problems which occur in applications. The course will begin with the description of the numerical techniques for PDEs, their Stability and Convergence. Particular emphasis in this course is to interconnect the theoretical results and computer implementation. Students will study not only the solid theoretical backgrounds in developing and understanding the algorithms but also a hands-on experience to implement the methods.

2. Text Books:

T1. Computational Techniques for Fluid Dynamics 1, by Fletcher, C.A.J, Springer-Verlag.

T2. Numerical Solution of Partial Differential Equations: Finite Difference Methods (Oxford Applied Mathematics & Computing Science Series), by G. D. Smith, Oxford University Press.

3. Reference Books:

1. Computational Fluid Dynamics, Vol 1, by Klaus A. Hoffmann and Steve T. Chiang.
2. The Finite Difference Methods in Partial Differential Equations by R.Mitchell and S. D. F. Griffiths, Wiley and Sons, NY, 1980.
3. Numerical methods of partial differential equations by Evans, G. Blackledge, J. and Yardley, P, Springer-Verlag, 1999.
4. A friendly introduction to Numerical Analysis by Bradie**,** 1st Edition, Pearson education, 2007.

Course Plan:

Lecture No.	Learning objectives	Topics to be covered	Chapter in the Text Book
1	Overview of the Course	Introduction to Numerical Methods for Partial Differential Equations	
2-4	Procedures will be developed for classifying PDEs as elliptic/parabolic/hyperbolic	Classification of PDEs, Interpretation of PDEs by characteristics and physical basis, appropriate initial and boundary conditions, nature of well-posed problems.	T1. Chapter 2
5-6	Overview of computational solution procedures	Discretization: spatial & time derivatives, approximation to derivatives, accuracy of discretisation process, finite difference method for partial derivatives	T1. Chapter 3.1-3.4
7-18	Systematic methods to find the numerical solution of Parabolic equations and their convergence, stability and consistency. Understanding relativestrengths and weakness of each computational method Systematic methods to find the numerical solution of hyperbolic equations	Explicit and Implicit Method, Derivative boundary condition, Crank-Nicolson method. Reduction of the local truncation error, the Douglas equation, three time level difference equation, Deferred correction method, Richardson extrapolation. Convergence of explicit method, stability by matrix method, theorems on bounds for Eigen values, Stability for derivative boundary condition, stability by Von Neumann method, Lax theorem	T2. Chapter 2 T2. Chapter 3
19-26	Systematic methods find the numerical solution of elliptic equations	Finite differences for Elliptic problems, Handling irregular boundaries, SOR method for iterative methods, Stone's iterative method, rate of convergence	T2. Chapter 5
27-30	Systematic methods to find the numerical solution of hyperbolic equations	Finite difference methods for first order PDE: Lax-Wendroff explicit method, CFL condition, Wendroff Implicit method	T2. Chapter 4
31-34	Introduction to finite volume method	Finite volume method for first order PDEs and second order PDEs. Application to Laplace equation.	T1. Chapter 5.2
35-37	How to deal with the propagation of discontinuities	Discontinuous Initial Values, Discontinuous Initial derivatives, Initial Derivatives, Discontinuities and finite difference approximation	T2. Chapter 4

38-40	Second order Hyperbolic PDE	Explicit Methods and Implicit Methods for second order equations	T2. Chapter 4

Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of Component
Projects		15%		Open
Lab Assignments		20%		Open
Mid-semester exam	90 min	25%	12/03 9.00am to10.30am	Closed Book
Comprehensive Exam	2 hrs	40%	11/05 FN	Closed Book

Chamber Consultation Hour: To be announced in the class.

Notices: All notices related to this course will be put only on CMS

Make-up Policy: Make-up for any component of evaluation will be given only in genuine cases of absence.

Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

INSTRUCTOR-IN-CHARGE