BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani
Pilani Campus
AUGS/ AGSR Division

SECOND SEMESTER 2020-21
COURSE HANDOUT

Date: 18.01.2021

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 Methodology for Partial Differential Equations
Instructor-in-Charge : DEVENDRA KUMAR
Instructor(s) : NA
Tutorial/Practical Instructors: NA

1. **Course Description:** There are problems arising in the field of science and engineering which are difficult to solve analytically. In that case, the best alternative is to use numerical methods. In this course, we find the numerical solution of partial differential equations with some appropriate initial and boundary conditions. Most of the part contains Finite Difference Methods and a few lectures have been assigned for the Finite Volume Method.

2. **Scope and Objective of the Course:** The study of differential equations is a fundamental subject area of Mathematics that 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 that 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.

3. Text Book:

1. Computational Techniques for Fluid Dynamics Vol. 1, by Fletcher, C.A.J, Springer.
2. Numerical Solution of Partial Differential Equations: Finite Difference Methods by Smith, G. D., 3rd Ed., Oxford University Press.

4. Reference Books:

1. The Finite Difference Methods in Partial Differential Equations by Mitchell, R. and Griffiths, S. D. F., Wiley and Sons, NY, 1980.
2. Numerical Methods of Partial Differential Equations by Evans, G. Blackledge, J. and Yardley, P., Springer, 1999.
3. A Friendly Introduction to Numerical Analysis by Bradie, 1^{st} Edition, Pearson Education, 2007.

5. Course Plan:

Module No.	Lecture Session	Reference	Learning outcomes
1	L1.1: System of linear algebraic equations, central interpolation, difference methods for derivatives		Review of numerical analysis
2	L2.1-L2.3: Classification of PDE, nature of well-posed problems, interpretation of PDEs by	T1: 2.1-2.4, 2.6	Understanding of classification of

	characteristics and physical basis, appropriate boundary/initial conditions		second-order PDEs as elliptic, parabolic, or hyperbolic
3	L3.1-L3.3: Discretization: spatial and time derivatives, an approximation to derivatives, the accuracy of discretization process, finite difference method for partial derivatives	T1: 3.1-3.4	Computational solution procedures
4	L4.1-L4.4: The explicit and implicit method, Crank-Nicolson method, derivative boundary conditions, the local truncation error and consistency, consistency or compatibility L4.5-L4.8: Reduction of the local truncation error–the Douglas equation, three-time level difference equation, deferred correction method, Richardson's deferred approach to the limit L4.9-L4.12: Convergence of explicit method, stability by matrix method, theorems on bounds for eigenvalues, stability for derivative boundary condition, stability, Von-Neumann method, Lax theorem	T2: pp. 11-43, T2: pp. 137-142, T1: 4.4 T2: pp 45-75	Learning of systematic methods to find the numerical solution of parabolic equations and their convergence, stability, and consistency. Understand the relative strengths and weakness of each computational method
5	L5.1-L5.8: Elliptic Equations:- Improvement of accuracy, elliptic problems with irregular boundaries, SOR method for iterative methods, rate of convergence, Stone's strongly implicit iterative method	R2: 2.4 T2: pp. 248-271, 302-308	Learning of systematic methods to find the numerical solution of elliptic equations and their convergence, stability, and consistency
6	L6.1-L6.6: Hyperbolic Equations:- Finite difference methods on a rectangular mesh: Lax-Wendroff explicit method, CFL condition, Wendroff implicit method, discontinuous initial values, discontinuous initial derivatives, discontinuities and finite difference methods, reduction of first-order equation to a system of ordinary differential equations L6.7-L6.10: Explicit methods and implicit methods, simultaneous first-order equations and their stability	T2: pp 181-195 T2: pp 213-220	Learning of systematic methods to find the numerical solution of hyperbolic equations Dealing with propagation of discontinuities
7	L7.1-L7.4: Finite volume method for first and second-order PDEs and its application to Laplace equation	T1: 5.2	Understanding the concept of finite volume method

6. Evaluation Scheme:

Component	**Duration**	**Weightage**	**Date & Time**	**Nature of component**

		(%)		**(Close Book/Open Book)**
Mid-Semester Test	90 Min.	35		CB
Comprehensive Examination	3 h	45		CB/OB
Quiz/seminar/assignment		20	Announced	CB/OB

7. Chamber Consultation Hour: Th 8

8. Notices: All notices related to this course will be put only on NALANDA.

9. Make-up Policy: No makeup will be given for quiz/seminar/assignment. Make-up for Mid-Semester Test / Comprehensive Examination will be given only in genuine case.

10. Note (if any): NA

Instructor-in-charge
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