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 : **CE F324**
Course Title : **Numerical Analysis**
Instructor-in-Charge : **SHIBANI KHANRA JHA**
Instructor(s) : **NA**
Tutorial/Practical Instructors: NA

1. Course Description: It is needless to say that the present digital world has forced students to use commercial software that involve numerical methods, quite often. The proper and justified use of these programs is only possible if knowledge of the basic theory underlying the methods have been sufficiently developed among the students. This course is framed to provide a sufficient background to numerical methods required to solve engineering problems, especially intended to focus on various civil engineering and natural problems.

2. Scope and Objective of the Course: We know that various scientific phenomena whether natural or man-made, can be modeled using mathematical expressions which may be of simple algebra to complex algebra, simple to complex ODE's, simple to complex PDE's etc. To represent these phenomena, one need to solve these mathematical models by analytical, graphical, or approximate methods. Numerical Analysis is the approach that deals with the approximate solution methodologies of various mathematical models. This course introduces the core concepts of error estimation and accuracy of numerical solutions. It then discuss the methods of solution of linear and non-linear equations. Both direct and iterative solution methods are discussed. Then ordinary differential equations frequently used in engineering applications are introduced and its various solution methodologies are discussed. Next the numerical solutions of partial differential equations which are again quite common forms of mathematical models for many natural problems, are discussed, along with a brief review of different category of partial differential equations and well known analytical techniques for the solutions of some of the simple models and finally discussing the necessity of numerical methods. Finite difference operators are introduced and used to solve typical initial and boundary value problems of engineering interests.

3. Text Books:

TB1. Numerical Methods for Engineers by Steven C. Chapra , Raymond P. Canale, Tata McGraw-Hill Edition, 6th Edition, 2012.

4. Reference Books:

RB1. Applied Numerical Analysis by Curtis F. Gerald, Patrick O. Wheatley, Pearson Education, 7th Edition, 2003.
RB2. Numerical Methods for Engineers and scientists by J. D. Hoffman, 2nd Edition. CRC 2010.
RB3. Introduction to Numerical Analysis 3rd Edition, Devi Prasad, Narosa 2006.

5. Course Plan:

Mod. No.	Lecture Sessions	References	Learning Outcomes
1- 2	Introduction, Kinds of errors in numerical procedures, measurement of efficiency of numerical procedures, order of accuracy	CHAP 1, 3, 4 TB1	To understand the significance of numerical methods in context of solving engineering problems
3-7	Bisection, secant, method of false – position, Newton's method, Fixed point iteration method, Order of convergence, multiple roots.	CHAP 5, 6, 8 TB1	To study the solution methodologies of non-linear equations and system of non-linear equations
8-15	The Elimination method, Gaussian Elimination, Other direct methods, Pathology in linear systems-singular matrices, Determinants and matrix inversions, Tri-diagonal systems, Thomas algorithm, Norms, condition numbers and errors in computed solutions, Jacobi's method, Gauss Seidel method, Newton's methods, fixed-point methods for non-linear systems	CHAP 9, 10, 11, 12 TB1	To solve a linear system using matrix and iterative methods to solve a set of algebraic equation
16-21	Least square regression, Existence and Uniqueness of interpolating polynomial, Lagrange polynomials, divided differences, evenly space points, error of interpolation	CHAP 17, 18 TB1	To understand regression and an interpolating polynomial and its efficient evaluation?
22-26	Derivatives from difference table, Higher order derivatives, Newton-Cotes Integration formulas, The Trapezoidal rule - a composite formula, Simpsons rule, Gaussian Quadrature, Richardson Extrapolation	CHAP 21, 22, 23, 24 TB1	To compute numerical derivatives and integration using discrete data points and to know how to integrate functions
27- 32	Taylor series method, Euler and Modified Euler's method, Runge-Kutta (RK) Methods, Multistep methods: Milne's method, Adams-Moulton method, Predictor – corrector formulas, System of equations and higher order equations, stiffness.	CHAP 25, 26 TB1	Ordinary Differential Equation: To understand initial value problems and computation of numerical solutions of initial value problems
33 - 36	General method for BVP, Eigenvalue problems, Finite difference method,	CHAP 27,	Ordinary Differential Equation: To study boundary value problems (BVP)

	solution of a set of equations, Derivatives, boundary conditions.	28 TB1	and its solution methodologies, Eigenvalue problems
37 - 42	Types of PDEs: Elliptic, Parabolic, Hyperbolic, physical significance of PDEs, Types of boundary conditions and its physical significance, Finite Difference formulation: Laplace equation, Poisson's equation, Diffusion equation, Advection-Diffusion equation, Explicit methods, A Simple Implicit Method, The Crank-Nicolson Method, Two dimension problems frequently used in engineering applications	CHAP 29, 30, 32 TB1	To understand different types of PDEs as well its significance in engineering and scientific problems, Development of Finite Difference Equations for these PDEs

6. Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of component (Close Book/ Open Book)
Mid-Semester Test	90 Min.	30	<TEST_1>	Close and Open
Comprehensive Examination	3 h	45	<TEST_C>	Close and Open
Project	-	25	-	Open

7. Chamber Consultation Hour: To be announced

8. Notices: All notices concerning the course will be displayed either on Nalanda webpage or will be announced in class on regular basis.

9. Make-up Policy:

1. Make-up will be granted only on genuine reasons. However, prior permission of IC is must.
2. For medical cases, a certificate from the concerned physician of the Medical Centre must be produced.

10. Note (if any):

Instructor-in-charge
Course No. CE F324