Course Type	Course Code	Name of the Course	L	T	P	Credits
DE	NFMD504	Numerical Methods in Metallurgical Engineering	3	0	0	3

Prerequisites: Linear algebra, Differential and integral calculus

Course Objective
To equip students with a fundamental understanding of numerical methods and their application in solving complex metallurgical engineering problems, including but not limited to metallurgical thermodynamics, heat and mass transfer, fluid flow, and material deformation processes.
Learning Outcomes
• Understand and apply various numerical methods to solve linear and nonlinear algebraic equations, ordinary and partial differential equations, perform numerical differentiation and integration, etc. • Develop and implement computer-based programs that employ numerical algorithms to solve mathematical models pertinent to Metallurgical Engineering problems.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1.	Defining errors and precision in numerical methods, Truncation and round-off errors; Error propagation, global and local truncation errors; introduction to programming languages used in numerical analysis.	3	To identify and explain different sources of errors in numerical computations.
2.	Linear algebra and matrix operations, Gauss Elimination, LU decomposition, Iterative methods: Gauss Siedel, Special Matrices: Tridiagonal matrix algorithm (TDMA). Non-Linear equations: Newton-Raphson methods for single and multiple variables.	6	To gain the ability to implement and compare various numerical methods for solving linear and nonlinear algebraic equations.
3.	Numerical Differentiation: Taylor series expansions, Forward, backward, and central difference methods. Numerical Integration: Trapezoidal rule, Simpson's $1/3^{rd}$ rule.	4	Obtain approximate integrals and derivatives of complicated functions.
4.	Principles of curve fitting and regression analysis: Linear and non-linear least square regression, goodness of fit; polynomial curve fitting, piecewise linear curve fitting.Data interpolation and extrapolation.	4	Employ curve-fitting techniques to create models and analyze experimental data.
5.	Numerical Optimization: Introduction to Optimization, gradient descent methods, and applications.	4	Apply optimization algorithms to identify optimal solutions.
6.	Numerical Solutions to Differential Equations: Numerical solutions of ordinary differential equations (ODEs), initial value problems, boundary value problems, Implicit and Explicit Euler's methods, and Runge-Kutta Methods.Introduction to numerical methods for partial differential equations (PDEs).	8	Apply numerical methods to solve ordinary and partial differential equations commonly found in Metallurgical Engineering.
7.	Finite difference methods (FDM), finite volume methods (FVM), finite element methods (FEM), and their applications.	6	Understand the different ways of utilizing numerical methods to solve practical problems.
8.	Case studies: Simulation of fluid flow and heat transfer processes in metallurgy. Stress and deformation analysis.	7	Conduct case studies to model & simulate fluid flow, heat transfer, and structural problems often encountered in Metallurgical Engineering.
	Total	**42**	

Text Books:

1. Numerical Methods for Engineers and Scientists: An introduction with applications using Matlab; Gilat & Subramaniam, Wiley.

Reference Books:

1. Applied Numerical Methods with MATLAB for Engineers and Scientists, Steven C. Chapra, McGraw-Hill.
2. J.H. Mathews and K.D. Fink, Numerical Methods using MATLAB, Pearson Publishing.