Course Type	Course Code	Name of Course	L	T	P	Credit
DE	**NMED530**	**Fundamentals of Lattice Boltzmann Method**	3	0	0	3

CourseObjective

Prerequisite: Prerequisite: Basic knowledge of fluid mechanics and heat transfer are essential

- To day out the basic concepts of the Lattice Boltzmann Method (LBM) to simulate fluid flow phenomenon.
- Students should be able to apply the principles of LBM to develop solvers for Computational Fluid Dynamic Applications.

LearningOutcomes

Upon successful completion of this course, students will:

- Understand the basics of the kinetic theory of gases;
- Understand the development of the Boltzmann equation, the physics behind the collision operator, the Boltzmann's H-theorem, and the connection between Navier-Stokes equation with Boltzmann equation;
- Understand how boundary and initial conditions are to be implemented in LBM framework for fluid dynamic problems
- Be able to analyze the LBM equations for solving fluid flow problems *vis-à-vis* with conventional high-accuracy methods applied in CFD.

Unit no	Topics to be covered	Lecture Hours	Learning outcomes
1	Development of Navier-Stokes Equation under continuum assumption, Basics of Kinetic Theory of Gases and Statistical Dynamics, Brief overview of conventional numerical methods for CFD (FDM,FVM and FEM)	7	Understanding of the basics of kinetic theory of gases, statistical dynamics and its relationship with the Navier-Stokes equations (NSE).
2	Introduction to Collision and Streaming Process, TheBoltzmann H-Theorem, Implementation of LBM: Initialization, Discretization in Space, Time andVelocity field: BGK Collision Operator	7	Understanding of the derivation of LBM, with collision and streamingprocesses.
3	The Chapman-Enskog Analysis, Alternative equilibrium models, Grad's Thirteen Moment Theory, Kinetic theory of dense fluids (The BBGKY Hierarchy)	9	Understanding of the importance of Chapman-Enskog Analysis and Grad's Thirteen Moment Theory and Their relationship with LBM.
4	Implementation of boundary (periodic, non-periodic, slip and no-slip wall)and initial conditions, The Chapman-Enskog Analysis for boundary conditions, Modeling of applied body forces, The Chapman-Enskog error analysis in the presence of forces	9	Understanding of the fluid dynamics application of LBM, implementation of various boundary and initial conditions.
5	Sample procedure for Poiseuille Flow simulation, LBM for Convection-diffusion equation, Boussinesq Approximation and Rayleigh-Bénard convection, LBM for aero-acoustics, Fluid-structure interaction problems, Introduction to entropic LBM.	10	Understanding of the how LBM can be applied to simulate various fluiddynamical problems of interest with a brief introduction of the entropic LBM for enhanced accuracy.
	Total	42 hrs	

Text Books

1. The lattice Boltzmann method, Principles and Practice, T.Krüger, H.Kusumaatmaja, A. Kuzmin, O.Shardt, G.Silva, &E.M.Viggen, (2017).. Springer International Publishing,10(978-3),4-15.

Reference Books

1. The lattice Boltzmann equation: for complex states of flowing matter, SauroSucci., Oxford university press,2018
2. The lattice Boltzmann equation: for fluid dynamics and beyond,SauroSucci,Oxford university press,2001.
3. Lattice Boltzmann method and its application in engineering, ZhaoliGuo, and Chang Shu, Vol. 3. World Scientific,2013.