	National Institute of Technology Meghalaya An Institute of National Importance	CURRICULUM

Programme	Master of Technology in Mechanical Engineering	Year of Regulation	2018
Department	Mechanical Engineering	Semester	II

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
ME504	**Computational Fluid Dynamics**	**3**	**0**	**0**	**5**	**50**	**50**	**100**	**200**

Course Objectives		Course Outcomes		
	To introduce with CFD philosophy, pre-processing, post-processing and classification of PDEs		CO1	Able to classify PDEs governing fluid flows and examine the role of characteristics (Understanding)
	To introduce discretization of partial differential equations using various schemes of finite difference method (FDM), finite volume method (FVM) and stream function vorticity approach		CO2	Able to outline the principles of discretization and illustrate common methods of discretization and infer on associated errors (Analzing).
	To introduce various iterative schemes for solving linearized algebraic equations, stability analysis of various schemes		CO3	Able to explain numerical schemes, techniques and solution methodologies for solving discretized set of equations to obtain a stable solution (Analysing)
	To introduce to the staggered formulation and the associated discretization schemes like SIMPLE, etc		CO4	Able to construct governing equations of fluid and thermal engineering problems and solving them using appropriate boundary conditions (Applying).

SYLLABUS

No.	Content	Hours	COs
I	**Introduction and Conservation Principles:** Definition and Importance of CFD, Fundamental conservation laws of fluid motion and heat transfer, Conservation of mass, Conservation of momentum, Conservation of energy, equations of state	**04**	**CO1**
II	**Classification of Partial Differential Equations and Approximate Solutions:** Mathematical classification of PDEs – parabolic, elliptic and hyperbolic equations, Role of characteristics in PDEs, Approximate solutions of differential equations, Primary and secondary variables, essential and natural boundary conditions, Weighted residual approach, Least square method, Point collocation method, Galerkin Method, RayleighRitz Method	**08**	**CO1**
III	**Fundamentals and Common Methods of Discretization:** Principles of discretization – preprocessing, solution and post processing, Types of boundary conditions, Conservativeness, boundedness, transportiveness, Overview of finite difference, Overview of finite element and finite volume methods	**05**	**CO2**
IV	**Numerical Solutions:** Numerical solution of parabolic partial differential equations using finite-difference and finite-volume methods: explicit and implicit schemes, consistency, stability and convergence, Numerical solution of systems of linear algebraic equations: general concepts of elimination and iterative methods, Gaussian elimination, LU decomposition, Tridiagonal matrix algorithm, Jacobi and Gauss-Seidel iterations, Necessary and sufficient conditions for convergence of iterative schemes, Gradient search methods, Steepest descent and conjugate gradient methods	**07**	**CO3**
V	**Diffusion:** The finite volume method of discretization for diffusion problems: Discretization of transient one-dimensional diffusion problems, Discretization for multi-dimensional diffusion problems, Stability analysis of parabolic and hyperbolic equation, FTCS, FTFS, FTBS, schemes, Convection-diffusion problems: Central difference, upwind schemes, exponential, hybrid and power-law schemes, QUICK scheme, Concept of false diffusion	**07**	**CO3, CO4**
VI	**Numerical Solution of Navier-Stokes Equations:** System for incompressible flows: stream-function vorticity, Staggered grid and collocated grid, SIMPLE, SIMPLEC and SIMPLER algorithms	**05**	**CO4**
	Total Hours	**36**	

Essential Readings

9. H. K. Versteeg and W. Malalasekera, “An introduction to computational fluid dynamics: The finite volume method”, Pearson Education, 2008

10. J. D. Anderson Jr., “Computational Fluid Dynamics”, McGraw-Hill International Edition, 2017

Supplementary Readings

19. J. H. Fergiger, M. Peric, “Computational Methods for Fluid Dynamics”, Springer, 2003

20. T. J. Chung, “Computational Fluid Dynamics”, Cambridge University Press, 2010

21. S.V. Patankar, “Numerical Heat Transfer and Fluid Flow”, Hemisphere, 2018