	National Institute of Technology Meghalaya An Institute of National Importance	CURRICULUM

Programme	**Bachelor of Technology in Mechanical Engineering**	Year of Regulation	**2018**
Department	**Mechanical Engineering**	Semester	**VIII**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
ME 412	**Computational Fluid Dynamics**	**3**	**0**	**0**	**3**	**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)
			CO2	Able to outline the principles of discretization and illustrate common methods of discretization and infer on associated errors (Analzing).
	To introduce discretization of partial differential equations using various schemes of finite difference method (FDM), finite volume method (FVM) and stream function vorticity approach		CO3	Able to explain numerical schemes, techniques and solution methodologies for solving discretized set of equations to obtain a stable solution (Analysing)
			CO4	Able to construct governing equations of fluid and thermal engineering problems and solving them using appropriate boundary conditions (Applying).
	To introduce various iterative schemes for solving linearized algebraic equations, stability analysis of various schemes		CO5	Able to develop computer program for finding out the feasible numerical solution of realistic fluid and thermal problems applying suitable initial and boundary conditions including graphical representation through report.

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**
2	CO2	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**
3	CO3	**3**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**
4	CO4	**3**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**
5	CO5	**0**	**2**	**0**	**0**	**3**	**0**	**0**	**2**	**0**	**2**	**0**	**0**	**3**	**0**	**0**

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**
VII	**Develop a code to simulate diffusion problems:** Develop a C/C++/FORTRAN code to develop diffusion problems using various finite difference schemes while implementing different iterative techniques. Analyze the results by comparing exact solutions with numerical solutions, compare between different iterative solvers and realize different types of numerical error through these numerical experiments.	**24**	**CO4** **CO5**
	Tutorials	**12**	
	Total Hours	**72**	

Essential Readings

1. H. K. Versteeg and W. Malalasekera, “An introduction to computational fluid dynamics: The finite volume method”, Pearson Education, 2008
2. J. D. Anderson Jr., “Computational Fluid Dynamics”, McGraw-Hill International Edition, 2017

Supplementary Readings

1. J. H. Fergiger, M. Peric, “Computational Methods for Fluid Dynamics”, Springer, 2003
2. T. J. Chung, “Computational Fluid Dynamics”, Cambridge University Press, 2010
3. S.V. Patankar, “Numerical Heat Transfer and Fluid Flow”, Hemisphere, 2018