

GANPAT UNIVERSITY									
FACULTY OF ENGINEERING AND TECHNOLOGY									
Programme		Master of Technology			Branch		Mechanical Engineering (Specialization in Additive Manufacturing)		
Semester		II			Version		1.0.0.0		
Effective from Academic Year			2025-26		Effective for the batch Admitted in			July 2025	
Subject code		3ME2119	Subject Name		Computational Fluid Dynamics				
Teaching scheme									
(Per week)	Lecture(DT)		Practical(Lab.)		Total		CE	SEE	Total
	L	TU	P	TW					
Credit	2	0	2	0	4	Theory	40	60	100
Hours	2	0	4	0	6	Practical	60	40	100

Pre-requisites:
Fluid Mechanics, Engineering Mathematics, Heat Transfer, and basic programming knowledge.

Course Learning Outcomes:
The course content should be taught and implemented with an aim to develop different skills leading to the achievement of the following competencies and course learning outcomes: CO1: Explain the governing equations of fluid flow and heat transfer and their physical significance. CO2: Analyze discretization techniques for solving fluid flow and heat transfer problems. CO3: Apply numerical methods to solve one-dimensional and two-dimensional fluid flow problems. CO4: Use commercial CFD software to simulate engineering flow problems and interpret results. CO5: Evaluate accuracy, stability, and convergence of CFD solutions for engineering applications.

Course Content		
Name of Unit	Content	Hrs
UNIT – I: Introduction to CFD and Governing Equations	Introduction to CFD, advantages and limitations, classification of CFD methods. Review of vector calculus, conservation principles. Derivation of continuity equation, momentum equations (Navier–Stokes equations), and energy equation. Classification of partial differential equations (elliptic, parabolic, hyperbolic). Initial and boundary conditions.	8
UNIT – II: Discretization Techniques	Finite difference method, finite volume method, finite element method. Grid generation: structured and unstructured grids, grid quality, mesh refinement. Spatial discretization schemes: central difference, upwind schemes, higher-order schemes. Temporal discretization methods.	10
UNIT – III: Solution of Algebraic Equations and Pressure–Velocity Coupling	Iterative and direct solvers. Gauss–Seidel method, Jacobi method, TDMA. Pressure–velocity coupling algorithms: SIMPLE, SIMPLER, PISO. Stability and convergence criteria. Under-relaxation techniques.	8

UNIT – IV: Turbulence and Heat Transfer Modeling	Fundamentals of turbulence and Reynolds averaging. Turbulence models: $k-\epsilon$, $k-\omega$, and Reynolds Stress Model (RSM). Near-wall treatment and boundary layer modeling. Heat transfer modeling: conduction, convection, and radiation. Introduction to multiphase flow and species transport models.	8
UNIT – V: Applications of CFD in Engineering	CFD applications in internal and external flows. Applications in heat exchangers, turbomachinery, aerospace, automotive, biomedical engineering, and additive manufacturing processes. Verification and validation of CFD models. Post-processing techniques and interpretation of CFD results.	6

List of Practical

The practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate course learning outcomes.

No.	Unit	Name of Practical
1	1	Simulation of laminar flow in a circular pipe using CFD software.
2	2	Mesh generation and grid independence study for a two-dimensional geometry.
3	3	CFD analysis of flow over a flat plate and determination of boundary layer thickness.
4	4	Heat transfer simulation in a heat exchanger or heated plate.
5	5	Turbulent flow analysis using $k-\epsilon$ or $k-\omega$ turbulence model.
6	5	Case study of an industrial CFD application (automotive / biomedical / AM process).

List of Instruments / Equipment / Trainer Board

No.	Instruments / Equipment
1	High-performance computers/workstations.
2	Commercial CFD software (ANSYS Fluent / OpenFOAM / COMSOL).
3	CAD software for geometry creation.
4	Mesh generation and post-processing tools.
5	Projection system and visualization tools.

List of Reference Books

No.	Title of Reference Books	Authors	Publication
1	Computational Fluid Dynamics: The Basics with Applications	John D. Anderson Jr.	McGraw-Hill
2	Numerical Heat Transfer and Fluid Flow	Suhas V. Patankar	CRC Press
3	An Introduction to Computational Fluid Dynamics: The Finite Volume Method	H. K. Versteeg, W. Malalasekera	Pearson
4	Computational Fluid Dynamics	T. J. Chung	Cambridge University Press
5	CFD Applications in Mechanical Engineering	Anderson & Tannehill	Wiley