INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

COMPUTATIONAL FLUID DYNAMICS FOR MECHANICAL ENGINEERING APPLICATIONS								
VI Semester: ME								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AMED31	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	0	0	3	40	60	100
Contact Classes: 48	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 48**		
Prerequisite: Nil								

I. COURSE OVERVIEW:
Computational Fluid Dynamics mainly focuses on complex engineering fluid dynamics and heat transfer analysis using numerical methods, which are provided with advanced engineering mathematics (Fourier series, partial differential equations). This course also describes the computational simulation tools required for the analysis of thermal engineering problems in the emerging technologies of interdisciplinary applications like aerospace and medical fields of research.

II. COURSES OBJECTIVES:
The students will try to learn

I. The evolution of the major theories, approaches, methodologies and programming techniques in Computational fluid dynamics.
II. The development of various fluid flow-governing equations from the conservation laws of motion and Fluid mechanics.
III. The rigorous and comprehensive treatment of numerical methods in fluid flow and heat transfer problems in engineering applications.
IV. The environment and usage of commercial Computational Fluid Dynamics packages and carry out research in interdisciplinary applications.

III. COURSE OUTCOMES:

At the end of the course students should be able to:

CO1 Demonstrate an ability to dimension and annotate two-dimensional engineering graphics.
CO2 Demonstrate the freehand sketching to aid in the visualization process and to efficiently communicate ideas graphically.
CO3 Make use of CAD software for the creation of 3D models and 2D engineering graphics.
CO4 Comprehend the principles and techniques for creating sectional views of three-dimensional solids in engineering graphics.
CO5 Explain the application of industry standards and best practices applied in engineering graphics.
CO6 Apply the general projection theory with emphasis on orthographic projection to represent three-dimensional objects in two-dimensional views.

IV. COURSE CONTENT:

MODULE -I: INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS (10)
History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, brief comparison of various Numerical Methods for CFD, general procedure for CFD Solution, review of Fluid Dynamics, models of the flow, the substantial derivative, physical meaning of the divergence of velocity.

MODULE -II:GOVERNING EQUATIONS OF FLUID FLOW AND HEAT TRANSFER (09)
The continuity equation, The momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching.

MODULE -III PARTIAL DIFFERENTIAL EQUATIONS AND ITS DISCRETIZATION (10)
Mathematical Behavior of Partial Differential Equations: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations, Well-Posed Problems.

Basic Aspects of Discretization: Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, errors and analysis of stability.

MODULE -IV: FINITE DIFFERENCE METHOD (10)
Grids with Appropriate Transformation: General transformation of the equations, Metrics and Jacobians, The transformed governing equations of the CFD, Boundary fitted coordinate systems, Algebraic and elliptic grid generation techniques, Adaptive grids. Hyperbolic Grid Generation, Parabolic Grid Generation
Stability Analysis: Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, Artificial dissipation and dispersion.

MODULE –V: OTHER NUMERICAL METHODS FOR CFD (09)
General description of Finite Volume Method, Cell Centered and Nodal point Approaches, 2-D Heat conduction with Triangular Elements, Flux vector splitting scheme.
General description of Finite Element Method, 2-D Heat conduction equation, construction of global matrix, boundary conditions, reduction of the half bandwidth of the global matrix.

V. TEXT BOOKS:

1. Anderson, J.D. (Jr), “Computational Fluid Dynamics”, McGraw-Hill Book Company, 2017.
2. Hoffman, K.A., and Chiang, S.T., “Computational Fluid Dynamics”, Vol. I, II and III, Engineering Education System, Kansas, USA, 2003.

VI. REFERENCE BOOKS:

1. Chung, T.J., “Computational Fluid Dynamics”, Cambridge University Press, 2003.
2. Muralidhar K and Sundararajan., “Computational Fluid Flow & Heat Transfer”, Alpha Science International Ltd 2009.
3. Anderson, D. A., Tannehill, J. C., and Pletcher, R. H., “Computational Fluid Mechanics and Heat Transfer”, CRC press, 2012.

VII. ELECTRONICS RESOURCES:

1. https://nptel.ac.in/courses/112105045/
2. https://akanksha.iare.ac.in/index?route=course/player&course_id=1685&section_id=3005&lesson_id=19706
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VIII. MATERIALS ONLINE:

1. Course template
2. Tutorial question bank
3. Tech talk topics
4. Open end experiments
5. Definitions and terminology
6. Assignments

7. Model question paper – I
8. Model question paper - II
9. Lecture notes
10. E-learning readiness videos (ELRV)
11. Power point presentation.