Course code	Course Name	L-T-P-Credits	Year of Introduction
AO401	COMPUTATIONAL FLUID DYNAMICS	3-1-0-4	2016

Prerequisite : Nil

Course Objectives

- To introduce Governing Equations of viscous fluid flows
- To introduce numerical modeling and its role in the field of fluid flow and heat transfer
- To enable the students to understand the various discretization methods, solution procedures and turbulence modeling.
- To create confidence to solve complex problems in the field of fluid flow and heat transfer by using high speed computers.

Syllabus

Fundamental concepts of CFD - Basic equations -Different CFD methods-Mathematical preliminaries for CFD techniques-Constancy, convergence and stability properties of computational techniques-Finite difference scheme for parabolic differential equation-Euler equation of inviscid and incompressible flow- Navier stokes equation – Finite difference techniques applied to elliptical equations - Two dimensional problems – Three dimensional problems

Expected Outcome

The students will be able to

i. create numerical modeling and its role in the field of fluid flow and heat transfer
ii. use the various discretization methods, solution procedures and turbulence modeling to solve flow and heat transfer problems.

Text Books:

1. John Anderson, Computational fluid dynamics, McGraw Hill, 1995
2. John F. Wendt (Ed.), Computational fluid dynamics - An introduction, Springer Verlag, 2009

References:

1. Fletcher, Computation technique for fluid dynamics , Vol-I and II , Springer
2. Pradip Niyogi, S.K Chakrabarty, M.K Laha, Introduction to computation fluid dynamics, Pearson Education, 2005
3. T J Chung, Computational fluid dynamics, Cambridge university press, 2010

Module	Contents	Hours	End Sem. Exam Marks
I	**Fundamental concepts of CFD** Aim and scope of CFD	1	15%
	Basic equations of fluid dynamics in conservative and non-conservative form	2	

	Different CFD methods- numerical source, panel method of non-lifting flows over arbitrary bodies	2	
	Vortex panel method of lifting flows over arbitrary bodies	1	
	Finite different methods of subsonic, supersonic and viscous flows	1	
	Finite element methods as applied is incompressible non-viscous flows	1	
	Finite volume techniques comparative study of these methods	1	
II	**Mathematical preliminaries for CFD techniques** Mathematical properties of fluid dynamics equations elliptical, parabolic and hyperbolic equations	2	15%
	Strong and weak formation of boundary value problems ,strong formulation, weighted residual formulation ,galerkin formulation ,variational formulation	3	
	Finite difference discretisation forward difference backward difference and central difference formulations	2	
	Transformation and grids coordinate transformation structured and unstructured grids, staggered grids	2	
FIRST INTERNAL EXAM			
III	**Constancy, convergence and stability properties of computational techniques** Errors in numerical approximation techniques- round off error, truncation error, Concepts of numerical dissipation, numerical dispersion	3	15%
	Consistency, convergence and stability property of different CFD methods, Lax equivalence theorem	3	
	Stability properties of explicit methods regions of weak stability and absolute stability	3	
IV	**Finite difference scheme for parabolic differential equation** Finite difference scheme for heat conduction equation : FTCS scheme, convergence and stability property of above scheme merits and demerits of this explicit method	4	15%
	Crank Nicholson Implicit scheme, truncation error, consistency and convergence of the above scheme. Dissipative and dispersive error stability of crank Nicholson scheme merits and demerits of this Implicit method	4	
SECOND INTERNAL EXAM			
V	**Simple finite difference technique applied to hyperbolic equations (non conservative form of Euler equation applicable to inviscid flow) and elliptical equation (Laplace equation) in two dimension** Euler equation of inviscid and incompressible flow. Lax Wendroff technique– its limitations ,Mac cormacks technique .Disspative and dispersive error stability property Pressure correction technique application to incompressible viscous flow incompressible Navier stokes equation – central differencing of above equations – need for a staggered grid.	6	20%

	Finite difference techniques applied to elliptical equations:- Laplace’s equation in two dimensions – numerical difference method. Iterative method for solution of linear algebraic system Jacobi and the gauss- seidel. scheme convergence of above method. Condition for stability	4	
VI	**Finite volume techniques** Two dimensional problems – Node centred control volume, cell centred control volume	3	20%
	Three dimensional problems -3-D geometry of data structure ,cell centred average scheme, three dimensional FVM equations .	3	
	Lax Vendroff time stepping , Runge kutta time stepping, Multistage time stepping finite difference method like finite volume technique	3	
	Central and upwind type discretisation treatment of derivatives.		
END SEMESTER EXAM			

Question Paper Pattern

Maximum marks: 100 Exam duration: 3 hours

The question paper shall consist of three parts

Part A
4 questions uniformly covering modules I and II. Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part B
4 questions uniformly covering modules III and IV. Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part C
6 questions uniformly covering modules V and VI. Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: In all parts, each question can have a maximum of four sub questions, if needed.