DEPARTMENT OF MECHANICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY TIRUCHIRAPPALLI

COURSE PLAN – PART I			
Course Title	COMPUTATIONAL FLUID DYNAMICS		
Course Code	MEPE11	**No. of Credits**	03
Course Code of Pre-requisite subject(s)	--		
Session	July 2018	**Section (if applicable)**	
Faculty	P Kaushik	**Department**	Mechanical Engineering
E-mail	pkaushik@nitt.edu	**Telephone No.**	+91 9632253573
Name of Course Coordinator (if applicable)	--		
Course Type	☐ **Core course**	☑ **Elective course**	☐ **Laboratory course**

Syllabus (approved in BoS)

Computational Fluid Dynamics: What, When, and Why?, CFD Advantages and Applications, Fundamental principles of conservation, Reynolds transport theorem, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, General scalar transport equation. Approximate Solutions of Differential Equations: Error Minimization Principles, Functional involving higher order derivatives, Essential and natural boundary conditions,

Discretization methods - Finite Element Method and Finite difference methods: Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Finite volume method (FVM), Illustrative examples and Some Conceptual Basics and Implementation of boundary conditions. Discretization of Unsteady State Problems: 1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme

Important Consequences of Discretization of Time Dependent Diffusion Type Problems: Consistency, Stability, Convergence, Grid independent and time independent study, Stability analysis of parabolic and hyperbolic equations. Finite Volume Discretization of 2-D unsteady State Diffusion type Problems: FVM for 2-D unsteady state diffusion problems

Solution of Systems of Linear Algebraic Equations: Criteria for unique solution, infinite number of solutions and no solution, Solution techniques for systems of linear algebraic equations: Elimination, Iteration and Gradient Search methods with examples. Norm of a vector, Norm of a

matrix, some important properties of matrix norm, Error analysis of elimination methods.

Finite volume discretization of Convection-Diffusion Equations: Schemes. The concept of false diffusion, QUICK scheme. Discretization of Navier Stokes Equations: Discretization of the Momentum Equation, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorithm. What is there in implementing a CFD code: The basic structure of a CFD code: Pre-processor, Solver and Postprocessor, User-defined subroutines.

Essential Readings

1. Tannehill, J.E., Anderson, D.A., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, 2nd ed., Taylor & Francis, 1997.
2. Hoffmann, K.A. and Chiang, S.T., Computational Fluid Dynamics for Engineers, Engineering Education Systems, 2000.
3. Anderson J.D., Computational Fluid Dynamics - The basics with Applications, Mc Graw-Hill, 1995.
4. Versteeg, H.K. and Malalasekera, W., An Introduction to Computational Fluid Dynamics - The finite volume method, Longman Scientific & Technical, 1995.
5. Patankar, S.V., Numerical Heat Transfer & Fluid Flow, Hemisphere, 1980.
6. Date A.W., Introduction to Computational Fluid Dynamics, Cambridge University Press, 2005.

COURSE OBJECTIVES

1. To conduct numerical modeling and apply its role in the field of heat transfer and fluid flow.

2. To 0utilize the various discretization methods and solving methodologies for problems in heat transfer and fluid flow.

3. To solve complex problems in the field of heat transfer and fluid dynamics by using high speed computers.

4. To interpret the knowledge, capability of analyzing and solving any concept or problem associated with heat energy dynamics and utilization.

5. To illustrate the working concepts of thermal engineering devices.

COURSE OUTCOMES (CO)

Course Outcomes	Aligned Programme Outcomes (PO)
Upon completion of the course, the student will be able to	
1. conduct numerical modeling and apply its role in the field of heat transfer and fluid flow.	PO2, PO4
2. utilize the various discretization methods and solving methodologies for problems in heat transfer and fluid flow.	PO1

3. solve complex problems in the field of heat transfer and fluid dynamics by using high speed computers.	PO1, PO3
4. interpret the knowledge, capability of analyzing and solving any concept or problem associated with heat energy dynamics and utilization.	PO2
5. illustrate the working concepts of thermal engineering devices	PO3

COURSE PLAN – PART II

COURSE OVERVIEW

The course provides a stuctured approach on the method of approaching to solve a problem in heat transfer and/or fluid flow by computational method. The design of the course includes understanding of the governing equations of fluid flow and heat transfer. The course further goes on to describe the types of these governing equations and strategies which are important to solve them. The course further describes the numerical schemes used to convert these equations and their corresponding boundary conditions into a system of ordinary equations. The numerical strategies used to solve these ordinary equations are further dilineated in the course. Solution of some special cases of fluid flow and heat transfer problems are illustrated.

COURSE TEACHING AND LEARNING ACTIVITIES

S. No.	Week	Topic	Mode of Delivery
1	1st week	Introduction – Basic Governing equations	PPT, Chalk & Talk
2	2nd week	Basic governing equations - General scalar transport equation	PPT, Chalk & Talk
3	3rd week	Classification of equations	Chalk & Talk
4	4th week	Approximate Solutions	Chalk & Talk
5	5th week	Discretization methods	Chalk & Talk
6	6th week	Finite volume method	Chalk & Talk
7	7th week	Time Dependent Diffusion Type Problems	Chalk & Talk

8	8th week	Solution of Systems of Linear Algebraic Equations	Chalk & Talk
9	9th week	Elimination, Iteration and Gradient Search methods with examples	Chalk & Talk
10	10th week	Error analysis of elimination methods	Chalk & Talk
11	11th week	Finite volume discretization of Convection-Diffusion Equations	Chalk & Talk
12	12th week	Discretization of Navier Stokes Equations	Chalk & Talk
13	13th week	SIMPLE Algorithm - SIMPLER Algorithm	Chalk & Talk
14	14th week	The basic structure of a CFD code	PPT, Chalk & Talk

COURSE ASSESSMENT METHODS (Shall range from 4 to 6)

S. No.	Mode of Assessment	Week/Date	Duration	% Weightage
1.	Assignment	1st week of August	-	10%
2.	Mid exam (1st and 2nd units)	05 Sep 2018	1.5 hour	30%
3.	Quiz (Multiple Choice Questions) (3rd and 4th units)	03 Oct 2018	30 mins	10%
CPA	Compensation test (first four units)	5 – 9 Nov 2018	1.5 hour	30%
4.	End Semester Examination (Descriptive)	12 – 22 Nov 2018	2 hours	50%

COURSE EXIT SURVEY

1. Students feedback through class committee meetings
2. Feedback questionnaire from students – at the end of the semester
3. Feedback from students on the course outcomes shall be obtained at the end of the course

COURSE POLICY (preferred mode of correspondence with students, policy on attendance, compensation assessment, academic honesty and plagiarism etc.)

Mode of Correspondence

1. The Faculty is available for consultation during the time intimated to the students then and there.
2. The students will be communicated through the email id: pkaushik@nitt.edu for any academic related issues (including sharing of study materials) with respect to this course.

Attendance

1. All the students are expected to attend all the contact hours. Students should maintain 75% minimum physical attendance by the end of the course to attend the end semester examination.
2. Students fall short of 75% attendance at the end of the course will have to appear the compensation assessment (CPA). Students with attendance in the range between 50% to 75% have to score at least 40% marks in the CPA to make themselves eligible for appearing the end semester exam. The students with attendance < 50% have to score 60% in the CPA to make themselves eligible for appearing the end semester exam.
3. Students not having 75 % minimum attendance at the end of the semester and also scores less than recommended marks in the CPA will be awarded 'V' Grade and have to REDO the course.
4. Marks obtained in the CPA will not be considered for cumulative marks for the students, who appeared due to attendance shortage.

Compensation Assessment

1. Attending all the assessments (2, 3, 4, 5) are mandatory for every student. Flexibility is given to the students to fix the date for each mode of evaluation convenient to majority of the students.
2. If any student fails to attend the cycle test 1 and 2 due to genuine reason like medical emergency, the student may be permitted to appear the compensation assessment (CPA) on submission of appropriate documents as proof. (Not valid for students having attendance lag).
3. Students not having 75 % minimum attendance at the end of the semester and also didn't the cycle test 1 and 2 will be awarded 'V' Grade and have to REDO the course.
4. In any case, compensation assessment (CPA) is not considered as an improvement test.
5. The minimum marks for passing this course and grading pattern will adhere to the regulations of the institute.

Academic Honesty & Plagiarism

1. In case if any student found guilty, indulging in any mal practice, the student will be awarded ZERO marks in that particular assessment. If found using mobile phones or any other gadgets for any mal-practice during the examination, the answer sheet of the student will not be evaluated and will be awarded ZERO marks for that assessment.

FOR APPROVAL

[P Kaushik, AP/ME]		
Course Faculty	**CC Chairperson**	**HoD (Dept. of ME)**