GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING (30)
CFD APPLICATIONS IN CHEMICAL ENGINEERING
SUBJECT CODE: 2733007
M.E. 3rd SEMESTER

Type of course: Chemical Engineering (Major Elective-IV)

Prerequisite: Numerical methods, Fluid Flow Operations, Heat transfer

Rationale: Computational fluid dynamics, usually abbreviated as CFD, is a branch of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows and having applications in various fields of engineering. CFD provides a qualitative (and sometimes even quantitative) prediction of fluid flows by means of mathematical modeling (partial differential equations), numerical methods (discretization and solution techniques) and software tools (solvers, pre- and postprocessing utilities).

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks		Practical Marks				
L	T	P	C	ESE (E)	PA (M)	ESE (V)		PA (I)		
						ESE	OEP	PA	RP	
3	2#	2	5	70	30	20	10	10	10	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1.	**Basic concept of CFD:** Overview of CFD, Role of CFD, Problem solving in CFD Advantages of Computational Fluid Dynamics, Typical Practical Applications,	5	9
2.	**Governing Equations** Governing equations of fluid flow and heat transfer, Navier-Stokes Equations, Energy Equations, Mass conservation Equations, Classification of fluid flow, Turbulence Modeling, etc.	9	17
3.	**Computational Techniques:** Finite difference method, Finite Volume method, Finite Element method, etc.	9	17
4.	**Grid Generation Techniques :** Structured Grid generation, Unstructured Grid generation, Adaptive Grid generation,etc.	8	15
5.	**Theoretical Background:** Convergence, Consistency, Stability, Solution Accuracy, Computational Efficiency	7	13
6.	**Special Topics :** Flow in a sudden pipe contraction/expansion, Flow and heat transfer in a complex tubes and channels, reactive flow, multiphase flow and turbulent flow process, Solution of Chemical Engineering Problems	12	22
7.	**Overview of CFD Simulation Softwares:** COMSOL, ANSYS FLUENT, FEMLAB, FEATLAB, etc.	4	07

Reference Books:

1. C.A.J. Fletcher, Computational Techniques for Fluid Dynamics 1, Springer-Verlag Berlin Heidelberg GmbH.
2. John D. Anderson, Computational Fluid Dynamics, McGraw Hill Education Private Limited.
3. H. K. Versteeg and W. Malalasekera, An introduction to CFD, Longman Scientific and Technical, 1st Edition, 1995.
4. E. S. Oran and J. P. Boris, Numerical simulation of reactive flow, Cambridge University Press, 2nd Edition, 2001.
5. J. H. Ferriger, M. Peric, Springer, Computational methods for fluid dynamics, 1st Edition, 1996.
6. S. V. Patankar, Numerical heat transfer and fluid flow, Mc Graw-Hill Book Company, 1st Edition, 1980.
7. W. Rodi, Turbulence models and their applications – a state of the art review, IAHR – AIRH Monograph series, 3rd Edition, 1993
8. Vivek V. Ranade, Computational flow modeling for chemical reactor engineering Academic Press, San Diego, 2002.
9. Hoffmann, K. A. and Chiang, S. T.,Computational Fluid Dynamics for Engineers, Vol. I, II, and III, 2nd Edition, Engineering Education System, 2000.
10. Chung, T. J., Computational Fluid Dynamics, 2nd Edition, Cambridge University Press, 2010.
11. Tannehill, J. C., Anderson, D. A. and Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer, 2nd Edition, Taylor & Francis, 2002.
12. P. S. Ghoshdastidar, Computer simulation of flow and heat transfer, TataMcGraw-Hill Publishing, 1st Edition, 1998.
13. K. Muralidhar and T. Sundararajan, Computational fluid flow and heat transfer,Narosa Publications, 2nd Edition, 2003.

Course Outcome:

After learning the course the students should be able to:

1. Learn basic principles used in CFD.
2. Formulate problems that can be solved using CFD techniques.
3. Design and solve heat transfer problems using CFD techniques.
4. Design and solve fluid flow problems using CFD techniques.
5. Apply CFD techniques for simulation of practical problems in fluid flow and heat transfer.
6. Use appropriate software for solving realistic problems.
7. Discretize the problems

Design based Problems (DP)/Open Ended Problem:

This course covers the basic discretization techniques and these techniques are in the form of mathematical equations which are ultimately to be solved using computers. So students are required to write codes for the solution of all these techniques in order to get solutions. They may also use different software packages available for this purpose. Students should solve problems of chemical engineering applications with the help of computers:

1. In the beginning of the academic term, faculties will have to allot their students at least one Open-ended Project out of all problems which should involve rigorous efforts for its solution.
2. These can be done in a group containing maximum three students in each.
3. Faculties should cultivate problem based project to enhance the basic mental and technical level of students.
4. Evaluation should be done on **approach of the student on his/her efforts** (not on completion) to study the design module of given task.

5. In the semester student should perform **minimum 5 set of numerical solutions of problems** and complete **one small open ended project** based on engineering applications. This project along with any performed experiment should be **EVALUATED BY EXTERNAL EXAMINER.**

List of Open Source Software/learning website:

- Students can refer to video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using software/spreadsheets. Students can develop their own programs/spreadsheets for the solution of problems.

Review Presentation (RP): The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. Every student or a group of students shall critically students shall critically study two paper, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website.