Computational Fluid Dynamics
AE 433

CHAPTER 0

–

Course Objectives and Syllabus

by

Dr. Emre Kara , Univ. of Gaziantep, TURKEY

Instructor

Emre Kara, Ph.D.

Office: Z04

Email: emrekara@gantep.edu.tr

Lecture webpage:

http://www1.gantep.edu.tr/~emrekara/index.php/ae433/

Course Information

Class Hours: Fri – 14:25-17:00 (Location: A03)
Number of Credit Hours: 3 hr credit

ME and CFD

Master's Thesis: Design of an Alternative Glaucoma Drainage Device Using CFD Tools (USE OF GAMBIT & FLUENT SOFTWARES)

Papers, proceedings and projects from master's thesis:

1. CFD analysis of the Ahmed Glaucoma Valve and design of an alternative device", Computer Methods in Biomechanics and Biomedical Engineering, 13:6, 655-662, (2010).
2. "CFD Analysis of Ahmed Glaucoma Valve and Design of an Alternative Device", Uluslararası Katılımlı 4. Biyomekanik Kongresi Bildiri Kitabı, 16-17 Ekim, Erzurum/Türkiye, (2008).
3. "HAD Araçları Kullanılarak Alternatif Bir Glokom Drenaj Cihazı Tasarımı", 1. Makine ve Aksamları AR-GE Proje Pazarı Yarışması Etkinlik Projeler Kitabı, 13 Nisan, İstanbul/Türkiye, (2012).
4. "Design of an Alternative Glaucoma Drainage Device Using CFD Tools", Special Session in the von Karman Institute (VKI) for Fluid Dynamics, 11 May, Brussels/Belgium, (2012).
5. "HAD Araçları Kullanılarak Alternatif Bir Glokom Drenaj Cihazı Tasarımı", Türkiye İnovasyon Haftası - AR-GE Proje Pazarı Finalist Sergisi (Poster), 6-8 Aralık, İstanbul/Türkiye, (2012).
6. "HAD Araçları Kullanılarak Alternatif Bir Glokom Drenaj Cihazı Tasarımı", 2. Makine ve Aksamları AR-GE Proje Pazarı Yarışması (Poster), 26 Ekim, İstanbul/Türkiye, (2013).

ME and CFD

Doctoral Thesis: Development of a Navier Stokes Solver for Compressible Flows on Cartesian Grids with Aerodynamics Applications (MY OWN CODES WRITTEN IN VISUAL FORTRAN !)

Papers, proceedings and projects from doctoral thesis (PART-1):

1. "An octree-based solution-adaptive Cartesian grid generator and Euler solver for the simulation of three-dimensional inviscid compressible flows", Progress in Computational Fluid Dynamics: An International Journal, 16:3, 131-145, (2016). DOI: 10.1504/PCFD.2016.076247
2. "A Navier Stokes solver for compressible turbulent flows on quadtree and octree based Cartesian grids", Journal of Applied Fluid Mechanics, xx:x, xxx-xxx, (2019). – Revize ediliyor.
3. "Shock Wave Capturing with Multi-Grid Accelerated, Solution Adaptive, Cartesian Grid Based Navier Stokes Solver", Journal of Aeronautics and Space Technologies, 9:2, 63-73, (2016).
4. "Lift Coefficient Calculation using a Geometric/Solution Adaptive Navier Stokes Solver On Two-Dimensional Cartesian Grids For Compressible And Turbulent Flows", AIP Conference Proceedings, 1889:1, 1-5, (2017). DOI: 10.1063/1.5004352
5. "Quad-Tree Based Geometric-Adapted Cartesian Grid Generation", Proceedings of the 8th International Conference on Continuum Mechanics (CM '13), 16-19 July, Series No. 14, Rhodes Island/Greece, (2013).
6. "A Quad-Tree Based Automatic Adaptive Cartesian Grid Generator with Applications on Multi-Element Airfoils", 7th Ankara International Aerospace Conference (AIAC'13), 11-13 September, Ankara/Turkey, (2013).

ME and CFD

Doctoral Thesis: Development of a Navier Stokes Solver for Compressible Flows on Cartesian Grids with Aerodynamics Applications (MY OWN CODES WRITTEN IN VISUAL FORTRAN !)

Papers, proceedings and projects from doctoral thesis (PART-2):

7. "A Solution Adaptive Multi-grid Euler Solver on Two-dimensional Cartesian Grids", 8th Ankara International Aerospace Conference (AIAC'15), 10-12 September, Ankara/Turkey, (2015).
8. "Object-Oriented Programming Application to a CFD Code on Cartesian Grid Techniques", International Conference on Computer Science and Engineering / Uluslararası Bilgisayar Bilimleri ve Mühendisliği Konferansı (UBMK 2016), 20-23 Ekim, Tekirdağ, (2016).
9. "Solution Refinement Effectiveness of Multi-Grid Accelerated, Cartesian Grid Based Navier Stokes Solver on Compressible and Laminar Flows", 8th International Academic Conference of Young Scientists "Mechanical Engineering, Materials Science, Transport 2016" (MEMST-2016), November 24-26, Lviv, Ukraine, (2016).
10. "Lift Coefficient Calculation using a Geometric/Solution Adaptive Navier Stokes Solver On Two-Dimensional Cartesian Grids For Compressible And Turbulent Flows", 16th conference on Power System Engineering, Thermodynamics & Fluid Flow (PSE17), June 13-15, Plzen, Czech Republic, (2017).
11. "Determination of Minimum Distance from a Cell Centroid to a Triangulated Surface: A Mesh Generation Implementation Technique", International Advanced Researches and Engineering Congress (IAREC 2017), 16-18 Kasım, Osmaniye, (2017).
12. "A Solution Adaptive Cartesian Grid Based Euler Solution for Compressible Flow around BOEING TR-1322 Multi-element Airfoil", Nevşehir Bilim ve Teknoloji Dergisi, 4:1, 69-80, (2015). DOI: 10.17100/nevbiltek.66399

ME and CFD

Doctoral Thesis: Development of a Navier Stokes Solver for Compressible Flows on Cartesian Grids with Aerodynamics Applications (MY OWN CODES WRITTEN IN VISUAL FORTRAN !)

Papers, proceedings and projects from doctoral thesis (PART-2):

12 studies (doctoral thesis) if you write own codes,
6 studies (master thesis) if you use a commercial program as ANSYS FLUENT !

7. "A Solution Adaptive Multi-grid Euler Solver on Two-dimensional Cartesian Grids", 8th Ankara International Aerospace Conference (AIAC'15), 10-12 September, Ankara/Turkey, (2015).
8. "Object-Oriented Programming Application to a CFD Code on Cartesian Grid Techniques", International Conference on Computer Science and Engineering / Uluslararası Bilgisayar Bilimleri ve Mühendisliği Konferansı (UBMK 2016), 20-23 Ekim, Tekirdağ, (2016).
9. "Solution Refinement Effectiveness of Multi-Grid Accelerated, Cartesian Grid Based Navier Stokes Solver on Compressible and Laminar Flows", 8th International Academic Conference of Young Scientists "Mechanical Engineering, Materials Science, Transport 2016" (MEMST-2016), November 24-26, Lviv, Ukraine, (2016).
10. "Lift Coefficient Calculation using a Geometric/Solution Adaptive Navier Stokes Solver On Two-Dimensional Cartesian Grids For Compressible And Turbulent Flows", 16th conference on Power System Engineering, Thermodynamics & Fluid Flow (PSE17), June 13-15, Plzen, Czech Republic, (2017).
11. "Determination of Minimum Distance from a Cell Centroid to a Triangulated Surface: A Mesh Generation Implementation Technique", International Advanced Researches and Engineering Congress (IAREC 2017), 16-18 Kasım, Osmaniye, (2017).
12. "A Solution Adaptive Cartesian Grid Based Euler Solution for Compressible Flow around BOEING TR-1322 Multi-element Airfoil", Nevşehir Bilim ve Teknoloji Dergisi, 4:1, 69-80, (2015). DOI: 10.17100/nevbiltek.66399

ME and CFD

NEW STUIES

Papers, proceedings and projects AFTER doctoral thesis:

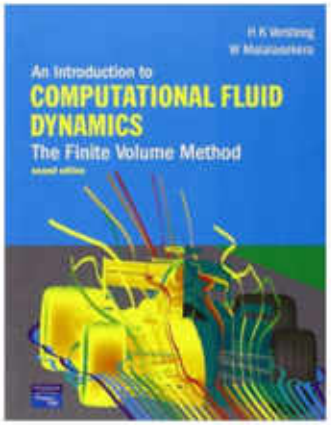
1. "Determination of the Wall Function for Navier-Stokes Solutions on Cartesian Grids", 2nd Workshop on Nonlinear PDEs in Applied Mathematics, August 8 - 10, IZTECH, İzmir, Turkey (2017).
2. Numerical Simulation of Hypersonic Flow over Double Ellipse Configuration with Multi-grid Accelerated and Cartesian Based Flow Solver. In Proceedings of the First International Conference on Applied Mathematics in Engineering (ICAME'18), June 27-29, Balıkesir, (2018).
3. "Numerical Investigation of Slant Angle Effect on a Simplified Car Model with Solution Adaptive Cartesian Grid Method", The IVth International Congress ofAutomotive and Transport Engineering, October 17 - 19, Technical University of Cluj-Napoca, Cluj, Romania (2018). – Kabul edildi.
4. "CFD Simulation of Turbulent Flow Around a Shrouded Spur Gear for Predicting Load-Independent Windage Power Losses", The IVth International Congress of Automotive and Transport Engineering, October 17 - 19, Technical University of Cluj-Napoca, Cluj, Romania (2018). – Kabul edildi.
5. "Çift Elips Yapısı Etrafında Çok Katmanlı Ağ ile Hızlandırılmış, Çözüm Uyarlamalı Navier-Stokes Çözücüsü Kullanarak Hipersonik Akış Analizi", Balıkesir Üniversitesi Fen Bilimleri Enstitüsü Dergisi (ULAKBİM – TR Dizin), x:x, xx-xx, (2018). – İncelemede.
6. "Numerical Investigation of Slant Angle Effect on a Simplified Car Model with Solution Adaptive Cartesian Grid Method", Proceedings of the 4th International Congress of Automotive and Transport Engineering: Chapter 4, Springer Nature Switzerland AG 2019, N. Burnete and B. O. Varga (Eds.): AMMA 2018, PAE, pp. 1–7, 2019. - Kabul edildi. DOI: 10.1007/978-3-319-94409-8_4
7. "CFD Simulation of Turbulent Flow Around a Shrouded Spur Gear for Predicting Load-Independent Windage Power Losses", Proceedings of the 4th International Congress of Automotive and Transport Engineering: Chapter 3, Springer Nature Switzerland AG 2019, N. Burnete and B. O. Varga (Eds.): AMMA 2018, PAE, pp. 1–8, 2019. - Kabul edildi. DOI: 10.1007/978-3-319-94409-8_3

12 studies (doctoral thesis) if you write own codes,
6 studies (master thesis) if you use a commercial program as ANSYS FLUENT !

Compulsory Texts

1. «An introduction to computational fluid dynamics: the finite volume method.»

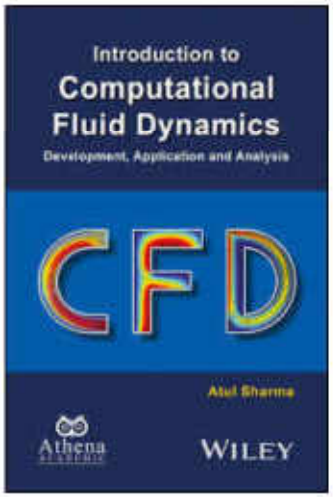
   Versteeg, H. K., & Malalasekera, W. (2007). Pearson Education.



2. «Introduction to Computational Fluid Dynamics: Development, Application and Analysis.»

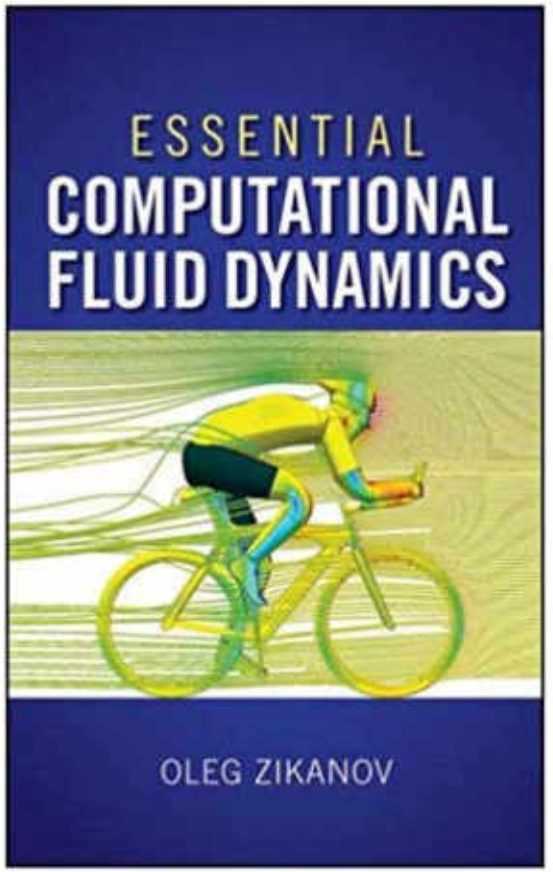
   Sharma, A.

   (2016). John Wiley & Sons.



Recommended Texts

- Essential Computational Fluid Dynamics, by Zikanov
- Computational Fluid Dynamics - A Practical Approach, by Tu, Yeoh and Liu
- Computational Methods for Fluid Dynamics, Ferziger and Peric
- Computational Fluid Mechanics and Heat Transfer, by Pletcher, Tannehill and Anderson



Internet Sources

1. https://www.cfd-online.com/

   An online center for Computational Fluid Dynamics, largest CFD site on the net with services like discussion forums, jobs, links and a wiki

2. https://cfd.ninja/

   Various free tutorials using ANSYS, OpenFOAM and more, with the goal learn, disseminate and share knowledge that is useful for the solution of current problems in engineering using tools of CFD

3. https://www.fetchcfd.com

   Platform to publish, share, collaborate, discover & download simulations also in 3D/VR/AR.

4. https://www.youtube.com

   Many video are available beginning with examples.

5. http://cfd2012.com/index.html

   Useful source site by Dr. Ahmed Al Makky of Cardiff University.

6. https://www.raefkobeissi.com/

   Useful source site by Raef Kobeissi.

7. https://www.learncax.com/

   Useful source site for FREE CFD Training : Courses, Projects, Career ...

Software and Resources

- CFD software was built upon physics, modeling, numerics.
- Two types of available software
  - Commercial (e.g., FLUENT, CFX, Star-CCM, COMSOL)
  - Research (e.g., CFDSHIP-IOWA, U^{2}RANS)
- More information on CFD can be got on the following website:
  - CFD Online: http://www.cfd-online.com/
  - CFD software
    - FLUENT: http://www.fluent.com/
    - COMSOL http://www.comsol.com/
    - CD-adapco: http://www.cd-adapco.com/
  - Grid generation software
    - Gridgen: http://www.pointwise.com
    - GridPro: http://www.gridpro.com/
  - Visualization software
    - Tecplot: http://www.amtec.com/
    - Fieldview: http://www.ilight.com/

Assessment (LOOK OUT !)

- Assignment (Term Project)
- Attendance
- Labs
- Examinations
- Final Grades

Assessment (LOOK OUT !)

- Assignment (Term Project):

It consists of a project presentation by each group of students to the full class and the instructor. Each CFD project will be performed by a group of two students. The CFD problem to be analyzed will be chosen by the students based upon their own interests and with advice from the instructor.

Assessment (LOOK OUT !)

- Attendance:

Regular attendance is **strictly required (at least 70 %).**

In case you have to miss a class, **you are responsible for keeping up** with the class work and being informed of all announcements made in the class concerning homework, quizzes, tests, etc.

If you encounter difficulties of any kind, feel free to come and see me in my office.

Assessment (LOOK OUT !)

- Labs:

There will be CFD Lab sessions in the second half of the semester, after the first midterm.

Assessment (LOOK OUT !)

- Examinations:

Two midterms are scheduled. First midterm will be about CFD concepts, definitions, and short exercises plus section with short computational problems (HAND WRITTEN). Second midterm will be in the PC lab. First part will be an open book computation of aerodynamics problem. Second part will be the CFD solution of it applied in PC lab.

A final comprehensive examination will be given according to the school schedules.

Make-up exams may be given for legitimate excuses if you contact the instructor as soon as you return to the school. It will be given for excused absences only and must be scheduled immediately upon returning to class. Excused absences require a medical excuse or notice of official school business by the V.P. of Academic Affairs.

Assessment (LOOK OUT !)

- Final Grades:

Assignment (Term Project)	20	%
Class Tests (Midterms)	2×20	%
Final Exam	40	%
Total	100	%

Letter grades will be given relative to the average of the class !

Objective

- The objective of this class is to introduce students to applied computational fluid dynamics and to teach them how to solve a fluid flow problem using commercially available CFD software.
- The class will be taught using textbooks, lecture notes, and the commercial CFD package and its modules.

Tentative Schedule

Lecture 1	: Introduction & basic aspects of CFD	Week	1	Reading: Chapter 1
Lecture 2	: Conservation laws of fluid motion and boundary conditions	Week	2	Reading: Chapter 2
Lecture 3	: Conservation laws of fluid motion and boundary conditions	Week	3	Reading: Chapter 2
Lecture 4	: Turbulence and its modelling	Week	4	Reading: Chapter 3
Lecture 5	: The finite volume method (FVM)	Week	5	Reading: Chapter 4
Lecture 6	: FVM and Boundary Conditions	Week	6	Reading: Chapter 5-6
MIDTERM 1 – November 9th, Friday, 14:30				
Lecture 7	: Introduction to GUI & Design Modeler	Week	8	
Lecture 8	: Basics of Meshing Module	Week	9	
Lecture 9	: Basics of the Solver Module	Week	10	
Lecture 10	: Tutorials / Group & Topic Selections	Week	11	
Lecture 11	: Presentations of Term Projects	Week	12	
MIDTERM 2 – December 21th, Friday, 14:30				

Last Lecture – Review