



Course Syllabus: Computational Fluid Dynamics - ME 305A

Division	Physical Science and Engineering Division
Course Number	ME 305A
Course Title	Computational Fluid Dynamics
Academic Semester	Spring
Academic Year	2016/2017
Semester Start Date	01/22/2017
Semester End Date	05/18/2017
Class Schedule (Days & Time)	09:00 AM - 10:30 AM Tue Thu

Instructor(s)				
Name	Email	Phone	Office Location	Office Hours
Ravindra Samtaney	ravi.samtaney@kaust.edu.sa	+966128082958 8082958		By appointment.

Teaching Assistant(s)	
Name	Email
None.	None.

Course Information	
Comprehensive Course Description	The first course in the year-long set of courses in computational fluid dynamics. We begin with the building blocks of CFD: elliptic, parabolic and linear wave equations. We discuss various methods to solve the linear and nonlinear wave equation gradually building up to the Euler equations for compressible flow. Linear stability of the developed methods will be discussed. We will emphasize Riemann solvers in the context of Godunov-like methods. The course involves many hands-on programming assignments and a course code project.
Course Description from Program Guide	Introduction to floating point arithmetic. Introduction to numerical methods for Euler and Navier-Stokes equations with emphasis on error analysis, consistency, accuracy and stability. Modified equation analysis (dispersion vs. dissipation) and Von Neumann stability analysis. Finite difference methods, finite volume and spectral element methods. Explicit vs. implicit time stepping methods. Solution of systems of linear algebraic systems. Higher-order vs. higher resolution methods. Computation of turbulent flows. Compressible flows with high-resolution shock-capturing methods (e.g. PPM, MUSCL, WENO). Theory of Riemann problems and weak solutions for hyperbolic equations.
Goals and Objectives	<ul style="list-style-type: none"> -A thorough understanding of finite difference and finite volume methods -Knowledge of shock capturing schemes -Stability analysis of numerical methods -Developing code for solving 1D wave equations and Euler equations -Knowledge of Riemann problem solvers
Required Knowledge	<ul style="list-style-type: none"> -Graduate level fluid dynamics -Basic linear algebra -Basic partial differential equations

Reference Texts	<ul style="list-style-type: none"> -Computational Fluid Dynamics John Anderson (Author) -Numerical Computation of Internal and External Flows, Volume 1, Second Edition: The Fundamentals of Computational Fluid Dynamics. Author: Charles Hirsch Publisher: John Wiley and Sons -Numerical Computation of Internal and External Flows, Computational Methods for Inviscid and Viscous Flows (Wiley Series in Numerical Methods in Engineering) (Volume 2) Author: Charles Hirsh Same publisher as Vol 1 -Computational Methods for Fluid Dynamics Joel H. Ferziger and Milovan Peric (Authors) -Finite Difference Methods for Ordinary and Partial Differential Equations: Steady-State and Time-Dependent Problems (Classics in Applied Mathematics) Randall Leveque (Author)
Method of evaluation	<p>25.00% - Final exam 25.00% - Midterm exam 25.00% - Homework /Assignments 25.00% - Course Project(s)</p>
Nature of the assignments	<p>Programming assignments.</p>
Course Policies	<ul style="list-style-type: none"> -All students are supposed to work independently on homework assignments. -All students must have access to a computer (desktop or laptop). All computer homework assignments require you to write a code in Fortran, C or C++. Matlab is also acceptable. Java, Python or other languages will not be acceptable. Please ensure that you setup a suitable computing environment for yourself, i.e. have installed compilers for C, C++ and/or Fortran. Also, install one or more visualization packages of which I recommended installing VisIt and gnuplot. Every computer homework must be submitted electronically with the code, a procedure so that the code can be compiled, build and executed; a report, plots of results and discussion of results. -Some notes and homework including solutions will be posted on the blackboard. -All communications regarding the class will be on the blackboard and via email. - Attendance: Students are expected to attend every lecture. -In accordance with the University policy and professional standards, the highest levels of academic integrity are expected in this class. The code of student conduct is strictly enforced. Academic dishonesty will result in reductions in grades and/or expulsions from this class and/or the University.
Additional Information	

Tentative Course Schedule

(Time, topic/emphasis & resources)

Week	Lectures	Topic
1	Tue 01/24/2017 Thu 01/26/2017	Introduction to CFD, Classification of PDEs Simplifications, Building Blocks of CFD
2	Tue 01/31/2017 Thu 02/02/2017	Finite Difference Methods Numerical Solutions to Heat Equation
3	Tue 02/07/2017 Thu 02/09/2017	Iterative Methods for Poisson Equation Analysis of Iterative Methods
4	Tue 02/14/2017 Thu 02/16/2017	Scalar Wave Equation Consistency, Convergence, Accuracy
5	Tue 02/21/2017 Thu 02/23/2017	Stability Analysis Error Analysis of Upwind Methods
6	Tue 02/28/2017 Thu 03/02/2017	Godunov Theorem Discontinuities and Weak Solutions
7	Tue 03/07/2017 Thu 03/09/2017	Uniqueness and Entropy Conditions Midterm
8	Tue 03/14/2017 Thu 03/16/2017	Conservation Form and Lax-Wendroff Theorem Lax-Wendroff Theorem
9	Tue 03/21/2017 Thu 03/23/2017	Nonlinear Scalar Conservation Laws Godunov and Roe Methods
10	Tue 03/28/2017 Thu 03/30/2017	Methods for Euler Equations Finite Difference for Euler Equations
11	Tue 04/04/2017 Thu 04/06/2017	Spring break - no classes
12	Tue 04/11/2017 Thu 04/13/2017	Flux Methods and Flux Vector Splitting Riemann Problem for Gas Dynamics
13	Tue 04/18/2017 Thu 04/20/2017	Godunov Method for Euler Equations Roe Method for Euler Equations
14	Tue 04/25/2017 Thu 04/27/2017	Multidimensional hyperbolic systems Split vs. Unsplit Methods
15	Tue 05/02/2017 Thu 05/04/2017	Fourth order finite volume method Fourth order finite volume continued
16	Tue 05/09/2017 Thu 05/11/2017	Review Student project presentations
17	Tue 05/16/2017 Thu 05/18/2017	Finals week - no classes
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Note

The instructor reserves the right to make changes to this syllabus as necessary.