جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

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	2017/2018
Semester Start Date	01/28/2018
Semester End Date	05/24/2018
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		By appoinment.

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 nalysis (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	-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	-Graduate level fluid dynamics -Basic linear algebra -Basic partial differential equations

Reference Texts	-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	**30.00**% - Midterm exam **30.00**% - Homework /Assignments **40.00**% - Course Project(s)
Nature of the assignments	Programming assignments.
Course Policies	-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, Pyhton 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 01/30/2018	Introduction to CFD, Classification of PDEs
1	Thu 02/01/2018	Simplifications, Building Blocks of CFD
2	Tue 02/06/2018	Finite Difference Methods
2	Thu 02/08/2018	Numerical Solutions to Heat Equation
3	Tue 02/13/2018	Iterative Methods for Poisson Equation
3	Thu 02/15/2018	Analysis of Iterative Methods
4	Tue 02/20/2018	Scalar Wave Equation
4	Thu 02/22/2018	Consistency, Convergence, Accuracy
5	Tue 02/27/2018	Stability Analysis
5	Thu 03/01/2018	Error Analysis of Upwind Methods
6	Tue 03/06/2018	Godunov Theorem
6	Thu 03/08/2018	Discontinuities and Weak Solutions
7	Tue 03/13/2018	Uniqueness and Entropy Conditions
7	Thu 03/15/2018	Midterm
8	Tue 03/20/2018	Conservation Form and Lax-Wendroff Theorem
8	Thu 03/22/2018	Lax-Wendroff Theorem
9	Tue 03/27/2018	Nonlinear Scalar Conservation Laws
9	Thu 03/29/2018	Godunov and Roe Methods
10	Tue 04/03/2018	Methods for Euler Equations
10	Thu 04/05/2018	Finite Difference for Euler Equations
11	Tue 04/10/2018	Spring break - no classes
11	Thu 04/12/2018	Spring break - no classes
12	Tue 04/17/2018	Flux Methods and Flux Vector Splitting
12	Thu 04/19/2018	Riemann Problem for Gas Dynamics
13	Tue 04/24/2018	Godunov Method for Euler Equations
13	Thu 04/26/2018	Roe Method for Euler Equations
14	Tue 05/01/2018	Multidimensional hyperbolic systems
14	Thu 05/03/2018	Split vs. Unsplit Methods
15	Tue 05/08/2018	Fourth order finite volume method
15	Thu 05/10/2018	Fourth order finite volume continued
16	Tue 05/15/2018	Software issues, libraries etc.
16	Thu 05/17/2018	Review
17	Tue 05/22/2018	Student project presentations
17	Thu 05/24/2018	Finals week - no classes

Note

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