SIMULATION NUMÉRIQUE DES ÉCOULEMENTS

NUMERICAL FLOW SIMULATION

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| Lecturers : 16.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 12.0 | Project : 0.0 | Language : FR

Objectives

The goal of the course is to provide the students with an "advanced user / beginner developer" level in computational fluid dynamics, with a focus on compressible flows of interest in aerospace and energy applications. Following the course, the student should be able to properly select and apply a solution method for an engineering problem of practical interest and should understand the observed numerical behaviour (accuracy, robustness). The student will also be able to perform basic developments in existing CFD codes: change of boundary conditions or implementation of a new numerical flux.

Keywords : Classification of PDEs. Method of characteristics. Finite difference. Finite volumes. Centered and upwind schemes. Riemann solvers. TVD schemes. Structured and unstructured grids. Spectral methods.

Programme

Lecture #1: Introduction to CFD. From pioneering works to 21st century challenges.
Lectures #2 and #3: Analysis of scalar problems : classification of PDEs, method of characteristics, finite difference schemes for model problems : 1D advection, 1D diffusion, 1D advection-diffusion.
Lectures #4 and #5: Extension of 1D finite-difference schemes to non-linear systems of conservation laws (Euler equations): from the 1st-order upwind scheme to high-resolution schemes.
Lectures #6 and #7: Finite-Volume Schemes in structured and unstructured grids. From Euler equations in Cartesian grids to the Navier-Stokes equations in triangular grids.

Learning outcomes

- Understanding the current challenges of CFD. Applying the method of characteristics to analyze exact solutions of scalar conservation laws. Computing truncation erros and amplification factors for finite difference schemes applied to model advection, diffusion and advection-diffusion problems in one and several space dimensions. Implementing a numerical flux in a CFD code solving the traffic flow equation.
- Analyzing centered and upwind schemes for the solution of 1D Euler equations (smooth flows and flows including discontinuities). Selecting a relevant numerical scheme for the flow under study and using the proper tuning parameters for this scheme (artificial

Independent study

Objectifs : Personal work on solved problems following the lectures: checking the good understanding of concepts and tools.
Personal work following the computer labs: ability to perform numerical development tasks, ability to perform, interpret and report on numerical experiments.

Méhodes : The 3 computer labs of 4h each are devoted to the presentation and application of the CFD codes provided. The students are prepared during these labs to the work which they will perform on their own, for 3 successive levels of difficulty: 1D scalar conservation law, 1D system of conservation laws, multi-D

Core texts

Thomas H. Pulliam, David W. Zingg, *FUNDAMENTAL ALGORITHMS IN COMPUTATIONAL FLUID DYNAMICS*, Springer, 2014
Eleuterio F. Toro *RIEMANN SOLVERS AND NUMERICAL METHODS FOR FLUID DYNAMIC - A PRACTICAL INTRODUCTION*, Springer-Verlag, 2009
Charles Hirsch*NUMERICAL COMPUTATION OF INTERNAL AND EXTERNAL FLOWS - THE FUNDAMENTALS OF CFD*, Butterworth-Heinemann, 2007

Assessment

Grade = 40% knowledge (final exam) + 60% know-how (reports on computer labs)
Knowledge grade = 100% final exam grade
Know-how grade = 100% average of the 3 computer labs reports