AA 214: NUMERICAL METHODS FOR COMPRESSIBLE FLOWS

1. Computational Fluid Dynamics (CFD)
- 1.1 What is CFD?
- 1.2 Why CFD?
- 1.3 What for CFD?
- 1.4 Impact of CFD
- 1.5 Anatomy of CFD

2. Hierarchy of Mathematical Models
- 2.1 Navier-Stokes equations
- 2.2 Large Eddy Simulation
- 2.3 Reynolds-averaged Navier–Stokes equations
- 2.4 Euler equations
- 2.5 Full potential equation
- 2.6 Linearized small-perturbation potential equation

3. Conservation and Integral Forms and Discontinuities
- 3.1 Conservation law form
- 3.2 Integral form
- 3.3 Relations at discontinuities

4. Linearization and Characteristic Relations
- 4.1 Non conservation form and Jacobians
- 4.2 Linearization around a localized flow condition
- 4.3 Hyperbolic requirement
- 4.4 Characteristic relations and Riemann invariants
- 4.5 Boundary conditions

5. Representative Model Problems
- 5.1 Convection-diffusion equation
- 5.2 Burgers' equation
- 5.3 Scalar conservation laws
- 5.4 Riemann problems
- 5.5 Roe's approximate Riemann solver for the Euler equations

6. The Finite Difference Method
- 6.1 Conservative finite difference methods in one dimension
- 6.2 Forward, backward, and central time methods
- 6.3 Domain of dependence and CFL condition
- 6.4 Linear (von Neumann) stability analysis
- 6.5 Formal, global, and local order of accuracy
- 6.6 Upwind schemes in one dimension
- 6.7 Nonlinear stability analysis
- 6.8 Multidimensional extensions

7. The Finite Volume Method

7.1 Conservative finite volume methods in one dimension
7.2 Introduction to reconstruction-evolution methods
7.2 First-order upwind reconstruction-evolution methods
7.3 Introduction to second- and higher-order reconstruction-evolution methods
7.4 The MUSCL/TVD method
7.5 Steger-Warming flux vector splitting method for the Euler equations
7.6 Multi-dimensional extensions

8. Treatment of Boundary Conditions

8.1 Two types of boundaries
8.2 Two types of grids
8.3 General results
8.4 Solid boundaries
8.5 Far-field boundaries

9. Pseudo-Time Integration

9.1 Vector form of the semi-discrete Euler equations
9.2 Local time-stepping for steady-state problems
9.3 Dual time-stepping for unsteady problems

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