Advanced Computational Fluid Dynamics

Spring semester, 2019

- **Textbook: Lecture Notes**
- **References: 1. Finite Volume Methods for Hyperbolic Problems by Leveque, Cambridge**
  2. Riemann Solvers and Numerical Methods for Fluid Dynamics by Toto, 2nd or 3rd Ed., Springer
  3. Computational Fluid Mechanics and Heat Transfer by Tannehill, Anderson and Pletcher, 2nd or 3rd Ed., Taylor & Francis or CRC

- **Main Contents**

Chap. 1. Review on 'Introduction to CFD' and Basics of Hyperbolic Scalar Conservation Laws

Chap. 2. Non-linear Stability and Methods for Hyperbolic SCL
- **Linear and Non-linear schemes, Gibbs-Wilbraham Phenomenon**
- **Godunov's Barrier Theorem and Monotonicity Constraint, Concept of Total Variation Stability**
- **Shock-capturing Methods: FCT, TVD, MUSCL, LED, ENO-WENO and MLP**

Chap. 3. Mathematical and Physical Aspects of the Euler Equations

Chap. 4. Discretization of the Euler Equations in 1-D setting
- **Finite Difference Discretization**
- **Finite Volume Discretization and Numerical Flux Functions**
- **Design of Numerical Flux Functions I - Flux Vector Splitting**
- **Design of Numerical Flux Functions II - Flux Difference Splitting and Approximate Riemann Solvers**
- **Design of Numerical Flux Functions III - Hybrid Flux Splitting**

<Term Project I>
- **Discretization of the 1-D Euler Equations and Coding**

Chap. 5. Discretization of the 2-D/3-D Euler Equations
- **Extensions to the 2-D and 3-D Cases**
- **FDM and FVM on Multidimensional Situation**

<Report and Oral Presentation for Term Project I>

Chap. 6. Time Integration and Boundary Conditions
- **Time Integration Techniques**

- Wall and Far Field Boundary Conditions

<Term Project II>

- Discretization of the 2-D Euler Equations and Coding

Chap. 7. Discretization of the Navier-Stokes Equations (Optional)

- Discretization of viscous terms, Comments on BCs and Time Integration
- RANS Formulations

Chap. 8. Introduction to High-Order (beyond 2nd-order) Methods

- Weak and Strong Formulations for Higher-Order Approximations
- Modal DG (Discontinuous Galerkin) and Nodal FR (Flux Reconstruction) Formulation
- Shock-Capturing Strategy for Higher-Order Methods

<Report and Oral Presentation for Term Project II>

- **Grading**

  Oral Presentation (50%) and Reports (50%) for Term Project I and II
- **Instructor: Prof. Chongam Kim**
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