Numerical Methods for Conservation Laws

Module-No./Abbreviation CE-WP17/NMfHCL	Credits 6 CP	Workload 180 h	Term 3rd Sem.	Frequency Winter term	Duration 1 Semester
Courses Numerical methods for conservation laws			**Contact hours** 4 SWS / 60 h	**Self-Study** 120 h	**Group Size:** No Restrictions

Prerequisites

Basic knowledge about: ordinary differential equations, numerical integration, and numerical methods for the solution of large linear and non-linear systems of equations

Learning goals / Competences

Students should attain familiarity with numerical methods for the solution of differential equations, in particular hyperbolic conservation laws. This includes understanding the notion of entropy solutions and being able to construct stable numerical schemes that are capable of finding such solutions.

After successfully completing the module, the students shall be able to

- design, implement and use numerical methods for computer solution of scientific problems involving differential equations,
- understand properties of different classes of differential equations and their impact on solutions and proper numerical methods,
- understand the different concepts of solutions to hyperbolic conservation laws and their physical interpretations, know how to select appropriate numerical methods that capture the physically correct solutions,
- use software for solving differential equations with understanding of fundamental methods, properties, and limitations.

Content

- Introduction to PDE's; classification of PDE's; well-posedness; outline of the course
- Heat equation Setting; well-posedness; space discretization; properties of the discretization; finite volumesin1D and 2D; stability of ODEs (repetition); time discretization
- First order hyperbolic equations and characteristics; example: Burgers equation; crash of characteristics; discontinuous solutions; basic discretizations; characteristics for linear advective systems; linear Riemann problems
- Basic discretizations finite volume methods; linearization of nonlinear conservation laws; boundary conditions
- Convergence theory for linear methods notation; convergence, consistency and stability; verifying stability: CFL numbers; Von Neumann analysis
- Weak solutions and viscosity solutions weak solutions; viscosity limits and modified equations; Lax entropy condition; applications of entropy conditions; explicit entropy solutions to Riemann problems; weak entropy conditions; entropy pairs
- Monotone schemes, Consistent methods; idea of monotone schemes; properties of monotone schemes; the Godunov scheme
- Higher Order Finite volume methods for non-linear hyperbolic equations Lax-Wendroff scheme; TVD schemes, slope/flux limiters

Teaching methods / Language

Lecture (3h / week), Exercises (1h / week) / Homework (30) / English

Mode of assessment

Written examination (120 min, 100%)

Requirement for the award of credit points
Passed final module examination
Module applicability
MSc. Computational Engineering
Weight of the mark for the final score
6 %
Module coordinator and lecturer(s)
Prof. Dr. P. Henning, Assistants
Further information