UNIVERSITY OF TRENTO - Italy
Department of Civil, Environmental and Mechanical Engineering

IAHR · AIRH
International Association for Hydro-Environment Engineering and Research
Supported by Spain Water and IWHR, China

COURSE I

Numerical Methods for Hyperbolic Equations with Applications to Gas Dynamics, Shallow Water and Blood Flow

Lecturer

Prof. Dr. **Eleuterio Toro**, OBE, PhD, DhC
Department of Civil and Environmental Engineering, Laboratory of Applied Mathematics, University of Trento, Italy

Dates and Venue

Dates: from Monday February 6 to Friday February 17, 2017

Venue: University of Trento, Department of Civil, Environmental and Mechanical Engineering (via Mesiano 77, I – 38123 Trento, Italy)

The course

This two-week, intensive short course is focused on mathematical modelling and simulation, and is intended for PhD students, post-doctoral research fellows, researchers in industry, academics and scientists in managerial positions. The contents embrace various disciplines, including applied mathematics, numerical analysis of differential equations, physics, fluid mechanics, engineering, biology and medicine. The course has two distinct but complementary parts: theory of hyperbolic equations and their numerical discretization, and applications that include compressible fluid dynamics, free-surface shallow flows and blood flow in arteries and veins. The theory will be supplemented with practical activities including solution of problems by hand and computer-based exercises using ready-made sample programs. Written lecture notes and sample computer programs will be provided.

**2017 TRENTO WINTER SCHOOL
on Numerical Methods
February 6, 2017-March 3, 2017**

**LABORATORY OF APPLIED MATHEMATICS
UNIVERSITY OF TRENTO, ITALY**

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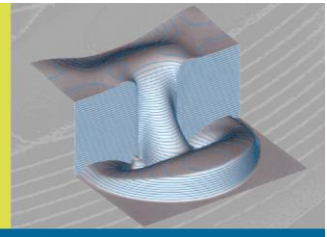
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Contents

The contents of the course will include: Linear hyperbolic equations: theory and exact solution of the Riemann problem. Non-linear scalar equations and shock formation. Non-linear hyperbolic systems. The shallow water equations. The Euler equations for compressible materials and equations of state. The cardiovascular and other body-fluid systems. One-dimensional models for blood flow and tube laws for arteries and veins. Compartmental models for blood flow. Basics on numerical methods for hyperbolic equations. The finite volume and discontinuous Galerkin finite element frameworks. Godunov-type methods. Source terms, the stiff and non-stiff cases. Parabolic equations formulated as hyperbolic equations with stiff source terms. Well-balanced methods. ADER high-order methods in space and time. Flow in networks and methods for junctions. Seminar-like presentations: (a) Riemann solvers and numerical fluxes: a review; (b) The role of high-order methods in computational science and (c) Neurodegenerative diseases and their link to body-fluid dynamics.
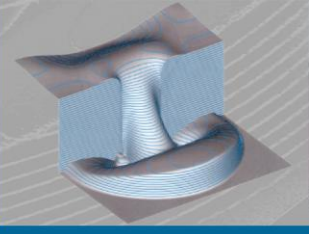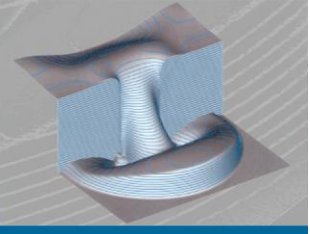
Winter school Week 1

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
09:00-10:30	Linear Advection Equation	Linear Hyperbolic Systems I	Theory of Numerical Methods I	Nonlinear Numerical Methods I	Nonlinear Scalar Equations I
10:30-11:00	*Cappuccino*	*Cappuccino*	*Cappuccino*	*Cappuccino*	*Cappuccino*
11:00-12:30	Finite Differences I	Linear Hyperbolic Systems II	Theory of Numerical Methods II	Nonlinear Numerical Methods II	Nonlinear Scalar Equations II
12:30-14:00	*Lunch*	*Lunch*	*Lunch*	*Lunch*	*Lunch*
14:00-15:30	Finite Differences II	Laboratory Exercises	Laboratory Exercises	Laboratory Exercises	Godunov's Method for Scalar Equations
15:30-16:00	*Tea*	*Tea*	*Tea*	*Tea*	*Tea*
16:00-17:30	Laboratory Exercises	Laboratory Exercises	Laboratory Exercises	Laboratory Exercises	Laboratory Exercises

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Winter school Week 2

	Monday	Tuesday	Wednesday	Thursday	Friday
09:00-10:30	Nonlinear Hyperbolic Systems	Godunov's Method for SWEs I	The Euler Equations for Compressible Materials I	Blood Flow Equations I	ADER High Order Methods
10:30-11:00	*Cappuccino*	*Cappuccino*	*Cappuccino*	*Cappuccino*	*Cappuccino*
11:00-12:30	Shallow Water Equations I	Godunov's Method for SWEs II	The Euler Equations for Compressible Materials II	Blood Flow Equations II	Body Fluids and Neurode-generative Diseases
12:30-14:00	*Lunch*	*Lunch*	*Lunch*	*Lunch*	*Lunch*
14:00-15:30	Shallow Water Equations II	Laboratory Exercises	Godunov's Method for Euler Equations I	Godunov's Method for Blood Flow	Selected Topics and Closing Remarks
15:30-16:00	*Tea*	*Tea*	*Tea*	*Tea*	*Tea*
16:00-17:30	Laboratory Exercises	Laboratory Exercises	Godunov's Method for Euler Equations I I	DG methods	Exams