University of Natural Resources
and Life Sciences, Vienna
Department of Water, Atmosphere
and Environment

Computational Methods in Hydrodynamics for Water Resources Management

Summer School
15th – 26th November 2021

Daniel Wildt and Michael Tritthart
version: 11th November 2021

Contents

1 Concept and Intended Learning Outcomes

The aim of this summer school is to support participants in developing technical and computational skills for managing a variety of problems in water resources management. The main focus is on applications in numerical hydrodynamics, but also physical laboratory experiments will be covered. Due to COVID-19 restrictions the summer school will be held in a virtual format. Unfortunately this makes field visits impossible. As an alternative a virtual exchange with the IAHR Young Professional Network Vienna is planned.

The attendees of the summer school will acquire the following knowledge and abilities:

- mathematical formulation of hydrodynamic problems using differential equations
- discretization of differential equations for numerical solutions
- implementation of models for numerical solution of simple hydrodynamic problems
- use of open-source code for the solution of complex computational fluid dynamics models

2 Venue and access to the online sessions

The summer school will be held at University of Natural Resources and Life Sciences, Vienna (Austria). Due to travel restrictions participants will join the sessions of the summer school via a Zoom video conference.

The following link can be used to access the Zoom sessions:

`https://bokuvienna.zoom.us/j/98798606663?pwd=`
`ckJmM1hmaGFERUlVL251YW9pOHlKQT09`
Meeting ID: 987 9860 6663
Passcode: 859380

Some individual sessions may be held in extra Zoom-meetings.

3 Program

3.1 Week 1: Numerical solution of problems in hydrodynamics

Monday, 15th November 2021

- 10:00–12:00 (Michael Tritthart and Daniel Wildt): Welcome session
  - Presentation of University, Department and Institute
  - Program of the Summer School
- 13:00–17:00 (Daniel Wildt): Introduction to unsteady problems in hydrodynamics
  - Balancing of water levels of two tanks connected through a pipe
  - Heat and mass transport in free-surface waterbodies

Tuesday, 16th November 2021

- 09:00–13:00 (Daniel Wildt): Ordinary differential equations
  - Water surface estimation in non-uniform flow
  - Retention
- afternoon: Self-organised learning

Wednesday, 17th November 2021

- 09:30–12:00 (Michael Tritthart): Theory on computer-based river modelling
  Join Zoom Meeting: `https://bokuvienna.zoom.us/j/96857851294?pwd=dm5vZzl4c3BLRVB2bXc2QmV1MHhEZz09`
  Meeting-ID: 968 5785 1294
  Passcode: 322112
- 15:00–18:00 (Daniel Wildt): Partial Differential Equations – Development of a flood wave

Thursday, 18th November 2021

- 10:00–12:00 (Daniel Wildt): 1D models, error estimation
  Join Zoom Meeting:
  `https://bokuvienna.zoom.us/j/97026800256?pwd=emw2K0ZkTEt0RjM4ZDZHcm1heklTQT09`
  Meeting ID: 970 2680 0256
  Passcode: 444712
  - Set-up of a 1D model of a channel system using the Excel worksheets UNDA
  - Error estimation in physical lab experiments
- 13:00–14:00 Presentation of hydraulic laboratories at BOKU

Friday, 19th November 2021

- 09:00–12:00 (Daniel Wildt): Unsteady pipe flow (hydraulic surge)
- 18:00–20:00 (Daniel Wildt): get-together with the IAHR Young Professional Network Vienna

3.2 Week 2: CFD with OpenFOAM

Monday, 22nd November 2021

- 09:30–12:00 (Michael Tritthart): Introduction to Linux operating systems and the Unix command line
- afternoon: Self-organised learning

Tuesday, 23rd November 2021

- 09:00–13:00 (Daniel Wildt): Introduction to OpenFOAM
- afternoon: Self-organised learning

Wednesday, 24th November 2021

- 09:00–13:00 (Daniel Wildt):
  "An Introduction to OpenFOAM: A User View" presentation by Prof. Hrojve Jasak at the University of Ghent (May 2016) Part I

- afternoon: Group project assignment and work on group projects

Thursday, 25th November 2021

- 09:00–13:00 (Daniel Wildt)
  "An Introduction to OpenFOAM: A User View" presentation by Prof. Hrojve Jasak at the University of Ghent (May 2016) Part II
- afternoon: self organized learning, group project work

Friday, 26th November 2021

- 09:00–13:00 (Daniel Wildt): Summary
  - Project Presentation
  - Recap of the summer school and feedback meeting

4 Teaching Materials

Participants will be supplied with various teaching materials in digital format:

- handouts
- MS Excel worksheets
- literature list and weblinks (see section 5)
- OpenFOAM test cases

The materials will be shared with the participants via the BOKUlearn E-Learning platform: `https://learn.boku.ac.at/user/index.php?id=44340`.

5 Literature and resources

5.1 Unsteady flow in water resources management

5.1.1 Textbooks

J. H. Ferziger and M. Perić (2002). *Computational Methods for Fluid Dynamics*. 3rd ed. Berlin Heidelberg NewYork: Springer-Verlag. 423 pp. ISBN: 3-540-42074-6

H. K. Versteeg and W. Malalasekera (2007). *An introduction to computational fluid dynamics: the finite volume method*. 2nd ed. Essex: Pearson Education Limited. 503 pp. ISBN: 978-0-13-127498-3

5.1.2 Scientific articles and reports

P. C. Chatwin (1980). 'Presentation of Longitudinal Dispersion Data'. In: *Journal of Hydraulics Division* 106 (1), pp. 71–83

H. B. Fischer et al. (1979). *Mixing in Inland and Coastal Waters*. San Diego: Academic Press, Inc. Harcourt Brace Jovanovich, Publishers

C. M. Hanif (1986). 'Boundary conditions for analysis of waterhammer in pipe systems'. Master Thesis. The University of British Columbia

A. van Mazijk et al. (1991). *Rheinalarmmodell Version 2.0 Kalibrierung und Verifikation*. Internationale Kommission zum Schutze des Rheins gegen Verunreinigung. URL: `https://www.chr-khr.org/de/veroffentlichung/rheinalarmmodell-version-20-kalibrierung-und-verifikation`

5.2 Unix and Linux

Lecture notes and exercises by William Knottenbelt:

W. Knottenbelt (2021). *Introduction to Unix*. URL: `http://www.doc.ic.ac.uk/~wjk/UnixIntro/` (visited on 28/07/2021)

5.3 OpenFOAM

5.3.1 Documentation by distributors

OpenFOAM v9 by The OpenFOAM Foundation (`www.openfoam.org` and `http://cfd.direct/`)

The OpenFOAM Foundation (2021[c]). *OpenFOAM v9 User Guide*. URL: `https://cfd.direct/openfoam/user-guide/` (visited on 28/07/2021)

The OpenFOAM Foundation (2021b). *OpenFOAM v9 C++ Source Code Guide*. URL: `https://cpp.openfoam.org/v9/` (visited on 28/07/2021)

The OpenFOAM Foundation (2021a). *OpenFOAM Technical Guides*. URL: https://openfoam.org/guides/ (visited on 28/07/2021)

- Fluid Dynamics
  - Computational Fluid Dynamics
  - Tensor Mathematics
  - Energy Equation in OpenFOAM
- Multiphase Flows and Particles
  - OpenFOAM Barycentric Tracking
  - Water Waves in OpenFOAM
  - Interface Capturing in OpenFOAM
  - Guide to CFD for Polydisperse Flows
- Computers and Software
  - OpenFOAM Linux Guide
  - Parallel I/O in OpenFOAM
  - Redesigning OpenFOAM for the Future

OpenFOAM v2012 by ESI Group (www.openfoam.com)

OpenCFD, Ltd. (2020c). *OpenFOAM User Guide*. URL: https://www.openfoam.com/documentation/user-guide (visited on 26/07/2021)

OpenCFD, Ltd. (2020b). *OpenFOAM Tutorial Guide*. URL: https://www.openfoam.com/documentation/tutorial-guide (visited on 26/07/2021)

OpenCFD Ltd. (2021). *OpenFOAM Programmer's Guide*

OpenCFD, Ltd. (2020a). *OpenFOAM Extended Code Guide*. URL: https://www.openfoam.com/documentation/guides/latest/doc/ (visited on 28/07/2021)

5.3.2 Wikkis and useful tools

OpenFOAM tutorials collection and a "3 weeks self-learning course":

OpenFOAM Community (2021). *Tutorial Wiki*. Ed. by OpenCFD, Ltd. URL: https://wiki.openfoam.com/Main_Page (visited on 28/07/2021)

Unofficial OpenFOAM Wikki:

> OpenFOAM Wiki (2021). *Unofficial OpenFOAM wiki*. URL: `www.openfoamwiki.net` (visited on 06/08/2021)

OpenFOAM Forum at CFD Online:

> CFD Online (2021[a]). *OpenFOAM Forum*. URL: `https://www.cfd-online.com/Forums/openfoam/` (visited on 06/08/2021)

A tool for optimizing `blockMesh` grading:

> OpenFOAMWiki (2020). *Scripts/blockMesh grading calculation*. URL: `https://openfoamwiki.net/index.php/Scripts/blockMesh_grading_calculation` (visited on 28/07/2021)

Tool for estimating required wall resolution:

> CFD Online (2021[b]). *y+ Wall Distance Estimation*. URL: `https://www.cfd-online.com/Tools/yplus.php` (visited on 28/07/2021)

5.3.3 CFD with OpenSource Software at Chalmers University of Technology

Prof. Håkan Nillson is offering a free course on OpenFOAM for PhD students and provides his course materials online. In the course of "The 3rd UCL OpenFOAM Workshop", 24th February 2021 he received the "OpenFOAM community contribution award" for this course.

> H. Nilsson, ed. (2020). *Proceedings of CFD with OpenSource Software*. Chalmers University of Technology. URL: `http://dx.doi.org/10.17196/OS_CFD#YEAR_2020`

5.3.4 Further reading

PhD thesis by Prof. Jasak:

> H. Jasak (1996). 'Error analysis and estimation for the finite volume method with applications to fluid flows'. Thesis of Dissertation. Imperial College London. URL: `https://spiral.imperial.ac.uk/handle/10044/1/8335`