CFD with OpenSource Software

- a course where the students become teachers and contribute to global learning

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Course details

- **Name:** CFD with OpenSource Software (mainly OpenFOAM)
- **Level:** PhD (and selectable for 2nd year Master students at Chalmers)
- **Credits:** 7.5hec
- **Years:** 2007-2015 (2016 full)
- **Scope:** Develop skills to apply OpenSource software to solve advanced problems in Computational Fluid Dynamics (CFD)
- **Prerequisites:** Knowledge in the advanced problem, and some in CFD
- **Design:** Project course with initial new skill training, and where the outcome of the project contributes to the course contents
- **URL:** http://www.tfd.chalmers.se/~hani/kurser/OS_CFD
  (add _2007, _2008, …, _2015 for specific year)

Schedule / overview

- Three initial occasions, every second week:
  - Two full days per week, hands-on training in computer lab
    1. Basic usage
    2. High-level development
    3. Advanced usage and development (invited lecturers)
  - Assignments before 2nd and 3rd occasion (in PingPong)
- Project work until 4th occasion:
  - Based on student background and special research interests
  - Intermediate draft at half-time
  - Presented as a hands-on training for the other students
  - Peer-reviewed by another student and by the teacher, and made available at the course homepage
- Allows long-distance commuting participants
- Option to attend a local OpenFOAM user group meeting

Particular contents

- CFD
- Linux
- OpenFOAM
- C++ / object orientation
- Doxygen
- Compilation procedures
- Debugging
- Paraview/VTK
- Gnuplot, Xmgrace
- m4
- sed
- Python, Numpy, Matplotlib
- Writing reports (here tutorial)
- LaTeX, Beamer
- Peer-reviewing reports
- Teach a tutorial

Idea of the course

- Boost the student advanced background knowledge with new OpenSource tools
  - Quick introduction to many tools as an overview
  - Assignments to aid initial learning
  - Project work to aid deeper learning aligned with research
  - **Teach, to force further learning and to share knowledge:** Use the student background knowledge to form each course
- Make teaching material available at the course homepage, to contribute to global learning
  - Lecture notes, pieces of code etc.
  - Special topics by invited lecturers
  - Student project results (tutorials)
    - Until now: 8+11+10+16+8+9+11+12+17 = 102

Students from

- Swedish universities:
  - Chalmers, GU, KTH, LTH, LTU, UU, University West, Högskolan i Jönköping
- Foreign universities:
  - NTNU, Norwegian University of Life Sciences, University of Copenhagen, DTU, Aalborg University, Tartu University (Estonia), Universität Stuttgart, Universitat Polytechnica de Valencia, Nanyang Technological University (Singapore), Universidade do Porto, Vrije Universiteit Brussel, Massachusetts Institute of Technology, University of Strathclyde, University of Cyprus, University of Rome Tor Vergata, Florence University (Italy), Loughborough University (UK), Kobe University (Japan), University of Plymouth (UK), Düsseldorf University
- Industries / institutes:
  - CBI, Vattenfall, ETC Piteå, Xdin, SMHI, FS Dynamics, Epsilon, ESAB, Vestas, SP, Volvo Cars, Marioff (Finland)

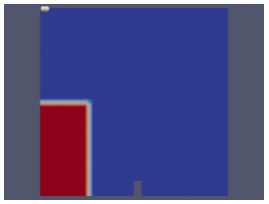
Examples of projects

- Reacting flow Movie
- Moving, deforming, adaptive meshes, and mesh modification Movie
- Fluid-Structure Interaction and stress analysis
- 6 Degree Of Freedom solvers
- Multiphase flow: VOF, LPT, Euler/Euler Movie
- Porous media
- Conjugate heat transfer, and radiation
- Phase change Movie
- Turbulence modeling: RANS, DES, LES, DNS, transition
- Compressible flow
- Electromagnetism
- Coupled solvers
- Actuator disk and lifting line Movie
- Finite Area Method

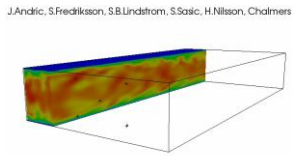
- http://www.tfd.chalmers.se/~hani/kurser/OS_CFD_2015/#_Student_reports/tutorials

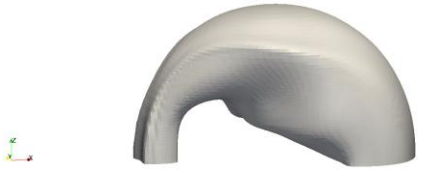
Alignment

teaching, research, utilization, collaboration



- Development of teaching material for LPT
  - used as base for research
- Research on flow with fibers (Jelena Andric)
  - Stefan Lindström, Linköping
  - Sam Fredriksson, GU
- Research on cavitation (Aurelia Vallier)
  - Johan Revstedt, Lund
- Contributed back with new teaching material and code:
  Particle interaction, matrix classes
  Injection, Transfer: VOF – LPT – VOF
  Rayleigh-Plesset and ODE solver





Participation and completion

Year:	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Registered	?	20	22	19	15	17	16	23	19	26
Passed	8	11	10	16	8	10	11	15	17	?
Percent	-	55	45	84	53	59	69	65	89	?

- Most who drop pass the first three occasions, but do not complete the project. A few have been failed.
  - Some students want to be ”given” knowledge rather than gaining it, although they say that they learn most by doing the project.
  - 2010, 2015, 2016 had major part Chalmers master students
  - How to make more finish the project and the course?
- Open to industry 2007-2011, but none of them completed
  - Appreciated industry course (CPE) week 46 since 2012

Course evaluations and comments

Year:	2007	2008	2009	2010	2011	2012	2013	2014	2015
Overall:	-	-	-	-	-	4.22	4.55	4.66	4.29

- Grades: 1-Poor, 2-Fair, 3-Adequate, 4-Good, 5-Excellent
- 2007-2011: No overall grade (only ”general impression” field)
  - Focus on written comments that helped develop the course
    - Very positive comments
    - The project work is where they think that they learn most

Homepage impact

- Homepage: http://www.tfd.chalmers.se/~hani/kurser/OS_CFD/
  - Individual visitors until 2016-06-26:

Year	2012	2013	2014	2015
Ind. visitors	19976	20223	25279	25459
# Countries	115	119	121	126

  - Highly cited on the Internet (e.g. OpenFOAM forum)
    One reason for the popularity is the student reports
  - Comments from non-participants (e.g.: *"I am aware of your course and we all think it is absolutely amazing. Probably the best OpenFOAM resource on the web."* – from a skilled OpenFOAM developer in an international company providing services with OpenFOAM)

Future ideas

- Integrate even more in e.g. PingPong (learning platform)
  - Experiences/suggestions from the audience?
- Flipped classroom
  - Recorded lectures
  - Improved tests in e.g. PingPong, to facilitate learning, and where the outcome of the tests determine what is discussed at the lectures.
  - Experiences/suggestions from the audience?
- Semi/full distance?
  - Experiences/suggestions from the audience?
- Verification & Validation procedures in projects instead of usage and basic development, since many topics have been covered

Want to get involved?

- Suggest projects.
- In Gothenburg 26-27 September? Have something interesting for an invited lecture?

Come to me and discuss!

Acknowledgements

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Thank you for your attention!

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