LTH 2019-08-28

Avdelningen för Strömningsteknik Avancerade metoder inom numerisk strömningsmekanik och värmeöverföring (Advanced Methods within Numerical Fluid Mechanics and Heat Transfer) MVKN70

The course is an undergraduate course (7.5 hp).

The aim of the course is to provide basic knowledge about numerical methods that are routinely used for simulating fluid flow and heat transfer. Knowledge on several ways of discretizing such as finite differences and finite volumes is provided. Knowledge on how to numerically treat some flow and heat transfer phenomena such as shock waves, multiphase flow, thermal radiation and mass transfer is given. The course is aimed at providing capability to perform this kind of simulations. Also, to provide capability in analyzing and assessing the results of such simulations. This knowledge should be sufficient in order to choose a proper solution method and assess the accuracy of the results for a given engineering problem.

Learning outcomes

Knowledge and understanding

For a passing grade the student must

- be able to give an account for potentials and limitations of the methods covered in the course
- be able to give an account for different methods for numerically solving fluid mechanics problems and their applicability on different types of fluid flow
- be able to describe the most common discretization methods and their advantages and disadvantages
- be able to describe the sources of errors in the process from mathematical description to numerical solution of fluid flow and heat transfer problems, and how these affect the results
- be able to describe how to treat certain phenomena numerically, e.g. shock waves, thermal radiation and chemical reactions
- be able to explain some, for the subject, important concepts

Competences and skills

For a passing grade the student must

- be able to analyze fluid flow or heat transfer case and suggest a solution strategy of it concerning equations, possible simplifications, choice of numerical method and turbulence model and to compare to alternative methods and models
- be able to critically review and assess the accuracy and plausibility of results of fluid flow simulations from given criteria

Judgement and approach

For a passing grade the student must

- be able to take active part in discussions on for the subject relevant problems
- be able to present, orally and in writing, a technical report containing analyses and choice of numerical solution method and turbulence model

To achieve these goals in a rather limited time, the course requires a continuous and active participation of the students. The form of the teaching of the course has been adapted so as to meet the goals listed above. *The course is not aimed as a CFD recipes review.* The students should be able to solve *scientific and engineering problems involving fluid dynamics and heat transfer using CFD* techniques as well as having detailed knowledge of some numerical algorithms!

Contents: The course treats methods for numerical simulation of fluid dynamics and heat transfer problems, both incompressible and compressible. Discretization using finite volumes, and to some extent and finite differences finite elements. Both compressible and incompressible flows are treated. Methods for handling adaptive and deforming meshes as well as methods for handling deforming objects are included.

Assessment: Examination is individual as well as based on group work. The compulsory home works and computer exercises are reported in writing, individually. The project assignment is reported both in writing and orally at a seminar. There will be a written test on the theoretical part of the course. To pass it is required that all compulsory parts, i.e. home works, computer exercises, project assignment and theory test are approved. The grade is based on the theory test, the home work and the project report.

The grade is based on the theory test and the project report. The weights are 60% on test and 40% on the report. In detail it works as follows:

- Maximum number of point on the test is 55 and 28 is required to pass.
- The approved final reports will be graded on a scale from 0 to 3 for the criteria listed below. Please note that concerning points 3-5 the focus is not on the actual choices but on how well they are argued:
  1. Overall quality of the report
  2. Clarity in the description of the fluid mechanics and heat transfer problem
  3. Validity of the assumptions made.
  4. Choice of solution method, discretization and grid
  5. Methods for assessing accuracy
  6. Presentation and discussion of numerical results

Hence, one can get in total 18 points on the report. The overall result is the calculated as $p=(p_{test}-28)+p_{report}$. The maximum result is then $p_{max}=(55-28)+18=45$ and the grade limits are then 3: $0 \le p \le 15$, 4: $16 \le p \le 30$ and 5: $p > 30$.

Literature: Material handed out during the course. As complementary material you can use any book on CFD. If you do not have one, the following book is a good choice: Dale A. Anderson, John C. Tannehill, and Richard H. Pletcher, Computational Fluid Mechanics and Heat transfer, Third Edition (Series in Computational and Physical Processes in Mechanics and Thermal Sciences), CRC Press,Taylor & Francis . ISBN 1466578300, 9781466578302.

Home work (HW): Altogether there are 5 home works. These HW are distributed every Tuesday for the first 5 weeks and should be completed by Tuesday in the week after. The HW may include both theoretical work (i.e. learning the material), problem solving and answering questions. Some of these HW include a computer lab/demo exercise. Furthermore, there are 5 applied mandatory exercises with the software package ANSYS Fluent.

Teachers:

RY: Dr Rixin Yu: tel: 222 3814; e-mail: rixin.yu@energy.lth.se

Prof. Bengt Sundén: tel: 2228605, email; Bengt.Sunden@energy.lth.se

Course schedule for MVKN70 (2019)

Advanced Methods for Numerical Fluid Dynamics and Heat Transfer

	Monday	Tuesday	Wednesday	Thursday
Week 36 Introduction/ Discretization (RY)	8-10 am, Sep. 2nd Room: M:D Lecture	3-5 pm, Sep. 3rd Room: M:L1 Lecture	1-3 pm, Sep. 4 Room: M:R Lecture + Exercise	
Week 37 Compressible flow 1 (RY)	8-10 am, Sep. 9 Room: M:D Lecture (RY)	3-5 pm, Sep. 10 Room: M:D Lecture	1-3 pm, Sep. 11 Room: M:R Lecture + Exercise	10-12 am, Sep. 12 Room: M: Ina3+4 Computer Exercise
Week 38 Heat transfer/ Thermal radiation (BS)	8-10 am, Sep. 16 Room: M:D Lecture	3-5 pm, Sep. 17 Room: M:D Lecture	1-3 pm, Sep. 18 Room: M:R Exercise	10-12 am, Sep. 19 Room: M: Ina3+4 Computer Exercise
Week 39 Compressible flow 2 (RY)	8-10 am, Sep. 23 Room: M:D Lecture	3-5 pm, Sep. 24 Room: M:D Lecture	1-3 pm, Sep. 25 Room: M:Q Lecture + Exercise	10-12 am, Sep. 26 Room: M: Ina1+2 Computer Exercise
Week 40 Reacting flow (RY)	8-10 am, Sep. 30 Room: M:D Lecture	3-5 pm, Oct. 1st Room: M:D Lecture	10-12am, Oct. 2nd Room: M:B Lecture + Exercise	10-12 am, Oct. 3rd Room: M: Ina1 + 2 Computer Exercise
Week 41	8-10 am, Oct. 7 Room: M:D Questions(RY)	3-5 pm, Oct. 8 Room: M:D Invited Lecture (Saab)	1-3 pm, Oct. 9 Room: M:R Invited Lecture (Volvo)	10-12 am, Oct. 10 Room: M: Emma1+2 Computer Exercise(RY)
Week 42 (RY/BS)	8-10 am, Oct. 14 Room: M:D Theory test			8-12 am, Oct. 17 Room: M:D Project presentation

Teacher: RY: Dr. Rixin Yu, rixin.yu@energy.lth.se, BS : Prof. Bengt Sunden, Bengt.Sunden@energy.lth.se,