UNIVERSITY OF PANNONIA

COURSE DATASHEET

Semester:	2015/16/1
Course:	Application of Computational Fluid Dynamics methods in engineering practice
Code:	VEMKFOM354A
Responsible department:	Department of Process Engineering
Department code:	MKFO
Responsible instructor:	Zsolt Ulbert

Course objectives:

Nowadays the CFD tools are widely used in a variety of engineering fields. Using CFD methods it makes possible to effectively analyse and design complex hydrodynamic systems such as fluid mixers, heat transport processes, chemical reactors, etc. Application of CFD tools provides a detailed insight into the fluid flow inside the equipment. CFD tools are based on the equations of fluid dynamics and the effective numerical methods solving them. The primary purpose of this course is to introduce students to the theoretical bases of fluid dynamic equations and numerical treatment of flow equations. During the practices students get familiar with the use of COMSOL Multiphysics software in solving fluid flow and heat transfer problems. In some of the practices students perform physical flow measurements in laboratory equipment and carry out its numerical simulations as well.

Course content:

1. Introduction to Computational Fluid Dynamics.

Brief history of CFD and CF tools.

The Computational Fluid Dynamics as a research tool.

The Computational Fluid Dynamics as a design tool.

Application examples of CFD.

2. The governing equations of fluid dynamics

Fundamental physical principles of fluid dynamics, conservation laws.

Derivation of differential balance equations of fluid flow over a stationary volume element.

The principle of mass conservation, the continuity equation.

The principle of conservation of momentum, the momentum equation.

The principle of conservation of energy, the energy equation.

Turbulence flow models (RANS, DNS, LES).

Physical boundary conditions.

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Course content:

3. Numerical solution of flow equations.

Overview of numerical methods for solving ordinary and partial differential equations.

The finite difference method.

The finite element method.

The finite volumes method.

Stability of numerical methods.

Implicit and explicit methods.

4. Mesh generation.

Modelling of the flow field geometry, symmetry relations, coordinate systems.

Structured, unstructured and hybrid calculation meshes.

Mesh generation methodologies, techniques and algorithms.

Methods for checking mesh quality.

5. Computational Fluid Dynamics tools.

Overview of CFD software.

Flow modelling using COMSOL Multiphysics and ANSYS Fluent software.

6. Fluid dynamic modelling.

Classification of fluids

The compressible and incompressible forms of fluid flow equations.

Application examples of fluids flow models.

7. Component flow modeling

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Course content:

Convective and conductive mass flow.

Component sources.

The conservation equations for the chemical components.

Application examples of component flow models.

8. Heat Flow Modeling

The convective and conductive heat flow.

Heat transfer and Heat sources.

Specific forms of energy equation.

Application examples of heat flow model.

9. Modeling particulate flows by discrete element method (DEM).

The physical properties of solid particles.

Calculation of particle motion. Forces acting on particles in particulate flows. Equation of motion.

Elastic and inelastic collision of particles.

Particle contact mechanics.

Normal contact models.

Tangential contact models.

Contact sliding between particles.

Rolling resistance.

10. Calculation of particulate flow using collision model of elastic particles.

Contact modell of elastic particles, the spring, damping and friction mechanical elements.

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Course content:

Calculation of normal contact forces.

Calculation of tangential contact forces.

Calculation of friction forces.

Algorithms of particle collision detection.

Sequence of calculations in DEM simulation.

The treatment of geometric surfaces - particle collisions.

11. Modeling of gas-solid two-phase flow systems.

Overview of the gas-solid two-phase flow modells.

The Two-Fluid model.

The Euler-DEM method.

Direct simulation of gas-solid two-phase flows.

Requirements, evaluation and grading:

The whole content of lectures is included in one final written examination. During the semester, students have to prepare a project assignments developing a hydrodynamic simulator (using COMSOL Multiphysics software) of a system including the development of governing equations. The project assignment has to be presented in a 10 minute presentation. The final mark is determined according to following table based on the weighted average of the written examinations and the project assignment (final written examination 70%, project assignments 30%).

above 80% excellent (5)

70%-79% good (4)

60%-69% medium (3)

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Requirements, evaluation and grading:

50%-59% pass (2)

below 50% fail (1)

Replacement of the final written examination is not possible, in this case the written examination contributes to the final mark by weight of 0%. The final written examinations can be improved one time in the first week of exam period.

Conditions for teacher's signature:

The project assignment to be prepared and presented, the absences from practical lessons will not exceed the 35% of total number of lessons.

Required and recommended readings:

John D. Anderson, Computation Fluid Dynamics, McGraw Hill, 1995

Oleg Zikanov, Essential Computational Fluid Dynamics, Wiley, 2010