Reg No: EMAD16/20202

Faculty of Health, Science and Technology
Environmental and Energy Systems

Syllabus

Advanced Computational Fluid Dynamics (CFD)

Course Code:	EMAD16
Course Title:	Advanced Computational Fluid Dynamics (CFD) *Avancerad Computational Fluid Dynamics (CFD)*
Credits:	7.5
Degree Level:	Master's level
Progressive Specialisation:	Second cycle, has only first-cycle course/s as entry requirements (A1N)

Major Field of Study:
KTA (Chemical Engineering)
MEI (Environmental and Energy Systems)

Course Approval
The syllabus was approved by the Faculty of Health, Science and Technology 2020-04-01, and is valid from the Autumn semester 2020 at Karlstad University.

Prerequisites
Fluid Mechanics (7.5 ECTS credits), Heat and Mass Transfer (7.5 ECTS credits), and registered on Applied CFD in Fluid Mechanics and Heat Transfer (7.5 ECTS credits), plus upper secondary level Swedish 3 or Swedish as a second language 3 and English 6, or equivalent

Learning Outcomes
Upon completion of the course, students should be able to:
1. understand and use discretisation methods to convert the governing differential equations into algebraic equations and solve the linear algebraic equations numerically in MATLAB,
2. describe different turbulence models and select and use the right turbulence model for fluid flow problems critically,

3. give an account of the purpose of the wall function in the turbulence model, and y+ (dimensionless wall distance) estimation of the boundary layer in the turbulence model,
4. describe advantages and disadvantages of different types of grid (structured grid, unstructured grid, and hybrid grid), and select appropriate grid techniques for various simulations,
5. conduct fluid flow and heat transfer simulations using commercial CFD software,
6. describe sources of error in the process from mathematical description to numerical solution of a problem related to fluid flow and heat transfer, and how those sources of error influence the results, and
7. present numerical methods and results of solving problems related to fluid flow and heat transfer through simulations, orally and in writing.

Content
The aim of the course is for students to acquire advanced knowledge of Computational Fluid Dynamics (CFD), including methods used to analyse applied questions of fluid flow and heat transfer, numerical methods, turbulence modelling used to describe fluid flow phenomena, and how to use advanced methods in commercial CFD software to simulate fluid flow and heat transfer phenomena. The aim of the course is also for students to acquire sufficient skills to conduct CFD simulation for multiphysics problems in technical applications, the ability to analyse and evaluate the simulation results, and enough knowledge to select an appropriate method for solving problems and evaluate the accuracy of results in relation to a certain technical problem.

The course covers the following:
- classification of the governing differential equations (continuity equation, momentum equation, energy equation) for CFD,
- discretisation methods (finite differences, finite volumes, and finite elements) used to convert the governing differential equations into algebraic equations,
- linear algebraic equations,
- turbulence models and wall function in turbulence models,
- different types of grid ((structured grid, unstructured grid, and hybrid grid) and grid refinement,
- grid-independent study and criteria for numerical convergence,
- CFD for external/internal forced convection with different turbulence models,
- CFD for heat transfer, including conduction, convection, and radiation,
- CFD for fluid flow in practice and heat transfer problems in technical applications.

Reading List
See separate document.

Examination
Assessment is based on individual hand-in assignments and a project presented orally.

If students have a decision from Karlstad University entitling them to special pedagogical support due to a documented disability, the examiner has the right to give such students an adapted examination or to examine them in a different manner.

Grades
One of the grades Distinction (VG), Pass (G), or Fail (U) is awarded in the examination of the course. For students in Engineering programmes, one of the grades 5 (Pass with Distinction), 4 (Pass with Some Distinction), 3 (Pass), or U (Fail) is awarded in the examination of the course.

Quality Assurance
Follow-up relating to learning conditions and goal-fulfilment takes place both during and upon completion of the course in order to ensure continuous improvement. Course evaluation is partly based on student views and experiences obtained in accordance with current regulations and partly on other data and

documentation. Students will be informed of the result of the evaluation and of any measures to be taken.

Course Certificate
A course certificate will be provided upon request.

Additional information
The local regulations for studies at the Bachelor and Master levels at Karlstad University stipulate the obligations and rights of students and staff.