Experimental measurement techniques in thermo-fluid mechanics and spectroscopy
(7.5 hp)

About the Course

Mälardalen University and the Future Energy Center (FEC) arrange a training course in experimental methods. The course comprises modules for introduction to experimental methods, measurement uncertainty and repeatability, different measurement techniques for the characterization of the flow and heat transfer field as well as spectroscopy methods. The course discusses intrusive and non-intrusive measurement techniques with their advantages and disadvantages. Particular focus is given on the fundamental phenomena on which the different measurement techniques are based.

Aim and Learning Outcomes

The first module of the course aims to introduce experimental measurements, the design of experimental facilities, and the design of experiments (DoE) approach. It also addresses the importance of reliable experimental measurements, measurement uncertainty and repeatability, and the risk assessment of an experiment. The second module of the course will focus on measurements of the flow field in fluids. This will discuss devices such as pressure probes, hot-wire probes, optical methods with the use of lasers. The third module will focus on spectroscopy and measurements of temperature and heat transfer. The fourth module will focus on post-processing and the use of experimental data in simulations, process control, and diagnostics.

The learning outcomes of the course are to be able to:

- Describe the basics of experimental measurements and the design of experiments approach with the ability to prepare a risk assessment document for a specific experiment.
- Argue for the importance of experimental measurements and measurement uncertainty and repeatability.
- Describe the optimal approach for the conduct of spectroscopy measurements and describe commonly used fluid flow and heat transfer measurement techniques. Compare the fundamental phenomena behind these techniques.
- Explain the challenges and limitations of different measurement techniques and rank parameters in order of measurement accuracy.
- Select and motivate the most suitable measurement technique for a specific application within fluid flow and heat transfer.
- Determine the requirements for an experiment depending on the purpose and the planned use of the experimental data.

The course has a practical orientation and does not require any specialized professional background in experimental methods. The training will be individually adapted to the needs of each participant. The course is suitable for all PhD students under energy, aerospace, controls, and production system optimization as well as embedded system applications. PhD students and post-docs working on experiments, simulations, control and optimization analysis of energy systems (within FEC), production systems (within IPR) and industrial embedded systems (within ES), as well as all PhD students from the ARRAY research school, are particularly encouraged to take this course, as it will be strongly linked to the research directions of the FEC, IPR and ES as well as ARRAY.

Fees

Attendance for MDH students and staff is free of charge, as well as for staff from companies holding research activities under the Future Energy Center. A fee of **10kSEK/student** may be applied for other course attendants from industry/academia, subject to the discretion of the course responsible.

Max. 20 students. Group of 6-7 persons per lab visits.

Course Examination (Konstantinos)

NAR1: 1.5hp, Participation in the course lectures and assessment.
NAR2: 2hp, Participation in the lab visits and manipulate experiment with data.
INL1: 4hp, Individual mini-project.

Mini-project Description

Participants will be able to select a mini-project from a pool of case studies relevant to the lectures. This will include applications of conceptual design of experimental facilities and practical processing and evaluation of real experimental data. Participants can also suggest and conduct their own project after discussion with the course responsible.

Course Responsible

Konstantinos Kyprianidis, Mälardalen University, Konstantinos.kyprianidis@mdh.se
Professor, Head of Research Education, Energy and Environmental Engineering
Specialty: Simulation, optimization, control and diagnostics for industrial applications.

Key Training Staff

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+ guest lecturers

Course Material

Material will be available online prior to the lectures in the course repository in Microsoft Teams.

Course Schedule

The course will be given during a four-week period from mid-October to mid-November 2020 on 12 half-days, according to the schedule below.

Week 1 : Introduction: 19th - 23rd October

19th October - *Introduction to the course. Introduction to experimental measurements.*
21st October - *Design of experimental facility: Preparatory work, design, and risk assessment*
23rd October - *Design of experimental facility: Measurement uncertainty and repeatability / Design of Experiments (DoE) / Statistical Processing*

Week 2 : Aerodynamic Measurements: 26th - 30th October

26th October - *Aerodynamic measurements – pressure.*
28th October - *Aerodynamic measurements – velocity.*
30th October - *Aerodynamic measurements – flow visualization.*

Week 3 Thermo - Fluid measurement techniques and spectroscopy: 2nd - 6th November

2nd November - *Spectroscopy measurements.*
4th November - *Temperature measurements.*
6th November - *Heat transfer measurements.*

Week 4 : Post Processing and applications: 9th - 13th November

9th November – *Presentation of experiment including discussion on measurement uncertainty and introduction to post processing*
11th November – *Use of experimental measurements in simulation / Post Processing using Matlab / Python*
13th November – *Use of experimental measurements for process control and diagnostics / Conclusion*