UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

Course guide
820758 - TETDTM - Experimental Energy Technology

Last modified: 21/06/2024

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 724 - MMT - Department of Heat Engines.

Degree: ERASMUS MUNDUS MASTER'S DEGREE IN DECENTRALISED SMART ENERGY SYSTEMS (DENSYS) (Syllabus 2020). (Optional subject).
MASTER'S DEGREE IN THERMAL ENGINEERING (Syllabus 2021). (Optional subject).
MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2022). (Optional subject).

Academic year: 2024 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Joaquim Rigola

Others: Oliva Llena, Asensio
Castro Gonzalez, Jesus
Oliet Casasayas, Carles

PRIOR SKILLS

Knowledge of Fluid Dynamics and Heat and Mass Transfer, is necessary to understand the basic operating principles of measurement sensors. Basic electrical and elextronical knowledge.

REQUIREMENTS

Knowledge equivalent to having completed the course of levelling the Master's

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.
CEMT-5. Employ technical and economic criteria to select the most appropriate thermal equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technological applications in the production, transportation, distribution, storage and use of thermal energy.

Transversal:
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

TEACHING METHODOLOGY

During the development of the course, the following teaching methodologies will be used:
- Theoretical-practical sessions: presentation of knowledge by the teaching staff through lectures or by external people through invited lectures.
- In person sessions with participatory practices: participate in the collective resolution of exercises, as well as in debates and group dynamics, with the teacher and other students in the classroom
- Laboratory sessions: Carrying out laboratory practices on different specific research equipment focusing on the experimental measurement techniques worked on in class. These facilities can be located in different research spaces and are scheduled as outings outside the classroom with the accompaniment and advice of the course teachers.
- Directed activities for the development of work, results, conclusions, etc.

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course, the student must acquire the following learning general objectives:
Get basic training in understanding the types of measurement sensors and their integration in an experimental system (unit and software for data acquisition, regulation and control system).
Acquire a very solid competition when the physical principles that determine the response of a given sensor, as well as the interactions that may exist between the presence of the measurement probe and reading to be performed (distortion effects of the problem by the intrusion of the probe, thermal inertia effects on transitional measures, etc.).
Learning to deal with the experimental data, making filtered when necessary evaluation of the corresponding measurement errors, etc.

At the end of the course, the student must acquire the following learning specific objectives:
Introduction to basics of experimental techniques in Thermal Energy, seeking the utmost rigor, its possibilities and limitations.
Introduction to the analysis of experimental data acquisition and control, as well as analysis and measurement.
Deepening experimental techniques for measuring such as temperature, pressure, flow, speed, humidity, gas analysis, etc.
Application to detailed experimental validation of basic phenomena of heat and mass transfer. Contrasting application of numerical results and experimental tests on thermal systems and equipment for major industrial and social compression refrigeration, heat exchangers, hermetic compressors, absorption refrigeration, HVAC (ventilation, air conditioning in buildings, optimization glass facades, etc.), active and passive solar systems, heat storage, etc.
Conducting laboratory practices that allow students to become aware of the specific applications of the developed possibilities, as well as experimental techniques and measurement and estimation of experimental errors in the experimental units available.

STUDY LOAD

Type	Hours	Percentage
Self study	85,0	67.73
Hours large group	40,5	32.27

Total learning time: 125.5 h

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CONTENTS

Content 1. Data Acquisition and Control

Description:
This content is intended as an introduction necessary in what concerns the data acquisition and control. The first point is to try to revise the principles of electronics that deal with conditions and signals emitted by different types of sensors (electrical response to a thermal/mechanical disturbance). Then the software and hardware for data acquisition is presented as a way to turn disturbances the user wants to measure in interpretable information in a data file. Finally, we present the software (PID control) and the basic control hardware to set the operating conditions of interest in each case (control temperature level, flow, etc.). Data management together with information post processes are also analysed.

Specific objectives:
Provide basic knowledge in data acquisition to be able to perform an experiment in the heat field.
Provide basic knowledge in control and regulation to be able to perform an experiment in the heat field.

Related activities:
Theory class
Practical class
Reduced scope work
Broad scope work

Related competencies :
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Full-or-part-time: 24h
Theory classes: 5h
Practical classes: 4h
Self study : 15h

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Content 2. Temperature sensors

Description:
A study of the most common temperature sensors based on the physical principle on which they are based (mechanical effects, electrical effects, radiation effects). It will especially insist on a wider use of sensors (thermoresistances, thermocouples). It will work on the aspects related with the accuracy of measurements depending on the location and construction of the probes (effects of heat transfer without modifying the actual temperature sensor) or transitory measures with respect to the thermal inertia of the sensor itself.

Specific objectives:
Know the types of temperature sensors and its most common application framework.
Provide criterion when managing measurement errors associated with the installation and the thermal inertia of the temperature sensors.

Related activities:
Theory class
Practical class

Related competencies :
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Full-or-part-time: 24h
Theory classes: 5h
Laboratory classes: 4h
Self study : 15h

Content 3. Pressure sensors and flowmeters

Description:
This content studies the second group of sensors and includes pressure sensors and flows, to be based on similar principles, with a base in fluid mechanics. It will present the most common type of sensor for measuring absolute pressure, relative and differential. Describe the most common type of flow meter (Coriolis, magnetic, turbine, vortex, etc.), explaining the physical foundation based on the framework and its application.

Specific objectives:
Description of the physical foundations and framework for the application of common pressure sensors.
Description of the physical foundations and framework for implementing the common flow sensors.

Related activities:
Theory class
Practical class
Reduced scope work

Related competencies :
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Full-or-part-time: 24h
Theory classes: 5h
Laboratory classes: 4h
Self study : 15h

Content 4. Hot wire anemometer

Description:
Presentation of principles for measuring hot wire anemometer and the parameters that characterise the measures (levels of turbulence, sampling, etc.). Presentation of different types of sensors (materials, geometry, uni/multidirectional, etc.). Detailed explanation of the operation of a unit and taking measurements. Statistical treatment of the data obtained and estimation of the measurement error.

Specific objectives:
Understand the principle and operation of a measurement unit for hot wire anemometry.
Interpret and treat the results obtained correctly.

Related activities:
Theory class
Practical class
Reduced scope work

Related competencies :
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Full-or-part-time: 21h
Theory classes: 3h
Laboratory classes: 3h
Self study : 15h

Content 5. Sensors moisture content/concentration

Description:
Background of humidity sensors. Fundamentals of psychrometry. Types of the most common humidity sensors (psychrometer, cold mirror hygrometers, relative humidity polymer sensors, aluminum oxide sensors for detecting traces, optical sensors), presenting their physical principle, operation and framework of use.

Specific objectives:
Know the most common humidity sensors, their physical principles and their application framework.
Relate sensors and proportionate measures with the basics of the corresponding psychrometry.

Related activities:
Theory class
Practical class
Reduced scope work
Broad scope work

Related competencies :
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Full-or-part-time: 21h
Theory classes: 3h
Practical classes: 3h
Self study : 15h

Content 6. Instrumentation and measurement in the vacuum field

Description:
Some technological applications where it is necessary to manage certain levels of vacuum, specific measuring instruments and specific technology to control it and quantify it are needed. Description of the construction technology of thermal equipment that must handle a high vacuum level (welding, pressure joints, materials, etc.) and particular measuring instruments governing this application (pressure sensors of very low rank, mass spectrometer). Detailed explanation of the operation of a mass spectrometer dedicated to evaluating the quality of the vacuum generated in a certain application.

Specific objectives:
Vacuum technology (construction, control, etc.)
Measurement instruments in vacuum applications; emphasis on mass spectrometry.

Related activities:
Theory class
Practical class
Reduced scope work
Broad scope work

Related competencies :
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Full-or-part-time: 16h
Theory classes: 3h
Practical classes: 3h
Self study : 10h

ACTIVITIES

Theory classes

Description:
Methodology in large group. The content of the course follows a model of class exhibition and participation. The material has been organised in different groups of content according to the areas of knowledge of the course.

Specific objectives:
At the end of this activity, the student must be able to master the knowledge acquired, consolidate it and apply it correctly to different technical problems. In addition, being an applied technoscientific subject, the theory classes must serve as a complement to other related technical subjects in the thermal field, such as HAVC&R (Heating Ventilation, Air Conditioning and Refrigeration), Thermal Engines, Solar Energy or Thermal Energy Accumulation.

Material:
Recommended bibliography. Notes from professors (ATENEA).

Delivery:
This activity is assessed together with activity 2 (practices) through coursework and knowledge tests.

Related competencies :
CEMT-5. Employ technical and economic criteria to select the most appropriate thermal equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technological applications in the production, transportation, distribution, storage and use of thermal energy.
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Full-or-part-time: 36h
Theory classes: 24h
Self study: 12h

Practical classes

Description:
Methodology in large group and medium group, as long as the availability of the professor permits it. On each topic there will be some problems in the classroom so that students acquire the necessary guidelines to carry out this resolution: simplifying assumptions, approach, numerical resolution, discussion of results.

Specific objectives:
At the end of this activity, students should be able to apply theoretical knowledge to solve different types of problems. Given the methodology, students should be able to:
1.- Understand the statement and analyse the problem.
2.- Propose and develop a scheme of the same resolution.
3.- Solve the problem using proposed equations with a suitable algorithm resolution.
4.- Critically interpret the results.

Material:
Recommended bibliography. Notes from professor (ATENEA).

Delivery:
This activity is evaluated together with the first activity (theory) through laboratory reports and exams.

Related competencies :
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Full-or-part-time: 42h
Practical classes: 10h
Laboratory classes: 11h
Self study: 21h

Guided activities

Description:
Students will have to carry out guided theoretical-practical work. The work will consist of solving small problems, whose starting data may be both the results of a laboratory experiment and data posed by the teacher. The structure to follow will be:
Preparation for the practice through a practice manual.
Groups of 2 to 3 people with a maximum duration of 3 hours.
Discussion of the results obtained and the problems that arose during the practice.
Preparation of a report related to the practice carried out with results, questions and conclusions. This report will be evaluated together with the completion of the practice.

Specific objectives:
Consolidate the knowledge acquired in theory and practical classes.

Material:
Recommended bibliography. Teacher's guide notes (ATENEA).

Delivery:
Reports will be made following guidelines given in class.

Related competencies :
CEMT-5. Employ technical and economic criteria to select the most appropriate thermal equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technological applications in the production, transportation, distribution, storage and use of thermal energy.
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Full-or-part-time: 30h
Self study: 30h

Reduced scope work

Description:
Resolution of two problems based on situations posed by the professor.

Specific objectives:
Consolidate the knowledge acquired in theory classes and practices.

Delivery:
The report should follow guidelines given in class.

Related competencies :
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Full-or-part-time: 11h
Self study: 11h

Broad scope work

Description:
Resolution of a problem based on situations posed by the professor or student.

Specific objectives:
Expand and consolidate the knowledge acquired in theory classes and practices.

Delivery:
The report should follow guidelines given in class.

Related competencies :
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Full-or-part-time: 11h
Self study: 11h

GRADING SYSTEM

Written knowledge control test: 25%
Work done individually or in groups throughout the course: 75%

EXAMINATION RULES.

Evaluation rules based on course activities:
- Written exam about contents: This is the final exam of the course. The student will have to complete both theoretical questions and problems related to the theoretical and practical contents of the subject.
- Work is carried out individually or in groups throughout the course: The student will have to follow the instructions explained in class and adhere to the archive corresponding to the work proposed to the student concerning the different teaching contents of the course. As a result of these activities, the student will have to submit a report (preferably in pdf format) to the teacher, along with the data limit that is fixed for each activity. The work's evaluation will involve its implementation and its possible oral defence.
The evaluation of the practice will involve both its implementation and its possible defense.

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- Herold, Keith E. [et al.]. Absorption chillers and heat pumps [on line]. 2nd ed. Bosa Roca, US: CRC Press, 2016 [Consultation: 29/03/2023]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=4497372. ISBN 9781498714358.

RESOURCES

Audiovisual material:

- Notes made by the professors of the course. Resource
- Transparencies, proposed problems to be used in class. Resource