Course guide
820758 - TETDTM - Experimental Energy Technology

Last modified: 16/02/2024

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: 2023 **ECTS Credits:** 5.0 **Languages:** Catalan, Spanish, English

LECTURER

Coordinating lecturer: Joaquim Rigola

Others: Assensi Oliva
Jesús Castro

PRIOR SKILLS

Knowledge of fluid dynamics and heat and mass transfer, necessary to understand the basic operating principles of measurement sensors. Basic electrical 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

Teaching methodology:

The course teaching methodologies are as follows:

- Lectures and conferences: presentation of knowledge by lecturers or guest speakers.
- Participatory sessions: collective resolution of exercises, debates and group dynamics, with the lecturer and other students in the classroom; classroom presentation of an activity individually or in small groups.
- Theoretical/practical supervised work (TD): classroom activity carried out individually or in small groups, with the advice and supervision of the teacher.
- Homework assignment of reduced extension: carry out homework of reduced extension, individually or in groups.
- Homework assignment of broad extension: design, planning and implementation of a project or homework of broad extension by a group of students, and writing a report that should include the approach, results and conclusions.
- Evaluation activities (EV).

Training activities:

The course training activities are as follows:

- Face to face activities
o Lectures and conferences: learning based on understanding and synthesizing the knowledge presented by the teacher or by invited speakers.
o Participatory sessions: learning based on participating in the collective resolution of exercises, as well as in discussions and group dynamics, with the lecturer and other students in the classroom.
o Presentations (PS): learning based on presenting in the classroom an activity individually or in small groups.
o Theoretical/practical supervised work (TD): learning based on performing an activity in the classroom, or a theoretical or practical exercise, individually or in small groups, with the advice of the teacher.

- Study activities
o Homework assignment of reduced extension (PR): learning based on applying knowledge and presenting results.
o Homework assignment of broad extension (PA): learning based on applying and extending knowledge.
o Self-study (EA): learning based on studying or expanding the contents of the learning material, individually or in groups, understanding, assimilating, analysing and synthesizing knowledge.

LEARNING OBJECTIVES OF THE SUBJECT

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).
Acquiring 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 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.

Learning Outcomes:

At the end of the course, the student:
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
Guided activities	10,0	8.00
Self study	85,0	68.00
Hours small group	30,0	24.00

Total learning time: 125 h

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.).

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: 17h
Theory classes: 5h
Guided activities: 2h
Self study : 10h

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: 22h
Theory classes: 5h
Guided activities: 2h
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: 21h 30m
Theory classes: 5h
Guided activities: 1h 30m
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:
To understand the principle and the operation of a unit of measure for the hot wire anemometer.
Interpret and correctly treat the obtained results.

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 30m
Theory classes: 5h
Guided activities: 1h 30m
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 30m
Theory classes: 5h
Guided activities: 1h 30m
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: 21h 30m
Theory classes: 5h
Guided activities: 1h 30m
Self study : 15h

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, students should be able to master the knowledge, consolidate it and apply it correctly to various technical problems. Moreover, being a techno-scientific subject, the lectures should serve as a basis for the development of other more technical subjects related to the field of heat, such as Refrigeration, Thermal Motors or Solar Energy.

Material:
Recommended bibliography. Notes from professor (copies and/or ATENEA).

Delivery:
This activity is evaluated in conjunction with activity 2 (problems) through coursework and written test.

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: 40h
Theory classes: 20h
Self study: 20h

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 (copies and/or ATENEA).

Delivery:
This activity is evaluated in conjunction with the first activity (theory) through coursework 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: 25h
Theory classes: 10h
Self study: 15h

Guided activities

Description:
Students must perform guided activities. The activities consist in solving small problems, of whcih the data may be the result of a laboratory experiment or proposed data by the professor. The structure to be followed:
Preparation of the activity by a manual of practice.
Groups of 2 or 3 people with a maximum duration of two hours.
Discussion of the results obtained and the problems that have arisen during the course of practice.
Completion of a report on 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 classes and practices.

Material:
Recommended bibliography. Notes from professor (copies and/or ATENEA).

Delivery:
Reports should follow 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: 14h
Guided activities: 4h
Self study: 10h

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.

Material:
Recommended bibliography. Notes from professor (copies and/or ATENEA).

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: 12h
Guided activities: 2h
Self study: 10h

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.

Material:
Recommended bibliography. Notes from professor (copies and/or ATENEA).

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: 12h
Guided activities: 2h
Self study: 10h

Written test

Description:
Development of a written test of the course contents 1 and 2.
It includes theoretical aspects and development problems.

Specific objectives:
Demonstrate the level of knowledge achieved in theoretical activities and problems.

Material:
Recommended bibliography. Notes from professor (copies and/or ATENEA).

Delivery:
The exam will be held freely and the statement delivered along with the statement duly filled in with the data required.

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.
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.
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: 22h
Guided activities: 2h
Self study: 20h

GRADING SYSTEM

Written test (PE). 30%
Work performed individually or in groups (TR). 50%
Attendance and participation in practical activities (AP). 20%

EXAMINATION RULES.

Here are the rules of the system for evaluating the educational activities of the course.

Written test (PE).

There will be a final exam for the course. Students must complete both theoretical questions and problems related to the theoretical and practical content of the course. Reviews and/or claims regarding the examinations will be conducted according to the dates and times established in the academic calendar.

Work done individually or in groups along the course (TR).

Students must follow the instructions explained in class and contained in the file for the work that will be proposed to the student in relation to different teaching content of the course. As a result of these activities, students must submit a report (preferably in PDF format) to the professor, with the deadline to be fixed for each activity. The evaluation work will involve both its realisation and a possible defense.

Attendance and participation in classes and laboratories (AP).

The labs will be assessed both in their implementation and in the implementation of practical exercises that will be proposed; they can begin during the class schedule planned for this type of activity to be completed (if applicable) as an autonomous activity, following the instructions given in class. The results of practical exercises delivered to the teacher must follow the instructions given in class.

The evaluation of the practice will involve both its realisation and a possible defense.

Quality and performance of group work (TG).

The reports of practices and/or group work will be assessed individually on the oral defense if necessary or of any single group on the report.

BIBLIOGRAPHY

Basic:
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- ASHRAE handbook. Fundamentals. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1985-. ISBN 1523-7230.
- 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