Course guide
820759 - CTEAB - Thermal Conditioning of Buildings. Bioclimatic Architecture

Last modified: 08/04/2026

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

Degree: MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Optional subject).
MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2022). (Optional subject).

Academic year: 2026 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Ivette Rodríguez

Others: Ivette Rodríguez

PRIOR SKILLS

Fundamental aspects of thermodynamics, fluid mechanics and heat transfer required to understand the thermal performance of buildings.

REQUIREMENTS

Those equivalent to have passed the Master leveling course.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEMT-1. Understand, describe and analyse, in a clear and comprehensive manner, the entire energy conversion chain, from its status as an energy source to its use as an energy service. They will also be able to identify, describe and analyse the situation and characteristics of the various energy resources and end uses of energy, in their economic, social and environmental dimensions, and to make value judgments.
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.
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.

TEACHING METHODOLOGY

During the development of the course the following teaching methods will be used:

- Lecture or conferences (EXP): Lectures taught by the professors of the course as well as invited lectures.
- Interactive classes (PART): resolution of exercises, collective discussions with both the teacher and the students. Presentation by the students of exercises carried out individually or in small groups.
- Oriented theoretical-practical works (TD): completion of a classroom activity, theoretical or practical, carried out individually or in small groups with the teacher's guidance.
- Project, activity or work of reduced scope (PR): Self-learning based on accomplishing an activity of reduced scope, individually or in small groups, just applying the knowledge acquired.
- Project or work of broader scope (PA): Self-learning based on accomplishing an activity of broader scope, individually or in small groups, just applying the knowledge acquired.
- Assessment exam (EV).

LEARNING OBJECTIVES OF THE SUBJECT

- Know the different heat transfer phenomena (radiation, convection, conduction) that occur in in the building.
- Know the different design criteria and basic concepts related to the thermal conditioning of buildings and the bioclimatic architecture.
- Know the regulations applicable to projects of bioclimatic buildings and thermal certification of buildings.
- Have a knowledge of the methodologies for calculating thermal loads in buildings: from simplified models to advanced numerical simulation techniques.
- Perform laboratory practices that allow the student to know the different phenomenologies present in buildings as well as the possibilities of numerical tools for the estimation of the building thermal loads.
- Know different techniques of air conditioning and heating using bioclimatic architecture criteria.

STUDY LOAD

Type	Hours	Percentage
Self study	85,0	65.38
Hours large group	30,0	23.08
Hours small group	15,0	11.54

Total learning time: 130 h

CONTENTS

Introduction

Description:
Role of the engineer in the design of air conditioning and heating systems. Basics of heat transfer (conduction, convection, radiation). Basic thermodynamic processes in buildings, psicrometical processes.

Specific objectives:
- Know the tasks to be carried out by an engineer designing heating and air conditioning systems and how to integrate them in order to achieve an efficient design from an energy standpoint as well as from the point of view of comfort and safety.
- Master the basic principles of heat transfer, as well as the air moist thermodynamic processes necessary to understand the different phenomenologies present in buildings.

Related activities:
- Lectures or conferences
- Interactive classes

Related competencies :
CEMT-1. Understand, describe and analyse, in a clear and comprehensive manner, the entire energy conversion chain, from its status as an energy source to its use as an energy service. They will also be able to identify, describe and analyse the situation and characteristics of the various energy resources and end uses of energy, in their economic, social and environmental dimensions, and to make value judgments.

Full-or-part-time: 7h
Laboratory classes: 4h
Self study : 3h

Air quality and thermal comfort

Description:
Comfort indexes, variables that influence thermal comfort, comfort assessment. Ventilation and indoor air quality. Sick building syndrome, evaluation of pollutants indexes. Efficacy of ventilation.

Specific objectives:
- Understanding the thermal conditioning of buildings involves creating spaces with thermal comfort conditions. It aims to study how human responses are interrelated to the environment thermal conditions.
- Know the different variables that can influence the thermal comfort and be able to assess the thermal comfort indices.
- Know what sick building syndrome is, what their characteristics and symptoms are and what the risk factors are: chemical polluting, physical and biological in a sick building and psychosocial aspects.

Related activities:
- Lectures or conferences
- Interactive classes
- Project, activity or work of reduced scope

Related competencies :
CEMT-1. Understand, describe and analyse, in a clear and comprehensive manner, the entire energy conversion chain, from its status as an energy source to its use as an energy service. They will also be able to identify, describe and analyse the situation and characteristics of the various energy resources and end uses of energy, in their economic, social and environmental dimensions, and to make value judgments.
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.

Full-or-part-time: 11h
Laboratory classes: 3h
Self study : 8h

Solar radiation and building. Boundary Conditions

Description:
Basic concepts of solar radiation. Estimation of solar radiation loads in buildings. Solar geometry and shade calculation. Other climatic variables: temperature and humidity. Influence of wind.

Specific objectives:
- Be able to evaluate the angular position of the Sun
- Be able to estimate the solar radiation thermal loads on the envelope of a building.
- Evaluate the shadows that can occur on the facade of a building.
- Determine all the boundary conditions necessary for a calculation of thermal loads in a building: solar radiation, temperature, humidity, wind speed.

Related activities:
- Lectures or conferences
- Interactive classes
- Project, activity or work of reduced scope

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-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.

Full-or-part-time: 19h
Laboratory classes: 4h
Self study : 15h

Heating and air conditioning thermal loads estimation

Description:
Estimation of thermal loads for both heating and cooling. Design conditions of indoor air. Heat transfer through the skin of the building. Air ventilation and infiltration. Internal heat gains (occupants, lighting, equipment, etc.). Other considerations.

Specific objectives:
- Know the construction characteristics of the building, in order to determine the influence of the the building skin on the heat gains/losses and its temporal evolution.
- Learn the different sources of heat losses and gains in a building that can influence the estimation of thermal loads for air conditioning and heating.
- Estimate the impact of the different sources of heat losses and gains on the total demand for heating and cooling in a building.
- Know the different methods for calculating thermal loads and the different tools available to an engineer in estimating the total demand for heating and cooling in a building.

Related activities:
- Lectures or conferences
- Interactive classes
- Project, activity or work of reduced scope

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.
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.

Full-or-part-time: 26h
Laboratory classes: 6h
Self study : 20h

Theoretical and practical considerations for thermal design. Energy efficiency in buildings

Description:
Regulations applicable to the thermal design of buildings. Technical building code (CTE) and thermal facilities regulations (RITE). Heat demand and the need to establish a maximum consumption. Energy efficiency in buildings and the introduction of renewable energy and the use of waste energy. Buildings with almost zero energy: principles and challenges. Smart-cities and heat pumps.

Specific objectives:
- Know the current regulations related to the thermal design of a building.
- Understand the role of the Technical Building Code and the thermal demands imposed by it.
- Know the current trends and the energy planning towards 2020 horizon in Europe.
- Understand what a building with almost zero energy means, what the current state of the art is and what the main challenges to be faced are.
- Know how to integrate different technologies to achieve buildings with almost zero energy.
- What are smart-cities technologies and how heat pumps can be used.

Related activities:
- Lectures or conferences

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.
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.

Full-or-part-time: 6h
Laboratory classes: 2h
Self study : 4h

Techniques for passive cooling and heating of the building

Description:
Study of different design techniques that consider all the climate impacts existing in a building: bioclimatic architecture. Techniques for passive cooling: evaporative cooling, radiation cooling, free cooling. Concepts and definitions. Types of facilities. Passive solar collection systems: direct gain systems, greenhouses, energy storage systems: Trombe wall, walls with phase change materials. Examples of application. Calculation and design of bioclimatic buildings.

Specific objectives:
- Know the bioclimatic architecture concepts.
- Recognize the different environmental elements that can be used in a bioclimatic project.
- Enable the student in the different bioclimatic design techniques and their integration in the building in order to achieve current designs, efficient and targeted within 2020 horizon for buildings with almost zero energy.
- Provide students with tools and knowledge for making decisions in the field of passive control of climatic variables.

Related activities:
- Lectures or conferences
- Interactive classes
- Oriented theoretical-practical works
- Project, activity or work of broader scope

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.
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.

Full-or-part-time: 40h
Laboratory classes: 7h
Guided activities: 6h
Self study : 27h

Advanced techniques for building thermal simulation

Description:
The student should be able of using numerical techniques for simulating the thermal behaviour of a building. The different subjects treated throughout the course should be necessaries to accomplish successfully this topic.

Specific objectives:
Use of the different concepts treated throughout the course to be applied in the simulation of a small building
Learn different techniques and tools for building simulation

Related activities:
- Lectures or conferences
- Interactive classes
- Oriented theoretical-practical works

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.
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.

Full-or-part-time: 13h
Laboratory classes: 4h
Guided activities: 6h
Self study : 3h

ACTIVITIES

Lectures and theoretical classes

Description:
The content of the course is taught following an expository and participative model. The material is organized into different groups according to the content areas of knowledge of the subject.

Specific objectives:
At the end of this activity, students should be able to master the knowledge, consolidate and apply them correctly to various technical problems. Moreover, being a subject techno applied the lectures should serve as a complement to other technical subjects related to the field heat as Refrigeration and Solar Heat Engines.

Material:
Recommended bibliography. Slides of the course

Delivery:
This activity is evaluated in conjunction with activity 2 (problems) via assessment exercises and tests of knowledge.

Full-or-part-time: 25h
Laboratory classes: 15h
Self study: 10h

Participative classes

Description:
During these activities, problems and exercises will be conducted using a participatory model class. On each topic, there will be some problems in class so that students can acquire the necessary methodology to carry out their resolution: simplifying assumptions, numerical resolution, discussion of the results.

Specific objectives:
At the end of this activity, students should be able to apply their theoretical knowledge to solve different kinds of problems. Given the methodology the student should be able to:
1- Understand and analyze the problem statement.
2 - Set up and develop a methodology for the resolution of the problem
3 - Solve the problem with a suitable resolution algorithm.
4. - Critically interpret the results.

Material:
Basic and complementary bibliography. Teacher slides

Delivery:
This activity is evaluated in conjunction with activity 1 (theory) via assessment exercises and tests of knowledge.

Full-or-part-time: 25h
Laboratory classes: 15h
Self study: 10h

Oriented theoretical-practical works

Description:
During these activities, laboratory activities for test equipment and systems studied in the course, as well as computer aided activities will be conducted.

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

Material:
Notes and material provided by the professor via atenea

Delivery:
Report on the results obtained

Full-or-part-time: 22h
Laboratory classes: 7h 30m
Guided activities: 4h 30m
Self study: 10h

Broader scope work

Description:
The student will deepen into a subject and will solve a problem in which there must be necessary to apply different concepts acquired in the course. It is expected that the student is capable of using the different methodologies taught in class in order to accomplish the work.

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

Material:
Recommended bibliography. Teacher slides

Delivery:
Report on the results

Full-or-part-time: 20h
Self study: 20h

name english

Description:
The student will carry out different theoretical or practic works throughtout the curs. These works can be whether the analysis of the current state-of-the-art in a certain subject or the evaluation of the thermal load through a building facade and/or in a small room.

Specific objectives:
-Acquire basic knowledge about topics of interest to the course such as thermal comfort and building energy efficiency
- Being able to apply the knowledge acquired in both the theoretical as practical lessons to estimate the thermal loads on a facade of a building and / or estimate the heating and cooling loads of a building
-Being able to analyze the results and their dependence on the geographic location, the time of year, etc.. and propose solutions to improve energy efficiency from a thermal point of view

Material:
Professor notes and recommended bibliography

Delivery:
Report on the results following the guidelines given by the professor

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

Assessment tests

Description:
Theoretical and practice exercises on the different subjects of the course will be assessed

Specific objectives:
At the end of this activity, students should be able to demontrate the knowledge acquired in the course, consolidate and apply the concepts correctly to various technical problems.

Full-or-part-time: 3h
Guided activities: 3h

GRADING SYSTEM

Any academic fraud, plagiarism or use or possession of unauthorised means in an assessment activity leads to a mark of zero (0) for the affected test or assignment. Furthermore, in accordance with the University's regulations, if disciplinary proceedings are initiated the subject is recorded as "Pending Assessment" until a decision is reached. These incidents are managed in accordance with the **Action Framework for Academic Integrity in Assessment at the UPC**.

- Final exam (PE): 50%
- Assessment exercises (individually or in small groups) (TR): 40%
- Attendance and participation in classes and laboratories (AP): 5%
- Quality and performance of the work in groups (TG): 5%

During the spring semester of the 2020-2021 academic year, and as a result of the health crisis due to Covid19, the qualification method will be:

The final grade will be obtained from the continuous evaluation following the formula:
final mark = 0.4xassessment_1 + 0.2xassessment_2 + 0.2xassessment_3x0.2xassessment_4

There will be 4 individual works that will cover all the contents of the subject. The final grade will be conditioned to the presentation and oral discussion with the teachers of the work done.

EXAMINATION RULES.

- Final exam (PE): There will be a final exam for the course. Students must complete both theoretical questions and problems related to theoretical and practical content of the course. Reviews and / or complaints regarding exams will be conducted in accordance with the dates and times established in the academic calendar.

- Assessment exercises (TR): Students must follow the instructions explained in class and contained in the work file that will be proposed to the students. As a result of these activities, the student must submit a report (preferably in pdf format) to the teacher, within the deadline fixed for each activity. The assessment will involve both its realization as a possible defense.

-Attendance and participation in classes and laboratories (AP): Laboratory practices are assessed both during the development of the lab and by accomplishing a practical exercises proposed; The report resulting from the lab will be handed in to the professor following the instructions given in class. The assessment will involve both practical realization, as a possible defense.

- Quality and performance of group work (TG): Practices and class exercises will be assessed individually or in small groups by means of their oral defense if necessary.

BIBLIOGRAPHY

Basic:
- Cook, Jeffrey. Passive cooling. Cambridge: MIT Press, cop. 1989. ISBN 0262031477.
- Balcomb, J. Douglas. Passive solar buildings. London: The MIT Press, cop. 1992. ISBN 0262023415.
- Hays, Steve M; Gobbell, Ronald V; Ganick, Nicholas R. Indoor air quality : solutions and strategies. New York: McGraw-Hill, cop. 1995. ISBN 0070273731.
- Kreider, Jan F. [et al.]. Heating and cooling of buildings : design for efficiency. 2n ed. rev.. Boca Raton: CRC Press, 2010. ISBN 9781439811511.
- American Society of Heating, Refrigerating and Air-Conditioning Engineers. The ASHRAE handbook. Fundamentals.... I-P and SI ed. Atlanta, GA: American Society of Heating, Refrigerating and air-Conditioning Engineers, 2013-. ISBN 9781936504473.

Complementary:
- Duffie, John A; Beckman, William A. Solar engineering of thermal processes, photovoltaics and wind [on line]. 5th ed. Hoboken: Wiley, 2020 [Consultation: 12/05/2026]. Available on: https://onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/book/10.1002/9781119540328. ISBN 9781119540328.
- Johnston, David; Gibson, Scott. Toward a zero energy home : a complete guide to energy self-sufficiency at home. Newtown: The Taunton Press, 2010. ISBN 9781600851438.

RESOURCES

Audiovisual material:
- Transparències. Slides, problems proposed to be used in class

Computer material:
- Apunts. Notes made ??by the subject teacher