Course guide
240171 - 240171 - Heat Technology

Last modified: 12/04/2024

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

Degree: BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Compulsory subject).
BACHELOR'S DEGREE IN AUTOMOTIVE ENGINEERING (Syllabus 2017). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: Ruiz Mansilla, Rafael

Others: Capdevila Paramio, Roser
Jaramillo Fernández, Juliana
Martínez Ballester, Santiago
Mas de les Valls, Elisabet
Ruiz Mansilla, Rafael
Velo García, Enric
Miquel Ardanuy
Luca Borghero
Thibault Péan

REQUIREMENTS

Thermodynamics and Fluid Mechanics

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Capacity to understand and apply basic knowledge principles of general chemistry, organic and inorganic chemistry and their engineering applications.
2. Capacity to solve mathematical problems that can appear in engineering . Aptitude to apply knowledge about: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and derived partial equations; numerical methods; numerical algorithm; statistics and optimisation.
3. Understanding and dominion of basic concepts on mechanics, thermodynamics, fields and waves and electromagnetism laws and their application to solve engineering problems.
4. Knowledge on applied thermodynamics and heat transfer. Basic principles and their application to solve engineering problems.
5. Knowledge of basic principles of mechanical fluids and their application to solve engineering problems. Calculation of pipes, channels and systems of fluids.
6. Basic knowledge applied to environmental and sustainability technologies.
7. Basic knowledge on the use and programming of computers, operative systems, data bases and computer software with an engineering application.

Transversal:
8. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
9. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
10. ENTREPRENEURSHIP AND INNOVATION: Knowing about and understanding how businesses are run and the sciences that govern their activity. Having the ability to understand labor laws and how planning, industrial and marketing strategies, quality and profits relate to each other.
11. SUSTAINABILITY AND SOCIAL COMMITMENT. Being aware of and understanding the complexity of social and economic phenomena that characterize the welfare society. Having the ability to relate welfare to globalization and sustainability. Being able to make a balanced use of techniques, technology, the economy and sustainability.
12. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
13. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
14. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.

TEACHING METHODOLOGY

The classes combine theory with problems, inviting students to participate actively. Case analysis, critical thinking and continuous work are encouraged throughout the course.
theory is presented contextualized to industry and society's needs in order to motivate and show students the relevance of heat transfer. This explanation is accompanied by mathematical calculation models, detailing their restrictions and their scope of application. The problems carried out in class allow students to deepen the basic concepts and the calculation of heat transfer with an increasing degree of difficulty, with special emphasis on the interpretation of results.
In the laboratory, students have the opportunity to learn about the devices and methodology for the experimental determination of quantities and thermal parameters, deepen the use of correlations, as well as the validation of the results obtained through the adjustment of energy balances .
Numerical practice with ANSYS allows you to approach a powerful tool of numerical methods to solve a complex driving problem and compare the results with a previously solved simplified numerical or analytical solution. In addition, it allows students to creatively apply the concepts learned in order to improve a design proposal.
Directed work usually consists of a problem-solving approach. These are proposed to be delivered on paper or in the environment of the ATENEA Campus. The teaching staff will therefore be able to propose and collect written exercises throughout the course.
As support for teaching, at the ATENEA Campus, students have study materials to monitor the subject. Also, for personal study, it also has subject notes and basic reference bibliography, available in the center's library. The notes you will find in the following link can help you,
https://upcommons.upc.edu/handle/2117/364535

LEARNING OBJECTIVES OF THE SUBJECT

Competences of the degree to which the subject contributes

Specific:

1. Know how to determine temperature distributions and heat transfer by conduction, convection and / or radiation in diverse systems.

2. Know the basic principles and their application to the resolution of engineering problems.

General objective

1. Introduce the theoretical concepts, terminology, conventions, principles, fundamental laws and methodologies for calculation of heat transfer by conduction, convection and radiation.

2. It is intended to provide basic knowledge to serve as a starting point for master subjects dealing with the modeling of heat transfer phenomena with generation and / or accumulation present in industry and the design of industrial equipment.

Specific objectives

1. Know how to determine and reduce, if convenient, the heat losses of any non-isothermal system (pipes, walls, fins, etc.) using analytical or numerical solutions.

2. Know the bases of heat exchangers. Knowing how to determine the exchange of thermal power between two fluids in motion at different temperatures (internal flow in ducts)

3. Know how to calculate a spectral balance of thermal radiant power between the surfaces of an enclosure (oven) with a non-participating medium (dry air or vacuum). Know the basics of the Greenhouse effect.

STUDY LOAD

Type	Hours	Percentage
Hours large group	50,0	33.33
Hours small group	10,0	6.67
Self study	90,0	60.00

Total learning time: 150 h

CONTENTS

INTRODUCTION

Description:
Object and scope of the subject. Concept of heat and heat transfer. Mechanisms of heat transfer. Driving and first law of Fourier. Convection and law of Newton's cooling. Radiation and the law of Stefan-Boltzmann.
Resistance and thermal conductance. Combined mechanisms. Global coefficient of heat transfer (U). Conservation of energy in a control volume. Thermal properties of matter. Units.

Full-or-part-time: 15h
Theory classes: 6h
Self study : 9h

UNIDIMENSIONAL CONDUCTION IN STATIONARY STATE

Description:
Heat diffusion equation. Initial and boundary conditions. Flat walls and radial systems. Integration of the first Fourier law. Thermal conductivity. Combined mechanisms. Contact resistance. Thermal insulation. Critical radio with variable h. Conduction with thermal energy generation. Heat transfer on extended surfaces or fins.

Full-or-part-time: 30h
Theory classes: 12h
Self study : 18h

NUMERICAL METHODS (STATIONARY AND TRANSITORY STATE)

Description:
Analytical solutions of the heat diffusion equation. Ideal solids. Method of negligible internal resistance. Solutions by numerical methods. Discretization of space and time. Finite differences. Energy balance method. Stationary and transient regime. Calculation of conductances. Introduction to high-level commercial software: ANSYS running under the WINDOWS operating system. Resolution with ANSYS of numerical exercises of complex geometries and with contour conditions drawn from the industrial world.

Full-or-part-time: 35h
Theory classes: 14h
Self study : 21h

CONVECTION

Description:
Navier-Stokes equations and energy conservation. Dimensional numbers. Number of Nusselt. Correlations. Hydrodynamic and thermal boundary layer. Balance equations. Profile of velocities and temperature. Definition of the convection coefficient. Turbulent internal flow in ducts. Number of Nusselt. Formulas of Filolenko and Gnielinski. Differential equation of the energy balance in a duct. Boundary conditions. Double tube. Heat exchangers.

Full-or-part-time: 22h
Theory classes: 9h
Self study : 13h

THERMAL RADIATION

Description:
Nature and characteristics of thermal radiation. Hemispheric surface flows. Black body. Intensity of radiation. Planck distribution law. Radiation function. Laws of Kirchhoff. Vision factors. Spectral balance of radiant energy in an enclosure of N Lambertian surfaces. Greenhouse effect.

Full-or-part-time: 35h
Theory classes: 14h
Self study : 21h

GRADING SYSTEM

Next notes are used:
1) Final exam note (NE_F) is the mark of the test that will be made on the date fixed by the school
2) Note partial exam (NE_P) is the note of the partial test that will be made in the middle of the quarter on the date set by the School.
3) Laboratory note (N_LAB) corresponds to the note of the laboratory practices and will be obtained from the delivered reports, the proactive attitude in the laboratory and from the previous basic knowledge questionnaire that will be carried out upon entering the laboratory.
4) Note of numerical methods exam, (NE_NUM) approximately TWO WEEKS AFTER the partial test, an individual test of the subject of numerical methods will be carried out. The date varies according to the calendar and will be set at the beginning of the semester. The date and time of this test will be published in Athena.
5) Numerical simulation work with ANSYS (N_PNUM) we will also expose some example of numerical simulation solved in ANSYS and we will explain (2h) how the different boundary conditions are applied with this program, the latest version for students (32500 nodes). Organized with groups of 4 students maximum, a complex geometry exercise will be proposed, which will be solved with this advanced numerical simulation tool.

The final note of the final subject N_FINAL (rounded according to current regulations) is:

N_FINAL = 0,55·NE_F + 0,20·NE_P + 0,10·NE_NUM + 0,10·N_PNUM+ 0,05·N_LAB

Exercises performed on the proposal of teachers (deliveries/tasks) are voluntary and can be requested at any time during the course. Only students who pass the subject will receive a mark increase that is marked between 0 and 1 points depending on the quality and quantity of the exercises delivered.

With the only objective of improving the grade, the faculty reserves the possibility of incorporating other elements or evaluation criteria in their case.

REASSESSMENT OF THE SUBJECT
The final grade of the subject in the reevaluation (N_FINAL_RE) is directly the grade obtained in the reevaluation examination (N_EF_RE), which replaces all previous notes.

CONVALIDATIONS
The note of numerical simulation work and/or laboratory practice are automatically validated (must have it approved in the previous semester). Repeating students who want to improve this grade can repeat them again (without risk of dropping a grade).

EXAMINATION RULES.

Final exam: focused on topics 4 and 5, it will consist of a test with conceptual questions and/or short calculation exercises (which may include concepts from laboratory practices) and a couple of open problems. Approximate total duration of the exam: 3 hours.
Mid-term exam: will include conceptual questions and/or calculation exercises. Its content will refer to the syllabus seen in class until the exam date.
An experimental laboratory practices are scheduled. The student must read in advance the text of the experiment that he will find in the digital campus and must deliver the corresponding report at the end of the practice session.
The re-take exam includes the entire syllabus and the lab content. Approximate duration 3-4 h. The re-take exams are similar to those carried out throughout the course.
During the completion of any of the exams, students will only be able to bring a programmable calculator and a printed sheet with the specific form of that test, which is on the digital campus.

BIBLIOGRAPHY

Basic:

- Ruiz Mansilla, R. Termotecnia : síntesis de la asignatura [on line]. Barcelona: Universitat Politècnica de Catalunya, 2022 [Consultation: 22/06/2022]. Available on: https://upcommons.upc.edu/handle/2117/364535.
- Bonals Muntada, Ll. A. Transferència de calor : apunts de classe (Termotècnia - 240171) [on line]. Barcelona: Iniciativa Digital Politècnica, 2016 [Consultation: 13/09/2022]. Available on: https://upcommons.upc.edu/handle/2117/90176. ISBN 9788495355898.
- Bergman, T. L.. Fundamentals of heat and mass transfer. 8th ed. New York: Wiley, 2020. ISBN 9781119722489.

Complementary:

- Mills, Anthony F. Transferencia de Calor. Mexico: Irwin, 1995. ISBN 8480861940.
- Rohsenow, Warren M. ed. Handbook of heat transfer. 3th ed. New York: McGraw-Hill, 1998. ISBN 0070535558.