Course guide
240782 - 240782 - Heat Transfer

Last modified: 27/06/2023

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

Degree: BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGIES AND ECONOMIC ANALYSIS (Syllabus 2018). (Compulsory subject).

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

LECTURER

Coordinating lecturer: Velo Garcia, Enrique

Others: Capdevila Paramio, Roser
Mas De Les Valls Ortiz, Elisabet

PRIOR SKILLS

REQUIREMENTS

Thermodynamics and Fluid Mechanics
Basic computer science

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEGTI 7. (ENG) Coneixements de fluïds, termodinàmica aplicada, transmisió de calor i engineria térmica.

Generical:
CGGTI 1. (ENG) Capacitat per a la redacció i desenvolupament de projectes en l'àmbit de la Ingeniera Industrial que tinguin per objecte, d'acord amb els coneixements adquirits segons la formació rebuda en tecnologies específiques, la construcció, reforma, reparació conservació, demolició, fabricació, instal.lació, muntatge o explotació de: estructures, equips mecànics, instal.lacions energètiques, instal.lacions elèctriques i electròniques, instal.lacions i plantes industrials i/o processos de fabricació i automatització.
CGGTI 3. (ENG) Coneixement en matèries bàsiques i tecnològiques que capacitin per a l'aprenentatge de nous mètodes i teories, i doti de versatilitat per adaptar-se a noves situacions.
CGGTI 4. (ENG) Capacitat pe resoldre problemes amb iniciativa, presa de decisions, creativitat, raonament crític i de comunicar i transmetre coneixements, habilitats i destreses en el camp de l'Enginyeria Industrial.
CGGTI 5. (ENG) Coneixements per a la realització de medicions, càlculs, valoracions, tasacions, peritacions, estudis, informes, plans de treball i altres treballs similars.
CGGTI25. (ENG) Identificar els factors clau d'un problema.

Transversal:
CT7. (ENG) TERCERA LLENGUA: Conèixer una tercera llengua, preferentment l'anglès, amb un nivell adequat oral i escrit, i en consonància amb les necessitats que indran els titultats i titulades.

Basic:
CBGTI1. (ENG) Que els estudiants hagin demostrat poseir i comprés coneixements en una àrea d'estudi que parteix de la base de l'eduació secundària general, i se sol trobar a un nivell què, si bé es recolça em llibres de text avançats. inclou també alguns aspectes que inpliquen coneixements procedents de la vanguàrdia del seu camp d'estudi.
CBGTI2. (ENG) Que els estudiants sàpiguen aplicar els seus coneixements al seu treball o vocació d'una forma professional i tinguin les comptències que se solen demostrar mitjançant l'elaboració i defensa d'argumnets i la resolució de problemes dins de la sera àrea d'estudi.
CBGTI3. (ENG) Que els estudiants tinguin la capacitat de reunir i intepretar dades rellevants (normalment dins de la seva àrea d'estudi) per emetre judicis que incloguin una reflexió sobre temes rellevants d'índole social, científica o ètica.

TEACHING METHODOLOGY

The classes combine theory and problems, inviting students to actively participate in them, in case analysis and technical decision-making. Continued work throughout the course is encouraged with the delivery of problem-based homework.

In face-to-face classes, the theory is presented simultaneously with problem solving (which allows the student to delve into the basic concepts of heat transfer). In class presentations, industrial-type images are shown with the purpose of motivating students and showing them the importance of studying this subject. The theoretical concepts are explained and the mathematical calculation models, their restrictions and their scope of application are developed. In the problem classes, the correct use of mathematical models is shown, using an increasing degree of difficulty. Special emphasis is placed on the interpretation of the results.

In the laboratory (5 h) students have the opportunity to know the devices and methodology for the experimental determination of magnitudes and thermal parameters, deepen the use of correlations, as well as the validation of the results obtained by adjusting the balances of energy.

An additional dedication of one hour and a half for every hour of class is expected from the student.

Directed work (or homework) usually consists on solving heat transfer problems. These are proposed for delivery on paper or using questionnaires in the ATENEA Campus. Teachers will therefore be able to propose and collect exercises throughout the course.

LEARNING OBJECTIVES OF THE SUBJECT

The overall objectives of the subject are:
1. Make an introduction to the theoretical concepts, terminology, conventions, principles, fundamental laws and methodologies for calculating heat transfer problems by conduction, convection and radiation.
2. Provide the student with basic knowledge that will serve as a starting point for master's subjects that include a) the modelling of heat transmission phenomena with heat generation and b) the design of industrial equipment.

The specific objectives are:

1. The student must know how to calculate, and reduce if necessary, the heat losses of any non-isothermal system (pipes, walls, fins, etc.) using analytical or numerical solutions.
2. The student must know how to determine the exchange of thermal power between two fluids moving at different temperatures (internal flow in ducts in heat exchangers).
3. The student must be able to calculate a thermal radiant power balance between the surfaces of an enclosure (such as an oven) with a non-participating medium (vacuum or dry air), as well as know the principles of the greenhouse effect.

STUDY LOAD

Type	Hours	Percentage
Hours large group	55,0	43.14
Hours small group	5,0	3.92
Self study	67,5	52.94

Total learning time: 127.5 h

CONTENTS

1. INTRODUCTION

Description:
Object and scope of the subject. Concepts of "heat" and "heat transfer". Heat transfer mechanisms. Fourier law of heat conduction. Convection and Newton's law of cooling. Radiation and Stefan-Boltzmann's law. Energy conservation in a control volume. Thermal properties of matter.

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

2. ONE-DIMENSIONAL, STEADY-STATE HEAT CONDUCTION

Description:
Heat diffusion equation. Initial and boundary conditions. The plain wall and radial systems. Thermal resistance and thermal conductance. Combined mechanisms. Contact resistance. Thermal insulation. Critical radius with variable h. Conduction with Thermal Energy Generation. Heat Transfer from Extended Surfaces (fins).

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

3. APPLICATION OF NUMERICAL METHODS FOR CONDUCTION

Description:
Solving heat transfer problems using numerical methods. Discretization of space and time. The Energy Balance Method. Stationary and transitory regime. Finite-Difference Methods. Calculation of conductances. Resolution with ANSYS of exercises with complex geometries and with boundary conditions extracted from the industrial environment.

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

4. CONVECTION

Description:
Newton law. Hydrodynamic boundary layer and thermal boundary layer. Velocity Profile and Temperature Profile. Definition of the convection coefficient. Dimensionless numbers. Nusselt number. Correlations and formulas. Heat balance equations. Internal flow in ducts. Petukow and Gnielinski formulas. Differential equation of the energy balance in a duct. Boundary conditions. Double Tube Heat Exchangers. Multi-tube heat exchangers.

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

5. THERMAL RADIATION

Description:
Nature and characteristics of thermal radiation. Hemispheric surface flows. Black body. Radiation intensity. Planck's distribution law. Radiation function. Kirchhoff's Laws. View factors. Radiant energy balance in an enclosure with N surfaces. Greenhouse effect.

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

GRADING SYSTEM

For ordinary evaluation the final mark will be

FINAL = 0.20 × E1 + 0.20 × NUM + 0.05 × LAB + 0.05 × PROB + 0.50 × E2

Where:

FINAL: Final mark rounded according to current regulations
E1: Mark of the first exam (held on the date set by ETSEIB in the middle of the semester) (topics 1 and 2)
NUM: Mark of the numerical methods part (topic 3)
LAB: Mark of the laboratory session (topic 1)
PROB: Mark of the exercises (problems) delivered during the development of the course. (topics 1, 2, 4 and 5)
E2: Mark of second exam (held on the date set by ETSEIB at the end of the semester for final exams) (topics 4 and 5)

Mark of numerical methods part (NUM):

Within the schedule of theory and problem classes, the fundamentals and methodology for solving heat transfer problems using numerical methods will be explained. The mark of this part has two items:

a) 50% Individual work. It will consist of the resolution on the ATENEA campus of an exercise to apply the energy balance method. The quiz will open approximately two weeks after the midterm exam, for a limited time and with a single attempt. The exercise will include both the study of a transient and steady state regime. The student will be able to use the calculus resources available to them, both at home and at the university. The date and time of this exercise will be published in ATENEA.

c) 50% Numerical simulation work using ANSYS. This exercise is made in groups of students (maximum 4 students).

Only with the aim of improving the final grade of the course, the teaching staff can incorporate other elements or evaluation criteria where appropriate.

COURSE REEVALUATION:

The students who failed have a new re-evaluation of the course. The final mark of the re-appraisal is directly the mark obtained at the re-appraisal examination, which substitutes all the previous marks.

VALIDATIONS

The mark for numerical methods and/or the grade for the laboratory session is validated if the student has passed them in a previous semester. The grade obtained previously will be maintained. However, you can repeat them if you want to improve your mark.

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EXAMINATION RULES.

First exam: will include conceptual questions and/or calculation exercises. Its content will refer to topics 1 and 2 of the course syllabus. Duration: around 1 hour.

Second exam: it will consist of a quiz with conceptual questions and short calculation exercises and a couple of problems. Total duration of the exam: between 3 and 4 hours. Its content will only refer to topics 4 and 5 of the course syllabus.

There is a single experimental lab class. Students must read the description of the experiment that they can find in the ATENEA campus, before coming to the lab. Students' groups must deliver the corresponding report at the end of the lab class. Read more details in ATENeA about the evaluation of this experimental class.

The retake exam includes the entire syllabus and the practical contents. Approximate duration 3-4 h. Retake exams are similar to those carried out during the academic year and will cover conduction, convection and radiation.

To carry out any of the face-to-face exams, the student may carry one or several programmable calculators and an A4 sheet (two faces) with all the information that the student considers appropriate like formulas for solving problems.

For solving convection exercises, it is necessary for students to have the properties of air and water provided throughout the course. The student can have them in the calculator of in the A4 form.

Questions to the teacher during exams can only refer to the understanding of the exam statement.

BIBLIOGRAPHY

Basic:
- Incropera, Frank P. ; David P. DeWitt. Fundamentos de transferencia de calor. 4a ed. México [etc.]: Prentice Hall, cop. 1999. ISBN 9701701704.
- Bergman, T. L. Fundamentals of Heat and Mass Transfer. 8th ed. New York: Wiley, 2020. ISBN 9781119722489.