240171 - Heat Technology

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering
Teaching unit: 724 - MMT - Department of Heat Engines
Academic year: 2017
Degree: BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
ECTS credits: 6
Teaching languages: Catalan, Spanish

Teaching staff

Coordinator: LLUIS ALBERT BONALS MUNTADA - 20
Others: ELISABET MAS DE LES VALLS - 30
ALEJANDRO GARCÍA MONACO - 10
VELO GARCÍA ENRIQUE -40

Opening hours

Timetable: Laboratory Manager: Nuria Vives (nvives@mmt.upc.edu) tel. 934015900
All consultations with the teaching staff will be previously arranged via email.

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Requirements

Thermodynamics and Fluid Mechanics
Basic Informatics

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-
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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

Classes combine theory and problems, inviting students to participate actively in them, case analysis and technical decision-making. Continued work is encouraged throughout the course with the proposal and collection of problems. In the face-to-face classes, the theory (45 h) is presented simultaneously with the explanation of problems (15 h) that allow the student to delve into the basic concepts of heat transfer. In class exhibitions, industrial-type images are shown with the purpose of motivating and showing the student the importance of studying this subject; Explain the theoretical concepts and develop the mathematical models of calculation, their restrictions and their scope of application. The problem classes show the correct use of mathematical models, with an increasing degree of difficulty, and 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, to deepen the use of correlations, as well as in the validation of the results obtained by adjusting the balance of energy.

Targeted work usually consists of the problem-solving approach. These are proposed for delivery in paper or using the environment of the Campus of Atenea. Teachers can therefore propose and collect written exercises throughout the course.

As a support for teaching, at the Atenea Campus, the student has a Frequently Asked Questions (FAQ) where he finds answers to some of his most habitual questions, as well as a collection of problems with answers. However, for the personal study, the student has notes of the subject and basic bibliography of reference, available in the library of the center. It will also be very useful the notes you will find in the following link, http://upcommons.upc.edu/bitstream/handle/2117/90176/9788495355898.pdf?sequence=1&isAllowed=y

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. Basic principles and their application to the resolution of engineering problems.

General objective
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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 impart basic knowledge to serve as a starting point for second cycle 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. The student must know how to determine and reduce his case, the heat losses of any non-isothermal system (pipes, walls, fins, etc.) using analytical or numerical solutions.

2. Bases of heat exchangers: know 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). Greenhouse effect.

<table>
<thead>
<tr>
<th>Study load</th>
<th>Total learning time: 150h</th>
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<tbody>
<tr>
<td>Hours large group:</td>
<td>55h</td>
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<tr>
<td>Hours medium group:</td>
<td>0h</td>
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<tr>
<td>Hours small group:</td>
<td>5h</td>
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<tr>
<td>Guided activities:</td>
<td>0h</td>
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<td>Self study:</td>
<td>90h</td>
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## Content

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<tr>
<th><strong>INTRODUCTION</strong></th>
<th><strong>Learning time:</strong> 15h</th>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td><strong>Theory classes:</strong> 6h</td>
</tr>
<tr>
<td><strong>Object and scope of the subject. Concept of heat and heat transfer.</strong></td>
<td><strong>Self study:</strong> 9h</td>
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<tr>
<td><strong>Mechanisms of heat transfer. Driving and first law of Fourier. Convection and law of Newton's cooling. Radiation and the law of Stefan-Boltzmann.</strong></td>
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<thead>
<tr>
<th><strong>UNIDIMENSIONAL CONDUCTION IN STATIONARY STATE</strong></th>
<th><strong>Learning time:</strong> 30h</th>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td><strong>Theory classes:</strong> 12h</td>
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<tr>
<td><strong>Heat diffusion equation. Initial and boundary conditions. Flat walls and radial systems. Integration of the first Fourier law.</strong></td>
<td><strong>Self study:</strong> 18h</td>
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<tr>
<td><strong>Thermal conductivity. Combined mechanisms. Contact resistance. Thermal insulation. Critical ratio with variable h. Conduction with thermal energy generation. Heat transfer on extended surfaces or fins.</strong></td>
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<tr>
<th><strong>NUMERICAL METHODS (STATIONARY AND TRANSITORY STATE)</strong></th>
<th><strong>Learning time:</strong> 35h</th>
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<tr>
<td><strong>Description:</strong></td>
<td><strong>Theory classes:</strong> 14h</td>
</tr>
<tr>
<td><strong>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.</strong></td>
<td><strong>Self study:</strong> 21h</td>
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<tr>
<th><strong>CONVECTION</strong></th>
<th><strong>Learning time:</strong> 22h</th>
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<tr>
<td><strong>Description:</strong></td>
<td><strong>Theory classes:</strong> 9h</td>
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# THERMAL RADIATION

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<th>Description:</th>
<th><strong>Learning time:</strong> 35h</th>
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Self study : 21h |
The four notes are used:

1) Final exam note (NEF) is the mark of the joint test that will be made on the date fixed by the school and will consist of a test with conceptual questions and/or short calculation exercises (the entire syllabus, laboratory practice and numeric) and a couple of open problems (manual correction). Total duration of the examination: between 3 and 4 hours.

2) Note partial test (NPP) is the note of the partial test that will be made in the middle of the quarter on the date set by the School. It will include conceptual questions and/or calculation exercises. Its content will refer to the agenda presented in class until the day of the test.

3) Laboratory note (NLAB) corresponds to the note of the laboratory practices and will be obtained from the report that the students deliver. An experimental practice is scheduled. Lists will be presented for the student to enroll in a subgroup of practices (maximum of 8 students), led by his professor of theory. The student should read in advance the text of the practice that will find in the digital campus and must deliver the corresponding report.

4) Note of numerical methods, (NNUM)

Within the theory / problem schedule they will explain (6h) the fundamentals and the methodology of solving problems of heat transfer using numerical methods in finite differences. The students,

a) Deliver at least one exercise at steady state and another at a transient state.

b) Perform a numerical methods exam on Monday, April 24, 2017 from 6:00 p.m. to 8:30 p.m. (it is recommended to carry a programmable calculator)

Next, a simulation work will be explained and (2h) explained how to apply the different boundary conditions with the ANSYS version 18 program for students (32,500 nodes). Organized with groups of 4, students will be offered an exercise in complex geometry, which will have to be solved with this advanced numerical simulation tool. It can be solved in the computer classrooms of the school or at home with the personal PC of each one.

c) Numerical simulation work using ANSYS

Between April 25th and 26th the simulation work will be assigned to ANSYS each group and between 2 and 3 May, this work will be delivered (Athena) (the date and time will be set by the teacher of each group).

A small report must be submitted in Word format, answering all the questions that will be asked to Athena.

From these three notes a), b) and c), the numerical method note (NNUM) will be weighted. 60% is the weight of the exam, 10% in the exercises delivered and 30% the work in ANSYS.

The final note of the final subject is:

\[ N_{FINAL} = 0.20 \times N_{PP} + 0.15 \times N_{NUM} + 0.05 \times N_{LAB} + 0.60 \times N_{EF} \]

\[ N_{FINAL} \] Final note rounded according to current regulations
\[ N_{EF} \] Final exam note
\[ N_{PP} \] Note of the partial test
\[ N_{LAB} \] Laboratory Practice Note
\[ N_{NUM} \] Numeric Methods Note

Exercises performed at home on the proposal of teachers 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.

Only with the 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. Thus, to the reevaluation exam, enters the whole syllabus and the contents of practices. Approximate duration 3-4 h.

N_FINAL_RE = N_EF_RE

Regulations for carrying out activities

During the execution of any of the tests (partial, continuous and final evaluation) only one calculator and one original A4 (two-sided) sheet with all the information that the student deems appropriate may be taken (any form that does not verify these will be removed Requirements).

It is necessary that the examination be carried in the calculator the properties of air and water provided throughout the course (or in any case recorded on the form).

The questions to the teacher can only refer to the understanding of the statement.

ADDITIONAL INFORMATION

LABORATORY PRACTICES (5h)
Registration and start of internships> see information published in the Campus Atena
Documentation> the student must read the script of the practice in the digital campus in advance. Report delivery> At the end of the training session.

VALIDATIONS
It is validated with a note 5 the work of numerical methods and/or laboratory practice (must be approved in a previous term) to students who present an instance in the Thermotechnics Unit, during the first 4 weeks of teaching must request the validation of the corresponding practices. (Include Surname, Name, Identification, e-mail, the call where you passed this practice, and the qualification you obtained). You can deposit it in the box of the Thermotechnical Unit. We do not perform partial validations (only numerical examination, only work with ANSYS, etc.)

Bibliography

Basic:


Complementary: