240171 - Heat Technology

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering
Teaching unit: 724 - MMT - Department of Heat Engines
Academic year: 2018
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
Others: RUIZ MANSILLA RAFAEL
ALEJANDRO GARCIA MONACO
ENRIC VELO GARCIA
GORKA BONALS SASTRE

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.
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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.
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.
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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 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.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group: 55h</th>
<th>36.67%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group: 0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Hours small group: 5h</td>
<td>3.33%</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Self study: 90h</td>
<td>60.00%</td>
</tr>
</tbody>
</table>
### Content

#### INTRODUCTION

**Learning time:** 15h  
Theory classes: 6h  
Self study: 9h

**Description:**  

#### UNIDIMENSIONAL CONDUCTION IN STATIONARY STATE

**Learning time:** 30h  
Theory classes: 12h  
Self study: 18h

**Description:**  

#### NUMERICAL METHODS (STATIONARY AND TRANSITORY STATE)

**Learning time:** 35h  
Theory classes: 14h  
Self study: 21h

**Description:**  

#### CONVECTION

**Learning time:** 22h  
Theory classes: 9h  
Self study: 13h

**Description:**  
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<table>
<thead>
<tr>
<th>THERMAL RADIATION</th>
<th>Learning time: 35h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature and characteristics of thermal radiation.</td>
<td>Theory classes: 14h</td>
</tr>
<tr>
<td>Hemispheric surface flows. Black body.</td>
<td>Self study: 21h</td>
</tr>
<tr>
<td>Intensity of radiation. Planck distribution law.</td>
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<tr>
<td>Greenhouse effect.</td>
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</tbody>
</table>

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.
Qualification system

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) 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. (Also on the bulletin board on the 7th floor) (it is recommended to bring a programmable calculator)

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. It can be resolved in the computer rooms of the school or at home with the personal PC of each one.

c) Numerical simulation work using ANSYS

Each group will have to deliver a zip with ANSYS files, a small report in Word format and in pdf format, answering all the questions asked. These files will be published in Atenea on the date indicated by the teacher.

From these three notes a), b) and c) the note of numerical methods, (NNUM) will be weighted. A 10% is the weight of the exercises delivered (stationary and transitory), a 60% is the weight of the exam and 30% of 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
\( N_{PP} \) Partial test note
\( N_{LAB} \) Note of laboratory practices
\( N_{NUM} \) Numerical 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.

The re-evaluat

**Regulations for carrying out activities**

During the realization of any of the tests (partial exam, numerical methods test, and final exam) the student will be able to take a programmable calculator and an A4 (double-sided) handwritten original with all the information that the student considers appropriate for the respective test (all forms that do not verify these requirements will be removed, for example a photocopy).

It is necessary that in the exam the student has entered in the calculator the properties of the air and water provided throughout the course (or in any case noted on the form).

Questions to the teacher can only refer to the understanding of the statement.

**ADDITIONAL INFORMATION**

**LABORATORY PRACTICES (5h)**
Registration and start of practices: see information published on the Campus Athena.
Delivery of the report: the end of the practice session.

**CONVALIDATIONS**
It is validated with a 5 note of numerical methods and / or laboratory practice (must have it approved in a previous call) to students who submit an instance to the Thermotechnology Unit, during the first 4 school weeks requesting the corresponding validation . (Include Surname, Name, ID, e-mail, call in which approved the practices, and the rating obtained). This request can be delivered by hand to the head of the Laboratory or deposited in the mailbox of the Thermotechnology Unit.

In the convalidation of the note of numerical methods we do not make partial convalidations, that is, we cannot convalidate a part, the ANSYS work for example. If you want to repeat you have to redo the full numerical practice.
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Bibliography

Basic:


Complementary:
