Last update: 08-05-2019

820776 - ITCMM2 - Advanced Course on Heat and Mass Transfer 2

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering
Teaching unit: 724 - MMT - Department of Heat Engines
Academic year: 2019
Degree: MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Teaching unit Optional)
MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Teaching unit Optional)
ECTS credits: 2,5 Teaching languages: Catalan, Spanish, English

Teaching staff

Coordinator: Jesús Castro Gonzàlez

Others: Carlos David Pérez Segarra, Assensi Oliva

Opening hours

Timetable: Tuesday 15h-17h, Wednesday 16h-18h, Thursday 15h-17h

Prior skills

The general aspects of thermodynamics, fluid mechanics and heat transfer and mass.

Requirements

Knowledge equivalent to having completed the course of levelling the Master?s

Degree competences to which the subject contributes

Specific:

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.

Transversal:

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

820776 - ITCMM2 - Advanced Course on Heat and Mass Transfer 2

Teaching methodology

Teaching methodology:

The course teaching methodologies are as follows:

- Lectures and conferences: presentation of knowledge by lecturers or guest speakers.
- Participatory sessions: collective resolution of exercises, debates and group dynamics, with the lecturer and other students in the classroom; classroom presentation of an activity individually or in small groups.
- Theoretical/practical supervised work (TD): classroom activity carried out individually or in small groups, with the advice and supervision of the teacher.
- Homework assignment of reduced extension: carry out homework of reduced extension, individually or in groups.
- Homework assignment of broad extension: design, planning and implementation of a project or homework of broad extension by a group of students, and writing a report that should include the approach, results and conclusions.
- Evaluation activities (EV).

Training activities:

The course training activities are as follows:

- Face to face activities
o Lectures and conferences: learning based on understanding and synthesizing the knowledge presented by the teacher or by invited speakers.
o Participatory sessions: learning based on participating in the collective resolution of exercises, as well as in discussions and group dynamics, with the lecturer and other students in the classroom.
o Presentations (PS): learning based on presenting in the classroom an activity individually or in small groups.
o Theoretical/practical supervised work (TD): learning based on performing an activity in the classroom, or a theoretical or practical exercise, individually or in small groups, with the advice of the teacher.

- Study activities
o Homework assignment of reduced extension (PR): learning based on applying knowledge and presenting results.
o Homework assignment of broad extension (PA): learning based on applying and extending knowledge.
o Self-study (EA): learning based on studying or expanding the contents of the learning material, individually or in groups, understanding, assimilating, analysing and synthesizing knowledge.

Learning objectives of the subject

Objectives:

Formation, at a medium level, in heat transfer by conduction, convection and radiation and fluid dynamics: phenomenological aspects, mathematical formulation (basic conservation laws and constitutive laws) and analytical and numerical resolution techniques. Methodologies of resolution of problems of technological interest which different forms of combined heat transfer are presented.

Learning results:

At the end of the course, the / the student:
- Intensification in the physical description of the phenomena of heat and mass transfer and its mathematical formulation.
- Application of different computational techniques for the numerical solution of these phenomenologies.
- Development of in-house numerical codes to the study of fluid dynamic and thermal behaviour of different cases of technological interest and motivating for students. Emphasis is placed on aspects of code verification, verification of numerical solutions obtained, and validation of the mathematical formulation used.

820776 - ITCMM2 - Advanced Course on Heat and Mass Transfer 2

Study load

	Hours large group:	0h	0.00%
	Hours medium group:	0h	0.00%
	Hours small group:	15h	24.00%
	Guided activities:	0h 49,8m	1.33%
	Self study:	46h 40,8m	74.68%

Total learning time: 62h	

30,6m	

Content

Analysis of gas flows at high speeds	Learning time: 21h 30m Theory classes: 5h Guided activities: 2h Self study : 14h 30m

Description:
Mathematical formulations of gas flows at high speeds (Navier-Stokes equations with consideration of the compressibility effects and phenomena of viscous dissipation). Conditions of stagnation and adiabatic wall temperature. Redefinition of Newton's law of heat transfer by convection. Treatment of the equations of boundary layer flows outside and inside ducts. Description and mathematical treatment of the shock waves. Examples of application nozzles and diffusers.

Specific objectives:
- Mathematical formulation of gas flows at any speed. Possible presence of shock waves.
- Resolution methods of the exterior of surfaces and the interior of constant section or variable section pipes (e.g. nozzles and diffusers).

Heat transfer in rarefied gases	Learning time: 20h 30m Theory classes: 5h Guided activities: 1h 30m Self study : 14h

Description:
Review of the continuum hypothesis and description of the different processes which treat gases required considering their molecular structure. Mathematical description based on the kinetic theory. Boltzmann equation. Gas-surface interaction and boundary conditions of sliding. Fluid dynamic analysis and heat transfer of rarefied gas flows around different objects (plates, cylinders, spheres).

Related activities:
- Theory classes
- Practical classes
- Guided practical work
- Reduced scope work
- Broad scope work

Specific objectives:
- Mathematical description of rarefied gases at arbitrary speeds. Treatment of the boundary conditions (especially fluid-solid interaction).
- Analysis of rarefied gas flows in plates, cylinders and spheres.

Solid-liquid phase change	Learning time: 20h 30m Theory classes: 5h Guided activities: 1h 30m Self study : 14h

Description:
Description of the phenomenology of solid-liquid phase change (solidification, fusion) and application cases. Mathematical formulation and analytical methods of resolution. Current methods of numerical equations. Treatment of complex domains based on computational methods with mesh of fixed discretisation (VOF or Volume of Fluid). Examples of application in cases of accumulation with PCMs (Phase Change Materials) and melting cases.

Related activities:
- Theory classes
- Practical classes
- Guided practical work
- Reduced scope work
- Broad scope work

Specific objectives:
- Description of the phenomenology and mathematical formulation of the phenomena of solid-liquid phase change.
- Analytical methods of resolution and numerical methods of VOF types. Examples of resolution.

Planning of activities

Theory classes	Hours: 20h Self study: 10h Theory classes: 10h

Description:
Methodology in large group. The content of the course follows a model of exhibition and participatory classes. The material is organised into different groups of content according to the areas of knowledge of the course.

Support materials:
Recommended bibliography. Notes from professor (copies and/or ATENEA)

Descriptions of the assignments due and their relation to the assessment:
This activity is evaluated in conjunction with the second activity (problems) through coursework and written test.

Specific objectives:
At the end of this activity, students should be able to master the knowledge, consolidate them and correctly apply them to different technical problems. Moreover, being a techno-scientific subject, the lectures should serve as a basis for the development of other more technical subjects in the related heat fields, such as Refrigeration, Thermal Motors or Solar Energy.

Practical classes	Hours: 11h Guided activities: 1h Self study: 5h Theory classes: 5h

Description:
Methodology in large and medium groups, as long as the availability of the professor allows it. In regards to the themes, there will be some problems in class that students will acquire the necessary guidelines for carrying out this resolution: simplifying assumption, approach, numerical resolution, discussion of the results.

Support materials:
Recommended bibliography. Notes from professor (copies and/or ATENEA)

Descriptions of the assignments due and their relation to the assessment:
This activity is evaluated in conjunction with the first activity (theory) through coursework and written test.

Specific objectives:
At the end of this activity, the student should be able to apply theoretical knowledge to solve different types of problems. Given the methodology the student should be able to:
1. Understand and analyse the problem.
2. Propose and develop a scheme resolver.
3. Solve the problem using the suggested equations with an adequate resolution algorithm.
4. Critically interpret the results.

Guided practical work	Hours: 6h Theory classes: 1h Self study: 5h

Description:

Students must make theoretical-practical guided work. The work consists in solving small problems which data may be both from results of a laboratory experiment or from data suggested by the teacher. The structure to be followed:
- Preparation of the activity using a manual of practice.
- Groups of 2 or 3 people with a maximum duration of 2 hours.
- Discussion of the results obtained and the problems that have arisen during the course of the activity.
- Completion of a report on the activity carried out with results, questions and conclusions. This report will be evaluated together with the completion of the activity.

Support materials:

Recommended bibliography. Notes from professor (copies and/or ATENEA)

Descriptions of the assignments due and their relation to the assessment:

The reports will follow guidelines given in class.

Specific objectives:

Consolidate the knowledge acquired in theory and practical classes.

Reduced scope work	Hours: 6h Theory classes: 1h Self study: 5h

Description:

Resolution of two problems based on situations posed by the teacher.

Support materials:

Recommended bibliography. Notes from professor (copies and/or ATENEA)

Descriptions of the assignments due and their relation to the assessment:

The reports will follow guidelines given in class.

Specific objectives:

Consolidate the knowledge acquired in theory and practical classes.

Broad scope work	Hours: 8h 30m Theory classes: 1h Self study: 7h 30m

Description:

Resolution of a problem based on situations posed by the teacher or student.

Support materials:

Recommended bibliography. Notes from professor (copies and/or ATENEA)

Descriptions of the assignments due and their relation to the assessment:

The reports will follow guidelines given in class.

Specific objectives:

Expand and consolidate the knowledge acquired in theory and practical classes.

Written Test	Hours: 11h Guided activities: 1h Self study: 10h

Description:
Development of the testing of the knowledge of the course content 1 and 2. It includes theoretical and development problems.

Support materials:
Recommended bibliography. Notes from professor (copies and/or ATENEA)

Descriptions of the assignments due and their relation to the assessment:
The exams will be held freely and delivered together with the duly completed statement with the personal data required.

Specific objectives:
Show the level of knowledge achieved in theoretical activities and problems.

Qualification system

Written test (PE). 50%
Work performed individually or in groups (TR). 40%
Attendance and participation in practical activities (AP). 5%
Quality and performance of group work (TG) 5%

Regulations for carrying out activities

Here are the rules of the system for evaluating the educational activities of the course.

Written test (PE).

There will be a final exam for the course. Students must complete both theoretical questions and problems related to the theoretical and practical content of the course. Reviews and/or claims regarding the examinations will be conducted according to the dates and times established in the academic calendar.

Work done individually or in groups along the course (TR).

Students must follow the instructions explained in class and contained in the file for the work that will be proposed to the student in relation to different teaching content of the course. As a result of these activities, students must submit a report (preferably in PDF format) to the professor, with the deadline to be fixed for each activity. The evaluation work will involve both its realisation and a possible defense.

Attendance and participation in classes and laboratories (AP).

The labs will be assessed both in their implementation and in the implementation of practical exercises that will be proposed; they can begin during the class schedule planned for this type of activity to be completed (if applicable) as an autonomous activity, following the instructions given in class. The results of practical exercises delivered to the teacher must follow the instructions given in class.

The evaluation of the practice will involve both its realisation and a possible defense.

Quality and performance of group work (TG).

The reports of practices and/or group work will be assessed individually on the oral defense if necessary or of any single group on the report.

820776 - ITCMM2 - Advanced Course on Heat and Mass Transfer 2

Bibliography

Basic:

Bergman, Theodore L.. Fundamentals of heat and mass transfer. 7th ed. Hoboken, NJ: John Wiley & Sons, cop. 2011. ISBN 9780470501979.

Eckert, E. R. G.; Drake, Robert M. Heat and mass transfer. 2nd ed. New York [etc.]: McGraw-Hill, 1959. ISBN 0070189242.

Thompson, Philip A. Compressible-fluid dynamics. New York, [etc.]: McGraw-Hill, 1972. ISBN 0070644055.

Patankar, Suhas V. Numerical heat transfer and fluid flow. Washington : New York: Hemisphere ; McGraw-Hill, cop. 1980. ISBN 0891165223.

Cebeci, Tuncer. Computational fluid dynamics for engineers : from panel to navier-stokes methods with computer programs [on line]. Long Beach, CA : New York: Horizons ; Springer, cop. 2005 [Consultation: 11/10/2016]. Available on: <http://dx.doi.org/10.1007/3-540-27717-X>. ISBN 3540244514.

Shapiro, Ascher H. The Dynamics and thermodynamics of compressible fluid flow. New York: John Wiley & sons, cop. 1953. ISBN 0471066915.

Anderson, John David. Computational fluid dynamics. New York [etc.]: McGraw-Hill, cop. 1995. ISBN 0070016852.

Complementary:

Rohsenow, Warren M; Hartnett, J. P; Cho, Young I. Handbook of heat transfer. 3rd ed. New York [etc.]: McGraw-Hill, cop. 1998. ISBN 0070535558.

Lakshminarayana, Budugur. Fluid dynamics and heat transfer of turbomachinery. New York [etc.]: John Wiley & Sons, cop. 1996. ISBN 0471855464.

Ferziger, Joel H; Peric, Milovan. Computational methods for fluid dynamics. 3rd, rev. ed. Berlin [etc.]: Springer, cop. 2002. ISBN 3540420746.

Prosperetti, Andrea; Tryggvason, Gretar. Computational methods for multiphase flow. Cambridge ; New York: Cambridge University Press, 2009. ISBN 0521138612.

Colin Tong, Xingcun. Advanced materials for thermal management of electronic packaging [on line]. New York: Springer, cop. 2011 [Consultation: 11/10/2016]. Available on: <http://dx.doi.org/10.1007/978-1-4419-7759-5>. ISBN 9781441977595.

Others resources:

Audiovisual material

Transparencies from class

Resource

Notes

Resource