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# 205016 - Advance Course Heat and Mass Transfer

Coordinating unit: 205 - ESEIAAT - Terrassa School of Industrial, Aerospace and Audiovisual Engineering

Teaching unit: 724 - MMT - Department of Heat Engines

Academic year: 2018

Degree: MASTER'S DEGREE IN AERONAUTICAL ENGINEERING (Syllabus 2014). (Teaching unit Optional)
MASTER'S DEGREE IN SPACE AND AERONAUTICAL ENGINEERING (Syllabus 2016). (Teaching unit Optional)

ECTS credits: 5 Teaching languages: English

## Teaching staff

Coordinator: Jesus Castro

Others: Carlos David Pérez Segarra
Assensi Oliva

## Teaching methodology

During the development of the course will be used the following teaching methods:
- Lecture or conference: presentation of knowledge by teachers through lectures by outsiders or by guest speakers.
- Participatory classes: collective resolution of exercises, conducting debates and group dynamics with the teacher and other students in the classroom; presentation of a classroom activity performed individually or in small groups.
- Presentations: introduce a classroom activity performed individually or in small groups (in person).
- Theoretical and practical guided work: conducting a classroom activity or exercise in theoretical or practical, individually or in small groups, with the advice of the teacher.
- Project, activity or work of reduced scope): learning based on performing individually or in group a work of reduced complexity or length, applying knowledge and presenting results.
- Project or work of high scope: learning based on the design, planning and implementation of a project in group with a complete degree of complexity, applying and expanding knowledge. A report has to be written explaining this approach, the results and conclusions.
- Activities Evaluation.

Training activities:
During the development of the course will be used in the following training activities:
- Face to face activities:
* Lectures and conferences: meet, understand and synthesize the knowledge presented master classes by teachers or lecturers.
* Participatory classes: participate in resolving collective bargaining exercises, as well as debates and group dynamics with the teacher and other students in the classroom.
* Guided theoretical work or study: perform an activity in the classroom or practical or theoretical exercise, individually or in small groups, with the advice of the teacher.
- Distant participation activities:
* Project, activity or work of reduced scope: carried out individually or in groups, work of reduced complexity or length, applying knowledge and presenting results (oral defence).
* Work of high scope: design, plan and carry out of a project or work of complete complexity individually or in a group, applying and expanding the acquired knowledge. A report has to be written explaining the approach, the results and the conclusions (oral defence).
* Self-Study: study or expand the content of the subjects individually or in groups, understanding, assimilating, analysing and synthesizing knowledge.

## Learning objectives of the subject

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## Study load

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|---|---|---|---|
| Total learning time: 125h | Hours large group: | 30h | 24.00% |
| | Hours medium group: | 0h | 0.00% |
| | Hours small group: | 15h | 12.00% |
| | Guided activities: | 0h | 0.00% |
| | Self study: | 80h | 64.00% |

## Content

| Module 1: Mathematical formulation of heat transfer and fluid dynamics | Learning time: 21h<br>Theory classes: 6h<br>Laboratory classes: 3h<br>Self study : 12h |
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**Description:**
Basic mathematical formulation in integral form of the phenomena of fluid dynamics and heat transfer: isolated systems, closed systems, interaction with the outside, point of view of Euler and Lagrange (particle and finite volume); open systems. Vector and tensor notation. Mathematical formulation in differential form: basic equations (conservation of mass, momentum, energy, entropy) and derived equations (kinetic energy, vorticity, heat, exergy ...). Constitutive laws.

**Related activities:**
- Theory class
- Practical class
- Practical work
- Reduced scope work
- High scope work

| Module 2: Introduction to turbulence. | Learning time: 27h<br>Theory classes: 7h<br>Laboratory classes: 3h<br>Self study : 17h |
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**Description:**
Introduction to mathematical formulation of turbulent flows. Physical fundamentals of turbulence and statistical characterization. Direct Numerical turbulence (DNS, Direct Numerical Simulation): possibilities and limitations. Temporarly averaged Navier-Stokes equations and turbulence models RANS (Reynolds-averaged Navier-Stokes): high and two low-Reynolds-equation models, wall functions, differentially-stress models, etc. Basic mathematical formulation LES (Large Eddy Simulation) type models, averaged in volume. Brief introduction to numerical methods for solving the Navier-Stokes equations.

**Related activities:**
- Theory class
- Practical class
- Practical work
- Reduced scope work
- High scope work

| Module 3: Resolution of convection by domains. Boundary layer and potential zones. | Learning time: 24h<br>Theory classes: 5h<br>Laboratory classes: 3h<br>Self study : 16h |
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Description:
Zonal resolution of the flow by dividing the domain in not viscous region and boundary layers (hydrodynamic and thermal). Formulation of the equations for the not viscous area (Euler equations). Formulation of the equations for boundary layers laminar and turbulent (analysis of orders of magnitude). Review of analytical solutions of the equations of laminar boundary layers (hydrodynamic and thermal) in isothermal plates and integral methods. Introduction to numerical methods for solving boundary layers laminar and turbulent. Coupling of the not viscous area and the boundary layers (concept of displacement thickness and zonal general methods).

Related activities:
- Theory class
- Practical class
- Practical work
- Reduced scope work
- High scope work

| Module 4: Radiation heat transfer | Learning time: 27h<br>Theory classes: 6h<br>Laboratory classes: 3h<br>Self study : 18h |
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Description:
Numerical resolution of radiation phenomena. Specific intensity of radiation. General formulation of the fundamental equation of radiation (or radiative transfer Equation RTE). Review of methods of analysis of radiation in not participanting media. Extension of the formulation in participant media. Introduction to numerical techniques of spectral and directional radiation intensity according DOM methods (Discrete Ordinate Methods) and FVM (Finite Volume Method).

Related activities:
- Theory class
- Practical class
- Practical work
- Reduced scope work
- High scope work

| Module 5: Vapor-liquid phase change | Learning time: 26h<br>Theory classes: 6h<br>Laboratory classes: 3h<br>Self study : 17h |
|---|---|

**Description:**
Analysis of the phenomenology of vapor-liquid phase change (condensation and evaporation). Mathematical formulation of film condensation in isothermal vertical plates. Analytical Resolution methods and extension to complex situations using computational methods. Condensation on the outside of horizontal tubes. Evaporation phenomena in free surfaces. Mathematical formulation of the phenomenology of fluid dynamics and heat and mass transfer. Fick's law and treatment ofthe boundary conditions. Examples resolution. Analysis of two-phase flows (evaporation or condensation) inside ducts. Different levels of simulation.

**Related activities:**
- Theory class
- Practical class
- Practical work
- Reduced scope work
- High scope work

## Qualification system

Written test control knowledge (PE) - 50%
Work done individually or in groups along the course (TR) - 40%
Attendance and participation in classes and laboratories (AP) - 5%
Quality and performance of group work (TG) - 5%

## Bibliography