# Course guide
# 220067 - ATFD - Analysis of Thermal and Fluid Dynamics Issues in Industrial And/Or Aeronautical Systems and Equipment

**Last modified:** 19/04/2023

**Unit in charge:** Terrassa School of Industrial, Aerospace and Audiovisual Engineering
**Teaching unit:** 724 - MMT - Department of Heat Engines.

**Degree:** BACHELOR'S DEGREE IN AEROSPACE TECHNOLOGY ENGINEERING (Syllabus 2010). (Optional subject).
BACHELOR'S DEGREE IN AEROSPACE VEHICLE ENGINEERING (Syllabus 2010). (Optional subject).
BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Optional subject).

**Academic year:** 2023 **ECTS Credits:** 3.0 **Languages:** English

## LECTURER

**Coordinating lecturer:** CARLOS DAVID PEREZ SEGARRA - ASENSIO OLIVA LLENA

**Others:** XAVIER TRIAS - JORGE CHIVA

## DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

**Specific:**
1. An understanding of, and skills for, the modelling and simulation of systems
2. An understanding of applied thermodynamics and heat transfer: basic principles and their application to solving engineering problems
3. An understanding of the basic principles of fluid mechanics and their application in solving engineering problems. The ability to calculate pipes, channels and fluid systems.
4. Applied knowledge of the fundamentals of fluid-mechanics systems and machines.
5. Applied knowledge of thermal engineering
6. GrETA/GrEVA - An adequate understanding of the following, as applied to engineering: concepts and laws that govern the processes of energy transfer, the movement of fluids, the mechanisms of heat transfer and phase transition, and their role in analysis of the main aerospace propulsion systems.
7. GrETA/GrEVA - An adequate understanding of the following, as applied to engineering: the basics of fluid mechanics; the basic principles of flight control and automation; the main characteristics and physical and mechanical properties of materials
8. GrETA/GrEVA - An understanding of the thermodynamic cycles of generators of mechanical power and thrust
9. GrETA/GrEVA - Applied knowledge of materials science and technology; mechanics and thermodynamics; fluid mechanics; aerodynamics and flight mechanics; navigation systems and air traffic; aerospace technology; structural theory; economy and production; projects; environmental impact.
10. Applied knowledge of: aerodynamics; mechanics and thermodynamics, flight mechanics, aircraft engineering (fixed wing and rotary wing), and theory of structures. (Specific technology module)
11. Adequate applied knowledge in: aerodynamics, mechanics, and thermodynamics, flight mechanics, aircraft engineering (fixed-wing and rotary-wing), and theory of structures. (Specific technology module: Aircraft)
12. Adequate and applied knowledge in engineering: fundamentals of fluid mechanics describing flow in all regimes to determine pressure distributions and forces on aircraft. (Specific technology module: Aircraft)
13. GrETA - An adequate understanding of the following, as applied to engineering: the fundamentals of fluid mechanics describing flow in all regimes in order to determine the distributions of pressures and forces acting on aircraft.

## TEACHING METHODOLOGY

The first lecture is dedicated to a general overview/description of different thermal systems and equipment in the industrial and aeronautical sectors. The main physical phenomena which limit their behaviour are then identified, with special emphasis in the thermal and fluid dynamic issues. Furthermore, a quick revision of the mathematical formulation is also carried out.
The students are encouraged to select a technical application of their interest. The subject proposed by the student is discussed with the lecturers in order to highlight its pros and cons, and to define an adequate strategy of analysis and simulation/s level/s. Periodic contacts between the students and the lecturers are favoured to assure an adequate progress.
The second part of the course shows a selected group of thermal systems and equipment in more detail. The lecture starts with a brief description of the specific application and its mathematical formulation (at different levels of analysis). After that, the methodology for solving the equations is explained, from CFD&HT methods to zero-dimensional balances. Finally, the most relevant working parameters are presented together with some examples.
All the above mentioned lectures will consist of a theoretical part where different exercises are solved in the lecture room.
The practical part of the course is focussed, as mentioned before, on the individual work (maximum two people) carried out by the students. This work starts with the definition of the problem to be analyzed, description of its mathematical formulation and the methodology of solution. A code (software) is then developed to simulate the chosen case together with the strategies used to verify whether the code is free of errors. The different numerical parameters (mesh densities, numerical schemes, relaxation factors, convergence criteria, etc.) used in the simulation are then analysed. Finally, the code is used to study the thermal and fluid dynamic behaviour of the studied case. Contacts with the students will be mainly carried out by email and ATENEA, and also offering individual meetings.
To review the knowledge acquired by the students, two exams will be carried out. The first one (partial exam) will cover approximately 40% of the topics presented in the course. The second one (final exam) involves all the topics presented in the course. Apart from that, the practical work is reviewed individually based on the report developed by the student and an oral presentation of the work .

## LEARNING OBJECTIVES OF THE SUBJECT

The goal of the course is to identify and evaluate the main thermal and fluid dynamic aspects which limit the behaviour of different thermal systems and equipment in both the industrial and the aeronautical sectors.
Examples of these systems and equipment can be found in the refrigeration field, HVAC (heating, ventilation and air conditioning) systems, active and passive solar energy, heat exchangers, CSP (concentrating solar power) plants, combustion engines (turbines, reciprocating engines, etc.), thermal systems in aircrafts and spacecrafts, aerodynamic designs, wind turbines, bioclimatic architecture, electric motors, electric and electronic components, TES (thermal energy storage) systems, aerospace heat accumulators, etc.
For the different representative cases mentioned above, a detailed description together with its main characteristics and working parameters are presented and discussed. Their mathematical formulation is then developed. Adequate computational methodologies at different levels, from CFD&HT (computational fluid dynamics and heat transfer) to zero-dimensional models, are shown. Therefore, the design and optimization of most thermal systems and equipment involve the solution of both multi-physic and multi-scale phenomena in a couple way and using different levels of analysis. The students will mainly use the knowledge acquired during their Degree to carry this out.
Early in the course, the students are encouraged to choose the subject of a practical work according to their interests and motivations. During the course, the students will develop their own code with the personalized support of the lecturers.

## STUDY LOAD

| Type | Hours | Percentage |
|---|---|---|
| Hours large group | 30,0 | 40.00 |
| Self study | 45,0 | 60.00 |

**Total learning time:** 75 h

## CONTENTS

**Module 1: General overview of different thermal systems and equipment**

**Description:**
This module is dedicated to a general overview of different technological problems where their design and optimization are strongly dependent on their thermal and fluid dynamic behaviour.
After main physical phenomena are identified, a short review of the fundamental equations which describe their thermal and fluid dynamic behaviour is given.

**Related activities:**
Individual meetings with the students in order to chose and define the practical work to be carried out.

**Full-or-part-time:** 8h
Theory classes: 4h
Self study : 4h

**Module 2: Detailed analysis of different thermal systems and equipment**

**Full-or-part-time:** 67h
Theory classes: 26h
Self study : 41h

## GRADING SYSTEM

The final grade depends on the following assessment criteria and weights:
- partial exam: 20%;
- Final exam: 35%;
- Lab work: 45%.

## BIBLIOGRAPHY

**Basic:**
- Patankar, Suhas V. Numerical heat transfer and fluid flow [on line]. New York: McGraw-Hill, 1980 [Consultation: 16/11/2022]. Available on: https://www-taylorfrancis-com.recursos.biblioteca.upc.edu/books/mono/10.1201/9781482234213/numerical-heat-transfer-fluid-flow-suhas-patankar. ISBN 0070487405.
- Ferziger, J.H.; Peric, M. Computational methods for fluid dynamics. 3rd ed. Berlin: Springer, 2002. ISBN 3540420746.
- Bergman, T.L.; Lavine, A.S,; Incropera, F.P. Fundamentals of heat and mass transfer. 7th ed. Hoboken, N.J: John Wiley & Sons, 2011. ISBN 9780470501979.
- Schlichting, H.; Gersten, K. Boundary-layer theory. 8th ed. Berlin: Springer-Verlag, 2000. ISBN 3540662707.