



# Course guide

## 240649 - 240649 - Aerodynamics

**Last modified:** 15/06/2023

**Unit in charge:** Barcelona School of Industrial Engineering  
**Teaching unit:** 729 - MF - Department of Fluid Mechanics.

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

**Academic year:** 2023    **ECTS Credits:** 4.5    **Languages:** English

### LECTURER

**Coordinating lecturer:** Alexandre Presas

**Others:** Alexandre Presas

### PRIOR SKILLS

Basic knowledge on physics and mechanics

### TEACHING METHODOLOGY

There are two types of sessions: theoretical and practical . In the theoretical sessions the teacher will explain the relevant subject .In practical sessions , through a program of simulation , students will implementt different studied cases.

### LEARNING OBJECTIVES OF THE SUBJECT

The aim of the subject is to introduce the student to the world of aerodynamics with the three most important applications in engineering: aviation, automotive and buildings. The main phenomena that take place in the three cases will be considered from a conceptual and very practical point of view, although laying the fundamental theoretical concepts.

### STUDY LOAD

Type	Hours	Percentage
Self study	67,5	60.00
Hours medium group	45,0	40.00

**Total learning time:** 112.5 h



## CONTENTS

### 1. WHAT IS AERODYNAMICS?

**Description:**

In this chapter is shown the importance of aerodynamics in the evolution of the three fields of application that will be studied throughout the course: aviation, automotive and buildings. For this reason, a brief overview of the history of the flight is made, beginning with the aerostatic flights, then the first motorized flights, and ending by the existing planes. Aerodynamics (meaning air in motion) is the science that has made this evolution possible and which helps to understand the flight of the aircraft. The application of the principles of aerodynamics in the automotive field was carried out later, but they have allowed the drastic reduction of drag of vehicles. As regards buildings, the knowledge of non-stationary phenomena has allowed us to design increasingly slender forms.

**Specific objectives:**

Let the student see the importance of aerodynamics in the three fields where it will be applied and begin to become familiar with the fundamental concepts of the subject.

**Full-or-part-time:** 2h

Practical classes: 2h

### 2. LIFT

**Description:**

The fundamental physical principles that explain the lift are introduced when a flow surrounds a body. First of all, wing profiles are studied. The generation of the lift in a generic profile is studied in detail, as it increases with the inclination of the plane until the stall. A review is made of the evolution of the profiles and their special nomenclature. Finally, the three-dimensional effects due to the finite dimensions of the wing are treated. The coefficient of support is introduced as a dimensionless dimension and the representations of this one in function of the angle of attack. To improve the lift, some elements are defined: flaps and spoilers.

The second part of the chapter deals with the subject of vehicle lift, collecting the concepts explained by aircraft. In this case, the desired effect is the opposite, that is to say, it is about getting negative lift and the elements to do it, especially in competing cars.

At the end of the chapter there will be mention of special cases in which in the buildings the lift force must be taken into account

**Specific objectives:**

Let the student understand how the support is generated in an airplane wing profile and the difference between the different types of profiles.

Know the phenomenon of loss entry profiles, although the physical explanation will come in the next chapter.

Know the devices that are added to the wing to increase the support

Know the three-dimensional effects due to the finite width of the wings.

Understand and know the support that is generated in a vehicle and how to counteract it

Let him know what elements of a building can generate positive sustainability by jeopardizing the structure

**Full-or-part-time:** 4h

Practical classes: 4h



### 3. DRAG AND THRUST

**Description:**

The concept of drag is introduced by a body that is surrounded by air. The effect of the friction with the wall is studied, the concept of the boundary layer is introduced, and the effect of the wake due to the detachment of the boundary layer in non-aerodynamic bodies is also studied. The dimensionless coefficient drag is introduced and it is applied to the case of blunt bodies such as vehicles and buildings. The case of thin bodies such as wing profile is also introduced. In the cases of cars and airplanes (when they land or take off), the ground effect is taken into account. On the other hand, thrust is the force that must be generated in order to overcome the natural resistance of drag. For the case of the planes, the principles of propulsion are briefly discussed.

**Specific objectives:**

Let the student understand the physical principles of drag in bodies surrounded by fluids.

Let him know how to distinguish the different types of drag according to the body to study.

Let's see how to minimize the drag to improve the consumption of vehicles and planes.

Understand the importance of wake in all cases and the non-stationary phenomena that can take place in it

Know the fundamental principles of propulsion in the aircraft

**Full-or-part-time:** 5h

Practical classes: 5h

### 5.PERFORMANCE

**Description:**

Combined the effects of drag and thrust the airplane's and vehicles performance can be determined. This chapter examines how the forces on the airplane and on the cars affect its behaviour in this areas. In general, lower drag and higher thrust would improve performance in planes, and lower drag and lower thrust in cars would improve performance. But there are limits on what is possible, and the degree to which performance improves with changes in planes or cars is not quite so obvious.

**Specific objectives:**

Understand what the requirements are for maximum performance.

Find the most suitable forms for the minimum drag in both cars and aircraft wing profiles ..

**Full-or-part-time:** 5h

Practical classes: 5h

### 5. STABILITY AND CONTROL

**Description:**

The forces generated produce a moment that must be compensated for stability in the flight of the aircraft and in the trajectory of the vehicle. We study the moments generated and discuss how to achieve the balance and stability of aircraft and cars with different control systems.

**Specific objectives:**

Let them know the resulting moments that are generated on the planes, cars and buildings.

To know the control mechanisms to achieve balance and stability in the studied cases

**Full-or-part-time:** 4h

Practical classes: 4h



## 6. HIGH SPEED FLIGHT

### Description:

When flights occur at high speeds, changes in air density must be considered and the flow study around the profiles becomes more complicated. In this chapter we study the effects that occur when the flights are at speeds higher than the sound velocity, and which forms have to adopt the wing profiles and the airplanes to have a good behavior from the point of fluiddynamic view.

### Specific objectives:

- To understand the difference between subsonical and supersonic flight
- To understand the shock wave concept
- To understand the forms that the profiles must adopt in order to fly at higher speeds (supersonic)

**Full-or-part-time:** 5h

Practical classes: 5h



## ACTIVITIES

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### SIMULATION OF FLOW FLUID AROUND A BODY.AERODYNAMIC OPTIMIZATION OF

**Description:**

Some initial geometries of different bodies are presented. Students have to choose one of them. From basic geometry , forces and moments exerted on the body by the fluid are calculated by fluid ynamic simulation (software FLUENT-ANSYS ). From there, according to the chosen body, students will propose geometrical improvements to achieve better aerodynamic performance.

**Specific objectives:**

The main objective is that the student solves a aerodynamics problem in general. To improve some parts of the geometry, a fluid dynamics analysis of the initial geometry is done. Then he can verify the improvement from the point of view of numerical simulation. This should be done throughout the course, so he can go applying his knowledge.

**Material:**

Package ANSYS-FLUENT includes CAD program for manipulating geometry, meshing program to define the various points where the fluid equations have to be solved and simulation program to make the calculations and solve the problem. The program is available to students not only during classes but always throughout the school year . Necessary tutorials to get started with the program are also available.

**Delivery:**

Deliveries will be made in three parts along the course. The last part will include an oral presentation of the work done.

**Full-or-part-time:** 15h

Laboratory classes: 15h

## GRADING SYSTEM

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final mark=0.5\*final exam+0.2\*midterm exam+0.3\*simulation work



## BIBLIOGRAPHY

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### Basic:

- Smith, Hubert ; H. C. Smith. The illustrated guide to aerodynamics. 2nd ed. New York: Mc Graw Hill, 1992. ISBN 9780830639014.
- John D. Anderson. Fundamental of aerodynamics. 5th ed. Singapore: Mc Graw Hill, 2011.
- Houghton, E.L. et al. Aerodynamics for Engineering Students [on line]. 6th ed. Amsterdam: Elsevier Science, 2013 [Consultation: 08/07/2022]. Available on: <https://www.sciencedirect-com.recursos.biblioteca.upc.edu/book/9780080966328/aerodynamics-for-engineering-students>. ISBN 9780080966328.

### Complementary:

- A J Scibor-Rylski. Road Vehicle Aerodynamics. London: Pentech, 1984. ISBN 9780727318053.