

Academic Year: ( 2023 / 2024 )

Review date: 04-11-2022

Department assigned to the subject: Aerospace Engineering Department

Coordinating teacher: FLORES ARIAS, OSCAR

Type: Compulsory ECTS Credits : 6.0

Year : 1 Semester : 1

**REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)**

Fluid mechanics  
Aerodynamics  
Numerical methods

**OBJECTIVES**

To acquire an advanced and applied knowledge in numerical methods and computational fluid mechanics, with application to internal and external aerodynamics.  
To acquire a basic knowledge of turbulence modeling techniques.

**DESCRIPTION OF CONTENTS: PROGRAMME**

- 1 Introduction to Computational Aerodynamics
- 2 The mathematical models for fluid flow simulations
  - 2.1 The equations of fluid dynamics
  - 2.2 The mathematical nature of the flow equations and boundary conditions
- 3 Discretization Techniques
  - 3.1 Finite Difference Methods
  - 3.2 Finite Volume Methods
  - 3.3 Structured and Unstructured Grids
- 4 The analysis of numerical schemes
  - 4.1 Consistency, Stability and Error Analysis
- 5 The resolution of numerical schemes
  - 5.1 Time integration methods
  - 5.2 Iterative methods for the resolution of algebraic systems
- 6 Applications to inviscid and/or viscous flows
- 7 Introduction to Turbulence and its modeling
  - 7.1 Direct numerical simulation (DNS)
  - 7.2 Large Eddy simulation (LES)
  - 7.3 Reynolds-averaged Navier-Stokes (RANS)

**LEARNING ACTIVITIES AND METHODOLOGY****LEARNING ACTIVITIES**

- Theory sessions.
- Problem sessions working individually and in groups.
- Lab-sessions with mathematical software.
- Individual work by the student

**METHODOLOGY**

- Teacher's presentations in class with the support of audiovisual media, in which the main concepts of the subject are explained. The corresponding bibliography is provided to complement the student's learning.
- Critical reading of texts recommended by the professor of the subject: reports, manuals, and/or academic articles, either for subsequent discussion in class, or to expand and consolidate knowledge of the subject.
- Resolution (individually or in groups) of practical cases, problems, etc.

- Work on projects and reports, individually or in groups

#### ASSESSMENT SYSTEM

End-of-term exam (25%)  
Continuous evaluation (75%)

The continuous evaluation may include lab sessions, group projects, exams in the computer room, etc.

The end-of-term exam may consist of a written part and/or exercises in the computer room.

In order to pass the subject, two requirements need to be met:

- 1) to have a minimum grade of 4.0/10 in the end-of-term exam;
- 2) to have a minimum overall grade of 5.0/10 (weighing 25% the end-of-term exam and 75% the continuous evaluation).

In the extraordinary call only, it will be possible to pass the subject either by meeting the previous two requirements or by having a minimum grade of 5.0/10 in the final exam.

<b>% end-of-term-examination:</b>	25
<b>% of continuous assessment (assignments, laboratory, practicals...):</b>	75

#### BASIC BIBLIOGRAPHY

- C. Hirsch Numerical Computation of Internal and External Flows, Elsevier, 2007
- Robert W. MacCormack Numerical Computation of Compressible and Viscous Flow, AIAA Education Series, 2014

#### ADDITIONAL BIBLIOGRAPHY

- J.D. Anderson Computational Fluid Dynamics. The Basics with applications, McGraw Hill, 1995
- J.H. Ferziger & M. Peric Computational Methods for Fluid Dynamics, Springer, 2013
- S. Pope Turbulent flows , Cam. Univ. Press, 2000