Guia docent
390438 - FMBE - Introducció a la Modelització de Fluids en la Bioenginyeria

Última modificació: 19/01/2026

Unitat responsable: Escola d'Enginyeria Agroalimentària i de Biosistemes de Barcelona
Unitat que imparteix: 745 - DEAB - Departament d'Enginyeria Agroalimentària i Biotecnologia.

Titulació: GRAU EN ENGINYERIA DE SISTEMES BIOLÒGICS (Pla 2009). (Assignatura optativa).

Curs: 2025 **Crèdits ECTS:** 3.0 **Idiomes:** Anglès

PROFESSORAT

Professorat responsable: Ramón Salcedo Cidoncha

Altres:

CAPACITATS PRÈVIES

Students are expected to have a basic background in physics and mathematics. Prior knowledge of hydraulics and differential equations is recommended, including familiarity with fundamental concepts such as conservation laws, pressure, velocity fields, and flow regimes. Basic skills in scientific reasoning, data interpretation, and the use of engineering software tools are also advisable. No prior experience with Computational Fluid Dynamics (CFD) is required, as the course introduces these concepts progressively.

REQUISITS

There are no mandatory prerequisites for enrollment in this course. It is recommended that students follow the guidance provided in the “Previous capacities” section to ensure an adequate background for the successful completion of the subject.

METODOLOGIES DOCENTS

The course is eminently applied and structured around the progressive development of a single two-dimensional CFD case study throughout the course. Most class time is dedicated to practical work, during which students actively build, analyze, and refine a numerical model using Computational Fluid Dynamics (CFD) tools.

Preliminary theoretical explanations will provide the necessary physical and mathematical foundations for understanding modeling decisions, such as turbulence representation, meshing strategies, boundary condition definition, and results interpretation. These concepts are immediately applied to the ongoing practical case study, reinforcing learning through direct implementation.

Students continuously work on the same CFD problem: a 2D flow simulation explored in different fluid scenarios relevant to bioengineering applications. This approach allows students to thoroughly experience the entire modeling workflow, from problem definition to simulation validation. Learning is based on active participation, guided problem-solving, and iterative improvement of the model.

OBJECTIUS D'APRENENTATGE DE L'ASSIGNATURA

The main objective of this course is for students to learn, understand, and apply the principles of fluid modeling in bioengineering contexts through the practical use of Computational Fluid Dynamics (CFD) tools. By the end of the course, students will be able to formulate a basic two-dimensional CFD problem relevant to the field of biosystems engineering. Students will learn the concepts of computational meshes, boundary conditions, and numerical simulations, as well as how to critically analyze and interpret results. Furthermore, the course aims to develop students' ability to validate models, evaluate their limitations, and clearly communicate technical findings in writing.

HORES TOTALS DE DEDICACIÓ DE L'ESTUDIANTAT

Tipus	Hores	Percentatge
Grup petit/Laboratori	10,0	8.33
Grup mitjà/Pràctiques	20,0	16.67
Aprenentatge autònom	90,0	75.00

Dedicació total: 120 h

CONTINGUTS

1. Problem definition and physical flow interpretation

Descripció:
Definition of the bioengineering problem to be modeled throughout the course. Analysis of the physical system, identification of the computational domain, main modeling assumptions, and relevant flow variables. Introduction to the case study that will be progressively developed using CFD.

Objectius específics:
To understand the bioengineering problem to be modeled, correctly interpret the physical flow behavior, identify the required assumptions, and select the relevant variables for CFD model formulation.

Activitats vinculades:
- Theoretical introduction to the bioengineering problem and physical system.
- Definition of the computational domain and boundary conditions.
- Guided analysis of the case study and flow variables.
- Deliverable

Dedicació: 10h
Grup mitjà/Pràctiques: 2h
Grup petit/Laboratori: 1h
Aprenentatge autònom: 7h

2. Geometry creation and mesh generation

Descripció:
Creation of the two-dimensional geometry of the case study and generation of the computational mesh. Mesh refinement strategies, quality criteria, and assessment of mesh suitability for CFD simulations are addressed

Objectius específics:
To define the two-dimensional geometry of the problem, generate an appropriate computational mesh, and assess its quality to ensure the consistency of the CFD model.

Activitats vinculades:
- Creation of the two-dimensional geometry of the case study.
- Generation of the computational mesh.
- Application of mesh refinement strategies.
- Analysis of mesh quality using technical criteria.
- Deliverable

Dedicació: 13h
Grup mitjà/Pràctiques: 3h
Grup petit/Laboratori: 2h
Aprenentatge autònom: 8h

3. Boundary conditions and numerical setup

Descripció:
Definition of boundary conditions, selection of physical models, solver configuration, and specification of numerical parameters required for CFD simulations.

Objectius específics:
To learn how to define boundary conditions and numerical parameters for ensuring a stable and physically consistent CFD simulation.

Activitats vinculades:
- Definition of boundary conditions for the case study.
- Selection of physical models (turbulence, flow, etc.).
- Configuration of the solver and numerical parameters.
- Deliverable

Dedicació: 20h
Grup mitjà/Pràctiques: 3h
Grup petit/Laboratori: 2h 30m
Aprenentatge autònom: 14h 30m

4. Simulation and post-processing

Descripció:
Execution of CFD simulations and post-processing of results, including visualization and extraction of relevant flow variables.

Objectius específics:
To run CFD simulations correctly and interpret flow results through appropriate post-processing techniques

Activitats vinculades:
- Execution of CFD simulations for the case study.
- Analysis of numerical solution convergence.
- Visualization of results using post-processing tools.
- Extraction of velocity fields, profiles and other variables.
- Physical interpretation of the obtained results.
- Deliverable

Dedicació: 31h 45m
Grup mitjà/Pràctiques: 7h
Grup petit/Laboratori: 2h 30m
Aprenentatge autònom: 22h 15m

5. Analysis, validation and reporting

Descripció:
Critical analysis and validation of CFD results, discussion of model limitations, and preparation of the final technical report.

Objectius específics:
To evaluate CFD results, assess model validity, and communicate findings in a structured technical report.

Activitats vinculades:
- Critical analysis of simulation results.
- Model validation using physical criteria or reference comparisons.
- Discussion of model limitations.
- Writing of the final technical report.
- Deliverable
- Presentation and discussion of results.

Dedicació: 45h 15m
Grup mitjà/Pràctiques: 5h
Grup petit/Laboratori: 1h
Aprenentatge autònom: 39h 15m

ACTIVITATS

Applied theory

Descripció:
Applied theory sessions will focus on introducing the fundamental concepts of the course through practical examples and real-case applications. Theoretical explanations will be combined with activities linked to the development of the course project.

Objectius específics:
To understand the bioengineering problem to be modeled, correctly interpret the physical flow behavior, identify the required assumptions, and select the relevant variables for CFD model formulation.

Material:
Computer classroom and computers with Autodesk CFD software available through the UPC software platform.

Lliurament:
1) Short document describing the bioengineering problem to be modeled, the physical interpretation of the flow, the assumptions made, and the key variables selected for the CFD model.
2) CFD model file including the defined two-dimensional geometry and the generated computational mesh, together with a brief description of mesh refinement criteria and mesh quality assessment
3) CFD model setup file including defined boundary conditions, physical models, and solver settings.
4) Post-processed results including figures and extracted flow variables.
5) Final technical report summarizing methodology, results, validation, discussion, and conclusions.

Dedicació: 50h
Grup mitjà/Pràctiques: 20h
Aprenentatge autònom: 30h

Practical exercises

Descripció:
Practical exercise sessions will focus on applying theoretical concepts through problem-solving activities and the use of Autodesk CFD software. Students will carry out simulations, analyze results, and work on the course case study under the guidance of the instructor.

Objectius específics:
- Apply CFD theoretical concepts to practical problems.
- Develop simulations using Autodesk CFD software.
- Correctly configure geometry, mesh, and boundary conditions.
- Analyze and interpret the obtained results.
- Solve technical problems related to the course case study.

Material:
Computer classroom with computers and Autodesk CFD software available through the UPC software platform.

Lliurament:
1) Short document describing the bioengineering problem to be modeled, the physical interpretation of the flow, the assumptions made, and the key variables selected for the CFD model.
2) CFD model file including the defined two-dimensional geometry and the generated computational mesh, together with a brief description of mesh refinement criteria and mesh quality assessment
3) CFD model setup file including defined boundary conditions, physical models, and solver settings.
4) Post-processed results including figures and extracted flow variables.
5) Final technical report summarizing methodology, results, validation, discussion, and conclusions.

Dedicació: 70h
Grup petit/Laboratori: 10h
Aprenentatge autònom: 60h

SISTEMA DE QUALIFICACIÓ

The course is assessed through a continuous assessment system.

N1: assignment corresponding to phase 1 of the CFD case study (problem definition).

N2: assignment corresponding to phase 2 of the CFD case study (numerical setup).

N3: assignment corresponding to phase 3 of the CFD case study (simulation).

N4: assignment corresponding to phase 4 of the CFD case study (analysis and interpretation of results).

N5: regular attendance and active participation in class, including participation in practical sessions and guided problem-solving activities.

NF = 0.20 N1 + 0.20 N2 + 0.20 N3 + 0.20 N4 + 0.20 N5

NORMES PER A LA REALITZACIÓ DE LES PROVES.

All assessment activities are part of the continuous assessment process. Practical assignments must be submitted within the deadlines established during the course and are directly related to the tasks carried out in class.

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BIBLIOGRAFIA

Complementària:

- Versteeg, H. K; Malalasekera, W. An Introduction to computational fluid dynamics : the finite volume method . 2nd ed. London : Pearson Education, cop. 2007. ISBN 9780131274983.
- Anderson, John David. Computational fluid dynamics . New York [etc.] : McGraw-Hill, cop. 1995. ISBN 9780070016859.
- Patankar, Suhas V. Numerical heat transfer and fluid flow . Boca Ratón : Washington : Taylor & Francis ; Hemisphere Pub. Co, 1980. ISBN 9780891165224.

RECURSOS

Enllaç web:

- Autodesk CFD – Software de simulació CFD per a estudiants UPC. Recurs