# UNIVERSIDAD DE CASTILLA - LA MANCHA

# GUÍA DOCENTE

## 1. General information

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|---|---|---|---|
| **Course:** | FLUID MECHANICS | **Code:** | 56716 |
| **Type:** | CORE COURSE | **ECTS credits:** | 6 |
| **Degree:** | 403 - UNDERGRADUATE DEGREE PROGRAMME IN AEROSPACE ENGINEERING | **Academic year:** | 2023-24 |
| **Center:** | 303 - E.DE INGENIERÍA INDUSTRIAL Y AEROESPOACIAL DE TOLEDO | **Group(s):** | 40 |
| **Year:** | 2 | **Duration:** | C2 |
| **Main language:** | Spanish | **Second language:** | English |
| **Use of additional languages:** | | **English Friendly:** | Y |
| **Web site:** | | **Bilingual:** | N |

Lecturer: **FRANCISCO COBOS CAMPOS** - Group(s): **40**

| Building/Office | Department | Phone number | Email | Office hours |
|---|---|---|---|---|
| Ed. Sabatini / 1.55 | MECÁNICA ADA. E ING. PROYECTOS | | Francisco.Cobos@uclm.es | |

## 2. Pre-Requisites

To study Fluid Mechanics, it is recomended to have passed the subjects: Algebra, Calculus I, Calculus II, Mathematical Methods, Physics I, Physics II, Chemistry and Technical Thermodynamics and Heat Transfer.

## 3. Justification in the curriculum, relation to other subjects and to the profession

Fluid Mechanics course, as part of the Thermofluid Dynamics subject, that covers the initial stage of introduction to fluid mechanics phenomena, coming to propose basic applications that ensure the handling of engineering tools in this field.

## 4. Degree competences achieved in this course

**Course competences**

| Code | Description |
|---|---|
| CA01 | Ability to carry out bibliographic searches, use databases and other sources of information for its application in tasks related to Technical Aeronautical Engineering. |
| CA02 | Ability to efficiently design experimentation procedures, interpret the data obtained and specify valid conclusions in the field of Aeronautical Technical Engineering. |
| CA03 | Ability to autonomously select and carry out the appropriate experimental procedure, operating the equipment correctly, in the analysis of phenomena within the scope of Engineering. |
| CA04 | Ability to select advanced tools and techniques and their application in the field of Aeronautical Technical Engineering. |
| CA05 | Knowledge of the methods, techniques and tools as well as their limitations in the application for the resolution of problems typical of Aeronautical Technical Engineering. |
| CA06 | Ability to identify and assess the effects of any solution in the field of Aeronautical Technical Engineering within a broad and global context and the ability to interrelate the solution to an engineering problem with other variables beyond the technological field, which must be considered. |
| CB02 | Apply their knowledge to their job or vocation in a professional manner and show that they have the competences to construct and justify arguments and solve problems within their subject area. |
| CB03 | Be able to gather and process relevant information (usually within their subject area) to give opinions, including reflections on relevant social, scientific or ethical issues. |
| CB04 | Transmit information, ideas, problems and solutions for both specialist and non-specialist audiences. |
| CB05 | Have developed the necessary learning abilities to carry on studying autonomously |
| CE02 | Understanding and command of the basic concepts of the general laws of mechanics, thermodynamics, fields and waves and electromagnetism and their application to solve engineering problems. |
| CE08 | knowledge of the thermodynamic cycles that generate mechanical power and thrust. |
| CE10 | Knowledge of flight dynamics based on aerodynamic forces and the role of the different variables involved in the phenomenon of flight |
| CE15 | Knowledge applied to Engineering of: The principles of the mechanics of the continuous medium and the techniques for calculating its response. |
| CE16 | Knowledge applied to Engineering of: The concepts and laws that govern the processes of energy transfer, the movement of fluids, the mechanisms of heat transmission and the change of matter and their role in the analysis of the main systems aerospace propulsion. |
| CE18 | Knowledge applied to Engineering of: The fundamentals of fluid mechanics; the basic principles of flight control and automation; the main characteristics and physical and mechanical properties of materials. |
| CE19 | Applied knowledge of: materials science and technology; mechanics and thermodynamics; fluid mechanics; aerodynamics and mechanics of flight; air traffic and navigation systems; aerospace technology; structure theory; air Transport; economy and production; Projects; environmental impact. |
| CE21 | Knowledge applied to Engineering of: The fundamentals of fluid mechanics that describe flow in any regime and determine pressure distributions and aerodynamic forces. |
| CE25 | Knowledge applied to Engineering of: The methods of calculation and development of defense materials and systems; the management of experimental techniques, equipment and measuring instruments typical of the discipline; the numerical simulation of the most significant physical-mathematical processes; inspection, quality control and fault detection techniques; the most appropriate |

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| | repair methods and techniques. |
| CG01 | Capacity for the design, development and management in the field of aeronautical engineering that have as their object, in accordance with the knowledge acquired as established in section 5 of order CIN/308/2009, aerospace vehicles, propulsion systems aerospace, aerospace materials, airport infrastructures, air navigation infrastructures and any space, traffic and air transport management system. |
| CG02 | Planning, drafting, direction and management of projects, calculation and manufacturing in the field of aeronautical engineering that have as their object, in accordance with the knowledge acquired as established in section 5 of order CIN/308/2009, aerospace vehicles , aerospace propulsion systems, aerospace materials, airport infrastructures, air navigation infrastructures and any space, traffic and air transport management system. |
| CT03 | Correct use of oral and written communication. |

## 5. Objectives or Learning Outcomes

**Course learning outcomes**

Description

Knowledge of the phenomenology associated with fluids and applicable experimental measurement techniques.

Knowledge of the principles of fluid mechanics to evaluate their behavior

## 6. Units / Contents

**Unit 1: Vectors and cartesian tensors.**

**Unit 1.1** Matrices and linear transformations.

**Unit 1.2** Cartesian tensors.

**Unit 2: Introduction to Fluid Mechanics.**

**Unit 2.1** Definition of fluid. Continuum hypothesis.

**Unit 2.2** Volume and surface forces.

**Unit 2.3** Stress tensor. Definition of pressure.

**Unit 3: Hydrostatics**

**Unit 3.1** Mechanical equilibrium in a fluid. Hydrostatic equation. International Standard Atmosphere (ISA). Pressure measurements. Hydrostability.

**Unit 3.2** Hydrostatic forces. Buoyancy theory.

**Unit 3.3** Fluid in rigid body motion.

**Unit 4: Integral relations for a control volume.**

**Unit 4.1** Flow clasification.

**Unit 4.2** Kinematics. Pathlines, streamlines and streaklines.

**Unit 4.3** Reynolds transport theorem.

**Unit 4.4** Equation of continuity.

**Unit 4.5** Conservation of momentum. Viscous tensor. Non-inertial frame of reference.

**Unit 4.6** Conservation of angular momentum.

**Unit 4.7** Conservation of energy. Heat transfer. Stagnation conditions.

**Unit 4.8** Bernoulli equations.

**Unit 4.9** One dimensional flow.

**Unit 5: Diferential relation for a fluid particle.**

**Unit 5.1** Reynolds transport theorem for an infinitesimal control volume.

**Unit 5.2** Differential conservation equations. Navier-Stokes equations. Euler equations. Boundary conditions. Boundary layer. Shock and rarefaction waves.

**Unit 5.3** Viscous laminar flow. Couette flow. Poiseuille flow. Lubrication theory.

**Unit 6: Dimensional analysis.**

**Unit 6.1** Dimensionless quantity.

**Unit 6.2** Fundamental units.

**Unit 6.3** Buckingham Pi theorem.

**Unit 6.4** Dimensionless numbers in Fluid Mechanics.

**Unit 6.5** Similarity.

**Unit 6.6** Aerodynamics coefficients. Pipe flow. Turbomachinery.

**Unit 6.7** Turbulence.

**Unit 7: Potential flow.**

**Unit 7.1** Pressure coefficient. Circulation. Steamline function. Velocity potential.

**Unit 7.2** Laplace equation and solutions.

**Unit 7.3** Flow over a semi-infinite body. Rankine oval. Flow over a cylinder. D'Alembert paradox.

**Unit 7.4** Kutta-Joukowski theorem. Magnus effect.

**Unit 7.5** Vorticity equation.

**Unit 8: Laboratory**

**Unit 8.1** Venturi effect. Gyroscopic instruments. Wind tunnels.

**Unit 8.2** Pitot tube. Pitot-static system. Other instruments to measure flow velocity.

**Unit 8.3** Examples of phenomena and devices in aerospace engineering.

**Unit 8.4** Introduction to Computational Fluid Dynamics (CFD).

## 7. Activities, Units/Modules and Methodology

| Training Activity | Methodology | Related Competences (only degrees before RD 822/2021) | ECTS | Hours | As | Com | Description |
|---|---|---|---|---|---|---|---|
| Class Attendance (theory) [ON- | | CA01 CA02 CA03 CA04 CA05 CA06 CB02 CB03 CB04 CB05 CE02 CE08 | | | | | Development in the classroom of the |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SITE] | Lectures | CE10 CE15 CE16 CE18 CE19 CE21 CE25 CG01 CG02 CT03 | 1.64 | 41 | N | - | theoretical contents. |
| Problem solving and/or case studies [ON-SITE] | Project/Problem Based Learning (PBL) | CA01 CA02 CA03 CA04 CA05 CA06 CB03 CB04 CB05 CE02 CE08 CE10 CE15 CE16 CE18 CE19 CE21 CE25 CG01 CG02 CT03 | 0.36 | 9 | Y | N | Resolution of exercises and problems in the classroom in a collective way. |
| Laboratory practice or sessions [ON-SITE] | Practical or hands-on activities | CA01 CA02 CA03 CA04 CA05 CA06 CB03 CB04 CB05 CE02 CE08 CE10 CE15 CE16 CE18 CE19 CE21 CE25 CG01 CG02 CT03 | 0.24 | 6 | Y | N | Laboratory experiments where the student developes the knowledge acquired in the theoretical classes through experimentation. |
| Writing of reports or projects [OFF-SITE] | Self-study | CA01 CA02 CA03 CA04 CA05 CA06 CB03 CB04 CB05 CE02 CE08 CE10 CE15 CE16 CE18 CE19 CE21 CE25 CG01 CG02 CT03 | 0.72 | 18 | Y | Y | Continuining the work begun in laboratory, students must cooperatively prepare a report where they analyze and show the results and conclusions of their experiments. The student who obtains less than 40% of the maximum mark will be able to recover this part in the final exam. |
| Study and Exam Preparation [OFF-SITE] | Self-study | CA01 CA02 CA03 CA04 CA05 CA06 CB03 CB04 CB05 CE02 CE08 CE10 CE15 CE16 CE18 CE19 CE21 CE25 CG01 CG02 CT03 | 2.88 | 72 | N | - | Self-study of theory and problems, from which the student parctices and fixes the knowledge learned in classes in the classroom. |
| Progress test [ON-SITE] | Assessment tests | CA01 CA02 CA03 CA04 CA05 CA06 CB03 CB04 CB05 CE02 CE08 CE10 CE15 CE16 CE18 CE19 CE21 CE25 CG01 CG02 CT03 | 0.06 | 1.5 | Y | N | Mid-term written test (first one) to eliminate the subject, which contains problems and/or theoretical questions corresponding approximately to the first half of the course. The student who obtains less than 40% of the maximum mark will be able to pass this part in the final exam. |
| Final test [ON-SITE] | Assessment tests | CA01 CA02 CA03 CA04 CA05 CA06 CB03 CB04 CB05 CE02 CE08 CE10 CE15 CE16 CE18 CE19 CE21 CE25 CG01 CG02 CT03 | 0.1 | 2.5 | Y | Y | Final test with problems and/or theoretical questions referring to the whole course. |
| | | **Total:** | **6** | **150** | | | |
| | | **Total credits of in-class work: 2.4** | | | | | **Total class time hours: 60** |
| | | **Total credits of out of class work: 3.6** | | | | | **Total hours of out of class work: 90** |

As: Assessable training activity
Com: Training activity of compulsory overcoming (It will be essential to overcome both continuous and non-continuous assessment).

## 8. Evaluation criteria and Grading System

| Evaluation System | Continuous assessment | Non-continuous evaluation* | Description |
|---|---|---|---|
| Final test | 50.00% | 90.00% | C: it does not apply<br>NC: final test (with the contents of all the partial tests) |
| Practicum and practical activities reports assessment | 10.00% | 10.00% | C: realization of laboratory experiments and delivery of a report<br>NC: this part will be evaluated in the final test through questions related to the laboratory experiences. |
| Mid-term tests | 40.00% | 0.00% | C: mid-term tests with contents of the course<br>NC: it does not apply |
| **Total:** | **100.00%** | **100.00%** | |

*According to art. 4 of the UCLM Student Evaluation Regulations, it must be provided to students who cannot regularly attend face-to-face training activities the passing of the subject, having the right (art. 12.2) to be globally graded, in 2 annual calls per subject , an ordinary and an extraordinary one (evaluating 100% of the competences).*

**Evaluation criteria for the final exam:**

**Continuous assessment:**

Who obtains equal to or more than 40% of the maximum mark in the first mid-term test and 40% of the maximum mark in the laboratory part, may decide to only take the second mid-term test (which corresponds to the second half of the subject) in the final exam. Otherwise, he must repeat the first mid-term test and/or the laboratory part during the final test. To pass the subject, it is necessary to obtain at least 40% of the mark in each mid-term test and in the laboratory, and to get an average mark equal to or greater than 50% of the maximum mark of the course.

**Non-continuous evaluation:**

Who does not access the continuous evaluation will be evaluated in the final test, which will include questions related to the laboratory experiences.

**Specifications for the resit/retake exam:**

Same evaluation criteria will be applied as in the non-continuous evaluation.

**Specifications for the second resit / retake exam:**

Same evaluation criteria will be applied as in the non-continuous evaluation.

## 9. Assignments, course calendar and important dates

**Not related to the syllabus/contents**

| **Hours** | **hours** |
|---|---|
| Writing of reports or projects [AUTÓNOMA][Self-study] | 18 |
| Study and Exam Preparation [AUTÓNOMA][Self-study] | 72 |
| Progress test [PRESENCIAL][Assessment tests] | 1.5 |
| Final test [PRESENCIAL][Assessment tests] | 2.5 |

**General comments about the planning:** This time distribution could be modified behind particular circumstances, happening during the development of the course, so advise. The contents, methodology and evaluation systems of the subject could be modified, with the authorization of the university authorities. In any case, the acquisition of the skills of the subject will be ensured.

**Unit 1 (de 8): Vectors and cartesian tensors.**

| **Activities** | **Hours** |
|---|---|
| Class Attendance (theory) [PRESENCIAL][Lectures] | 2 |

**Unit 2 (de 8): Introduction to Fluid Mechanics.**

| **Activities** | **Hours** |
|---|---|
| Class Attendance (theory) [PRESENCIAL][Lectures] | 4 |

**Unit 3 (de 8): Hydrostatics**

| **Activities** | **Hours** |
|---|---|
| Class Attendance (theory) [PRESENCIAL][Lectures] | 6 |
| Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)] | 2 |

**Unit 4 (de 8): Integral relations for a control volume.**

| **Activities** | **Hours** |
|---|---|
| Class Attendance (theory) [PRESENCIAL][Lectures] | 8 |
| Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)] | 2 |

**Unit 5 (de 8): Diferential relation for a fluid particle.**

| **Activities** | **Hours** |
|---|---|
| Class Attendance (theory) [PRESENCIAL][Lectures] | 8 |
| Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)] | 2 |

**Unit 6 (de 8): Dimensional analysis.**

| **Activities** | **Hours** |
|---|---|
| Class Attendance (theory) [PRESENCIAL][Lectures] | 4 |
| Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)] | 2 |

**Unit 7 (de 8): Potential flow.**

| **Activities** | **Hours** |
|---|---|
| Class Attendance (theory) [PRESENCIAL][Lectures] | 6 |
| Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)] | 1 |

**Unit 8 (de 8): Laboratory**

| **Activities** | **Hours** |
|---|---|
| Class Attendance (theory) [PRESENCIAL][Lectures] | 3 |
| Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities] | 6 |

**Global activity**

| **Activities** | **hours** |
|---|---|
| Class Attendance (theory) [PRESENCIAL][Lectures] | 41 |
| Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)] | 9 |
| Progress test [PRESENCIAL][Assessment tests] | 1.5 |
| Final test [PRESENCIAL][Assessment tests] | 2.5 |
| Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities] | 6 |
| Writing of reports or projects [AUTÓNOMA][Self-study] | 18 |
| Study and Exam Preparation [AUTÓNOMA][Self-study] | 72 |
| **Total horas:** | 150 |

## 10. Bibliography and Sources


| Author(s) | Title/Link | Publishing house | Citv | ISBN | Year | Description |
|---|---|---|---|---|---|---|
| F.M. White | Mecánica de Fluidos | McGraw-Hill | | 978-84-4819-128-3 | 2008 | |
| A. Crespo Martínez | Mecánica de Fluidos | Paraninfo | | 978-84-9732-475-5 | 2010 | |
| R. W. Fox, A. T. McDonald | Introducción a la Mecánica de Fluidos | McGraw-Hill | | 970-10-0669-0 | 1995 | |
| G. K. Batchelor | Introducción a la Dinámica de Fluidos | Centro de Publicaciones Secretaría General Técnica Ministerio de Medio Ambiente | | 84-8320-015-5 | 1997 | |