



IDENTIFYING DATA

Fluid mechanics

Subject	Fluid mechanics			
Code	P52G382V01208			
Study programme	Grado en Ingeniería Mecánica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	2nd
Teaching language	Spanish			
Department				
Coordinator	Febrero Garrido, Lara			
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General description Fluid Mechanics is a basic subject, in which the fundamental principles of physics and mechanics are applied to fluid matter. The aim is for students of the degree in mechanical engineering to acquire the knowledge and tools necessary to know how to analyse and understand fluid problems of different categories, to serve as support for other subjects in the syllabus related to the properties and movement of fluids, both basic and more oriented to real problems in the field of engineering. The development of generic skills and competences such as teamwork and autonomous learning is also encouraged.

Fluid Mechanics describes the relevant physical phenomena of fluid motion, describing the general equations of these movements. This knowledge provides the basic principles necessary to analyse any system in which fluid is the working medium. The field of applications of Fluid Mechanics in engineering is very broad: transport of fluids in pipelines, aeronautics, engines, ships, biological flows, etc. The principles of Fluid Mechanics are necessary for such diverse fields as:

- Design of hydraulic machinery.
- Lubrication.
- Heating and ventilation, heating and cooling systems.
- Design of piping systems.
- Means of transport: transmission, air conditioning, exhaust systems, aerodynamics and hydrodynamics, refrigeration, etc.
- Aerodynamics of structures and buildings
- Thermal and fluid power plants for conventional and renewable energy production.

Training and Learning Results

Code	
B4	Ability to solve problems with initiative, decision making, creativity, critical thinking and the ability to communicate and transmit knowledge and skills in the field of Industrial Engineering in Mechanical specialty.
B5	Knowledge to carry out measurements, calculations, assessments, appraisals, surveys, studies, reports, work plans and other similar works.
C8	Knowledge of the basic principles of fluid mechanics and their application to solving problems in the field of engineering. Calculation of pipes, channels and fluid systems.
D2	Problems resolution.
D9	Apply knowledge.
D10	Self learning and work.

Expected results from this subject

Expected results from this subject	Training and Learning Results
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Understand the basic principles of fluid movement	B4 B5	C8	D2 D9 D10
Ability to calculate pipes and channels	B4 B5	C8	D2 D9 D10
Ability to handle fluid magnitude meters	B4 B5	C8	D2 D9 D10
Ability to know and master the tools with which fluid flow problems are approached	B4 B5	C8	D2 D9 D10
ENAAE LEARNING OUTCOMES: 1. KNOWLEDGE AND UNDERSTANDING: Sub-learning outcome: 1.2 Knowledge and understanding of engineering disciplines underlying their specialisation, at a level necessary to achieve the other programme outcomes, including some awareness at their forefront. Level of development: Suitable (2)		C8	
ENAAE LEARNING OUTCOME: 2. ENGINEERING ANALYSIS: Sub-learning outcome: 2.1 Ability to analyse complex engineering products, processes and systems in their field of study; to select and apply relevant methods from established analytical, computational and experimental methods; to correctly interpret the outcomes of such analyses. Level of development: Suitable (2)	B4		D2 D9
ENAAE LEARNING OUTCOME: 2. ENGINEERING ANALYSIS: Sub-learning outcome: 2.2 Ability to identify, formulate and solve engineering problems in their field of study; to select and apply relevant methods from established analytical, computational and experimental methods; to recognise the importance of non-technical (societal, health and safety, environmental, economic and industrial) constraints. Level of development: Suitable (2)	B4		D2 D9
ENAAE LEARNING OUTCOME: 3. ENGINEERING DESIGN: Sub-learning outcome: 3.1 Ability to develop and design complex products (devices, artefacts, etc.), processes and systems in their field of study to meet established requirements, that can include an awareness of non-technical (societal, health and safety, environmental, economic and industrial) considerations; to select and apply relevant design methodologies. Level of development: Basic (1)	B4 B5	C8	D2 D9
ENAAE LEARNING OUTCOME: 3. ENGINEERING DESIGN: Sub-learning outcome: 3.2 Ability to design using some awareness of the forefront of their engineering specialisation. Level of development: Suitable (2)	B4 B5		
ENAAE LEARNING OUTCOME: 4. INVESTIGATIONS: Sub-learning outcome: 4.3 Laboratory/workshop skills and ability to design and conduct experimental investigations, interpret data and draw conclusions in their field of study. Level of development: Suitable (2)		C8	D9
ENAAE LEARNING OUTCOME: 5. ENGINEERING PRACTICE: Sub-learning outcome: 5.2 Practical skills for solving complex problems, realising complex engineering designs and conducting investigations in their field of study. Level of development: Suitable (2)	B4 B5		D2 D9
ENAAE LEARNING OUTCOME: 5. ENGINEERING PRACTICE: Sub-learning outcome: 5.3 Understanding of applicable materials, equipment and tools, engineering technologies and processes, and of their limitations in their field of study. Level of development: Basic (1)			D9
ENAAE LEARNING OUTCOME: 7. COMMUNICATION AND TEAM-WORKING: Sub-learning outcome: 7.2 Ability to function effectively in a national and international context, as an individual and as a member of a team and to cooperate effectively with engineers and non-engineers. Level of development: Suitable (2)			D10
ENAAE LEARNING OUTCOME: 8. LIFELONG LEARNING: Sub-learning outcome: 8.1 Ability to recognise the need for and to engage in independent life-long learning. Level of development: Basic (1)			D10
ENAAE LEARNING OUTCOME: 8. LIFELONG LEARNING: Sub-learning outcome: 8.2 Ability to follow developments in science and technology. Level of development: Basic (1)			D10

Contents

Topic

UD I. INTRODUCTION	<ul style="list-style-type: none"> I.1. Fundamental Concepts. Concept of a Fluid I.2. The Fluid as a Continuum I.3. Characteristics of fluids I.4. Thermodynamic Properties of a Fluid. Newtonian vs non-Newtonian Fluids I.5. Viscosity and Other Secondary Properties
UD II. FLUID STATICS	<ul style="list-style-type: none"> II.1. Pressure and Pressure Gradient II.2. Equilibrium of a Fluid Particle II.3. Hydrostatic Pressure Distributions II.4. Hydrostatic forces on Plane Surfaces II.5. Hydrostatic forces on Curved Surfaces II.6. Buoyancy and Stability II.7. Pressure Distribution in Rigid-Body Motion II.8. Pressure Measurement
UD III. FLUID FLOW FUNDAMENTALS	<ul style="list-style-type: none"> III.1. Properties of the velocity field. Eulerian and Lagrangian method III.2. Flow Patterns: Streamlines, Pathlines and Streaklines III.3. Types of Flows <ul style="list-style-type: none"> 3.1. According to Kinematic Conditions 3.2. According to Geometric Conditions 3.3. According to Mechanical Boundary Conditions 3.4. According to Internal Movement Conditions 3.5. According to Reaction to Obstacles III.4. Systems and Control Volume III.5. Extended Integral Fluid Volumes <ul style="list-style-type: none"> 5.1. Reynolds transport theorem
UD IV. INTEGRAL RELATIONS FOR A CONTROL VOLUME	<ul style="list-style-type: none"> IV.1. Conservation of Mass IV.2. Conservation of Momentum IV.3. The Angular Momentum Theorem IV.4. The Energy Equation IV.5. Frictionless Flow: The Bernoulli Equation
UD V. DIFFERENTIAL RELATIONS FOR A FLUID PARTICLE	<ul style="list-style-type: none"> V.1. The Acceleration Field of a Fluid V.2. Differential Equation of Conservation of Mass V.3. Differential Equation of Momentum V.4. Differential Equation of Angular Momentum V.5. Differential Energy Equation V.6. Boundary conditions for the basic equations V.7. The Stream Function V.8. Vorticity and Irrotationality V.9. Non-viscous Irrotational Flows
UD VI. DIMENSIONAL ANALYSIS AND SIMILARITY	<ul style="list-style-type: none"> VI.1. Dimensionless Parameters VI.2. Nature of Dimensional Analysis VI.3. The Buckingham Pi Theorem. Applications VI.4. Important Dimensionless Groups in Fluid Mechanics <ul style="list-style-type: none"> 4.1. Physical Meaning of Dimensional Numbers VI.5. Similarity <ul style="list-style-type: none"> 5.1. Partial Similarity 5.2. Scale Effect VI.6. Fluid Meters
UD VII. LAMINAR FLOW	<ul style="list-style-type: none"> VII.1. Introduction VII.2. Permanent Laminar Movement <ul style="list-style-type: none"> 2.1. Hagen-Poiseuille Flows 2.2. Flows in Circular Ducts 2.3. Flows in Other Sections VII.3. Effect of Finite Length of the Tube VII.4. Pressure Drop <ul style="list-style-type: none"> 4.1. Coefficient of Friction VII.5. Stability of Laminar Flow
UD VIII. TURBULENT FLOW	<ul style="list-style-type: none"> VIII.1. Regimes Depending on Reynolds VIII.2. Modelling of Turbulence VIII.3. Internal Flows and External Flows VIII.4. Pressure Drop in Turbulent Flows <ul style="list-style-type: none"> 4.1. Nikuradse Chart 4.2. Moody Chart VIII.5. Concept of Boundary Layer VIII.6. Empirical Formulas for Flow in Pipes
UD IX. INTRODUCTION TO BOUNDARY LAYER	<ul style="list-style-type: none"> IX.1. Concept of Boundary Layer IX.2. Incompressible Two-Dimensional Boundary Layer Equations IX.3. Boundary Layer Thickness

UD X. FLOW IN PIPES OF VARIABLE SECTION

- X.1. Introduction
- X.2. Local Losses
 - 2.1. Loss at the Entrance of a Tube
 - 2.2. Loss at the Outlet of a Tube
 - 2.3. Contraction Loss
 - 2.4. Widening Loss
 - 2.5. Loss on Elbows
- X.4. Branch Pipes
- X.5. Serial Pipes
- X.6. Parallel Pipes
- X.7. Pipes Networks

LABORATORY PRACTICES

- Practice PL1. Archimedes' principle [2h].
 Objectives: To determine the buoyancy of bodies immersed in liquids.
 Practical equipment: 1250.1683 Principio de Arquímedes (Didaciencia).
- Practice PL2. Measurement of hydrostatic pressure [2h].
 Objectives: Measurement of hydrostatic pressure with a U-shaped manometer. Practical equipment: 1250.1676 Manómetro en U con escala (Didaciencia).
- Practice PL3. Bernoulli's equation [2h].
 Objectives: Study the pressure in pipes with variable and constant diameters through which liquid flows. The vertical tubes indicate the static pressure. Practical equipment: 1250.1689 Principio de Bernoulli (Didaciencia).
- Practical PL4 Dimensional analysis and similarity [2h].
 Objectives: Apply the learning received in the theoretical sessions on dimensional analysis to a practical problem typical of Fluid Mechanics, specifically to the drag force of a sphere. Practical equipment: GUNT HM 135.
- Practical PL5 Flow meters [2h].
 Objectives: Measure the flow rate in pipes using differential pressure flowmeters (Venturi, nozzle and calibrated orifice) and rotameter. Measure the velocity inside a pipe with a Pitot-Prandtl tube. Practical equipment: GUNT HM 150.13.
- Practice PL6. Demonstration of losses in pipes and connectors [2h].
 Objectives: Study of pressure losses in pipes and accessories. Experimental determination of friction factors and loss constants in singular elements. Practical equipment GUNT HM 150.11.
- Practice PL7. Supervised work [2h].
 Objectives: On the basis of problems posed by the students themselves, following the guidelines established by the lecturer, the students, divided into groups, will have to carry out a project based on a pre-established template based on the Final Degree Project. The aim is to familiarise them with the standard structure of a scientific article, working with formats, references, indexes, etc., as well as the distribution of tasks, teamwork, etc.

The scheduled laboratory or computer classroom practicals may vary in content and order depending on the material available to carry them out, as well as the organisational needs of the academic year.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	28	28	56
Laboratory practical	12	14	26
Seminars	7	7	14
Essay questions exam	5	7	12
Essay	2	8	10
Essay questions exam	6	7	13
Problem and/or exercise solving	15	4	19

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Lecturing	<p>In these sessions, the basic theoretical contents of the programme will be explained in detail, giving explanatory examples with which to deepen the understanding of the subject.</p> <p>Computer presentations and the blackboard will be used. As far as possible, the slides will be provided to the students before the presentation, focusing the effort of the lecturer and the students on the presentation and understanding of the knowledge.</p>
Laboratory practical	<p>In the practical classes, the concepts developed in each subject will be applied to laboratory practices. A series of practicals (PL1 to PL6) have been designed in accordance with the development of the theory subject in order to fix concepts explained in that class.</p> <p>Integrated methodologies</p> <ul style="list-style-type: none"> - Project-based learning. The last practical session (PL7: Supervised work) will be devoted to monitoring the work proposed to the various groups into which the students are divided. Material and bibliography will be provided, although the aim is to encourage the ability to search for information, synthesis skills, etc.
Seminars	<p>Resolution of problems and/or exercises. Problems and/or exercises related to the subject will be formulated. The student will have to develop adequate or correct solutions by applying formulas or algorithms, applying transformation procedures to the available information and interpreting the results. It will be used as a complement to the lecture.</p> <p>Integrated methodologies</p> <ul style="list-style-type: none"> - Collaborative learning. The aim is to motivate the student in the research activity, and to encourage personal relationships by sharing problems and solutions. A fraction of the classroom classes will be reserved for the resolution of the problems posed by teams. This dedication may vary throughout the term and depending on the specific needs of the subject. - Project-based learning. A teaching-learning method whose starting point is a problem that, designed by the lecturer, the student has to solve in order to develop certain competences. This teaching methodology will be used to solve simple problems.

Personalized assistance

Methodologies	Description
Lecturing	<p>In the field of tutorial action, a distinction is made between academic tutoring and personalised tutoring. In the first case, students will have at their disposal hours of tutorials in which they can expose any questions related to the contents, organisation and planning of the course, etc. In the personalised tutorials, each student, individually, will be able to discuss with the lecturer any problem that is preventing them from following the course properly, in order to find some kind of solution between the two of them. By combining both types of tutorial action, the aim is to compensate for the different learning rhythms through attention to diversity. The lecturers of the course will answer to students' questions and queries synchronously in physical or virtual offices by prior arrangement or asynchronously by telematic means (e-mail, Moovi forums, etc.).</p>
Laboratory practical	<p>In the field of tutorial action, a distinction is made between academic tutoring and personalised tutoring. In the first case, students will have at their disposal hours of tutorials in which they can expose any questions related to the contents, organisation and planning of the course, etc. In the personalised tutorials, each student, individually, will be able to discuss with the lecturer any problem that is preventing them from following the course properly, in order to find some kind of solution between the two of them. By combining both types of tutorial action, the aim is to compensate for the different learning rhythms through attention to diversity. The lecturers of the course will answer to students' questions and queries synchronously in physical or virtual offices by prior arrangement or asynchronously by telematic means (e-mail, Moovi forums, etc.).</p>
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Assessment

Description	Qualification	Training and Learning Results

Laboratory practical	The evaluation of the laboratory practicals (PL1-PL6) will be carried out by means of questionnaires through Moovi, where the student will be evaluated on the knowledge acquired in the laboratory or through the evaluation of the practical reports. The practical mark (MP) will be the average of the marks of all the practical questionnaires carried out and the marks of the practical reports.	15	B4 B5	C8 D9	D2 D10
Essay questions exam	Final test (PF): The final test (PF) aims to evaluate the learning of all the theoretical contents selected for the subject. It will be designed to judge what the student knows about the whole subject (PF). It should consist of a series of questions that prioritise conceptual and logical reasoning, in order to verify the intellectual maturity of the students to draw conclusions from the notions or theories presented in class. The final continuous assessment test will take place during the week of assessment and will be assessed out of 10 points. It will be necessary to obtain a mark of 4 or more points out of 10 in the final continuous assessment exam in order to qualify for a pass in continuous assessment.	40	B4 B5	C8 D9	D2 D10
Essay	Since the tutored work must be assessed in a way that ensures individual accountability and positive interdependence (i.e. all group members must have worked on and contributed to the final product and must have mastered, at a minimum, all aspects of the work), in the oral presentation and defence session, all group members will be involved and any group member must be able to answer questions on the work, regardless of the part on which he/she specialised. Everyone must therefore demonstrate a thorough knowledge of the delivered product, regardless of the part on which they have focused their efforts.	15	B4 B5	C8 D9	D2 D10
Essay questions exam	Partial tests (P1 and P2): Tests P1 and P2 are aimed at assessing the learning of all the theoretical contents selected for the subject. They will be designed to judge what the student knows about a part of the subject (P1, P2). Secondly, they must consist of a series of questions that prioritise conceptual and logical reasoning, in order to verify the intellectual maturity of the students to draw conclusions from the notions or theories presented in class. There will be two (2) partial continuous assessment tests. Each control will account for 15% of the continuous assessment mark.	30	B4 B5	C8 D9	D2 D10

Other comments on the Evaluation

To pass the subject by Continuous Assessment, the final mark (NEC) must be greater than or equal to 5 and will be calculated as follows:

$$NEC = 0,40PF + 0,15P1 + 0,15P2 + 0,15TT + 0,15MP$$

The student will have to take the ordinary exam of all the contents of the course, which will represent 100% of the mark, if the final mark of the continuous assessment is less than 5 points out of 10:

- Failure to complete or hand in any of the above markers.
- Obtaining a mark of less than 4 points out of 10 in the final continuous assessment exam.

In any of these cases, the grade for the continuous assessment will be the minimum of the continuous assessment mark and 4 points (in this case, the student will obtain a maximum of 4 points). In any case, the student who has passed the continuous assessment will have the possibility to sit the ordinary exam in order to obtain a higher mark.

ACADEMIC INTEGRITY: Students are expected to show adequate ethical behaviour, committing to act honestly. Based on article 42.1 of the *Regulation on the evaluation, qualification and quality of teaching and the student learning process of the University of Vigo*, as well as point 6 of the fifth rule of *Order DEF/711/2022, of July 18th, which establishes the requirements for evaluation, progress, and ongoing enrolment in military educational training centres for incorporation into the ranks of the Armed Forces*, **any violation of academic integrity in the assessment process, as well as the cooperation in it will result in the assignment of a failing grade to the student (zero) for the entire course in the corresponding assessment opportunity**, regardless of the percentage of importance that the test in question had in the overall continuous assessment and independently of other disciplinary actions that may be applied.

Sources of information

Basic Bibliography

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CENGEL, Y. A.; CIMBALA, J. M., **MECÁNICA DE FLUIDOS: FUNDAMENTOS Y APLICACIONES**, MCGRAW HILL, 2018

CENGEL, Y. A.; CIMBALA, J. M., **FLUID MECHANICS: FUNDAMENTALS AND APPLICATIONS**, MCGRAW HILL, 2018

GILES, R.V., **MECÁNICA DE LOS FLUIDOS E HIDRÁULICA**, MCGRAW HILL, 1994

Complementary Bibliography

LÓPEZ-HERRERA SÁNCHEZ, J.M., **MECÁNICA DE FLUIDOS: PROBLEMAS RESUELTOS**, MCGRAW HILL, 2005

BARRERO RIPOLL, A.; PÉREZ-SABORIDO SÁNCHEZ-PASTOR, M., **FUNDAMENTOS Y APLICACIONES DE LA MECÁNICA DE FLUIDOS**, MCGRAW HILL, 2005

GORDILLO ARIAS DE SAAVEDRA, J. M.; RIBOUX ACHER, G.; FERNÁNDEZ GARCÍA, J.M., **INTRODUCCIÓN A LA MECÁNICA DE FLUIDOS**, PARANINFO, 2017

VERA COELLO, M.; IGLESIAS ESTRADÉ, I.; SÁNCHEZ PÉREZ, A. L.; MARTÍNEZ BAZÁN, C., **INGENIERÍA FLUIDOMECÁNICA**, PARANINFO, 2012

Recommendations

Subjects that it is recommended to have taken before

Physics: Physics 1/P52G382V01106

Mathematics: Calculus 1/P52G382V01103

Physics: Physics II/P52G382V01202

Mathematics: Calculus II and differential equations/P52G382V01201

Thermodynamics and heat transfer/P52G382V01203

Other comments

In order to successfully complete this course, students should follow the following recommendations:

- Regular and active attendance to classes, both theoretical and practical.
- Maintain a minimum of daily study.

It is recommended to have passed Calculus I, Calculus II and Differential Equations, Physics I, Physics II, Thermodynamics and Heat Transmission
