COURSE GUIDE	2025/26		
Faculty	345 - Faculty of Engineering - Bilbao	**Cycle**	.
Degree	GITECI30 - Bachelor`s Degree in Industrial Technology Engineering	**Year**	Second year

COURSE

27311 - Fluid Mechanics	**Credits, ECTS:**	6

COURSE DESCRIPTION

The general objective of the course entails that the students understand the properties and fundamental basic laws governing the behaviour of fluids (liquids and gases) and that they learn about the basic tools of the analysis of static fluids and fluid flow, and the use of similitude and dimensional analysis in mock-ups (scale model of a design). The students will be able to apply the basic tools to the solution of elementary problems with a clear practical orientation (e.g. the study of forces on surfaces, equilibrium and stability of buoyant bodies, the problem of cavitation in the impellers of hydraulic pumps or in the propellers of boats; different types of propulsion, impact of jets on obstacles; generation of drag and lift forces; aerodynamic forces on structures; design of scaled laboratory mock-ups; design of the water distribution pipeline system, irrigation channels; measurement and control of variables; the analysis of sound propagation; supersonic acceleration of gases in the combustion process of a rocket). In summary, the student will be able to solve a wide variety of basic problems regarding different technological areas (e.g. aeronautics, fluid machinery) that will be considered as a relevant part of their near future possible engineering career.
In order to develop the subject of Fluid mechanics properly it is necessary to hold or to develop in parallel some knowledge on:
- Vector and matrix related calculus: in order to describe the properties of fluids with a vectorial character and the use of the stress tensor and deformation rate tensor used in the differential analysis.
- Differential and integral calculus: for the sake of a complete and correct analysis of a fluid from the macroscopic point of view (integral laws applied to control volumes) and the microscopic point of view (differential laws applied to fluid particles).
- Physics: the universal laws of conservation must be known in their elementary form (applied to punctual masses) before applying them to a fluid continuum: mass conservation, energy conservation, conservation of linear momentum and angular momentum.
- Mechanics: the principles of kinematics and dynamics developed for solids should accompany their use in case of an intangible, deformable substance such as a fluid.
-Thermodynamics: The complete analysis of a fluid entails the knowledge and application of thermodynamics fundamentals such as the zero principle, the 1st and 2nd principles of Thermodynamics; together with all the properties used in that context (e. g. temperature, pressure, internal energy, enthalpy, exergy, efficiency)
- Engineering Graphics: In order to understand and describe the 3 dimensional fluid flows or static situations, it is necessary to show a certain ability of spatial geometrical abstraction.

COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT

Skills developed in the subject:

M02 Common to the industrial branch
- M02R2: Knowledge of fundamentals of fluid mechanics and its application to solve engineering problems. Calculation of pipelines, channels and fluid systems.

Specific of the bachelor degree:
- G003. Knowledge of basic and technological subjects designed to learn new methods, techniques and theories, and to become capable of getting used to new situations.
- G004. Ability to solve problems with initiative, decision-making, creativity, critical thinking, and ability to communicate and share knowledge, abilities and skills in the field of industrial engineering.
- G005. Capability of performing measurements, calculations, assessments, valuations, technical analysis, technical studies and reports, and analogous pieces of work.

Learning outcomes:
- Ability to calculate and produce reports of hydraulic facilities and compressible fluid systems

Theoretical and Practical Contents

CHAPTER 1. INTRODUCTION AND FUNDAMENTAL CONCEPTS
Scope of Fluid Mechanics. Brief history of Fluid Mechanics. Fluid as a continuum. Definition of a fluid. Dimensions and units. Physical properties of a fluid. Acting forces on a fluid.
CHAPTER 2. FLUID STATICS
Pressure on a point. Pascal´s law. The basic hydrostatic equation. Measurement of pressure. Forces on surfaces. Mechanics of buoyant bodies and submerged bodies. Motion of a rigid body.
CHAPTER 3. FUNDAMENTAL CONCEPTS USED IN FLUID FLOW ANALYSIS

Display of the fluid flow. Description and classification of fluid flow. The boundary layer concept. Concepts: streamtube, volumetric flow rate, mass flow rate, average velocity. Reynolds’ transport theorem. The continuity equation
CHAPTER 4. THE ENERGY EQUATION
The energy equation. The mechanical energy equation. Definition of energy loss and headloss. Bernoulli´s equation in steady state. Piezometric head constancy. Concepts related to terms of energy per unit time (power).
CHAPTER 5. INVISCID INCOMPRESSIBLE FLUID FLOW
Application of Bernoulli´s equation in an incompressible steady state flow. Emptying time of a tank.
CHAPTER 6. INVISCID COMPRESSIBLE FLOW. IDEAL GAS ISENTROPIC FLOW
Bernoulli´s equation for gases. Saint-Venant´s equation. Different behaviour of compressible fluid and incompressible fluid in isentropic flow. Concepts: stagnation state, critical state, limit velocity. Hugoniot´s theorem. Application to the design of nozzles and diffusers.
CHAPTER 7. THE MOMENTUM EQUATION
The momentum thorem. 1st Euler theorem. Applications of momentum theorem.
CHAPTER 8. DIMENSIONAL ANALYSIS AND SIMILITUDE
Necessity of experimental measurements with scaled models. Dimensional homogeneity. Buckingham Pi theorem. Mechanical similitude of fluid flows.
CHAPTER 9. INCOMPRESSIBLE VISCOUS FLOW
Introduction. Transport of fluids in pressurised pipes. Equations of fluid flow. Energy loss (headloss). Energy head diagram. Calculation of a pipe. Fluid transport through open channels. General steady state non uniform motion equation in open flows. Steady state uniform motion in open flows.
CHAPTER 10. INTRODUCTION TO CFD (COMPUTATIONAL FLUID DYNAMICS)
Description of fluid field properties and physical phenomena in a problem solved by Computational Fluid Dynamics. Fundamental concepts of modelling, numerical solving and computation of a fluid flow problem.

FLUID MECHANICS LABORATORY CONTENT

EXPERIMENT 1: HYDROSTATIC PRESSURE APPARATUS

EXPERIMENT 2: STABILITY OF FLOATING BODIES

EXPERIMENT 3: CAVITATION DEMONSTRATION

EXPERIMENT 4: DESCRIPTION OF FREE AND FORCED VORTEX

EXPERIMENT 5: BERNOULLI,S PRINCIPLE DEMONSTRATION

EXPERIMENT 6: JET TRAJECTORY METHOD IN THE ANALYSIS OF THE DISCHARGE THROUGH ORIFICES

EXPERIMENT 7: IMPACT OF JET APPARATUS

EXPERIMENT 8: DRAG COEFFICIENTS FOR SPHERES

EXPERIMENT 9: CALIBRATION OF FLOWMETERS

EXPERIMENT 10: CONTROL VALVE CHARACTERIZATION

*Note: This lab program is provisional; the experiments can be modified or substituted depending on infrastructure availability.

TEACHING METHODS

There exist 4 evaluable tasks with different weight in the final mark:

T1 - Final exam: 65 %
T2 - Laboratory experiments: 15 %
T3 - Seminars: 10 %
T4 - Problems: 10 %

T1 - Final exam (individual work): It consists of a theory section and a problems section. The theory section and the problems section have their own weight in the final exam mark (theory 40%, problems 60%). The final mark of the exam must be greater than or equal to 4.0 to pass the subject, and, in addition, each part of the exam (theory and problems) have to be awarded a minimum mark of 3.0, both the average of the theory exercises (in the case of having more than one) and the average of the problems, to pass the subject. The final mark of the exam will be the minimum mark of the part that does not fulfil the established requirement, if that is the case. Only the students registered officially in the course have the right to sit the exam. There is one final exam to evaluate the whole course; there are not midyear exams.

T2 - Laboratory experiments (cooperative work - in groups): In this task the experimental manual ability will be evaluated together with the previous no presential preparatory work, the electronic data analysis and the concluding remarks obtained in each experiment (reports); all this with a weight of 80 % of the total mark in the laboratory task. The global knowledge acquired in this task will be assessed in a final evaluation exercise with a weight of 20 % on the final mark of the laboratory task. All the laboratory practicals must be performed (including the attendance to the explanation sessions). Should any practical not be carried out, then a mark of 0 out of 10 will be awarded in the laboratory task. At the beginning of the course the working groups of students will be agreed. The laboratory qualifications will be considered only during the current academic year (and at the advanced examination session of the following year), i.e. the qualifications of the laboratory will not be retained. The organisation of the laboratory sessions (group formation, working in the laboratory, deliverables) will be explained by the lecturer at the appropriate time.

T3 - Seminars (cooperative work - in groups): During the 3 seminar sessions oral presentations made by the students will be evaluated together with discussions (questions, doubts, commentaries from the other students). The lecture will be focused on the experience acquired in the laboratory experiments (task T2) and its application to real engineering problems. At the beginning of the course the group of the students will be designated to develop this task.

T4 - Problems (individual work): 3 practical tests will be performed by the students during the normal practice sessions in the classroom.

The four tasks are developed with the help of the teacher during the 4 different kind of sessions: lectures, problems, lab practicals and seminars.

In the case that the sanitary conditions make impossible the development of an in-person academic activity, an online method will be followed and the students will be informed correspondingly.

TYPES OF TEACHING

Types of teaching	M	S	GA	GL	GO	GCL	TA	TI	GCA
Hours of face-to-face teaching	22,5	4,5	15	18					
Horas de Actividad No Presencial del Alumno/a	33,75	6,75	22,5	27					

Legend:

M: Lecture-based | S: Seminar | GA: Applied classroom-based groups
GL: Applied laboratory-based groups | GO: Applied computer-based groups | GCL: Applied clinical-based groups
TA: Workshop | TI: Industrial workshop | GCA: Applied fieldwork groups

Evaluation methods

- End-of-course evaluation

Evaluation tools and percentages of final mark

- Written test, open questions 65%
- Exercises, cases or problem sets 15%
- Individual assignments 10%
- Oral presentation of assigned tasks, Reading¿ 10%

ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

GRADING POLICY AND TASKS: the grading system corresponds to "continuous assessment".

There exist 4 evaluable tasks with different weight in the final mark:
T1 - Final exam: 65 %
T2 - Laboratory experiments: 15 %
T3 - Seminars: 10 %
T4 - Problems: 10 %

To pass the subject the final mark obtained from the corresponding weights of the tasks must be equal or greater than 5.0. In addition, to pass the subject a minimum mark of 4.0 must be obtained in task T1 (final exam). If this requirement is not fulfilled, the final mark of the subject will be that of the final exam (always by following the rules established in the previous section of methodology).

Not sitting the final exam T1 will be considered a withdrawal from the ordinary call.
The exercise of the final exam will be the same in all the groups of the subject.

In the ordinary call the student can be evaluated by the final exam system (by an exercise on 100% of the subject), providing they claim for it to the teacher responsible of the group where they are enrolled in. The request must be forwarded by electronic mail during the 9 first weeks of the year. In this case the structure of the exam will maintain the same percentages and calculation method to obtain the final mark from the 4 tasks of the subject T1, T2, T3 and T4 (assessed through specific exercises), as in the case of the continuos assessment.

In the case that the sanitary conditions make impossible the development of an in-person assessment, an online method will be followed and the students will be informed correspondingly.

EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

The positive results obtained in the continuous assessment of the ordinary call will be preserved (exclusively and jointly the marks of tasks T2, T3 and T4) in the extraordinary call.

Not being awarded a mark of 0 in the laboratory task (T2) is considered as having obtained a "positive result" in all the continuously assessed tasks (T2, T3 and T4). Otherwise, the student has to sit an exam with a grading weight of 100% and maintaining the partial weights and calculation method from the partial marks in tasks T1, T2, T3 and T4 (from specific exercises of each task), in the same way as in the continuous assessment system.

Nevertheless, any student can sit the final exam in the extraordinary call if they wish, having a grading weight of 100 % (by carrying out specific exercises of the 4 tasks T1, T2, T3 and T4), in spite of having obtained positive results in the continuously assessed tasks. If that is the case, the student has to inform on their decision of not keeping those marks by electronic mail to the teacher who is responsible of the group, before 2 working days from the date of the exam.

The marks of the continuously assessed tasks T2, T3 and T4 ("positive result") can be preserved in the extraordinary call only as a block (either all together or none of them).

The global mark must be equal to 5.0 or greater than 5.0 to pass the subject. The weights and criteria followed to obtain the final mark are the same as in the ordinary call.

Not sitting the final exam T1 in the extraordinary call will be considered a withdrawal from that call.

The exercise of the final exam will be the same in all the groups of the subject.

In the case that the sanitary conditions make impossible the development of an in-person assessment, an online method will be followed and the students will be informed correspondingly.

MANDATORY MATERIALS

- Slides of the course, 2022, Gustavo A. Esteban (they will be available in electronic format by Moodle).
- Laboratory workbook, 2022, Gustavo A. Esteban, Department of Nuclear Engineering and Fluid Mechanics.
- Workbook of practical problems, 2022, Department of Nuclear Engineering and Fluid Mechanics.

BIBLIOGRAPHY

Basic bibliography

- Çengel, Y. A. Y Cimbala, J. M. Fluid Mechanics, Fundamentals and Applications, 2nd Ed., McGraw-Hill, 2009.
- Franzini, J. B. y Finnemore, E. J. Fluid Mechanics with Engineering Applications, 10th Ed., McGraw-Hill. 2001.
- Gerhart, P. M., Gross, R. J. y Hochstein, J. I. Fundamentals of Fluid MEchanics, 2nd Ed. Addison - Wesley Iberoamericana S. A., 1992.
- White, F.M. Fluid Mechanics, 7th Ed., Ed. McGraw-Hill, 2010
- Fox, R. W. y McDonald, A. T. Introduction to Fluid Mechanics, 8th Ed., McGraw-Hill, 2011.
- Mott, R. L. Applied Fluid Mechanics, 6th Ed., Prentice, 2005.

Detailed bibliography

- Batchelor, G. K. An Introduction to Fluid Dynamics, Cambridge University Press, 2000
- Kundu, P. K. y Cohen, I. M. Fluid Mechanics, 5h Ed., Academic Press, 2011
- Landau, L. D. y Lifshitz, E. M. Fluid Mechanics. Butterworth-Heinemann, 1990
- Shames, I. H. Mechanics of Fluids, 4th Ed., McGraw - Hill, 2002

Journals

- Computers and Fluids
- European Journal of Mechanics. Series B. Fluids
- Experimental Thermal and Fluid Science
- Experiments in Fluids
- Flow Measurement and Instrumentation
- Fluid Dynamics Research

- Geophysical and Astrophysical Fluid Dynamics
- International Journal of Multiphase Flow
- International Journal of Heat and Fluid Flow
- International Journal of Heat and Mass Transfer
- Journal of Fluid Mechanics
- Journal of Fluids Engineering
- Journal of Hydraulic Engineering
- Journal of Hydronautics
- Journal of Non-Newtonian Fluid Mechanics
- Physicochemical Hydrodynamics
- Physical review A. Statistical physics, plasmas, fluids, and related interdisciplinary topics
- Physical review E. Statistical physics, plasmas, fluids, and related interdisciplinary topics
- Physics of fluids
- Physics of fluids A. Fluid dynamics

Web sites of interest

National Committee for Fluid Mechanics Films (NCFMF)
http://web.mit.edu/fluids/www/Shapiro/ncfmf.html
IIHR- Hydroscience & Engineering, College of Engineering, The University of Iowa
http://www.iihr.uiowa.edu/
Enciclopedia básica sobre fluidos:
http://hyperphysics.phy-astr.gsu.edu/hbase/fluid.html#flucon
Simulación de redes de distribución de fluidos:
http://www.instagua.upv.es/Epanet/
UNESCO-IHE Institute for Water Education:
http://www.unesco-ihe.org/
Mecánica de fluidos computacional (CFD):
Genérica: http://www.cfd-online.com/
ANSYS: http://www.ansys.com/
FEATFLOW : http://www.featflow.de/
STAR-CD: http://www.cd-adapco.com/
PHOENICS: http://www.cham.co.uk/
Calculadora de aerodinámica compresible:
http://www.aoe.vt.edu/~devenpor/aoe3114/calc.html

OBSERVATIONS

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