

Fluid Mechanics (250954)

General Information

School	ETSECCPB
Departments	Departament d'Enginyeria Civil i Ambiental (DECA)
Credits	5.0 ECTS
Programs	MÀSTER UNIVERSITARI EN MÈTODES NUMÈRICS EN ENGINYERIA (pla 2012) MÀSTER UNIVERSITARI EN MÈTODES NUMÈRICS EN ENGINYERIA (pla 2012)
Course	2025/26

Main teaching language at each group

- Group 10Q1 English (Q1)

Faculty

Responsible Faculty: Pablo Saez Viñas
Faculty: Matteo Giacomini, Pablo Saez Viñas

Objectives of Education

The course provides the elements to understand the basic tools for the analysis and solution of different types of flows, from the ideal to the viscous flow, contrasting the numerical results with the experiments.

* The students will be able to understand and assimilate the foundations of fluid mechanics * The students will develop practical skills to work with tensors, formulate and develop analysis of diverse problems of solids and fluids in engineering.

The course includes six main topics:

- * Basic concepts and reviews: Summary of vectorial analysis: classic theorems: Greens, Gauss, Stokes - derivative Eulerian/Lagrangian and Reynolds transport theorems.
- * Regulatory Equations: Equations of continuity and laws of conservation. Mass, impulse, and conservation of energy. Classification of equations. Boundary Conditions. Examples
- * Ideal fluids: incompressible, potential irrotational flow. Efficiency,
- * Efficiency functions. Examples.
- * Incompressible viscous fluids: Navier-Stokes incompressible equations: Couette's flow, Poiseuille's flow, Fluids in pipes.
- * Characteristics and equations of compressible fluids.
- * Nature of turbulences
- * Modeling of complex fluids.

Learning resources:

- o I.G. Currie, Fundamental Mechanics of Fluids, 2nd edition, McGraw Hill International Editions, 1993.
- o B. Le Mehaute, An Introduction to Hydrodynamics and Water Waves, Springer-Verlag, 1976.
- o A.R. Patterson, A First Course in Fluid Dynamics, Cambridge University Press, 1983.
- o A.J.Chorin & J.E. Marsden, A Mathematical Introduction to Fluid Mechanics, Springer-Verlag, 1979.

Learning objectives: to be able to understand

- the fundamentals of theoretical fluid mechanics: fluid's characteristics and equations of motion,
- the simplifications that can be made leading to models such as incompressible flow, inviscid flow, ideal fluid flow, boundary layer flow, irrotational flow, ...
- how classical solution techniques may be used to solve a range of problems involving these simplified flow problems

Measurable outcomes: to be able to

- identify and solve basic fluid static problems
- obtain and solve Bernoulli's equations
- describe and deduce the potential flow equations and solve them for simplified cases
- select the appropriate boundary conditions and formulate the equations of fluid motion for compressible and incompressible Newtonian fluids
- write a problem in dimensionless form and select the appropriate dimensionless numbers

Total hours of student work

		Hours	Percentage
Supervised Learning	Large group	45.0 h	100.00 %
	Medium group	0.0 h	0.00 %
	Laboratory classes	0.0 h	0.00 %
	Guided Activities	0.0 h	0.00 %
Self Study		80.0 h	

Contents

Review of basic concepts

Review: stress and body forces; Pascal's law; Archimedes' principle.
Applications: hydraulic force transmission; pressure measurement.
Stratified fluids. Pressure on solid surfaces and immersed bodies

Exercises: mathematical notation (tensors, summation conventions); differential operators and properties; integral theorems.

Fluid properties

Description of physical and thermodynamic properties of a fluid
Dimensions and units of measurement

Governing equations

Lagrangian and Eulerian description of motion. Material and time derivative. Reynolds' theorem.
Deduction of the conservation equations (mass, momentum and energy).
Streamlines, streak lines, particle paths. Vorticity fields
Fluid constitutive equations. Newtonian and non-Newtonian fluids

Dimensional analysis

Dimensional homogeneity. PI-theorem.
Modeling and applications. Drag and lift.

Irrotational flow

Vorticity. Circulation. Kelvin's theorem. Stream function.
Exercises: plane flows and superposition principle
Potential flow. D'Alembert's paradox

Incompressible flow

Velocity-pressure formulation of the Navier-Stokes equations
Dimensionless form.
Stokes equations for viscous flows.

Exercises: Couette flow, Poiseuille flow, pipe flow...
Lubrication theory
Boundary layer theory: hypothesis.
Derivation of the boundary-layer equations
Boundary layer on a flat plate. Boundary layer thickness.
Drag coefficient. Separation. Laminar and turbulent wakes.

Modeling of complex fluids

Modeling of complex fluids based on variational principles

Evaluation

Exam1+Exam2

Teaching Methodology

Taught module delivery: ten weeks of teaching, coursework and self-study. Apart from the 3 hours per week in the classroom, self-study must last an average of 5 hours per week minimum.

Although most of the sessions will be given in the language indicated, sessions supported by other occasional guest experts may be held in other languages.

Grading Rules

() The evaluation calendar and grading rules will be approved before the start of the course.*

The assessment of this module will be based upon submitted exercises (HW), a mid-term examination (Ex1) and an end of semester examination (Ex2).

The final mark will be computed as: $0.25 * HW + 0.75 * (0.5 * Ex1 + 0.5 * Ex2)$

Test Rules

The exercises (HW) must be submitted on the announced due date. Work submitted late will normally be awarded half marks. Any late submission must be justified and the lecturer must be informed in advance.

Notes, textbooks, solved problems or any other documents are forbidden during tests.

You may discuss the problems with others, but the worked solutions that you submit are expected to be yours alone.

Unfair practice will be severely punished, in accordance with current academic regulations.

Students must ensure that they do not engage in any form of unfair practice, whereby they take action which may result in them obtaining for themselves or others, an unpermitted advantage.

Unfair practice is defined as any act whereby a person may obtain for himself/herself or for another, an unpermitted advantage. This shall apply whether candidates act alone or in conjunction with another/others. An action or actions shall be deemed to fall within this definition whether occurring during, or in relation to, a formal examination, a piece of coursework, or any form of assessment undertaken in pursuit of the module.

Examples of unfair practice in non-examination conditions are as follows:

* Plagiarism. Plagiarism can be defined as using without acknowledgment another person's work and submitting it for assessment as though it were one's own work, for instance, through copying or

unacknowledged paraphrasing;

* Collusion. Collusion can be defined as involving two or more students working together, without prior authorisation from the academic member of staff concerned (e.g. Programme leader, lecturer etc) to produce the same or similar piece of work and then attempting to present this work entirely as their own. Collusion may also involve one student submitting the work of another with the knowledge of the originator.

* Commissioning of work produced by another;

* Falsification of the results of laboratory, field-work or other forms of data collection and analysis.

Office Hours

Will be announced at the beginning of the course.

Bibliography

Basic

- Kundu, P.K.; Cohen, I.M.; Dowling, D.W. [Fluid mechanics](#). 6th ed. Waltham, MA: Elsevier Academic Press, 2016. ISBN 9780124059351.
- Currie, I.G. [Fundamental mechanics of fluids](#). 4th ed. Boca Raton: CRC Press, 2013. ISBN 9781439874608.
- Batchelor, G.K. [An Introduction to fluid dynamics](#). Cambridge: Cambridge University Press, 1973. ISBN 0521663962.
- Chorin, J.; Marsden, J.E. [A mathematical introduction to fluid mechanics](#). 3rd ed. New York: Springer-Verlag, 1992. ISBN 0387979182.
- Fay, J.A. [Introduction to fluid mechanics](#). Cambridge ; London: MIT Press, 1994. ISBN 9788120310445.