Introduction to fluid mechanics

Academic Year: (2023 / 2024) **Review date: 04-06-2021**

Department assigned to the subject: null

Coordinating teacher: FERNANDEZ TARRAZO, EDUARDO ANTONIO

Type: Compulsory ECTS Credits : 6.0

Year : 2 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Calculus I & II, Linear Algebra, Physics I & II

OBJECTIVES

Fundamental and applied knowledge of the laws that determine the fluid motion and their application to problems of interest in engineering.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Introduction to Fluid Mechanics
 1.1. Solids, liquids and gases.
 1.2. The fluid as a continuum: Fluid particles.
 1.3. Density, velocity and internal energy.
 1.4. Local thermodynamic equilibrium.
 1.5. Equations of state.

2. Flow kinematics
 2.1 Coordinate systems
 2.2 Eulerian and Lagrangian descriptions. Uniform flow. Steady flow. Stagnation points.
 2.3 Trajectories. Paths. Fluid lines, Fluid surface, Fluid Volume.
 2.4 Streamlines, stream surface and stream tubes
 2.5 Material derivative. Acceleration
 2.6 Circulation and vorticity.
 2.7 Irrotational flow. Velocity Potential
 2.8 Stream function
 2.9 Local flow deformation. Strain-rate tensor
 2.10 Convective flow
 2.11 Reynolds transport theorem.

3. Conservation Laws
 3.1. Continuity equation in integral form
 3.2 Volume and surface forces
 3.3 Stress tensor. Navier-Poisson law
 3.4 Forces and moments on submerged bodies
 3.5 Momentum equation in integral form
 3.6 Angular momentum equation in integral form
 3.7 Heat conduction
 3.8 Energy equation in integral form. Different forms of the energy equation.

4. Conservation equations in differential form: Navier-Stokes equations.
 4.1 Continuity equation
 4.2 Momentum equation
 4.3 Energy equation. Internal energy and kinetic energy equations. Enthalpy and entropy equations.
 4.4 Initial and boundary conditions
 4.5 Bernoulli's equation.

5. Fluid statics
 5.1 Equilibrium equations
 5.2 Hydrostatics
 5.3 Forces and moments on submerged bodies. Archimedes' Principle.
 5.4 The standard atmosphere

6. Dimensional analysis
 6.1 Dimensions of a physical magnitude
 6.2 Physical quantities with independent dimensions
 6.3 The Pi theorem
 6.4 Nondimensionalization of the Navier-Stokes equations; Dimensionless numbers in Fluid Mechanics
 6.5 Physical similarity. Partial similarity. Applications.

7. Viscous flow
 7.1 Uni-directional viscous flow in channels and pipes: Poiseuille and Couette flows
 7.2 Uni-directional unsteady flows: Rayleigh's problem and Stokes' flow
 7.3 Flows dominated by viscosity in ducts and channels of slowly varying cross section
 7.4 The pipe entrance region
 7.5 Introduction to hydrodynamic lubrication. The wedge effect.

LEARNING ACTIVITIES AND METHODOLOGY

The methodology will combine lecture classes for presentation of the fundamentals with problem solving sessions. The laboratory sessions, to take place in the computer room, will consist of a crash course on CFD methods to enable students to use FLUENT for solving realistic flow problems. The evaluation of the laboratory sessions will be based on an individual CFD project in which the student will be asked to address the optimized design of a simple flow system.

ASSESSMENT SYSTEM

LAB (20%)
Part I exam (Midterm exam) (P1) (40%)
Part II exam (P2) (40%)
Course Grade CG = 0.20xLAB + 0.40xP1 + 040xP2

The continuous assessment allows to pass the course provided a Course grade equal or greater than 5.0 is achieved (a minimum 4.0 in each of the exams is required).

If the student fails to pass in the continuous assesment, the Final Grade (FG) is obtained after a Final Exam:

- Ordinary Final Exam (OFE)
  If OFE >= 4.0 => FG = 0.4xCG + 0.3xMAX(P1, OFE) + 0.3xMAX(P2,OFE)
  If OFE < 4.0 => FG = 0.4*CG + 0.6*OFE

- Extraordinary Final Exam (EFE)
  FG = MAX(0.4xCG+0.6xEFE, EFE)

% end-of-term-examination:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

BASIC BIBLIOGRAPHY

- A. Crespo Martínez Mecánica de Fluidos, Thompson, 2006
- F. M. White Fluid Mechanics, McGraw-Hill, 2015
- G. K. Batchelor An Introduction to Fluid Dynamics, Cambridge University Press, 1967
- L. D. Landau & E. M. Lifshitz Fluid Mechanics, Pergamon Press, 1987
- P. A. Lagerstrom Laminar Flow Theory, Princeton University Press, 1996

ADDITIONAL BIBLIOGRAPHY

- G.F. Carrier, C.E. Pearson. Ordinary Differential Equations. , SIAM (SIAM Classics in Applied Mathematics vol. 6). , 1991
- T. M. Apostol Calculus, John Wiley and Sons, 1969