UNIVERSITÀ DI PAVIA

Anno Accademico 2021/2022

FLUID MECHANICS

Enrollment year	2021/2022
Academic year	2021/2022
Regulations	DM270
Academic discipline	ICAR/01 (HYDRAULICS)
Department	DEPARTMENT OF CIVIL ENGINEERING AND ARCHITECTURE
Course	CIVIL ENGINEERING
Curriculum	Idraulico
Year of study	1°
Period	1st semester (27/09/2021 - 21/01/2022)
ECTS	6
Lesson hours	48 lesson hours
Language	Italian
Activity type	WRITTEN AND ORAL TEST
Teacher	MANENTI SAURO (titolare) - 6 ECTS
Prerequisites	Basics of vector, matrix and tensor algebra. Mathematical foundations: vector and tensor fields; differential operators; differential of a scalar valued function of vector variable. Integral theorems of Stokes and Gauss.
Learning outcomes	The course will provide the fundamental theoretical concepts and mathematical tools for the analysis and numerical modelling of relevant problems in the field of applied Fluid Mechanics. The students will become familiar with basic aspects of computer analysis and will acquire the techniques to investigate fundamental problems, such as: convective and diffusive potential flows; experimental measure of rheological properties of fluids; linear surface water wave propagation and transformation.
Course contents	Short review of mathematical foundations of vector and tensor algebra; state of stress at a material point of a continuum.

	Introduction to the analysis of local deformation and strain. Lagrangian and Eulerian description of motion. Rate of deformation tensor; vorticity tensor. Control volume and material volume; Reynolds transport theorem. Fundamental laws of continuum mechanics: continuity and momentum balance equations; general formulation of energy conservation principle. Mathematical formulation of the dynamic problem for the isothermal flow of a Newtonian fluid. Navier-Stokes equation. Properties of conservative vector field. Special cases: fluid at rest, Stevin's law; perfect fluid, Euler equation; steady barotropic potential flow of perfect fluid with conservative body forces, Bernoulli equation; Darcy's filtration law in porous media. Potential flow of incompressible fluid: Laplace equation. Two-dimensional shear flow and viscosity of a fluid. Non-Newtonian rheological models: Bingham, pseudoplastic, dilatant. Thixotropic fluids. Experimental measure of viscosity, coaxial cylinder rotational viscometer. Small amplitude wave theory: definitions; generalized boundary conditions; mathematical formulation and solution of the linearized boundary value problem (BVP). Relative water depth conditions. Wave celerity and the dispersion equation. Water particle kinematics and trajectories. Pressure field: dynamic pressure and pressure response factor. Energy of the linear wave field: specific wave energy and group celerity. Wave propagation on cylindrical bathymetry: mild slope conditions; shoaling and refraction. Outline of spectral wave models and applications.
Teaching methods	Lectures on: basic principles of Fluid Mechanics; conservation principles; constitutive equations for Newtonian fluids; non-Newtonian fluids; development and applications of Navier-Stokes, Euler, Bernoulli, and Laplace equations. Practical classes on: analytical/numerical solution of Navier-Stokes equations for the analysis of practical problems in the field of Fluid Mechanics; experimental measure of fluid viscosity.
Reccomended or required readings	# Aris R. "Vectors, tensors, and the basic equations of fluid mechanics" 1990 Dover pub ISBN-10: 0486661105. # Bear J. & Buchlin J-M. "Modelling and Applications of Transport Phenomena in Porous Media" Springer Science+Business Media, B.V. 1991. ISBN 978-94-010-5163-7 # Chou P.C. & Pagano N.J. "Elasticity, tensor, dyadic, and engineering approaches" 1992 Dover pub ISBN-13: 978-0486669588. # Citrini D., Noseda D. "Idraulica" CEA, Milano 1987 # Dean R.G. & Darlymple R.A. "Water wave mechanics for engineers and scientists" 1991 World Scientific ISBN: 978-981-02-0421-1. # De Girolamo P., Franco L., Noli A. "Fondamenti di oceanografia e idraulica marittima per ingegneri", dispense del corso (in Italian). # Ghetti A. "Idraulica" Libreria int. Cortina - Padova 2004. # Kundu P. K., Cohen I. M., Dowling D. R. "Fluid Mechanics" 6th Ed. 2016 Elsevier A.P. ISBN: 9780124059351. # Prager W. "Introduction to mechanics of continua" Ginn and Co. 1961 # Wilkinson W.L. "Non-Newtonian fluids" 1960 Pergamon Press. # Young I.R. "Wind Generated Ocean Waves" Volume 2, 1st Edition.

	Elsevier 1999 - ISBN: 9780080433172
Assessment methods	Oral exam on problems proposed during practical classes, with discussion of related theoretical aspects.
Further information	Lecture notes can be downloaded from the course page on the platform KIRO (https://elearning2.unipv.it/ingegneria/)
Sustainable development goals - Agenda 2030	$lbl_legenda_sviluppo_sostenibile