GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Advanced Numerical Fluid Mechanics, PG_00070354		
Field of study	Naval Architecture and Offshore Structures		
Date of commencement of studies	February 2026	Academic year of realisation of subject	2026/2027
Education level	second-cycle studies	Subject group	Specialty subject group Subject group related to scientific research in the field of study
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	1	Language of instruction	English
Semester of study	2	ECTS credits	3.0
Learning profile	general academic profile	Assessment form	exam
Conducting unit	Division of Hydromechanics and Ship Design -> Institute of Naval Architecture -> Faculty of Mechanical Engineering and Ship Technology -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. inż. Paweł Dymarski	
	Teachers	Jacek Pozorski Filip Hahs	

Lesson types

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	15.0	0.0	0.0	45.0	0.0	60

E-learning hours included: 0.0

eNauczanie source addresses:

Moodle ID: 7520 Advanced Numerical Fluid Mechanics
https://enauczanie.pg.edu.pl/2025/course/view.php?id=7520

Moodle ID: 7520 Advanced Numerical Fluid Mechanics
https://enauczanie.pg.edu.pl/2025/course/view.php?id=7520

Learning activity and number of study hours

Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
Number of study hours	60	5.0	10.0	75

Subject objectives

The aim of the course is to introduce students to computational fluid dynamics (CFD) methods. RANSE-CFD methods based on the finite volume method will be discussed. During laboratory sessions, students will learn to set up computational cases, perform calculations, and analyze the resulting data. In particular, students will learn to simulate flows involving a free surface.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_U13] evaluates the feasibility and potential for utilizing new technical and technological achievements in accomplishing tasks characteristic for the field of Naval Architecture and Offshore Structures	The student evaluates the applicability and potential use of the computational methods learned—particularly computational fluid dynamics—in tasks related to the hydromechanics of ships and offshore structures.	[SU4] Assessment of ability to use methods and tools [SU1] Assessment of task fulfilment
[K7_U01] applies acquired analytical, simulation, and experimental methods, as well as mathematical models for analysis and evaluation of shipborne and offshore systems and processes	The student uses computational fluid dynamics (CFD) methods and mathematical models to analyse flows and assess hydrodynamic phenomena in ship and ocean engineering systems.	[SU5] Assessment of ability to present the results of task

Subject contents	Course content – lecture 1. Introduction: basic concepts and methods of fluid mechanics, the role of CFD in the analysis of engineering problems, discretization of continuous systems 2. Basic conservation equations, integral formulation, constitutive relations, equations in conservative form, dimensionless form, critical numbers 3. Bernoulli's equation (optional), potential flows; surface waves; 4. Viscous flows, boundary conditions, the wall-layer approximation 5. Discretization of differential operators (difference schemes), the finite difference method (FDM) 6. Numerical integration of ordinary differential equations: initial and boundary value problems 7. Numerical integration of the diffusion equation: compatibility, convergence, and stability of solutions 8. Numerical integration of the advection-diffusion equation: upwind schemes 9. Fundamentals of the Finite Volume Method (FVM) 10. Discretization of the computational domain: structured and unstructured grids, single- and multi-block grids, grids for moving systems (stator-rotor, hull, propeller) of the overset (chimera-type) and sliding (sliding mesh) 11. Modeling free-surface flows: the VOF method 12. Alternative approaches in CFD: vortex methods, particle methods (SPH), the Lattice Boltzmann Method (LBM) 13. Fundamentals of flow turbulence: examples, hydrodynamic instability, capabilities and limitations of the DNS method, averaging techniques, the Reynolds equation 14. Modele turbulencji: metoda RANS, pojęcie lepkości turbulentnej, metoda symulacji dużych wirów (LES) 15. Perspektywy metod sztucznej inteligencji (AI) w CFD --- Course content – project 1. Introduction: basic concepts and methods of fluid mechanics, the role of CFD in the analysis of engineering problems, discretization of continuous systems 2. Basic conservation equations, integral formulation, constitutive relations, equations in conservative form, dimensionless form, critical numbers 3. Bernoulli's equation (optional), potential flows; surface waves; 4. Viscous flows, boundary conditions, the wall-layer approximation 5. Discretization of differential operators (difference schemes), the finite difference method (FDM) 6. Numerical integration of ordinary differential equations: initial and boundary value problems 7. Numerical integration of the diffusion equation: compatibility, convergence, and stability of solutions 8. Numerical integration of the advection-diffusion equation: upwind schemes 9. Fundamentals of the Finite Volume Method (FVM) 10. Discretization of the computational domain: structured and unstructured grids, single- and multi-block grids, grids for moving systems (stator-rotor, hull, propeller) of the overset (chimera-type) and sliding (sliding mesh) 11. Modeling free-surface flows: the VOF method

	12. Alternative approaches in CFD: vortex methods, particle methods (SPH), the Lattice Boltzmann Method (LBM) 13. Fundamentals of flow turbulence: examples, hydrodynamic instability, capabilities and limitations of the DNS method, averaging techniques, the Reynolds equation 14. Turbulence models: RANS method, concept of turbulent viscosity, large eddy simulation method (LES) 15. Prospects of artificial intelligence (AI) methods in CFD
Prerequisites and co-requisites	Basic knowledge in numerical methods and fluid mechanics

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Project	70.0%	65.0%
Exam	60.0%	35.0%

Recommended reading

Basic literature	Ferziger J.H., Perić M.: Computational Methods for Fluid Dynamics. Springer 2002 Gryboś R.: Podstawy mechaniki płynów. Wydawnictwo Naukowe PWN 1998 Anderson J.D.: Fundamentals of Aerodynamics. Mc Graw Hill 2011 Andersson B., Andersson R., Hakansson L., Mortensen M., Sudiyo R., van Wachem B.: Computational Fluid Dynamics for Engineers. Cambridge University Press 2011
Supplementary literature	Tesch K.: Numeryczna mechanika płynów. Wydawnictwo PG 2021 Versteeg H.K., Malalasekera W.: An Introduction to Computational Fluid Dynamics. Pearson Education Limited 2007 Faltinsen O.M.: Sea Loads On Ships and Offshore Structures. Cambridge 1990 Krężelewski M.: Hydromechanika ogólna i okrętowa część II. Skrypt PG
eResources addresses	

Example issues/ example questions/ tasks being completed	
Practical activites within the subject	Not applicable

Document generated electronically. Does not require a seal or signature.