



Subject card

Subject name and code	Fundamentals of Numerical Modelling of Fluid Flows, PG_00061839						
Field of study	Design and Construction of Yachts						
Date of commencement of studies	October 2026	Academic year of realisation of subject				2028/2029	
Education level	first-cycle studies	Subject group					
Mode of study	Full-time studies	Mode of delivery				at the university	
Year of study	3	Language of instruction				Polish	
Semester of study	6	ECTS credits				6.0	
Learning profile	general academic profile	Assessment form				assessment	
Conducting unit	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						
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	45.0	0.0	0.0	45.0	0.0	90
	E-learning hours included: 0.0						
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	90	0.0		0.0	90	
Subject objectives	<p>The aim of the course is to familiarize students with the methods of numerical fluid mechanics. Both methods used to model potential flow and RANSE-CFD methods based on the finite volume method will be discussed.</p> <p>During project classes, students will learn to prepare computational tasks, perform calculations and analyze the obtained results. In particular, students will learn how to perform flow calculations with a free surface.</p>						
Learning outcomes	Course outcome	Subject outcome			Method of verification		
	[K6_K02] can work in a team, assuming various roles, can act in a rational and ethical way	The student is able to work in a team to solve a numerical fluid dynamics task using an appropriate CFD tool			[SK1] Assessment of group work skills [SK5] Assessment of ability to solve problems that arise in practice		
	[K6_W02] has knowledge in the field of technical mechanics, fluid mechanics, strength of materials, necessary to understand the basic physical phenomena occurring in ocean engineering	The student has knowledge in the field of fluid mechanics necessary to understand and model basic physical phenomena in the field of FM occurring in ocean engineering.			[SW3] Assessment of knowledge contained in written work and projects		
	[K6_U04] has skills that allow for self-education and preparation for work in an industrial environment, including the application of occupational health and safety rules	The student is able to self-educate using a manual (tutorial) dedicated to specific CFD software.			[SU1] Assessment of task fulfilment [SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools		

Subject contents	<p>Course content – lecture</p> <ol style="list-style-type: none"> <li>1. Basic equations governing the movement of fluids <ol style="list-style-type: none"> <li>1.1 Basic (simplified) mathematical models used in FM <ul style="list-style-type: none"> <li>- incompressible fluids</li> <li>- non-viscous liquids</li> <li>- potential flows</li> </ul> </li> </ol> </li> <li>2. Introduction to numerical methods <ol style="list-style-type: none"> <li>2.1 What is CFD</li> <li>2.2 Classification of methods <ul style="list-style-type: none"> <li>- methods of solving potential flows</li> <li>- methods for solving viscous flows: <ul style="list-style-type: none"> <li>-- finite CD method,</li> <li>-- FVM finite volume method,</li> </ul> </li> </ul> </li> </ol> </li> <li>3. Methods of modeling potential flows <ol style="list-style-type: none"> <li>3.1 Laplace's equation</li> <li>3.2 Formulating boundary conditions: <ul style="list-style-type: none"> <li>- Neumann problem,</li> <li>- Dirichlet problem.</li> </ul> </li> <li>3.3 Functions satisfying Laplace's equation - hydromechanical singularities <ol style="list-style-type: none"> <li>3.3.1 Modeling simple flows using hydrodynamic singularities <ul style="list-style-type: none"> <li>- Rankin oval,</li> <li>- flow around a circular cylinder,</li> <li>- flow around the sphere</li> </ul> </li> <li>3.4 General method for determining potential non-circulating flows <ul style="list-style-type: none"> <li>- source-sink method</li> </ul> </li> <li>3.5 Methods for determining the flow on a hydromechanical sheet - circulation flows <ul style="list-style-type: none"> <li>- 2D flows, Kutta condition,</li> <li>- vortex fiber in 3D space - Biot-Savart equation,</li> <li>- flow around an airfoil with a finite span</li> </ul> </li> <li>3.6 Hydrodynamic reactions in stationary potential flow. Discussion</li> <li>3.7 Unstationary potential flow <ol style="list-style-type: none"> <li>3.7.1 Water wave motion potential</li> <li>3.7.2 Flow around bodies in wave motion</li> <li>3.7.3 Bernoulli equation. Determination of the hydrodynamic reaction</li> </ol> </li> </ol> </li> <li>4. Methods for determining viscous flows. Finite volume method <ol style="list-style-type: none"> <li>4.1 Definition of mesh element (CV control volume)</li> <li>4.2 Surface and volume integrals within CV</li> <li>4.3 Interpolation schemes and their impact on the accuracy/stability of calculations</li> <li>4.4 Formulating boundary conditions</li> </ol> </li> <li>5. Computational grids <ol style="list-style-type: none"> <li>5.1 Types of computational grids and their impact on calculation accuracy</li> <li>5.2 Techniques for "thickening" the mesh. Why do we use different densities? <ol style="list-style-type: none"> <li>5.2.1 Mesh refinement near the "wall". Problem <math>y^+</math></li> </ol> </li> <li>5.3 Special/non-standard nets <ol style="list-style-type: none"> <li>5.3.1 non-machining grid</li> <li>5.3.2 Moving grids: <ul style="list-style-type: none"> <li>- sliding mesh</li> <li>- "overset" mesh (overlapping meshes)</li> </ul> </li> </ol> </li> <li>5.4. Examples of "good" and "bad" mesh.</li> <li>5.5. Analysis of the influence of mesh density on the solution</li> </ol> </li> <li>6. Techniques used to solve systems of linear and nonlinear equations <ol style="list-style-type: none"> <li>6.1 Exact methods</li> <li>6.2 Iterative methods. The problem of "empty" matrices</li> <li>6.3 Systems of nonlinear equations.</li> </ol> </li> <li>7. Methods used for non-stationary calculations <ol style="list-style-type: none"> <li>7.1 Discussion of "basic" time integration methods <ul style="list-style-type: none"> <li>- Euler methods (explicit and implicit)</li> <li>- trapezoidal method</li> <li>- midpoint method</li> </ul> </li> <li>7.2 Predictor-corrector integration methods</li> <li>7.3. Runge-Kutta methods and others</li> <li>7.4. The impact of the methods used on the accuracy/stability and speed of the obtained solution.</li> </ol> </li> <li>8. (optional) Issues related to solving the N-S equation</li> <li>9. Turbulence models</li> <li>10. Special and practical issues <ol style="list-style-type: none"> <li>10.1 Testing the convergence of calculations</li> <li>10.2 Calculation of the hydrodynamic reaction</li> <li>10.3 Calculation of object dynamics - fluid-rigid body interaction</li> <li>10.4 Boundary conditions for calculations of a ship/object subjected to wave action</li> <li>10.5 Hull-propeller systems.</li> </ol> </li> </ol> </li></ol>
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Prerequisites and co-requisites	Knowledge of fluid mechanics, Knowledge of the basics of numerical methods: - the concept of interpolation, - basics of numerical integration Knowledge of 3D object modeling software, Knowledge of basic mechanics: - understanding the concept of reaction force, understanding the second law of dynamics, - knowledge of vector calculus		
Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	Lecture	60.0%	50.0%
	Project	70.0%	50.0%
Recommended reading	Basic literature	Ferziger J.H., Perić M. Computational Methods for Fluid Dynamics. Springer 2002 Gryboś Ryszard: Podstawy mechaniki płynów. Wydawnictwo Naukowe PWN 1998 John D. Anderson: Fundamentals of Aerodynamics. Mc Graw Hill 2011	
	Supplementary literature	H K Versteeg and W Malalasekera: An Introduction to Computational Fluid Dynamics. Pearson Education Limited 2007 O.M. Faltinsen: Sea Loads On Ships and Offshore Structures . Cambridge 1990 M. Krężelewski: Hydromechanika ogólna i okrętowa część II. Skrypt PG	
	eResources addresses		
Example issues/ example questions/ tasks being completed			
Practical activities within the subject	Not applicable		

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