GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Numerical Fluid Mechanics, PG_00060548						
Field of study	Naval Architecture and Offshore Structures						
Date of commencement of studies	October 2024			Academic year of realisation of subject		2026/2027	
Education level	first-cycle studies			Subject group		Optional 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	3			Language of instruction		Polish	
Semester of study	6			ECTS credits		7.0	
Learning profile	general academic profile			Assessment form		assessment	
Conducting unit	Institute of Ocean Engineering and Ship Technology -> Faculty of Mechanical Engineering and Ship Technology						
Name and surname of lecturer (lecturers)	Subject supervisor			dr hab. inż. Paweł Dymarski			
	Teachers						
Lesson types and methods of instruction	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		9.0	76.0		175
Subject objectives	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. 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.						

Learning outcomes

Course outcome	Subject outcome	Method of verification
[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_U06] in compliance with a formulated specification and with the aid of appropriate tools and methods, is able to complete a simple engineering task within the range of design, construction and operation of ocean technology objects and systems	The student is able to prepare a computational task and perform calculations using CFD software in order to perform an engineering task in the field of design and operation of offshore structures.	[SU1] Assessment of task fulfilment [SU4] Assessment of ability to use methods and tools [SU5] Assessment of ability to present the results of task
[K6_W06] has an organized knowledge on engineering methods and design tools allowing the conducting of projects within the construction and operation of ocean technology objects and systems	The student has structured knowledge of numerical fluid mechanics. Knows CFD methods and tools enabling the implementation of projects in the field of construction and operation of offshore structures.	[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	1. Basic equations governing the movement of fluids 1.1 Basic (simplified) mathematical models used in FM - incompressible fluids - non-viscous liquids - potential flows 2. Introduction to numerical methods 2.1 What is CFD 2.2 Classification of methods - methods of solving potential flows - methods for solving viscous flows: -- finite CD method, -- FVM finite volume method, 3. Methods of modeling potential flows 3.1 Laplace's equation 3.2 Formulating boundary conditions: - Neumann problem, - Dirichlet problem. 3.3 Functions satisfying Laplace's equation - hydromechanical singularities 3.3.1 Modeling simple flows using hydrodynamic singularities - Rankin oval, - flow around a circular cylinder, - flow around the sphere 3.4 General method for determining potential non-circulating flows - source-sink method 3.5 Methods for determining the flow on a hydromechanical sheet - circulation flows - 2D flows, Kutta condition, - vortex fiber in 3D space - Biot-Savart equation, - flow around an airfoil with a finite span 3.6 Hydrodynamic reactions in stationary potential flow. Discussion 3.7 Unstationary potential flow 3.7.1 Water wave motion potential 3.7.2 Flow around bodies in wave motion 3.7.3 Bernoulli equation. Determination of the hydrodynamic reaction 4. Methods for determining viscous flows. Finite volume method 4.1 Definition of mesh element (CV control volume) 4.2 Surface and volume integrals within CV 4.3 Interpolation schemes and their impact on the accuracy/stability of calculations 4.4 Formulating boundary conditions 5. Computational grids 5.1 Types of computational grids and their impact on calculation accuracy 5.2 Techniques for "thickening" the mesh. Why do we use different densities? 5.2.1 Mesh refinement near the "wall". Problem y+ 5.3 Special/non-standard nets 5.3.1 non-machining grid 5.3.2 Moving grids: - sliding mesh - "overset" mesh (overlapping meshes) 5.4. Examples of "good" and "bad" mesh. 5.5. Analysis of the influence of mesh density on the solution 6. Techniques used to solve systems of linear and nonlinear equations 6.1 Exact methods 6.2 Iterative methods. The problem of "empty" matrices 6.3 Systems of nonlinear equations. 7. Methods used for non-stationary calculations 7.1 Discussion of "basic" time integration methods - Euler methods (explicit and implicit) - trapezoidal method - midpoint method 7.2 Predictor-corrector integration methods 7.3. Runge-Kutta methods and others 7.4. The impact of the methods used on the accuracy/stability and speed of the obtained solution. 8. (optional) Issues related to solving the N-S equation 9. Turbulence models 10. Special and practical issues 10.1 Testing the convergence of calculations 10.2 Calculation of the hydrodynamic reaction 10.3 Calculation of object dynamics - fluid-rigid body interaction 10.4 Boundary conditions for calculations of a ship/object subjected to wave action 10.5 Hull-propeller systems.

<table>
<tr><td>Prerequisites
and co-requisites</td><td colspan="2">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</td></tr>
<tr><td>Assessment methods
and criteria</td><td colspan="2"><table><tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr><tr><td>Lecture</td><td>60.0%</td><td>50.0%</td></tr><tr><td>Project</td><td>70.0%</td><td>50.0%</td></tr></table></td></tr>
<tr><td rowspan="3">Recommended reading</td><td>Basic literature</td><td>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</td></tr>
<tr><td>Supplementary literature</td><td>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</td></tr>
<tr><td>eResources addresses</td><td>Adresy na platformie eNauczanie:</td></tr>
<tr><td>Example issues/
example questions/
tasks being completed</td><td colspan="2"></td></tr>
<tr><td>Work placement</td><td colspan="2">Not applicable</td></tr>
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