GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Wind turbine aerodynamics, PG_00062650		
Field of study	Naval Architecture and Offshore Structures		
Date of commencement of studies	February 2024	Academic year of realisation of subject	2024/2025
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	Polish
Semester of study	2	ECTS credits	3.0
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	dr inż. Joanna Grzelak dr hab. inż. Paweł Dymarski	

Lesson types and methods of instruction

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	30.0	0.0	15.0	0.0	0.0	45
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	45	6.0	24.0	75

Subject objectives

The aim of the course is to familiarize students with issues related to the aerodynamics of wind turbines. In particular, the student will acquire knowledge in the field of flow around a 2D profile, flow around an airfoil with a finite span and flow around a wind turbine rotor. Students will learn the principle of operation of the turbine and methods for determining aerodynamic forces on its blades. During the laboratory exercises, the student will learn about experimental research methods for vertical axis wind turbines

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_W02] Explains the essence and relationships of key components describing systems and processes in ocean engineering, utilizing current knowledge from major scientific fields related to the field of study	The student will be aware that a wind turbine rotor is part of a larger system which is an (offshore) wind farm.	[SW3] Assessment of knowledge contained in written work and projects
[K7_K01] Understands the need for lifelong learning, critically evaluate acquired knowledge, and comprehend the significance of knowledge in addressing cognitive and practical problems	The student will be introduced to a part of a larger area of knowledge, which is the aerodynamics of wind turbines. He will learn the tools/methods that will allow him to deepen his knowledge in the future	[SK5] Assessment of ability to solve problems that arise in practice
[K7_W03] Demonstrates advanced skills in applying analytical methods and problem-solving techniques related to ocean engineering, using appropriate tools	Student possesses basic skills in using analytical and empirical methods to solve problems related to the aerodynamics of wind turbines.	[SW3] Assessment of knowledge contained in written work and projects

Subject contents	1. Fluid mechanics review 1.1 Flow kinematics - streamlines, stream surface, stream tube - path (trajectory) of a fluid element, stream surface, stream 1.2 Flow rate: mass flow, volume flow 1.3 Mass conservation principle 1.4 Momentum conservation principle, Bernoulli's equation 1.5 Scalar field, vector field 1.6 Gradient, potential vector field 1.7 Vorticity and divergence of a vector field 1.8 Velocity circulation 1.9 Relationship between circulation and vorticity. 2. Aerodynamic profile theory 2.1 Geometric description 2.2 Lift force, drag force, moment on the profile (2D) 2.3 Pressure coefficient CP, pressure distribution 2.4 Mechanism of lift force generation, Kutta-Zhukovsky equation 2.5 Influence of Reynolds number on Cl, Cd characteristics of the airfoil profile 2.6 Fundamentals of numerical modeling of the flow around the aerodynamic profile 3. Fundamentals of the theory of a finite span airfoil (wing) 3.1 Geometric description of the airfoil 3.2 Lift and drag force on the airfoil (3D) 3.3.1 Helmholtz theorem. The concept of a horseshoe vortex. Bound vortex, free vortices. 3.3.2 System of vortex fibers on and behind the airfoil. 3.3.3 Lift line theory. Calculation of the lift and drag force of the airfoil. 4. Basics of Wind Turbine Aerodynamics 4.1 Ideal Wind Turbine. Momentum Principle for One-Dimensional (1D) Flow 4.1.1 Betz Limit 4.2 Turbine Spinning Effect. Momentum Principle. 4.3 Blade Element Method (BEM) in Stationary Flow 4.4 Unsteady Flow. Turbine Yaw Effect. 5. Wind Modeling 5.1. (Stationary) Wind Speed Profile 5.2. Wind Spectrum (Spectra) 5.3. Determining the Wind Velocity Field in Unsteady Approach 6. Application of Lifting Line Theory to Determining the Flow Around a Turbine Rotor 7. Familiarization with the aerodynamics of vertical axis wind turbines during laboratory exercises
Prerequisites and co-requisites	Basic knowledge of fluid mechanics: - the concept of mass flow and volume flow - the principle of flow continuity - the principle of conservation of momentum - Bernoulli's equation - the concept of field vorticity and circulation - basic solutions of flow (potential flow) -- Rankine's oval -- flow around a circular cylinder - the concept of hydrodynamic reaction Basics of vector calculus: - the scalar product of two vectors - the vector product - the gradient of a scalar field

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Labs (reports)	60.0%	33.0%
Lecture (colloquium)	60.0%	67.0%

Recommended reading

Basic literature	1. Snorri Gudmundsson: GENERAL AVIATION AIRCRAFT DESIGN: APPLIED METHODS AND PROCEDURES. Amsterdam, Elsevier 2014 2. Ira H. Abbott, Albert E. Von Doenhoff THEORY OF WING SECTIONS Including a Summary of Airfoil Data. DOVER PUBLICATIONS, INC., NEW YORK 1949, 1959 3. Ryszard Gryboś: Podstawy mechaniki płynów. Warszawa, Wydawnictwo Naukowe PWN, 1998 4. Martin O. L. Hansen: Aerodynamics of Wind Turbines 2nd ed. London * Sterling, Earthscan, 2008 5. John D. Anderson, Jr.: Fundamentals of Aerodynamics Sixth Edition
Supplementary literature	6. J. Jonkman, S. Butterfield, W. Musial, and G. Scott: Definition of a 5-MW Reference Wind Turbine for Offshore System Development. Technical Report NREL/TP-500-38060, February 2009 7. Gaertner Evan, Jennifer Rinker, Latha Sethuraman, i inni. (2020). Definition of the IEA 15-Megawatt Offshore Reference Wind Turbine. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-75698. https://www.nrel.gov/docs/fy20osti/75698.pdf

	eResources addresses	Adresy na platformie eNauczanie: Aerodynamika turbin wiatrowych (PG_00062650), W i L, II st. stacj., sem. 2, zima 24/25 - Moodle ID: 40673 https://enauczanie.pg.edu.pl/moodle/course/view.php?id=40673
Example issues/ example questions/ tasks being completed		
Work placement	Not applicable	

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