



Subject card

Subject name and code	Wind turbine aerodynamics, PG_00064894						
Field of study	Aerodynamika turbin wiatrowych						
Date of commencement of studies	February 2025		Academic year of realisation of subject		2025/2026		
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		exam		
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	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		8.0		22.0	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_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 applies analytical, numerical, and experimental methods to analyze wind turbines. The student understands the basic properties of the most important turbine types.		[SU4] Ocena umiejętności korzystania z metod i narzędzi [SU1] Ocena realizacji zadania		
	[K7_W12] identifies and interprets the main developmental trends and significant new achievements in the field of engineering and technical sciences and disciplines relevant to the course of study		The student identifies and interprets the main development trends and the most important new achievements in the field of wind turbine aerodynamics.		[SW1] Ocena wiedzy faktograficznej		
	[K7_U02] formulates and tests hypotheses concerning problems related to shipborne and offshore systems/processes, as well as simple research problems		The student is able to solve basic tasks related to wind turbine design. The student is able to solve simple research problems.		[SU4] Ocena umiejętności korzystania z metod i narzędzi [SU3] Ocena umiejętności wykorzystania wiedzy uzyskanej w ramach przedmiotu [SU1] Ocena realizacji zadania		

Subject contents	Course content – lecture 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 C_p, pressure distribution 2.4 Mechanism of lift force generation, Kutta-Zhukovsky equation 2.5 Influence of Reynolds number on C_l, C_d 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 Course content – laboratory 1. Using Basic Hydrodynamic Singularities to Model Flows - Flow Around a Circular Cylinder -- Non-Circulation Flow -- Circulation Flow 2. Mechanism of Lift Generation. Kutta-Zhukovsky Equation 3. Flow Around a 2D Airfoil. Kutta Condition 4. Finite-Span Wing. Calculating Lift and Drag Forces - Lifting Line Method. Calculation Algorithm		
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 8. Sven Schmitz: Aerodynamics of Wind Turbines: A Physical Basis for Analysis and Design, WILEY 2020
	eResources addresses	
Example issues/ example questions/ tasks being completed		
Practical activities within the subject	Not applicable	

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