GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Wind turbine aerodynamics, PG_00065541		
Field of study	Naval Architecture and Offshore Structures		
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	Part-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	18.0	0.0	9.0	0.0	0.0	27

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	27	7.0	41.0	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.	[SU1] Assessment of task fulfilment [SU4] Assessment of ability to use methods and tools
[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] Assessment of factual knowledge
[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.	[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	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 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 Course content – laboratory 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 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 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 activites within the subject	Not applicable	

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