



Subject card

Subject name and code	Aeroelasticity and Durability of Wind Turbines, PG_00064895						
Field of study	Aeroelastyczność i wytrzymałość 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			2.0	
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	15.0	15.0	0.0	0.0	0.0	30
	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	30		5.0		15.0	50
Subject objectives	The aim of the course is to familiarize students with the phenomenon of aeroelasticity of a wind turbine blade, i.e. deformation and / or vibration of a turbine blade due to the action of aerodynamic forces.						
Learning outcomes	Course outcome		Subject outcome			Method of verification	
	[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 simple design tasks related to the analysis of the aeroelasticity of a wind turbine blade.			[SU4] Ocena umiejętności korzystania z metod i narzędzi [SU1] Ocena realizacji zadania	
	[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 uses the analytical and numerical methods learned to analyze and evaluate the characteristics related to the aeroelasticity of wind turbine blades			[SU4] Ocena umiejętności korzystania z metod i narzędzi [SU1] Ocena realizacji zadania	

Subject contents	Course content – lecture 1. The theory of the aerodynamic profile 1.1 Geometric description 1.2 Lifting force, drag force, profile moment (2D) 1.3 Pressure coefficient CP, pressure distribution 1.4 Mechanism of lift force generation, Kutta-Joukowski equation 2. The theory of the aerofoil (wings) 2.1 Geometric description of the aerofoil 2.2 Lift force on the aerofoil/wing (3D) 3. Numerical analysis of the aerofoil 3.1 Arrangement of the vortex filaments on and behind the wing 3.2 The lifting line theory 4. The blade as a bending beam 4.1 Revision of basic knowledge of the subject 4.1.1 Characteristics of the beam cross-section 4.1.2 Basic solutions for a bending beam. 4.3 Beam stiffness 4.4 Equation of beam deflection 4.5 Stiffness matrix 4.6 Aeroelasticity: static case - blade bending 5. The blade as a twisted beam 5.1.1 Characteristics of the aerofoil cross-section as a closed-profile beam (torsion) 5.1.2 Basic solutions for a twisted beam 5.2 Aeroelasticity: static case - blade twisting 6. Introduction to aerofoil dynamics 6.1 Dynamics of a system with one degree of freedom. Mass spring system 6.2 Dynamics of a system with many degrees of freedom. Model of concentrated (point) masses (lumped mass model) 7. The "real" velocity field of the flowing wind turbine blade. 7.1 Determining the Velocity Field of the Selected Turbine Blade Profile. Stationary case 7.2 Determination of the non-stationary velocity field of the selected turbine blade profile for the stationary wind speed profile. 7.3 The case of a non-stationary wind velocity field. 7.3.1 The spectrum of the wind 7.3.2 Determination of the non-stationary velocity field of the selected turbine blade profile. 8. Basics of blade/foil analysis in the frequency domain 9. Dynamics of the turbine rotor - tower system. Introduction. Course content – exercises see lecture											
Prerequisites and co-requisites	- the student has basic knowledge of fluid mechanics: -- flow continuity equation -- Bernoulli equation -- the concept of lift force and drag force on the aerofoil - the student has a basic knowledge of the strength of materials: -- cross-section characteristics: moments of inertia and strength factors -- basic knowledge of beam bending (statically determinate) -- basic knowledge of screwing closed profiles -- basic knowledge of the theory of vibrations - mass on a spring with a damping element - basic knowledge of general mechanics -- equilibrium equations (statics) -- Newton's laws of motion - basics of numerical methods -- numerical integration -- basic time integration methods											
Assessment methods and criteria	<table><tr><td>Subject passing criteria</td><td>Passing threshold</td><td>Percentage of the final grade</td></tr><tr><td>Lecture</td><td>60.0%</td><td>50.0%</td></tr><tr><td>Exercises</td><td>60.0%</td><td>50.0%</td></tr></table>			Subject passing criteria	Passing threshold	Percentage of the final grade	Lecture	60.0%	50.0%	Exercises	60.0%	50.0%
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Recommended reading	Basic literature	1. Snorri Gudmundsson: GENERAL AVIATION AIRCRAFT DESIGN: APPLIED METHODS AND PROCEDURES. Amsterdam, Elsevier 2014 2. R.K. Bansal: A Textbook of Strength of Materials, 4th edition, Boston 2009 3. John D. Anderson, Jr.: Fundamentals of Aerodynamics, Sixth Edition 4. Martin O. L. Hansen: Aerodynamics of Wind Turbines 2nd ed. London * Sterling, Earthscan, 2008 5. Srinivasan Chandrasekaran: Dynamic Analysis and Design of Offshore Structures. Springer 2015, 2018										

	Supplementary literature	6. Ira H. Abbott, Albert E. Von Doenhoff THEORY OF WING SECTIONS Including a Summary of Airfoil Data. DOVER PUBLICATIONS, INC., NEW YORK 1949, 1959 7. Dewey H. Hodges, G. Alvin Pierce: Introduction to Structural Dynamics and Aeroelasticity. Cambridge University Press 2002, 2011 8. James F. Wilson: "Dynamics of Offshore Structures" 2nd ed. John Wiley & Sons 2003 9. E. Gaertner, J. Rinker, L. Sethuraman: Definition of the IEA Wind 15-Megawatt Offshore Reference Wind Turbine. Technical Report, NREL, March 2020
	eResources addresses	
Example issues/ example questions/ tasks being completed	Examples of issues: 1.determination of the lift force / drag force / torque on the aerofoil based on the characteristics of the CL, CD, CM coefficients as a function of the angle of attack α 2. Explanation of the phenomenon of the formation of lift force. Kutta-Joukowski theorem 3. Lift force on finite span aerofoils. Overview of the carrier line method 4. Characteristics of the cross-section of a bending beam 5. Determination of internal forces in a bending beam and the deflection line. A beam restrained on one side with a constant (or variable) cross-section 6. Characteristics of the cross-section of a closed profile twisted beam 7. Determination of internal forces in a twisted beam and the angle of twist. One-sidedly restrained beam 8. The problem of beam stiffness. Stiffness matrix 9. Overview of the dynamics of a system with one degree of freedom (on the example of a mass on a spring with a damping element). Equation of motion, response to sinusoidal input 10. Overview of the dynamics (equation of motion) of a system with many degrees of freedom (on the example of 2-3 degrees of freedom) 11. Velocity field (velocity components) in the problem of turbine blade flow. 12. Wind modeling - stationary / non-stationary model. The spectrum of the wind	
Practical activities within the subject	Not applicable	

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