GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Aeroelasticity and Durability of Wind Turbines, PG_00065542		
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	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	9.0	9.0	0.0	0.0	0.0	18

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	18	4.0	28.0	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_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	[SU1] Assessment of task fulfilment [SU4] Assessment of ability to use methods and tools
[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.	[SU1] Assessment of task fulfilment [SU4] Assessment of ability to use methods and tools

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

Subject passing criteria	Passing threshold	Percentage of the final grade
Exercises	60.0%	50.0%
Lecture	60.0%	50.0%

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 alpha 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 activites within the subject	Not applicable	

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