Warsaw University of Technology

COURSE OFFERED IN THE DOCTORAL SCHOOL

Code of the course	4606-ES-00000HI-0347	Name of the course	Polish	**Podstawy teorii maszyn przepływowych**
			English	**Basis of Turbomachinery**
Type of the course	specialty subjects			
Course coordinator	Prof. dr hab. Inż. Jarosław Milewski			
Implementing unit	MEL	Scientific discipline / disciplines*	Environmental Engineering, Mining and Energy, Mechanical engineering	

Level of education	PhD	Semester	summer		
Language of the course	English				
Type of assessment:	credit with a grade	Number of hours in a semester	45	ECTS credits	4
Minimum number of participants	10	Maximum number of participants	30	Available for students (BSc, MSc)	~~Yes~~/No

Type of classes		Lecture	Auditory classes	Project classes	Laboratory	Seminar
Number of hours	in a week	2		1		
	in a semester	30		15		

* does not apply to the Researcher's Workshop

1. Prerequisites

To enroll in the course "Basis of Turbomachinery," students should possess the following knowledge and skills:

Students should have a solid understanding of fluid mechanics, including the fundamental equations that describe fluid flow (continuity equation, Bernoulli's equation, Navier-Stokes equations) and the principles of laminar and turbulent flow.

A good grasp of thermodynamics is essential, including the first and second laws of thermodynamics, as well as the ability to analyze thermodynamic cycles such as the Carnot, Rankine, and Brayton cycles.

Advanced mathematics knowledge is required, including differential and integral calculus, and differential equations. Students should be capable of solving differential equations in the context of engineering problems.

Students should have a basic understanding of classical mechanics and dynamics in physics, with the ability to apply physical laws to analyze and solve technical problems.

Familiarity with computational tools for numerical analysis (such as MATLAB, ANSYS, Fluent) will be an additional asset. Students should be able to use these tools for modeling and simulating flow processes.

Proficiency in English is necessary to read technical literature and participate in lectures conducted in English.

Meeting these prerequisites will ensure a better understanding of the course material and active participation in class activities.

2. Course objectives

The course aims to provide students with a comprehensive understanding of the fundamental principles of turbomachinery, including compressors, turbines, and pumps. It focuses on teaching methods for analyzing and designing various types of turbomachinery, with an emphasis on energy and mechanical efficiency. The course introduces mathematical modeling and numerical simulations to analyze fluid flow in turbomachinery, applying theoretical knowledge to practical engineering problems such as optimizing performance under different operating conditions.

Students will develop research skills by planning and executing experiments and analyzing results in the field of turbomachinery. The course also aims to familiarize students with the latest technological advancements in turbomachinery and their industrial applications. Additionally, it seeks to enhance students' communication skills through presentations and discussions on projects and research findings related to turbomachinery. These objectives are designed to equip students with the knowledge and skills necessary to excel in turbomachinery engineering in both academic and industrial settings.

3. Course content (separate for each type of classes)
Lecture
The scope of the lecture includes: 1. **Fundamentals of Gas Turbine Design** - overview of gas turbines (single-shaft, multi-shaft, unconventional); their configurations and classification, differences and similarities. 2. **Fundamentals of Thermodynamics and Fluid Dynamics** - principles of gas turbine operation; loads acting on turbine components; their modeling at the architectural level; assumptions and simplifications. 3. **Gas Turbine Model Design** - mathematical models of gas turbine operations; objectives for modeling; methods for formulating equations; simplification of models at the level of physical and mathematical modeling. 4. **Analysis of Gas Turbine Properties** - analysis of turbine performance and efficiency; evaluation of operational qualities of gas turbines; objective and subjective criteria for performance evaluation. 5. **Fundamentals of Control System Design for Gas Turbines** - methods used for designing control systems for gas turbines; sources of information for control system design; structure of automatic control systems; control methods for linear systems.
Project
The scope of the project includes: 1. Development of a physical, mathematical, and simulation model of the gas turbine. 2. Study of the operational properties of the modeled gas turbine. 3. Development and analysis of a control system.

4. Learning outcomes			
	Learning outcomes description	Reference to the learning outcomes of the WUT DS	Learning outcomes verification methods*
Knowledge			
W01	Understanding of the principles of construction and operation of prospective energy technologies	SD_W1	Oral/written exam; research project
W02	Knowledge of forward-looking energy technologies	SD_W3	Presentation; discussion; essay
W03	Understanding of hydrogen technologies	SD_W3	Research report; group work
Skills			
U01	Ability to critically analyze and solve problems	SD_U1 SD_U2 SD_U3	Tests; course-related assignments
U02	Environmental awareness and promotion of sustainable development	SD_K1	Interdisciplinary project; group discussions
Social competences			
K01	Ability to work in a team and cooperate internationally	SD_K3	Evaluation of group cooperation; instructor feedback

*Allowed learning outcomes verification methods: exam; oral exam; written test; oral test; project evaluation; report evaluation; presentation evaluation; active participation during classes; homework; tests

5. Assessment criteria
Credit project

6. Literature
1. Primary references Gorla, Rama S. R., and Aijaz A. Khan. *Turbomachinery: Design and Theory, CRC Press*. This book encapsulates the fundamental principles involved in the design and analysis of turbomachinery, blending both theoretical frameworks and practical applications, making it an essential resource for both students and professionals in the field. Shepherd, Dennis G. (1956) *Principles of Turbomachinery, Macmillan Pub. Co* This seminal text offers an in-depth exploration of the principles and applications of turbomachinery, covering a broad spectrum of topics from thermodynamics and fluid mechanics to performance analysis. Dixon, S. Larry, and Cesare Hall (2013) *Fluid Mechanics and Thermodynamics of Turbomachinery (7th ed), Butterworth-Heinemann.* This publication delves into the fluid mechanics and thermodynamics principles fundamental to turbomachine operations, enriched with detailed explanations, diagrams, and real-world applications. Lewis, R. I. (1996) *Turbomachinery Performance Analysis, Butterworth-Heinemann.* This comprehensive resource addresses performance analysis in turbomachinery, incorporating both theoretical and experimental approaches to provide practical insights for engineers and researchers. 2. Secondary references Logan Jr., Earl, 1993, *Turbomachinery: Basic Theory and Applications, (2nd ed.), CRC Press* Tailored for both academia and industry, this book discusses the fundamental theories and diverse applications of turbomachinery, suitable for undergraduate and graduate studies as well as engineering practice. Horlock, John H., 1996, *Axial Flow Turbines: Fluid Mechanics and Thermodynamics*., Butterworths This text provides an extensive analysis of the design and operation of axial flow turbines, focusing on their fluid dynamics and thermodynamic properties. Stepanoff, Alexey J., 1957, *Centrifugal and Axial Flow Pumps: Theory, Design, and Application, Wiley* Covering centrifugal and axial flow pumps, this book offers insights into the theory, design, and practical applications of these critical turbomachinery components.

7. PhD student's workload necessary to achieve the learning outcomes**		
No.	Contact hours with an academic teacher resulting from the plan	Number of hours
1	Contact hours with the academic teacher as part of consultations, exams, tests, etc.	45
2	Hours of independent work of a doctoral student in preparation for classes and preparation of reports, projects, presentations, reports, homework	10
3	Hours of independent work of a doctoral student in preparation for an exam, test, credit	40
4	Contact hours with an academic teacher resulting from the plan	15
	Total number of hours	**110**
	ECTS credits	**4**

** 1 ECTS = 25-30 hours of the PhD student work (2 ECTS = 60 hours; 4 ECTS = 110 hours, etc.)

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