

COURSE OFFERED IN THE DOCTORAL SCHOOL

Code of the course	4606-ES-00000FH-0066	Name of the course	Polish English	Teoria niezawodności i analiza ryzyka Theory of Reliability and Risk Analysis			
Type of the course	specialized						
Course coordinator	Andrzej Wolff, Ph.D., D.Sc., – Assistant Professor						
Implementing unit	Faculty of transport	Scientific discipline / disciplines*	Civil engineering, geodesy and transport, mechanical engineering				
Level of education	Education of doctoral students	Semester	Winter/summer semester				
Language of the course	English						
Type of assessment:	credit with a grade	Number of hours in a semester	45	ECTS credits	3		
Minimum number of participants	12	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 in a semester	3 45					

* does not apply to the Researcher's Workshop

1. Prerequisites

No requirements.

2. Course objectives

Ability to evaluate the operational reliability of technical systems. Description of changes in the technical state of objects and assessment of their operational reliability using probabilistic models. Creating operational strategies of technical systems, especially in the field of prevention.

Knowing the most important risk analysis methods of selected man-technology-environment systems and the ability to apply them in practice.

3. Course content (separate for each type of classes)

Lecture

Technical and operational states of objects. Description of random changes in operating objects - probabilistic and statistical models. Reliability of technical objects. Reliability models of non-repairable and repairable objects in a two-state approach. Basic functional and numerical measures. Renewal processes. Readiness of technical systems. Various theoretical probability distributions characterizing the operation time. Reliability networks of complex objects. Active and standby redundancy. Analysis and synthesis of systems with various reliability networks. Multi-state exploitation processes and their measures. Methods to ensure the required reliability and readiness of technical systems. Prevention, operational strategies.

Risk concepts and measures - relationships between risk measures and reliability and danger measures. General concept of the risk model - danger identification, partial and total risk, general structure of the risk model. Modelling of losses and dangers - measuring and modelling human and financial losses, determining danger measures, statistical methods, expert and probit loss estimation. The fault tree and event tree method in risk analyzes (FTA and ETA). Quantitative risk estimation and analysis - risk analysis by probabilistic method, statistical methods of risk estimation. Qualitative risk analysis - matrix methods and indicator risk analysis. Failure Mode and Effect Analysis (FMEA).

4. Learning outcomes

Outcome type	Learning outcomes description	Reference to the learning outcomes of the WUT DS	Learning outcomes verification methods*
Knowledge			

K01	The student knows and understands probabilistic models that describe changes in the technical state of objects and can assess their operational reliability. He has knowledge of multi-state operational processes using models concerning the theory of reliability.	SD_W2	Assessment of activity during classes and a multimedia presentation at the last meeting.
K02	The student has knowledge about the latest achievements in science regarding the security of technical systems.	SD_W2 SD_W3	Assessment of activity during classes and a multimedia presentation at the last meeting.
K03	The student knows and understands the main development trends regarding the theory of reliability and risk analysis of the functioning of modern human-technology-environment systems.	SD_W3	Assessment of activity during classes and a multimedia presentation at the last meeting.
Skills			
S01	The student is able to effectively obtain information related to the theory of reliability and risk analysis of the functioning of technical systems from various sources, also in foreign languages, and make their selection and interpretation.	SD_U1 SD_U4 SD_U6	Assessment of activity during classes and a multimedia presentation at the last meeting.
S02	The student is able to analyze and synthesize complex technical systems with various functional and reliability networks.	SD_U1 SD_U2	Assessment of activity during classes and a multimedia presentation at the last meeting.
S03	The student is able to critically evaluate the results of research on the reliability and safety of systems and is able to assess the possibility of using the theoretical results in practice.	SD_U2 SD_U3	Assessment of activity during classes and a multimedia presentation at the last meeting
Social competences			
SC01	The student demonstrates self-criticism in creative work, feels the need for continuous learning, and especially analyzing the latest achievements related to the theory of reliability and risk analysis of technical systems.	SD_K1 SD_K2	Assessment of activity during classes and a multimedia presentation at the last meeting.

*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

Formative assessment: students activity during classes (e.g. answers to basic questions asked).

Summative assessment: multimedia presentation concerning the lectured subject.

6. Literature

Basic literature:

- [1] Aven T.: *Foundations of Risk Analysis: A Knowledge and Decision-Oriented Perspective*, John Wiley & Sons Ltd., 2003.
- [2] Birolini A.: *Reliability Engineering: Theory and Practice*, Springer, 2014.
- [3] Dhillon B. S.: *Design Reliability. Fundamentals and Applications*, CRC Press LLC, London 1999.
- [4] Hecht H.: *Systems Reliability and Failure Prevention*, Artech House Inc., London 2004.
- [5] Kuo Way, Zuo Ming J.: *Optimal Reliability Modeling: Principles and Applications*, Wiley & Sons, New York, 2003.
- [6] Nakagawa T.: *Maintenance Theory of Reliability*, Springer, 2005.
- [7] Radkowski S.: *Podstawy bezpiecznej techniki*, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2003.
- [8] Szopa T.: *Niezawodność i bezpieczeństwo*, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa, 2009.
- [9] Todinov M. T.: *Reliability and Risk Models*, John Wiley & Sons Ltd., 2005.

Supplementary literature:

- [1] Chin-Diew Lai, Min Xie: *Stochastic Ageing and Dependence for Reliability*, Springer, 2006.
- [2] Krystek R. (red. pr. zbior.): *Zintegrowany system bezpieczeństwa transportu, tom II: Uwarunkowania rozwoju integracji systemów bezpieczeństwa transportu*, WKŁ, Warszawa 2009.

7. PhD student's workload necessary to achieve the learning outcomes**

No.	Description	Number of hours
1	Hours of scheduled instruction given by the academic teacher in the classroom	45
2	Hours of consultations with the academic teacher, exams, tests, etc.	1
3	Amount of time devoted to the preparation for classes, preparation of presentations, reports, projects, homework	24
4	Amount of time devoted to the preparation for exams, test, assessments	20
Total number of hours		90
ECTS credits		3

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