

Subject card

Subject name and code	Probability and Information Theory, PG_00158042						
Field of study	Probability and Information Theory						
Date of commencement of studies	October 2025		Academic year of realisation of subject		2025/2026		
Education level	Master's studies		Subject group		Obligatory subject group in the field of study		
Mode of study	full-time studies		Mode of delivery		at the university		
Year of study	1		Language of instruction		English		
Semester of study	1		ECTS credits		6.0		
Learning profile	academic		Assessment form		exam		
Conducting unit							
Name and surname of lecturer (lecturers)	Subject supervisor		dr inż. Marek Winczewski				
	Teachers						
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	30.0	0.0	0.0	0.0	60
	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	60		0.0		30.0	90
Subject objectives	The aim of this lecture is to provide students with specific knowledge of probability theory and statistics necessary to understand some aspects of quantum mechanics and quantum information theory. The student will also acquire basic knowledge in the field of application of the main concepts of information theory such as entropy, mutual information or relative entropy and their properties. The student will also learn the capacities of communication channels and methods of estimating them.						

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[QITL3_W01] has extended knowledge in the field of general physics and advanced knowledge in the area of quantum information theory; knows the history of the development of quantum information theory and its importance for the progress of science, knowledge of the world and social development	Students knows the history of Information Theory, Probability and Statistics.	[SW4] test/egzamin - ustny lub pisemny
	[QITL3_W04] knows advanced methods of theoretical and mathematical physics necessary in creating models of quantum mechanics	Student knows and can apply structures of Information Theory and Statistics in modeling communication and cryptographic problems.	[SW4] test/egzamin - ustny lub pisemny
	[QITL3_U03] is able to critically analyze observations or theoretical calculations and assess the accuracy of the results	Student knows statistical methods for hypothesis testing and error estimation.	[SU4] test/egzamin - ustny lub pisemny
	[QITL3_U01] is able to apply the scientific method in solving physical problems and reasoning in the field of quantum information theory	Student is aware about experimental realizations of communication and cryptographic tasks, and can relate their characteristics to theoretical models.	[SU4] test/egzamin - ustny lub pisemny
	[QITL3_U02] has the skills to plan and conduct basic and advanced research and calculations in the area of quantum information theory or its applications	Student can model and solve problems of communication, error correction and cryptography using statistical and Information-Theoretic methods.	[SU4] test/egzamin - ustny lub pisemny
	[QITL3_W02] has in-depth knowledge in the field of advanced mathematics and mathematical and computer methods, necessary to solve physical problems of medium complexity, and advanced knowledge in the area of quantum information and its technological aspects	Student can model and solve problems associated with basic quantum systems using Mathematica software and QuTiP library.	[SW4] test/egzamin - ustny lub pisemny
	[QITL3_U06] is able to adapt to related scientific disciplines the knowledge and theoretical methods and methodology of physics	Student can model problems of communication, cryptography, secret sharing, measurement and computing.	[SU4] test/egzamin - ustny lub pisemny
	[QITL3_U05] has the ability to synthesize methods and ideas from various areas of physics and other branches of science; is able to notice that distant phenomena are sometimes described by similar models	Student knows examples of application of Information-Theoretic and Statistical Methods in biological, physical and engineering contexts.	[SU4] test/egzamin - ustny lub pisemny
	[QITL3_K01] knows the limitations of his/hers knowledge and skills; can formulate questions precisely; understands the need for further education of oneself and other people	Student is aware about past challenges in Information Theory, and participates in discussions with his peers about possible ways of overcoming the current ones.	[SK1] wypowiedź ustna/rozmowa/ dyskusja
	[QITL3_W06] has knowledge of current directions in the development of physics, in particular in the field of quantum information theory	Student is aware about current theoretical and experimental challenges of quantum communication, computing and cryptography.	[SW4] test/egzamin - ustny lub pisemny

Subject contents	1. Basic notions of probability: probability space, standard normal distribution, random variable, expected value, variance.2. Density function and the cumulative distribution function, independence of random variables.3. Bayes theorem.4. Law of large numbers and the central limit theorem for independent and identically distributed random variables.5. Shannon entropy function, its interpretation and properties.6. Entropy functions of many variables, including conditional entropy, mutual information, relative entropy, conditional mutual information and their properties, including data processing inequality and the chain principle for conditional mutual information.7. Asymptotic Equipartition Property theorem, compression codes, error correction codes.8. The concept of typical and total typical sequences, Shannon's theorem on the capacity of a communication channel, random code technique9. Capacities of selected communication channel and Slepian-Wolf theorem on joint coding10. Kraft and McMillan inequality		
Prerequisites and co-requisites	None.		
Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	tutorial part: test	51.0%	50.0%
	lecture part: exam	51.0%	50.0%
Recommended reading	Basic literature	E. Shannon, W. Weaver The Mathematical Theory of Communication Thomas M. Cover, Joy A. Thomas Elements of Information theory R. W. Yeung A First Course in Information Theory M. Nielsen, I. Chuang Quantum Information and Computation	
	Supplementary literature	None.	
	eResources addresses		
Example issues/ example questions/ tasks being completed			
Work placement	Not applicable		

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