University of Gdańsk

Subject card

Subject name and code	Probability and Information Theory, PG_00205753						
Field of study	Quantum Information Technology						
Date of commencement of studies	October 2026		Academic year of realisation of subject		2026/2027		
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		7.0		
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	60.0	0.0	0.0	0.0	90
	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	90		0.0		85.0	175
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] knows and understands in depth selected facts, objects and phenomena, as well as the methods and theories related to them, explaining the complex relationships between them, constituting advanced general knowledge in the field of quantum information technology, as well as the scientific research methodology specific to this discipline and its importance in the context of contemporary directions of development of science and technology	The student has an advanced understanding of the fundamental concepts and methods of probability theory and information theory, including probabilistic models, entropy measures, information transmission, and coding theory, as well as their role in the analysis and development of modern quantum information technologies.	[SW4] test/exam - oral or written
[QITL3_U02] is able to use their knowledge of quantum information technology – formulate and solve complex and unusual problems and innovatively perform tasks in unpredictable conditions by appropriately selecting sources and information derived from them, evaluating, critically analyzing, synthesizing, creatively interpreting, and presenting this information, as well as by selecting and applying appropriate methods and tools, including advanced information and communication techniques and adapting existing methods and tools or developing new ones	The student is able to apply probabilistic and information-theoretic methods to formulate and solve complex problems involving stochastic processes, information measures, and coding schemes relevant to quantum information technologies.	[SU4] test/exam - oral or written

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 indenepent 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 theirproperties, 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 Mc Millan inequality

Prerequisites and co-requisites

None.

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
lecture part: exam	51.0%	50.0%
tutorial part: test	51.0%	50.0%

Recommended reading

Basic literature	The Mathematical Theory of Communication. Claude E. Shannon & Warren Weaver (1949). The Mathematical Theory of Communication. Urbana: University of Illinois Press. ISBN: 978-0-252-72548-7. Elements of Information Theory. Thomas M. Cover & Joy A. Thomas (2006). Elements of Information Theory (2nd ed.). Hoboken, NJ: John Wiley & Sons. ISBN: 978-0-471-24195-9. A First Course in Information Theory. Raymond W. Yeung (2002). A First Course in Information Theory. New York: Kluwer Academic Publishers. ISBN: 978-0-306-46791-1. Quantum Computation and Quantum Information. Michael A. Nielsen & Isaac L. Chuang (2010). Quantum Computation and Quantum Information: 10th Anniversary Edition. Cambridge: Cambridge University Press. ISBN: 978-1-107-00217-3.
Supplementary literature	None.
eResources addresses	

Example issues/ example questions/ tasks being completed	• Probability spaces, random variables, and probability distributions. • Probability density functions and cumulative distribution functions. • Expected value and variance. • Independence of random variables. • Bayes' theorem and its applications. • The Law of Large Numbers. • The Central Limit Theorem for independent and identically distributed random variables. • Shannon entropy and its interpretation. • Joint entropy, conditional entropy, and mutual information. • Relative entropy (Kullback–Leibler divergence). • Conditional mutual information. • The chain rule for entropy and mutual information. • The Data Processing Inequality. • Examples demonstrating the operational meaning of information measures.
Work placement	Not applicable

Document generated electronically. Does not require a seal or signature.