

Subject card

Subject name and code	Mathematical Aspects of Quantum Information Theory , PG_00186923						
Field of study	Physics						
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 Optional subject group		
Mode of study	full-time studies		Mode of delivery		at the university		
Year of study	1		Language of instruction		Polish		
Semester of study	1		ECTS credits		5.0		
Learning profile	academic		Assessment form		credit		
Conducting unit							
Name and surname of lecturer (lecturers)	Subject supervisor		dr hab. Marcin Marciniak				
	Teachers		dr hab. Marcin Marciniak				
			dr Anubhav Chaturvedi				
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		0.0	60
Subject objectives	Quantum information theory employs a mathematical formalism that encompasses elements of linear algebra, functional analysis, and probability theory. The aim of the course is to present this formalism as well as the main theorems and mathematical problems arising from the theory.						

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[FIZMU2_K05] understands the need to popularize knowledge in the field of physics, including the latest scientific and technological achievements	The student is aware of the potentially significant impact of quantum information theory on the development of communication and computational technologies in the coming years and shares knowledge on this subject.	[SK1] oral statement/conversation/discussion
	[FIZMU2_U12] is able to use English in the field of physics, mathematics and computer science, in accordance with the requirements set out for level B2+ of the Common European Framework of Reference for Languages, to the extent that allows them to independently complete their education and communicate with specialists in the same or related specialisation	The student is able to use English-language literature on the mathematical methods of quantum information theory.	[SU2] presentation/project/paper/report
	[FIZMU2_U11] is able to determine the directions of further improvement of knowledge and skills (including self-education) in the field of the selected specialization and beyond it	The student is capable of utilizing quantum information to acquire profound self-understanding and establish proper life objectives.	[SU1] oral statement/conversation/discussion [SU8] observation of student's independent or team work
	[FIZMU2_U10] is able to popularize science within their specialty or related areas of physics	The student can clearly present the main principles of quantum information theory and its mathematical formalism.	[SU2] presentation/project/paper/report
	[FIZMU2_U06] is able to adapt the knowledge and methodology of physics, as well as the applied experimental and theoretical methods to related scientific disciplines	The student is able to use the mathematical methods of quantum information theory for the description of biological and chemical phenomena.	[SU2] presentation/project/paper/report
	[FIZMU2_U05] has the ability to synthesize methods and ideas from various areas of physics and other exact and natural sciences; is able to notice that even distant phenomena are described by similar models	The student can recognize analogies between the mathematical formalism of quantum information theory and other areas of physics, such as thermodynamics and statistical mechanics.	[SU1] oral statement/conversation/discussion
	[FIZMU2_W06] has knowledge of the current directions of development of physics and fundamental dilemmas of modern civilization	The student is aware of how quantum information theory relates to other developing fields of physics.	[SW1] oral statement/conversation/discussion
	[FIZMU2_K01] knows the limitations of his own knowledge and skills; can formulate questions precisely; understands the need for further education and other	The student is able to participate in discussions, formulate questions, and verify the correctness of their own problem solutions.	[SK1] oral statement/conversation/discussion [SK8] observation of student's independent or team work
	[FIZMU2_K02] is aware of the conclusive role of experiment in the verification of physical theories; is aware of the scientific method in the accumulation of knowledge	The student is aware that the mathematical formalism of quantum information theory is a model, which should be experimentally verified.	[SK1] oral statement/conversation/discussion

Subject contents	- Basics of probability theory and classical information theory - Elements of Hilbert Space Theory and Bounded Operators - Operator Algebras and Their Fundamental Properties - Tensor Products of Hilbert Spaces and Operator Algebras, Quantum Entanglement Theory - Positive Maps and Their Applications in Entanglement Detection - Quantum Correlations, Bell Inequalities - Quantum Control Theory, Steering Inequalities - Quantum Channels, Channel Capacity, the Channel Additivity Problem		
Prerequisites and co-requisites	Courses completed: Linear Algebra, Mathematical Analysis for Physicists, Mathematical Methods of Physics.		
Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	Test	51.0%	50.0%
	Written exam	51.0%	50.0%
Recommended reading	Basic literature	T. Heinosaari, M. Ziman, Guide to mathematical concepts of quantum theory, Acta Physica Slovaca vol. 58, 487-674 (2008), arXiv:0810.3536 E. Størmer, Positive linear maps of operator algebras, Springer, Berlin 2012. M. M. Wilde, Quantum Information Theory, Cambridge University Press, 2017, https://fenix.tecnico.ulisboa.pt/downloadFile/1407993358931417/Quantum%20Information%20Theory%20[Mark%20M.%20Wilde]%20(2017).pdf	
	Supplementary literature	not applicable	
	eResources addresses		
Example issues/ example questions/ tasks being completed	not applicable		
Work placement	Not applicable		

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