University of Gdańsk

Subject card

Subject name and code	Mathematical Methods of Quantum INformation, PG_00205752		
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 Subject group related to scientific research 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	Faculty of Mathematics, Physics and Informatics Office -> Faculty of Mathematics, Physics and Informatics -> Rector		
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Paweł Mazurek	
	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 mathematical knowledge to understand basic concepts of quantum information theory as well as formulate and solve problems within this theory. Physical motivation and intuition behind the structures is provided in the accompanying course Introduction to Quantum Mechanics.

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 explaining the complex relationships between them, constituting advanced general knowledge in the field of quantum information technologies.		
[QITL3_U02] is able to use their knowledge of quantum information technologies – formulate and solve complex and unusual problems and perform tasks innovatively in unpredictable conditions by appropriately selecting sources and information derived from them, evaluating, critically analyzing, synthesizing, creatively interpreting, and presenting this information.		

<table>
<tr><td>Subject contents</td><td>Basic concepts of linear algebra: linear space, linear operator, matrix calculus
Basic concepts of functional analysis: Banach and Hilbert spaces, bounded and unbounded operators, differe similar operators, spectral theorem, functional calculus, positive definite operators
POVM and quantum measurement
Tensor products of Banach spaces and Hilbert spaces, operators on tensor products, Schmidt decomposition mathematical definition of entanglement, PPT states Fock space, CCR and CAR relations
Positive and fully positive maps on matrix algebras: k-positivity, decomposability, entanglement witnesses
Quantum channels, capacity of quantum channels, additivity problem
Tensor products of positive maps and entanglement distillation, bound entanglement</td></tr>
<tr><td>Prerequisites and co-requisites</td><td>No formal requirements</td></tr>
<tr><td>Assessment methods and criteria</td><td><table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>lecture part: exam</td><td>51.0%</td><td>50.0%</td></tr>
<tr><td>tutorial part: test</td><td>51.0%</td><td>50.0%</td></tr>
</table></td></tr>
<tr><td>Recommended reading</td><td><table>
<tr><td>Basic literature</td><td>O. Bratteli, D Robinson, Operator algebras and statistical mechanics vol.
E. Stormer, Positive maps on operator algebras
M. Hayashi, Quantum information theory. Mathematical foundation
B.C. Hall Quantum theory for mathematicians"</td></tr>
<tr><td>Supplementary literature</td><td>None</td></tr>
<tr><td>eResources addresses</td><td></td></tr>
</table></td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td></td></tr>
<tr><td>Work placement</td><td>Not applicable</td></tr>
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