University of Gdańsk

Subject card

Subject name and code	Mathematical Methods of Quantum INformation, PG_00158897		
Field of study	Quantum Information Technology		
Date of commencement of studies	October 2024	Academic year of realisation of subject	2024/2025
Education level	postgraduate 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	
Conducting unit	Dziekanat wydziału Matematyki, Fizyki i Informatyki -> Faculty of Mathematics, Physics and Informatics		
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Paweł Mazurek	
	Teachers	dr inż. Paweł Mazurek Amrapali Sen	

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 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_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/exam - oral or written
[QITL3_W04] knows advanced methods of theoretical and mathematical physics necessary in creating models of quantum mechanics	Student knows and can apply structures of linear algebra and functional analysis in modeling quantum mechanics	[SW4] test/exam - oral or written
[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/exam - oral or written

<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>Adresy na platformie eNauczanie:</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>
</table>

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