KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI

UNIWERSYTET GDAŃSKI

UNIA EUROPEJSKA
EUROPEJSKI
FUNDUSZ SPOŁECZNY

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Course title **Mathematical methods of quantum information**	**ECTS code** 13.2.0415

Name of unit administrating study
Department of Mathematics, Physics and Informatics

Studies

Faculty	**Field of study/ phd studies/doctoral school/postgraduate studies**	**Type**	**Form**
Quantum Information Technology	MSc studies	stationary	

Teaching staff
Dr hab. Marcin Marciniak, prof. UG, dr hab. Adam Rutkowski, prof UG

Forms of classes, the realization and number of hours

A. Forms of classes, in accordance with the UG Rector's regulations
Lecture, auditory exercises

B. The realization of activities
classes in the teaching room of the University of Gdańsk
blended learning

C. Number of hours
Lecture: 30, exercises: 30

ECTS credits

Total: 5 ECTS including:
30 h of lecture – 1 ECTS point;
30 h of exercises – 1 ECTS point;
30 h of consultation – 1 ECTS point;
60 h of student's own work - 2 ECTS points.

The academic cycle
According to study program

Type of course
mandatory

Language of instruction
English

Teaching methods
problem lecture
lecture with multimedia presentation

discussion
case analysis
problem solving
student's own work (e.g., homework)

Form and method of assessment and basic criteria for evaluation or examination requirements

A. Final evaluation, in accordance with the UG study regulations
Exam
Credit with grade

B. Assessment methods
Lecture: test (oral or written) with open-end questions.
Exercises: determination of the final grade based on partial grades received during the semester

C. The basic criteria for evaluation or exam requirements
Exams (Lecture and Exercises): correct answer to at least 60% of the questions.
Evaluation criteria and exams' tentative schedule will be communicated to the students during the first classes.

D. Method of verification of the established effects of education

established effect of education	exam	activity	tests
W01	+	+	+
W02	+	+	+
U01	-	+	+
U02	-	+	+

Required courses and introductory requirements

A. Formal requirements

None

B. Prerequisites

Basic knowledge of mathematics at high school level is required.

Aims of education

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.

Course contents

The course contents includes presentation of the following concepts (lecture and exercises will be devoted to the same topics):

- **Basic concepts of linear algebra: linear space, linear operator, matrix calculus**
- **Basic concepts of functional analysis: Banach spaces and Hilbert spaces, bounded and unbounded operators, various types of norms, selfadjoint operators, spectral theorem, functional calculus, positive definite operators**
- **POVMs and quantum measurement**
- **Tensor products of Banach spaces and Hilbert spaces, operators on tensor products, Schmidt decomposition, Schmidt rank and Schmidt number, mathematical definition of entanglement, PPT states**
- **Fock space, CCR and CAR relations**
- **Positive and completely positive maps on matrix algebras: k-positivity, decomposability, entanglement witnesses**
- **Quantum channels, capacity of quantum channels, problem of additivity**
- **Tensor products of positive maps and distillation of entanglement, bound entanglement**

Bibliography of literature

A. Literature required to pass the course

- **O. Bratteli, D Robinson, „Operator algebras and statistical mechjanics" vol. I**
- **E. Stormer, "Positive maps on operator algebras"**
- **M. Hayashi, Quantum information theory. Mathematical foundation"**
- **B.C. Hall "Quantum theory for mathematicians"**
- **Material provided by the lecturer.**

B. Extracurricular readings

The learning outcomes (for the field of study and specialization) *K_W02* *Student has in-depth knowledge of advanced mathematics, mathematical and computer methods necessary to solve physical problems of medium complexity and advanced in the area of quantum information and its technological aspects* *K_W04* *Student knows the advanced methods of theoretical and mathematical physics necessary in creating models of quantum mechanics* *K_U02* *Student can apply mathematical knowledge to*	**Knowledge** W01: Student knows and understands the basic mathematical concepts used in foundations of quantum information. (K_W02) W02 Student knows the mathematical formulation of quantum mechanics and quantum information concepts (KW_04) **Skills** U01 Student is able to formulate and solve mathematical problems within the framework of quantum information theory (K_U02) U02 Student is able to translate physical and quantum information problems into mathematical formalism and vice versa (K_U02) **Social competence**

formulating, analyzing and solving problems related to information theory	

Contact
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