KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI

UNIWERSYTET GDAŃSKI

UNIA EUROPEJSKA
EUROPEJSKI
FUNDUSZ SPOŁECZNY

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Course title **Probability and statistics**	**ECTS code** 13.2.0420

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 Anita Dąbrowska

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

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 specific knowledge of probability theory and statistics necessary to understand some aspects of quantum mechanics and quantum information theory.

Course contents

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

- **Introduction to measure theory: measurable spaces, measurable functions, integration over a measurable space, Lebesgue theorems and Fatou lemma**
- **Basic notions of probability theory: elementary events, σ-field of events, probability as a measure, conditional probability, independence.**
- **Random variables: measurability, distribution, density function; expectation, variance, moments; random vectors, joint distribution, independence of random variables.**
- **Limit theorems: various types of convergence of random variables, central limit theorem, laws of large numbers, law of iterated logarithm**
- **Probability models in quantum information: correlation boxes**
- **Noncommutative probability: noncommutative probability space and related notions; free probability**
- **Random matrices: Winger theorem**
- **Descriptive statistics**
- **Statistical hypothesis and statistical tests: Kolmogorov test, Student test**
- **Elements of quantum statistical mechanics**

Bibliography of literature

A. Literature required to pass the course

- **P. Billingsley, "Probability and measure"**
- **O. Bratteli, D Robinson, „Operator algebras and statistical mechjanics" vol. I, II**
- **Material provided by the lecturer.**

B. Extracurricular readings

- **Mathematical blog "Is Quantum Mechanics a Probability Theory?"**

https://www.math.columbia.edu/~woit/wordpress/?p=10533

- **D. Voiculescu, K.J. Dykema and A. Nica, Free Random Variables, CRM Monograph Series 1, American Mathematical Society, 1992.**
- **A. Nica, R. Speicher, "Lectures on the Combinatorics of Free Probability Theory"**

https://www.math.uni-sb.de/ag/speicher/publikationen/Nica-Speicher.pdf

- **G. Pisier, Grothendieck's Theorem, past and present, arXiv:1101.4195**

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*	**Knowledge** W01: Student knows and understands the basic probability and statistical 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 probabilistic interpretation 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)

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 formulating, analyzing and solving problems related to information theory*	**Social competence**
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