Course title

Probability and statistics

ECTS code

13.2.0420

Name of unit administrating study

Faculty of Mathematics, Physics and Informatics

Studies

faculty	field of study		
Faculty of Mathematics, Physics and Informatics	Quantum Information Technology	type	all
		form	all
		specialty	all
		specialization	all

Teaching staff

dr hab. Marcin Marciniak; dr Hanna Wojewódka-Ściążko; dr Anita Dąbrowska; mgr Paulo Cavalcanti

Forms of classes, the realization and number of hours

Forms of classes

Auditorium classes, Lecture

The realization of activities

classroom instruction, online classes

Number of hours

Auditorium classes: 30 hours, Lecture: 30 hours

ECTS credits

5

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

2022/2023 winter semester

Type of course

obligatory

Language of instruction

english

Teaching methods

- critical incident (case) analysis
- discussion
- multimedia-based lecture
- problem solving
- problem-focused lecture

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

Final evaluation

- Graded credit
- Examination

Assessment methods

- (mid-term / end-term) test
- written exam (test)

The basic criteria for evaluation

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

Method of verifying required learning outcomes

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

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.
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 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	**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) **Social competence**

Contact

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