Course title:	Foundations of Quantum Computing
Course title in Polish:	Podstawy Obliczeń Kwantowych
Course for discipline:	Information and communication technology

Semester:	6	**Status of course:**	faculty	**Language:**	english
Academic year:	2027/28	**Catalog number:**	128/2025/26		

Coordinator of course:	dr Piotr Stachura	
Lecturer od course:	dr hab. Arkadiusz Orłowski, dr Piotr Stachura, dr Andrzej Zembrzuski	
Executing unit:	Institute of Information Technologuy	
Ordering unit:	Doctoral School SGGW	
Assumptions, goals and description of the course:	The aim of the course is to introduce PhD students to the fundamentals of quantum computing at a level that enables further independent study in this rapidly developing field. We will begin with a brief overview of selected problems that illustrate the potential advantages of quantum computation and quantum computers, including quantum supremacy, understood as the reduction of computational complexity for certain classes of algorithms, and its implications for public-key cryptography. The next stage will consist of introducing and discussing elementary but essential mathematical concepts (elements of linear algebra and probability theory) and physical notions (the most relevant aspects of quantum mechanics in this context, such as quantum states, observables, superposition, pure and mixed states, entanglement, and nonlocality) required for a proper understanding of the subject. After presenting the most important quantum algorithms (the quantum Fourier transform, Shor's algorithm, and Grover's algorithm), we also plan to discuss other topics, including basic concepts of quantum cryptography (key distribution), dense coding, and quantum teleportation. We will briefly address quantum annealing and D-Wave computers as an example of an alternative approach to quantum computation, emphasizing the differences between universal, gate-based quantum computers and devices dedicated to solving optimization problems. We also intend to briefly outline the most important technological and physical aspects of the practical implementation of quantum computing and to present the current state of the field. Active student participation is planned in the form of project work and short presentations.	
Didactic form, number of hours:	lecture, 15	
Teaching methods:	lecture, student presentation, discussion	
Limit of people in the group:	20	
	Learning outcomes	
KNOWLEDGE - the graduate knows and understands:	**SKILLS - the graduate is able to:**	**COMPETENCES - the graduate is ready to:**
To the extent enabling to revise the existing pradigms in the field/discipline - the world achievments, gathering theoretical background as well as general and selected detailed issues	Carry out critical assessment of the scientific research findings and expert activities and their contribution to the knowledge development in the field/discipline	Critically evaluate the achievments in the field/discipline represented
Major general development trends in the field/discipline	X	Recognise knowledge in solving cognitive and practical problems characteristic for the area of research (field/discipline) and in an interdisciplinary aspect
X	X	Support the ethos of scientific circles and conduct independent research
The method of verification of learning outcomes:	presentation of choosen topic	
Form of documentation of achieved learning outcomes:	presentation file	
Elements and weights of the final grade:	attendence and activity - 30%, presentation - 70%	
Place of the course:	Lecture room	
	Basic and supplementary literature	
Basic literature: M. A. Nielsen & I.L. Chuang "Quantum Computation and Quantum Information" Cambridge Univ. Press (selected chapters); R. de Wolf "Quantum Computing: Lecture Notes", arXiv:1907.09415 ; Supplementary literature: A. Zeilinger "Experiment and the foundations of quantum physics", Rev. Mod. Phys. Vol. 71, No. 2, (1999); M. Keyl "Fundamentals of quantum information theory", Phys. Rep. 369 (2002); C. Easttom "Hardware for Quantum Computing ", Springer; N. S. Yanofsky and M. A. Mannucci "Quantum computing for computer scientists", Cambridge Univ. Press; E. Johnston, N. Harrigan, M. Gimeno-Segovia " Programming Quantum Computers : Essential Algorithms and Code Samples", O'Reilly Media 2019		
Comments:		

Estimated number of hours of work of the doctoral student necessary to achieve the assumed learning outcomes:	30

	Leraning outcomes reference to the second degree characteristics of the National Qualification Framework (level 8) covering doctoral competences:	
Symbol:	**Learning outcomes:**	**8 level NQF**
SD1_KW01	To the extent enabling to revise the existing pradigms in the field/discipline - the world achievments, gathering theoretical background as well as general and selected detailed issues	P8S_WG
SD1_KW02	Major general development trends in the field/discipline	P8S_WG
SD1_KU05	Carry out critical assessment of the scientific research findings and expert activities and their contribution to the knowledge development in the field/discipline	P8S_UW
SD1_KK01	Critically evaluate the achievments in the field/discipline represented	P8S_KK

SD1_KK03	Recognise knowledge in solving cognitive and practical problems characteristic for the area of research (field/discipline) and in an interdisciplinary aspect	P8S_KK
SD1_KK08	Support the ethos of scientific circles and conduct independent research	P8S_KR