GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	, PG_00066247		
Field of study	Technical Physics		
Date of commencement of studies	October 2023	Academic year of realisation of subject	2025/2026
Education level	first-cycle studies	Subject group	Optional subject group Subject group related to scientific research in the field of study
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	3	Language of instruction	Polish
Semester of study	6	ECTS credits	2.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Institute of Physics and Applied Computer Science -> Faculty of Applied Physics and Mathematics -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	prof. dr hab. Paweł Horodecki	
	Teachers	prof. dr hab. Paweł Horodecki	

Lesson types

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	30.0	0.0	0.0	0.0	0.0	30

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	30	2.0	18.0	50

Subject objectives

Introduction to basic ideas and aspects of quantum information

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K6_U09] Can use technical literature in English.	The student is able to conduct a search in specialist Englishlanguage literature on quantum information. He is able to familiarize himself with the content of a specialist article, in particular to identify the most important information from the point of view of current scientific needs.	[SU2] Assessment of ability to analyse information [SU4] Assessment of ability to use methods and tools
[K6_W02] Has systematized knowledge of the basics of physics, including mechanics, thermodynamics, electricity and magnetism, optics, atomic and particle physics, solid-state physics, nuclear and elementary particle physics.	The student knows and understands the mathematical foundations of quantum mechanics, with particular emphasis on quantum discrete variables. Knows and understands the elements of quantum entanglement description, including their physical specificity, the LOCC paradigm, and Bell's inequalities. Can explain quantum compression, quantum teleportation, and dense coding protocols, selected quantum algorithms, selected quantum cryptography protocols, the concept of quantum channel capacity, and quantum metrology. Can present selected issues of quantum information theory and solve simple problems within its scope.	[SW3] Assessment of knowledge contained in written work and projects [SW1] Assessment of factual knowledge

Subject contents	Course content – lecture Elements of the Hilbert space formalism. Axioms of quantum mechanics Quantum interference and its concequeces. The concept of qubit Complementary bases and quantum uncertainty principle No-cloning theorem BB84 protocol. Benetta-Brasarda-Mermina (BBM 1992) protoclol Quantum systems consisting of subsystems quantum entanglement and quantum witnesses . The concept of quantum stqate and its two interpretations Bloch sphere and purity of a quantum state Entanglement measures Paradigms of LOCC i SLOCC. Quantum teleportation and quantum dense coding. Multiparty quantum information. The classes of W and GHZ. Distillation of quantum entanglement Local hidden variable model and Bell inequalities. Scheme of quantum compression of Shumacher. Quantum channels and their capacity. Universal quantum gates. Deutsh-Jozsa algorithm Bernsteina -Vazirani algorithm Grover's algorithm and remarks on other quantum alghoritms The concept of quantum metrology and quantum Fischer information. Mertological bounds of (i) shot noise limit (ii) Heisenberg limit.

<table>
<tr><td>Prerequisites and co-requisites</td><td colspan="3">Fundamentals of algebra and mathematical analysis. Knowledge of the basic course in quantum mechanics.</td></tr>
<tr><td>Assessment methods and criteria</td><td colspan="3"><table><tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr><tr><td>passing the class</td><td>50.0%</td><td>100.0%</td></tr></table></td></tr>
<tr><td rowspan="3">Recommended reading</td><td>Basic literature</td><td colspan="2">1) Quantum computing and quantum information (ang.),
Michael Nielsen and Isaac Chuang, Cambridge University Press (2000)

2) An introduction to quantum alghoritms, Krzysztof Giaro, Marcin Kamiński, Akademicka Oficyna Wydawnicza, EXIT, Warszawa 2003.</td></tr>
<tr><td>Supplementary literature</td><td colspan="2">Quantum metrology from a quantum information science perspective, Geza Toth, Iagoba Apellaniz, J. Phys. A: Math. Theor. 47, 424006 (2014), https://iopscience.iop.org/article/10.1088/1751-8113/47/42/424006</td></tr>
<tr><td>eResources addresses</td><td colspan="2"></td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td colspan="3">Discuss the steps of the protocol of quantum teleportation

Present Grovers alghoritm and explain how it works.

Discuss Bell-CHSH inequality together with the concept

of local hidden variables.</td></tr>
<tr><td>Practical activites within the subject</td><td colspan="3">Not applicable</td></tr>
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