Subject card

Subject name and code	Basics of Quantum Resources, PG_00183327		
Field of study	Quantum Information Technology		
Date of commencement of studies	October 2025	Academic year of realisation of subject	2026/2027
Education level	Master’s studies	Subject group	
Mode of study	full-time studies	Mode of delivery	at the university
Year of study	2	Language of instruction	English
Semester of study	4	ECTS credits	6.0
Learning profile	academic	Assessment form	exam
Conducting unit			
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. Karol Horodecki, prof. UG	
	Teachers		

Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	0.0	30.0	0.0	0.0	60
	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	60	0.0	0.0	60

Subject objectives	The goal of this lecture is to provide the student a broad perspective on quantum information processing by introducing in details frameworks of several resource theries, exhibiting similarities and differences among the latter. It aims also at letting to know the quntum resources as applicable phenomena in context of quantum and classical information processing.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[QITL3_W05] knows the theoretical foundations of computational methods and IT techniques used to model and simulate physical systems considered in quantum information theory	The student knows the theoretical foundations of computational methods used to study quantum resources, including the construction of resource witnesses, calculation of resource measures, identification of free operations, and simulation of selected quantum systems using information technology tools.	[SW4] test/exam - oral or written
[QITL3_W06] has knowledge of current directions in the development of physics, in particular in the field of quantum information theory	The student has knowledge, among other things, of multipartite entanglement and quantum error correction, and is familiar with open problems related to the discussed resources.	[SW3] text preparation/written work [SW5] implementation of a problem task
[QITL3_W01] has extended knowledge in the field of general physics and advanced knowledge in the area of quantum information theory; knows the history of the development of quantum information theory and its importance for the progress of science, knowledge of the world and social development	The student knows the history of research and applications of quantum and extra-quantum contextuality, quantum coherence, quantum non-stabilization, purity (non-uniformity) and elements of quantum thermodynamics	[SW4] test/exam - oral or written

Subject contents	During lecture, we will introduce several important quantum resources *(not* covered or not covered in deep by the lecture "Podstawy Informatyki Kwantowej") including quantum and supra-quantum contextuality as generalization of quantum non-locality, quantum coherence, quantum non-stabilizerness, quantum purity (non-uniformity), elements of quantum thermodynamics, device dependent private randomness, and multipartite entanglement. We plan to discuss their exemplary applications: fault tolerant quantum computing, classical communication complexity, privacy, quantum engines etc.). Laboratories will involve among others verifying construction of resource witnesses, computing measures of a given resource, recognizing free operations, and revealing formal interrelation among the resources. In particular numerical and theoretical validation of the facts from lecture will be considered. To this end, during laboratories Mathematica programming language will be used.
Prerequisites and co-requisites	It is recommended, but not obligatory, that a student either have completed course "Podstawy Informatyki Kwantowej" (or its equivalent), or is attending the latter course (or equivalent) in parallel. While these two courses are independent, student will have deeper undertanding of Basics of Quantum Resources if she/he knows a broader context.

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
test1	51.0%	20.0%
written exam	51.0%	50.0%
homework	51.0%	10.0%
test2	51.0%	20.0%

Recommended reading

Basic literature	- "The resource theory of stabilizer quantum computation" Victor Veitch *et al* 2014 *New J. Phys.* **16** 013009 -"Resources of the Quantum World" arxiv.org/abs/2402.05474 Gilad Gour - "Kochen Specker Contextuality" Rev. Mod. Phys. **94**, 045007 Costantino Budroni, Adán Cabello, Otfried Gühne, Matthias Kleinmann, and Jan-Åke Larsson - Quantum computation and Quantum information M. A. Nielsen and I. L. Chuang Cambridge University Press,Cambridge (2000) - Quantum entanglement R. Horodecki, M. Horodecki, P. Horodecki, K. Horodecki Rev. Mod. Phys. (2009) -"Bell nonlocality" N. Brunner, D. Cavalcanti, S. Pironio, V. Scarani, S. Wehner. Rev. Mod. Phys., 86:839, (2014).
Supplementary literature	- Karol Horodecki et al. "The rank of contextuality" New J. Phys. 25 073003 (2023) - C. Sparaciari et al. "The first low of general quantum resources" Quantum 4, 259 2022
eResources addresses	

Example issues/ example questions/ tasks being completed	Describe the formal definition of resource theory of non-stabilizerness. What is the difference between state-dependent and state-independent quantum contextuality (provide examples of both)? Give examples and show differences among known classes of free operations in theories of quantum coherence. Compute in Mathematica the amount of local purity that one can obtain from a pure 2-qubit state. How many parameters are needed to describe a 3-qubit pure state (up to local unitary transformations)? Describe Landauer's principle. What is thermomajorization, and what is its role in quantum thermodynamics?
Work placement	Not applicable

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