University of Gdańsk

Subject card

Subject name and code	Categorical Quantum Mechanics, PG_00158052		
Field of study	Quantum Information Technology		
Date of commencement of studies	October 2026	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	1	Language of instruction	English
Semester of study	2	ECTS credits	6.0
Learning profile	academic	Assessment form	exam
Conducting unit			
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. John Selby	
	Teachers	Sina Soltani dr hab. John Selby Matthias Salzger	

Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	30.0	0.0	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	30.0	90

Subject objectives	
	This course aims to introduce you to an exciting new approach to understanding and using quantum theory, based entirely on a pictorial representation of quantum processes. On the one hand, these diagrams prove an intuitive way to understand quantum phenomena and protocols, and, on the other hand, they provide powerful mathematical techniques for proving new results. This diagrammatic approach to quantum theory finds important applications both within the foundations of physics as well as increasingly within the quantum industry.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[QITL3_U02] is able to use their knowledge of quantum information technology – formulate and solve complex and unusual problems and innovatively perform tasks in unpredictable conditions by appropriately selecting sources and information derived from them, evaluating, critically analyzing, synthesizing, creatively interpreting, and presenting this information, as well as by selecting and applying appropriate methods and tools, including advanced information and communication techniques and adapting existing methods and tools or developing new ones	The student is able to apply category-theoretic methods to model, analyze, and solve complex problems involving quantum information processes by selecting appropriate categorical structures, string diagrams, and formal analytical techniques, and by critically evaluating the obtained results.	[SU4] test/exam - oral or written [SU5] implementation of a problem task
[QITL3_W02] knows and understands on deepened level key and selected advanced detailed issues in the field of quantum information technology, including methods of their research and development, and their applications in the context of dynamic technological changes, in particular in the area of information processing, cryptography and the development of advanced computing systems	he student has an advanced understanding of categorical models of quantum mechanics, including monoidal, compact, and dagger categories, string diagrams, and their applications to the modeling, analysis, and verification of quantum information processes and quantum computation.	[SW4] test/exam - oral or written

Subject contents

1. The basics of diagrams
2. Pure quantum theory in diagrams
3. ZX calculus as a complete diagrammatic tool
4. Mixed quantum theory in diagrams
5. Interacting quantum and classical theory in diagrams

Prerequisites and co-requisites

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
tutorial part: test	51.0%	50.0%
lecture part: exam	51.0%	50.0%

Recommended reading

Basic literature

1. Coecke, B., & Kissinger, A. (2017). Picturing Quantum Processes: A First Course in Quantum Theory and Diagrammatic Reasoning. Cambridge: Cambridge University Press. doi: 10.1017/9781316219317
2. Coecke, B., & Gogioso, S. (2023). Quantum in Pictures: A New Way to Understand the Quantum World. Cambridge Quantum. ISBN-10:1739214714

Supplementary literature: None.

eResources addresses:

Example issues/ example questions/ tasks being completed

- Explain the principles of diagrammatic reasoning in categorical quantum mechanics. Discuss the relationship between string diagrams and the algebraic formalism of monoidal categories.
- Describe the diagrammatic representation of pure quantum theory and explain how quantum protocols such as quantum teleportation can be derived using string diagrams.
- Present the ZX calculus, its rewrite rules, and explain why it provides a complete framework for reasoning about quantum computations.
- Explain how mixed quantum theory and classical–quantum interaction can be represented diagrammatically. Discuss the role of completely positive maps and measurements.
- Discuss the applications of categorical quantum mechanics in quantum computation, quantum communication, and formal verification of quantum protocols. Explain the advantages of diagrammatic methods compared with matrix-based approaches.

Work placement

Not applicable