GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Quantum machine learning, PG_00064604		
Field of study	Technical Physics		
Date of commencement of studies	February 2026	Academic year of realisation of subject	2026/2027
Education level	second-cycle studies	Subject group	Obligatory subject group in the field of study 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	1	Language of instruction	Polish
Semester of study	2	ECTS credits	3.0
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	dr inż. Marcin Nowakowski	
	Teachers		

Lesson types

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	15.0	0.0	30.0	0.0	0.0	45
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	45	5.0	25.0	75

Subject objectives

The aim of this course is to familiarize students with the fundamentals of contemporary quantum machine learning methods, particularly those using quantum algorithms for efficient data processing and analysis. Students will gain knowledge of the theoretical foundations of quantum information processing, including superposition, quantum entanglement, and quantum measurements, and will learn how these phenomena can be used to create new, more effective machine learning models.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_W01] has extended and systematized knowledge of the leading of physics.	Has basic knowledge of quantum computation and quantum mechanics.	[SW1] Assessment of factual knowledge
[K7_W04] has enhanced knowledge of mathematical, numerical and simulation methods applied in the description and modelling of physical phenomena	Has basic knowledge of quantum machine learning models for both classical and quantum systems.	[SW1] Assessment of factual knowledge
[K7_U05] can plan and conduct theoretical calculations, experimental research and computer simulations, critically analyze their results, draw conclusions and form reasoned opinions	Possesses basic knowledge of programming methodology and techniques for selected issues in the quantum environment.	[SU1] Assessment of task fulfilment

Subject contents

Course content – lecture
What is QML about? QM and QC: quantum states, evolution in closed systems, measurements, and gates (towards qCNN). Quantum algorithms (Quantum Fourier Transform, Quantum Phase Estimation, Quantum Matrix Inverse). Open quantum systems: the classical Ising model. Quantum many-body physics and QML methods. ML strategies for solving many-body problems. Adiabatic quantum computation. Sampling of thermal states. Quantum annealing and implementations. Quantum Approximate Optimization Algorithm (QAOA). Variational circuits and methods. Quantum information encoding. Ensemble learning. Clustering by quantum optimization. (Quantum-enhanced) nuclear methods. Probabilistic graph models. Optimization and sampling. Quantum-assisted Gaussian processes. Quantum CNNs, GANs. Towards Quantum Generative Methods. Future Prospects: Technological and Market Trends.

Course content – laboratory
Simulations of quantum algorithms and quantum machine learning algorithms in Qiskit.

Prerequisites and co-requisites

Discrete mathematics, linear algebra, probability theory, quantum mechanics - fundamentals, basic artificial intelligence methods. Knowledge of programming in object-oriented languages.

<table>
<tr><td>Assessment methods and criteria</td><td colspan="2"><table><tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr><tr><td>Lab Project</td><td>60.0%</td><td>100.0%</td></tr></table></td></tr>
<tr><td rowspan="3">Recommended reading</td><td>Basic literature</td><td>1. M. Ekman, Learning Deep Learning, NVidia DL Institute, 2023.

2. M. Schuld, F. Pettrucione, Machine Learning with QuantumComputers, Springer, 2021.

3. M. Le Bellac, Wstep do Informatyki Kwantowej, PWN, 2018</td></tr>
<tr><td>Supplementary literature</td><td>4. E. R. Johnston et al., Komputer Kwantowy, Helion, 2020.

5. I. Goodfellow, Deep Learning, MIT, 2020</td></tr>
<tr><td>eResources addresses</td><td></td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td colspan="2">Simulation of a quantum neural network performing stratification of a selected feature space.</td></tr>
<tr><td>Practical activites within the subject</td><td colspan="2">Not applicable</td></tr>
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