COURSE DESCRIPTION CARD - SYLLABUS

Course name
Selected Applications of Quantum Computers [S1FT2>WZKK]

Course

Field of study
Technical Physics

Year/Semester
4/7

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
30

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

dr Gustaw Szawioła
gustaw.szawiola@put.poznan.pl

Lecturers

Prerequisites

Knowledge and skills in quantum physics, fundamentals of quantum engineering, mathematical and programming competencies as defined in the learning outcomes for the 1st and 2nd year (semesters 1 and 2) of the Technical Physics program.

Course objective

The module presents the structure, practical implementations of selected quantum algorithms, and the perspective of their practical applications.

Course-related learning outcomes

Knowledge:
The student explains the logical structure and limitations of selected quantum algorithms (specified in the syllabus) using appropriate quantum computing concepts and methods.
The student explains the details of practical application and implementation of a selected quantum algorithm in Python using open quantum libraries

Skills:

The student plans the implementation of a specified quantum algorithm in Python using open quantum libraries
The student implements on a quantum simulator (or an available quantum computer in the cloud) the specified quantum algorithm coded in Python using open quantum libraries
The student conducts selected physical tests of a quantum computer

Social competences:
The student is aware of the relationship between the dynamics of information technology development and achievements in quantum engineering
The student dutifully and ethically fulfills duties, showing a constructive attitude in discussions

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Written Exam: In the form of a test (W) with a maximum score of Wmax=12 points.
Two Home Programming Assignments (U): With a maximum score of Umax=10 points (5 points per task), the completion of tasks is verified during an oral exam.
Quality and Argumentation in Oral Exam (Kmax=3p): Evaluation of substantiveness and argumentation during the oral exam.

Programme content

I. Fundamentals of quantum computer programming in Python.
I.1 Overview of open quantum programming platforms, programming languages, and development environments. Setting up the programming environment.
I.2 Overview of Python syntax and key quantum libraries.
I.3 Implementation of basic quantum gates and fundamental quantum circuits in Python. Example of simulating a selected quantum communication protocol.
I.4 Problem of synthesis and decomposition of quantum circuits. Universality of quantum gates. Transpilation of quantum circuits.
II. "Canon" of quantum algorithms.
II.1 Implementation of the algorithms: Deutsch-Jozsa, Bernstein-Vazirani, Simon.
II.2 Implementation of the quantum Fourier transform algorithm.
II.3 Implementation of the quantum phase estimation algorithm.
II.4 Implementation of Shor's algorithm.
III. Selected applications.
III.1 Quantum algorithm for solving linear equations.
III.2 Quantum eigensolver algorithm using variational methods - application to molecular simulation.
III.3 Quantum dynamics simulation. Suzuki-Trotter approximation.
III.4 Quantum random walk.
IV. Quantum hardware.
IV.1 Hardware requirements for quantum computing.
IV.2 Comparative tests of quantum computers (quantum benchmarks).

Course topics

none

Teaching methods

Lecture: Multimedia presentation illustrated with examples of quantum algorithm implementations.

Bibliography

Basic:
1. A. Asfaw, i in. , ,,Learn Quantum Computation Using Qiski, (2020) http://community.qiskit.org/textbook
2. J.D. Hidary ,,Quantum Computing: An Applied Approach" Springer , 2019
3. M. Lutz, "Python. Wprowadzenie. Wydanie V", Helion 2020

Additional:

1. M. Senekane, ,,Hands-On Quantum Information Processing with Python'', Packt Publishing, 2021
2. Python Tutorial, https://www.w3schools.com/python/default.asp

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,00
Classes requiring direct contact with the teacher	30	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	20	1,00