



## Subject card

|                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                          |                                         |                                     |         |                                                                                                                         |     |
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| Subject name and code                       | Quantum Computing, PG_00048247                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                          |                                         |                                     |         |                                                                                                                         |     |
| Field of study                              | Informatics                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                          |                                         |                                     |         |                                                                                                                         |     |
| Date of commencement of studies             | February 2026                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                          | Academic year of realisation of subject |                                     |         | 2026/2027                                                                                                               |     |
| Education level                             | second-cycle studies                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                          | Subject group                           |                                     |         | Optional subject group<br>Specialty subject group<br>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                            |                                     |         | 2.0                                                                                                                     |     |
| Learning profile                            | general academic profile                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                          | Assessment form                         |                                     |         | assessment                                                                                                              |     |
| Conducting unit                             | Department of Algorithms and Systems Modelling -> Faculty of Electronics Telecommunications and Informatics -> Faculties of Gdańsk University of Technology                                                                                                                                                                                                                                                                                                                    |                                                          |                                         |                                     |         |                                                                                                                         |     |
| Name and surname of lecturer (lecturers)    | Subject supervisor                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                          | prof. dr hab. inż. Krzysztof Giaro      |                                     |         |                                                                                                                         |     |
|                                             | Teachers                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                          | prof. dr hab. inż. Krzysztof Giaro      |                                     |         |                                                                                                                         |     |
| Lesson types                                | Lesson type                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Lecture                                                  | Tutorial                                | Laboratory                          | Project | Seminar                                                                                                                 | SUM |
|                                             | Number of study hours                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 15.0                                                     | 15.0                                    | 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                                                       |                                         | 4.0                                 |         | 16.0                                                                                                                    | 50  |
| Subject objectives                          | As a result of a better understanding of the behavior of microscopic objects, scientists at the end of the twentieth century created concepts for the use of microscopic phenomena to the non-classical information processing, communication, computing. These ideas have been extensively developed in the following decades, giving rise to the theory of quantum computers and quantum cryptography. The aim of the course is to present the main ideas of these concepts. |                                                          |                                         |                                     |         |                                                                                                                         |     |

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| Learning outcomes                                              | Course outcome                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Subject outcome                                                                                                                                                                                                                                                                                 | Method of verification                                               |
|                                                                | [K7_W01] knows and understands, to an increased extent, mathematics to the extent necessary to formulate and solve complex issues related to the field of study                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | The student understands the geometric properties of unitary spaces, formalism of linear operators, description of the complex system as a tensor product of spaces and operators.                                                                                                               | [SW3] Assessment of knowledge contained in written work and projects |
|                                                                | [K7_U01] can apply mathematical knowledge to formulate and solve complex and non-typical problems related to the field of study by: - appropriate selection of source information and its critical analysis, synthesis, creative interpretation and presentation, - application of appropriate methods and tools                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Student describes the conception of q-bit and quantum gates. Student explains quantum cryptographic protocols and quantum teleportation.                                                                                                                                                        | [SU4] Assessment of ability to use methods and tools                 |
|                                                                | [K7_W02] knows and understands, to an increased extent, selected laws of physics and physical phenomena, as well as methods and theories explaining the complex relationships between them, constituting advanced general knowledge in the field of technical sciences related to the field of study                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | The student understands the quantum description of states of physical systems and their evolution modeled using the formalism of Hilbert spaces and the operators.                                                                                                                              | [SW3] Assessment of knowledge contained in written work and projects |
|                                                                | [K7_U12] is able, to an increased extent, to analyze the operation of components and systems related to the field of study, as well as to measure their parameters and study their technical characteristics, and to plan and carry out experiments related to the field of study, including computer simulations, interpret the obtained results and draw conclusions                                                                                                                                                                                                                                                                                                                                                                                                         | The student analyzes the operation of quantum gate circuits and the course of quantum protocols, interprets the impact of changes in the states of quantum systems on the results of measurements performed by the user.                                                                        | [SU1] Assessment of task fulfilment                                  |
| Subject contents                                               | Course content – lecture<br>1. History of quantum computing. 2. Linear space. 3. Hilbert space. 4. Linear operators in Hilbert space. 5. Axioms of quantum physics. 6. Quantum bit and register. 7. Quantum gates. 8. Spin, EPR states and quantum and teleportation. 9. Quantum cryptographic protocols. 10. Probabilistic algorithms. 11. Computation with quantum gates. 12. Grovers search algorithm. 13. BBHT search algorithm.<br>Course content – exercises<br>1. Unitary space geometry. 2. Algebra of matrices and operators. 3. Projections and unitary operators. 4. Subspaces of eigenvectors. 5. Tensor product of vectors and operators. 6. Quantum register and its states. 7. Probabilities of measurement results. 8. Quantum circuits and their functioning. |                                                                                                                                                                                                                                                                                                 |                                                                      |
| Prerequisites and co-requisites                                | Basics of:<br>- Linear Algebra<br>- Probability and Mathematical Statistics<br>- Fundamentals of Algorithm Analysis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                 |                                                                      |
| Assessment methods and criteria                                | Subject passing criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Passing threshold                                                                                                                                                                                                                                                                               | Percentage of the final grade                                        |
|                                                                | Midterm colloquium                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 40.0%                                                                                                                                                                                                                                                                                           | 100.0%                                                               |
| Recommended reading                                            | Basic literature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | N. Nielsen, I. Chuang, Quantum Computation and Quantum Information, Cambridge University Press 2000.<br>J. Gruska, Quantum Computing, McGraw Hill 1999.<br>K. Giaro, Elementy kwantowego modelu obliczeń i algorytmiki kwantowej, OWSiZ, 2013.<br>M. Hirvensalo, Algorytmy kwantowe, WSiP 2004. |                                                                      |
|                                                                | Supplementary literature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | K. Giaro, M. Kamiński, Wprowadzenie do algorytmów kwantowych, Exit 2003<br>L. Tarasow, Podstawy mechaniki kwantowej, PWN 1984.                                                                                                                                                                  |                                                                      |
|                                                                | eResources addresses                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                 |                                                                      |
| Example issues/<br>example questions/<br>tasks being completed |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                 |                                                                      |
| Practical activites within the subject                         | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                 |                                                                      |

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