<table>
<tr><td colspan="2">NAME OF THE COURSE</td><td colspan="6">Quantum computers</td></tr>
<tr><td>Code</td><td>PMP202</td><td>Year of study</td><td colspan="4">DS-1, DS-2</td></tr>
<tr><td>Course teacher</td><td>D. Horvat</td><td>Credits (ECTS)</td><td colspan="4">5</td></tr>
<tr><td rowspan="2">Associate teachers</td><td rowspan="2">I. Weber</td><td rowspan="2">Type of instruction (number of hours)</td><td>L</td><td>S</td><td>E</td><td>F</td></tr>
<tr><td>30</td><td>15</td><td></td><td></td></tr>
<tr><td>Status of the course</td><td>Elective</td><td>Percentage of application of e-learning</td><td colspan="4"></td></tr>
<tr><td colspan="7">COURSE DESCRIPTION</td></tr>
<tr><td>Course objectives</td><td colspan="6">To train students for:
- understanding and application of classical logic circuits (gates and networks);
- understanding the structure and interpretation of single and multiqubit states, andunderstanding their representation using light polarisation vectors and by spin electrons;
- setting up and solving quantum computer reversible circuits and networks;
- understanding the results of quantum mechanical measurements of the outcome of quantum assemblies and networks;
- setting up and solving basic quantum computer procedures (cloning, teleportation, quantum Fourier transform);
- understanding, application and continuous adoption of quantum computer algorithms (Deutsch, Deutsch-Jozsa, Bernstein-Vazirani, Simon, Grover, Shor);
- understanding the realization of quantum computers (ion traps, NMR, linear and nonlinear optics);
- understanding of quantum information theory and cryptography;
- understanding of new trends in quantum computing (adiabatic quantum computing).</td></tr>
<tr><td>Course enrolment requirements and entry competences required for the course</td><td colspan="6">Quantum Physics</td></tr>
<tr><td>Learning outcomes expected at the level of the course (4 to 10 learning outcomes)</td><td colspan="6">After successfully mastering the course, students will be able to:
1. solve classical logic circuits;
2. solve quantum computing reversible logic circuits built of single-qubit and multi-qubit states;
3. apply reversible quantum computer circuits in solving networks given procedures;
4. apply quantum computational procedures to construct quantum computing algorithms;
5. apply quantum computer algorithms to solve teleportation problems and quantum communications;
6. calculated quantum Fourier transform;
7. calculate the number factorisation using a quantum-mechanical algorithm.</td></tr>
<tr><td>Course content broken down in detail by weekly class schedule (syllabus)</td><td colspan="6">(2h) Introduction to qubit representation. Polarization of light and the problem of superposition
which leads to Malus's law. Field amplitude and intensity calculation. MachZender interferometer experiment and amplitude recombination.
(2x) Classic logic gates and logic circuits. Truth tables.
(2h) Seminars.
(3h) One-qubit state. Matrix representation of qubit. Bloch's sphere.
Density operator. Spectral decomposition theorem. Dynamic evolution</td></tr>
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<tr><td></td><td colspan="6">quantum states. Classic reversible door.
(2h) Seminar.
(2h) Single qubit quantum gate. Two-qubit and multi-qubit states and their matrix representation. Multiqubit quantum gate.
(2h) Seminars.
(3h) Bell states (base). Controlled quantum gate. Quantum networks
(3h) The problem of measurement in quantum mechanics. Einstein-Podolski-Rosen-problem and
entanglement. Measurement in quantum computing. Universal set of quantum gates.
Mixed conditions.
(3h) Superdense quantum coding. EPR-problem and classical communication. Teleportation. Non-cloning theorem.
(1h) Seminar.
(3h) Quantum algorithms. Deutsch algorithm.
(2h) Seminar.
(3h) Deutsch-Jozsa algorithm. Bernstein-Weighted Algorithm.
(2x) Simon's algorithm. Grover's algorithm.
(2h) Seminars.
(2h) Quantum Fourier transform. Shore's algorithm.
(2h) Seminars.
(2h) Basic ideas of (quantum) cryptography. Adiabatic quantum computation. Perspectives of quantum computing and quantum information technology.
(2h) Seminars.</td></tr>
<tr><td>Format of instruction</td><td colspan="3">☒ lectures
☒ seminars and workshops
☒ exercises
☐ on line in entirety
☐ partial e-learning
☐ field work</td><td colspan="3">☐ independent assignments
☐ multimedia
☐ laboratory
☐ work with mentor
☐ (other)</td></tr>
<tr><td>Student responsibilities</td><td colspan="6"></td></tr>
<tr><td rowspan="5">Screening student work (name the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the ECTS value of the course)</td><td>Class attendance</td><td></td><td>Research</td><td></td><td>Practical training</td><td>2</td></tr>
<tr><td>Experimental work</td><td></td><td>Report</td><td></td><td>Self-study (Other)</td><td></td></tr>
<tr><td>Essay</td><td>1</td><td>Seminar essay</td><td></td><td>(Other)</td><td></td></tr>
<tr><td>Tests</td><td></td><td>Oral exam</td><td></td><td>(Other)</td><td></td></tr>
<tr><td>Written exam</td><td></td><td>Project</td><td>2</td><td>(Other)</td><td></td></tr>
<tr><td>Grading and evaluating student work in class and at the final exam</td><td colspan="6">Homework: 20%
Intermediate exam: 20%
Final exam: 40%
Seminar paper: 20%</td></tr>
<tr><td rowspan="4">Required literature (available in the library and via other media)</td><td colspan="4">Title</td><td>Number of copies in the library</td><td>Availability via other media</td></tr>
<tr><td colspan="4">[1] M. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press, Cambridge, 2000.</td><td></td><td></td></tr>
<tr><td colspan="4">[2] D. Horvat, Uvod u kvantna računala, – interna skripta, FER-Zagreb, PMF-Split, 2017</td><td></td><td></td></tr>
<tr><td colspan="4">[3] Ph. Kaye, R. Laflamme and M. Mosca, An Introduction to Quantum Computing, Oxford University Press, Oxford, 2007.</td><td></td><td></td></tr>
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	[4] A. O. Pittenger, An Introduction to Quantum Computing Algorithms, Birkhauser, Bassel, 2000.		
Optional literature (at the time of submission of study programme proposal)			
Quality assurance methods that ensure the acquisition of exit competences	Statistics of students' results and students' evaluation via anonymous questionnaires at the end of the course. The survey is conducted according to the rules of the University of Split.		
Other (as the proposer wishes to add)			