Syllabus

1. Data about the program of study

1.1 Institution	Technical University of Cluj-Napoca
1.2 Faculty	Automation and Computer Science
1.3 Department	Computer Science
1.4 Field of study	Computer Science and Information Technology
1.5 Cycle of study	Bachelor of Science
1.6 Program of study / Qualification	Computer science / Engineer
1.7 Form of education	Full time

2. Data about the subject

2.1 Subject name	***Basics of quantum information***			Subject code	**103**
2.2 Course responsible / lecturer	CS1 dr. Zârbo Liviu - liviu.zarbo@itim-cj.ro				
2.3 Teachers in charge of seminars / Laboratory / project	CS Mathe Levente - levente.mathe@itim-cj.ro AC Pioras-Timbolmaș Larisa - larisa.timbolmas@itim-cj.ro				
2.4 Year of study	II	2.5 Semester	3	2.6 Type of assessment (E - exam, C - colloquium, V – verification)	C
2.7 Subject category	Formative category: DF – fundamental, DS – specialty, DC – complementary				DC
	Optionality: DOB – mandatory, DOP – optional (alternative), DFA – optional (free choice)				DFA

3. Estimated total time

3.1 Number of hours per week	3	of which:	Course	2	Seminar	-	Laboratory	1	Project	-
3.2 Number of hours per semester	42	of which:	course	28	Seminar	-	Laboratory	14	Project	-

3.3 Individual study	
(a) Manual, lecture material and notes, bibliography	10
(b) Supplementary study in the library, online and in the field	10
(c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays	10
(d) Tutoring	-
(e) Exams and tests	3
(f) Other activities:	-

3.4 Total hours of individual study (sum of (3.3(a)...3.3(f)))	33
3.5 Total hours per semester (3.2+3.4)	75
3.6 Number of credit points	3

4. Pre-requisites (where appropriate)

4.1 Curriculum	Linear Algebra Mathematical Analysis Physics Programming
4.2 Competence	-

5. Requirements (where appropriate)

5.1. For the course	
5.2. For the applications	

6. Specific competences

6.1 Professional competences	Basic high-school level or first year undergraduate physics: mechanics, electricity and magnetism, optics Basic knowledge of linear algebra and calculus, first year undergraduate student level Basic programming knowledge, first year undergraduate student level
6.2 Cross competences	-

7. Expected Learning Outcomes

Knowledge	Basic knowledge of quantum information: • The concept of qubit, quantum gate, quantum circuit • A few basic quantum algorithms • Quantum phenomena employed in quantum computing and communications (superposition, entanglement) • Basics of quantum measurement, quantum communication protocols
Skills	Implementing quantum circuits via qiskit, or uranium-like platforms. Implementing quantum algorithms via qiskit and uranium-like platforms.
Responsibilities and autonomy	Respecting the ethics according to the law and university's guidelines.

8. Course objectives

8.1 General objective	Developing general knowledge relevant to applications in the field of quantum computation and quantum communications
8.2 Specific objectives	1. Assimilating the basics of quantum computation: qubits, quantum gates, quantum circuits, quantum algorithms 2. Developing the basic skills for developing quantum algorithms 3. Understanding the basics of quantum communications protocols.

9. Contents

9.1 Course	Nr.ore	Teaching methods	Notes
1. Introductory notions. • From classical to quantum computing • The dual behavior of the quantum objects • Tunneling • Double slit experiment	2	Blackboard, video-lectures, discussions of examples, problem solving.	
2. Quantum states • Notations • Probabilities • Matrix and vector representation of quantum states • Qubits • Pure states and mixed states	2		
3. Observables and quantum measurement 1 • Observables and operators • The Heisenberg principle • Projective measurements • The Stern-Gerlach experiment	2		

4. Observables and quantum measurement 2 • Quantum state vectors. • Observables and operators, the density matrix. • Probabilities and expectation values. • Partial measurements	2		
5. Qubits • The two-level system and real-life examples • Quantum gates • Superpositions and entanglement of qubits • The Bloch sphere.	2		
6. Quantum gates • Single qubit gates • Entangling gates • Quantum circuits.	2		
7. Quantum Algorithms: Deutsch algorithm • Boolean variables • Quantum parallelism • Deutsch algorithm	2		
8. Quantum search: the Grover algorithm. • Quantum oracle • Grover reflection • Phase kick back • Grover iteration	2		
9. Quantum Fourier transform • Discrete Fourier transform • Conditional rotations. • The quantum Fourier transform.	2		
10. Quantum phase estimation • Controlled unitaries. • Quantum phase estimation. • The Shor algorithm • HHL algorithm	2		
11. Variational algorithms • The concept behind variational algorithms • Example of a variational algorithm	2		
12. Physical platforms for quantum computing • Superconducting qubits • Cold atoms • Ion traps • Full stack quantum computing	2		
13. Quantum measurement and applications. • The no-cloning theorem • Quantum teleportation • Quantum number generation • Quantum sensors	2		
14. Quantum communications • BB84 protocol. • Quantum cryptography • Quantum networks and use cases.	2		

Bibliography:

1. Nielsen and Chuang, Quantum Computation and Quantum Information, Cambridge University Press (2010).
2. Ioan Burda, Introduction to Quantum Computation, Universal Publishers (2005).
3. David McIntyre, Quantum Mechanics: A Paradigms Approach, Pearson Addison-Wesley (2012).
4. Cohen-Tannoudji, Quantum Mechanics, Wiley-VCH; 2nd edition (2019).

9.2 Applications - seminar / laboratory / project	Hours	Teaching methods	Notes

1. Visualizing qubit operations: Bloch sphere, single qubit gates, destructive and constructive interference (Quantum Odyssey)	2	Lab work in INCDTIM Quantum Software lab, using tools such as Uranium, Quantum Odyssey, Google Colab.	
2. Quantum circuits in Q. Odyssey: vectors, eigenvalues, basis change	2		
3. Generating entanglement in quantum circuits (quantum gates: CNOT, SWAP, Toffoli). Visualization in Q. Odyssey, circuits on the Uranium platform.	2		
4. Uranium platform: multiqubit quantum circuits and quantum measurements; Deutsch algorithm	2		
5. Quantum oracles, Grover's algorithm (Uranium, Q. Odyssey)	2		
6. The Quantum Fourier Transform	2		
7. Quantum phase estimation	2		

Bibliography:

1. Nielsen and Chuang, Quantum Computation and Quantum Information, Cambridge University Press (2010).
2. Ioan Burda, Introduction to Quantum Computation, Universal Publishers (2005).
3. David McIntyre, Quantum Mechanics: A Paradigms Approach, Pearson Addison-Wesley (2012).
4. Cohen-Tannoudji, Quantum Mechanics, Wiley-VCH; 2nd edition (2019).

10. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

11. Evaluation

Activity type	Assessment criteria	Assessment methods	Weight in the final grade
Course	Solving 2 problems + 1 theory set of questions	Written exam	60%
Seminar	-	-	-
Laboratory	3-4 short exercises/questions testing the understanding of the contents of the class.	Periodic lab quizzes	40%
Project	-	-	-

Minimum standard of performance:
Being able to determine the final state of a simple 2-10 gates quantum circuit; being able to create superpositions, entangled states, and destroy them using quantum gates. Final grade: 60% final exam + 40% lab quizzes.
Final exam participation condition: max 2 lab absences.

Date of filling in: 12.05.2026	**Responsible**	**Title, First name Last name**	**Signature**
	Course	Dr. Liviu ZÂRBO	
	Applications	CS Levente MATHE	
		AC Larisa PIORAS-TIMBOLMAȘ	

Date of approval in the department

Head of Department,
Prof. dr. eng. Rodica Potolea

Date of approval in the Faculty Council

Dean,
Prof. dr. eng. Vlad Mureșan