syllabus

1. Information regarding the programme

1.1 Higher education institution	Babeş Bolyai University
1.2 Faculty	Faculty of Mathematics and Computer Science
1.3 Department	Department of Computer Science
1.4 Field of study	Computer Science
1.5 Study cycle	Bachelor
1.6 Study programme / Qualification	Computer Science

2. Information regarding the discipline

2.1 Name of the discipline (en) (ro)			Quantum computing with applications in cryptography and AI Tehnici de calcul cuantice cu aplicatii in criptografie si IA				
2.2 Course coordinator			Mihoc Tudor Dan				
2.3 Seminar coordinator			Mihoc Tudor Dan				
2.4. Year of study	3	2.5 Semester	6	2.6. Type of evaluation	C	2.7 Type of discipline	Opt.
2.8 Code of the discipline		MLE5216					

3. Total estimated time (hours/semester of didactic activities)

3.1 Hours per week	4	Of which: 3.2 course	2	3.3 seminar / laboratory	1 lab + 1 proiect
3.4 Total hours in the curriculum	48	Of which: 3.5 course	24	3.6 seminar / laboratory	24
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					8
Additional documentation (in libraries, on electronic platforms, field documentation)					2
Preparation for seminars/labs, homework, papers, portfolios and essays					8
Tutorship					2
Evaluations					8
Other activities:					
3.7 Total individual study hours	127				
3.8 Total hours per semester	175				
3.9 Number of ECTS credits	6				

4. Prerequisites (if necessary)

4.1. curriculum	· Basic knowledge of calculus and linear algebra
4.2. competencies	· Basic programming skills in C++

5. Conditions (if necessary)

5.1. for the course	· Course hall with a projector

5.2. for the seminar /lab activities	· Laboratory with computers. Access to the IBM Quantum Composer and the IBM Quantum Lab

6. Specific competencies acquired

Professional competencies	**C1.5 Development of program units and corresponding documentation** **C3.3 Use of computer science and mathematical models and tools for solving specific** **problems in the application field**
Transversal competencies	**CT2 Efficient fulfillment of organized activities in an interdisciplinary group and development of empathetic abilities of interpersonal communication, relationship and collaboration with various groups**

7. Objectives of the discipline (outcome of the acquired competencies)

7.1 General objective of the discipline	· To present mathematical algorithms used in quantum computing with applications in cryptography and artificial intelligence
7.2 Specific objective of the discipline	· Number-theoretic and algebra algorithms will be studied and implemented in projects

8. Content

8.1 Course	Teaching methods	Remarks
1. Introduction – mathematical prerequisites	Exposition, dialog, discussion	
2. Fundamental notions of quantum computing (Qubits and the Bloch Sphere)	Presentation, dialog, exemplification	
3. Qubit gates. Quantum circuits	Exemplification, exposition	
4. The quantum Fourier transform and its applications	Interactive exposure, explanation, didactic demonstration	
5. Quantum search algorithms	Presentation, dialog	
6. Schor's algorithm	Exemplification, exposition	
7. Quantum cryptography and post quantum cryptography. Quantum Computing Attacks on RSA	Presentation, dialog	
8. Quantum key distribution (QKD). Noise in QKD (eye dropper)	Presentation, dialog, , exemplification	
9. Clustering Structure and Quantum Computing	Presentation, dialog, exemplification	
10. Quantum Pattern Recognition	Presentation, dialog, exemplification	
11. Quantum Classification	Example, algorithms implementation	
12. Quantum Regression	Example, algorithms	

	implementation	
13. Physical implementation of quantum systems	Example, algorithms implementation	
14. Quantum information theory	Example, algorithms implementation	

Bibliography

1. Nielsen, Michael A., and Isaac Chuang. "Quantum computation and quantum information." (2002): 558-559.
2. Gisin, Nicolas, et al. "Quantum cryptography." Reviews of modern physics 74.1 (2002): 145.
3. Yan, Song Yuan. “Cryptanalytic attacks on RSA.” (2007).
4. Bruß, Dagmar, and Norbert Lütkenhaus. "Quantum key distribution: from principles to practicalities." Applicable Algebra in Engineering, Communication and Computing 10.4 (2000): 383-399.
5. Shor, Peter W. "Polynomial-time algorithms for prime factorization and discrete logarithms on a quantum computer." SIAM review 41.2 (1999): 303-332.
6. P. Wittek, Quantum machine learning: what quantum computing means to data mining, Academic Press, Elsevier, 2014.
7. S. D. Sarma, D. Dong-Ling, and D. Lu-Ming, Machine learning meets quantum physics, arXiv preprint arXiv:1903.03516, 2019.

8.2 Seminar / laboratory	Teaching methods	Remarks
1. Quantum random number generators	example, algorithms implementation	The lab is structured as 2 hours classes every second week
2. Quantum FFT	example, algorithms implementation	
3. Deutsch’s algorithm. The Deutsch–Jozsa algorithm	example, algorithms implementation	
4. Grover’s Search	example, algorithms implementation	
5. Quantum Algorithm for Integer Factorization	example, algorithms implementation	
6. Quantum algorithm for discrete logarithms	example, algorithms implementation	
7. Quantum Neural Networks	example, algorithms implementation	

Bibliography

1. Nielsen, Michael A., and Isaac Chuang. "Quantum computation and quantum information." (2002): 558-559.
2. Gisin, Nicolas, et al. "Quantum cryptography." Reviews of modern physics 74.1 (2002): 145.
3. Yan, Song Yuan. “Cryptanalytic attacks on RSA.” (2007).
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9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

The contents are directed towards the introduction of basic knowledge of Quantum computing with quantum cryptography and AI. The topic is present in the computer science study program of the major universities.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	Use of basic concepts in examples	Colloquium	50
10.5 Seminar/lab activities	Implement course concepts and algorithms	Student projects	50
10.6 Minimum performance standards			
➢ Grade 5			

Date	Signature of course coordinator	Signature of seminar coordinator
.....	Univ. Lect. Dr. Mihoc Tudor Dan	Univ. Lect. Dr. Mihoc Tudor Dan

Date of approval	Signature of the head of department
.....	.....….....