Teaching Guide				
Identifying Data				2023/24
Subject (*)	Quantum Computing Tools		Code	614551006
Study programme	Máster Universitario en Ciencia e Tecnoloxías de Información Cuántica			
Descriptors				
Cycle	Period	Year	Type	Credits
Official Master's Degree	1st four-month period	First	Optional	3
Language	Spanish			
Teaching method	Face-to-face			
Prerequisites				
Department	Ciencias da Computación e Tecnoloxías da InformaciónEnxeñaría de Computadores			
Coordinador	Mosqueira Rey, Eduardo	E-mail	eduardo.mosqueira@udc.es	
Lecturers	Alvarez Estevez, Diego Martin Santamaria, Maria Jose Mosqueira Rey, Eduardo	E-mail	diego.alvareze@udc.es maria.martin.santamaria@udc.es eduardo.mosqueira@udc.es	
Web	n9.cl/huuwq			
General description	A computación cuántica é unha área emerxente cun potencial significativo, especialmente na área de problemas de optimización. Dado que a computación cuántica funciona cun mecanismo diferente ao da computación clásica, o enfoque do software para a computación cuántica tamén é diferente. Seguindo o paradigma dos circuítos cuánticos, nesta materia farase un desenvolvemento completo, profundo e rigoroso das diferentes técnicas e ferramentas necesarias para o desenvolvemento e execución de software cuántico.			

Study programme competences / results	
Code	Study programme competences / results
A4	CON_04 Have knowledge of quantum computing, algorithms, circuits, their programming in different languages and accessible platforms.
A6	CON_06 Acquire knowledge about physical systems capable of implementing information processing in quantum degrees of freedom.
A13	CON_13 Have knowledge of the physical and technical limitations of implementing quantum information processing systems: noise, decoherence, etc., as well as the mitigation or correction strategies that are proposed.
A15	CON_15 Have knowledge of high-level aspects of quantum computing: learning quantum machines, quantum simulators, architectures, etc.
B1	HD01 Analyze and break down a complex concept, examine each part and see how they fit together
B3	HD03 Compare and contrast and point out similarities and differences between two or more topics or concepts
B6	HD11 Prepare accurately the relevant questions for a specific problem.
B8	HD13 Improvise solutions in an innovative way to solve a problem.
B12	HD23 Communicate using the expected norms for the chosen medium.
B13	HD24 Actively participate in face-to-face activities in the classroom.
B14	HD31 Assign resources and responsibilities so that all members of a team can work optimally
B16	HD33 Set goals for the group to analyze the situation, decide what outcome is desired and clearly set an achievable goal.
C1	C1. Adequate oral and written expression in the official languages.
C2	C2. Mastering oral and written expression in a foreign language.
C3	C3. Using ICT in working contexts and lifelong learning.
C4	C4. Acting as a respectful citizen according to democratic cultures and human rights and with a gender perspective.
C7	C7. Developing the ability to work in interdisciplinary or transdisciplinary teams in order to offer proposals that can contribute to a sustainable environmental, economic, political and social development.
C8	C8. Valuing the importance of research, innovation and technological development for the socioeconomic and cultural progress of society.

Learning outcomes

Learning outcomes	Study programme competences / results		
Capacidade para deseñar circuítos cuánticos básicos e avanzados en Qiskit	AJ4	BJ1 BJ3 BJ6 BJ8 BJ12 BJ13 BJ14 BJ16	CJ1 CJ2 CJ3 CJ4 CJ7 CJ8
Coñecer os distintos simuladores cuánticos existentes e os seus modelos de ruído	AJ13 AJ15	BJ3 BJ6 BJ12 BJ13 BJ14 BJ16	CJ1 CJ2 CJ3 CJ4 CJ7 CJ8
Ser capaz de enviar e transpilar circuítos cuánticos para a súa execución en computadores cuánticos reais	AJ6	BJ1 BJ6 BJ12 BJ13 BJ14 BJ16	CJ1 CJ2 CJ3 CJ4 CJ7 CJ8
Coñecer as distintas técnicas de supresión, mitigación e corrección de erros	AJ13	BJ3 BJ6 BJ13 BJ14 BJ16	CJ1 CJ2 CJ3 CJ4 CJ7 CJ8

Contents	
Topic	Sub-topic
1. Introdución	
2. Qiskit: circuítos básicos	
3. Qiskit: circuítos avanzados	
4. Simuladores	
5. Computadores cuánticos reais	
6. Transpiladores	
7. Supresión, mitigación e corrección de erros	

Planning				
Methodologies / tests	Competencies / Results	Teaching hours (in-person & virtual)	Student?s personal work hours	Total hours
Guest lecture / keynote speech	A4 A6 A13 A15 B13 C1 C2 C8	10.5	15.75	26.25
Laboratory practice	A4 A13 A15 B1 B3 B6 B8 B12 B14 B16 C3 C4 C7	10.5	34.65	45.15
Objective test	A4 A6 A13 A15 B1 B3 B8 C1 C2 C3 C8	2.6	0	2.6

Personalized attention		1	0	1
(*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.				

Methodologies	
Methodologies	**Description**
Guest lecture / keynote speech	Clases maxistrais coa exposición dos coñecementos teóricos e prácticos usando diferentes recursos dixitais.
Laboratory practice	Prácticas baseadas nos coñecementos que cada estudante vai adquirindo nas clases maxistrais.
Objective test	Proba mediante a que se valoran os coñecementos adquiridos polo estudantado. Cada estudante deberá aplicar os seus coñecementos tanto a nivel teórico coma a nivel práctico.

Personalized attention	
Methodologies	**Description**
Laboratory practice	Personalized attention to students includes not only tutorials (either virtual or in-person) to discuss questions, but also the following actions: - Monitor the work of laboratory practices proposed by the teacher. - Evaluate of the results obtained in practice and seminars. - Conduct personalized meetings to answer questions about the contents of the subject.

Assessment			
Methodologies	**Competencies / Results**	**Description**	**Qualification**
Laboratory practice	A4 A13 A15 B1 B3 B6 B8 B12 B14 B16 C3 C4 C7	Practice exercises based on the knowledge acquired in the theoretical classes.	60
Objective test	A4 A6 A13 A15 B1 B3 B8 C1 C2 C3 C8	Test conducted at the end of the semester with theoretical and practical content.	40

Assessment comments
Porcentaxes concretas de avaliación de cada parte. A avaliación da materia realizarase en dous partes: avaliación continua (prácticas) e proba obxectiva (parcial e/ou final). Como se avalía o non presentado. A entrega dalgunha das actividades ou probas de avaliación continua supoñerá que o alumno optou por presentarse á materia. Por tanto, a partir dese momento, aínda non presentándose a proba obxectiva haberá consumido unha oportunidade. Cómo se avalía a segunda oportunidade. Na segunda oportunidade (xullo) conservaranse as notas da avaliación continua e/ou a proba obxectiva obtidas durante o cuadrimestre. Se o alumno preséntase á segunda oportunidade na avaliación continua ou a proba obxectiva, a nota obtida na primeira oportunidade para esa parte anúlase, e a cualificación correspondente desa parte será a da segunda oportunidade. A nota final da materia na segunda oportunidade calcularase co mesmo criterio que na primeira oportunidade. PlaxiosA realización fraudulenta das probas ou actividades de avaliación, unha vez comprobada, implicará directamente a cualificación de suspenso "0" na materia na convocatoria correspondente, invalidando así calquera cualificación obtida en todas as actividades de avaliación de cara a convocatoria extraordinaria

Sources of information

Basic	- Robert Loredo (2020). Learn Quantum Computing with Python and IBM Quantum Experience. Packt, O'Reilly - Hassi Norlen (2020). Quantum Computing in Practice with Qiskit and IBM Quantum Experience. Packt, O'Reilly - Qiskit (2023). Qiskit documentation. https://qiskit.org/documentation - Qiskit (2023). Qiskit tutorials. https://qiskit.org/documentation/tutorials.html
Complementary	- James L. Weaver (2022). Qiskit Pocket Guide. O'Reilly - Qiskit (2023). Qiskit Terra API Reference. https://qiskit.org/documentation/apidoc/terra.html

Recommendations
Subjects that it is recommended to have taken before
Introduction to Quantum Computing/614551004
Subjects that are recommended to be taken simultaneously
Quantum Computing and Machine Learning/614551008 Programming and Implementation of Quantum Algorithms/614551007
Subjects that continue the syllabus
Practical Applications of Quantum Computing/614551010
Other comments

(*)The teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.