Teaching Guide				
Identifying Data				2024/25
Subject (*)	Quantum Computing Architectures		Code	614551022
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	SpanishGalician			
Teaching method	Face-to-face			
Prerequisites				
Department	Ciencias da Computación e Tecnoloxías da Información			
Coordinador	Mosqueira Rey, Eduardo	E-mail	eduardo.mosqueira@udc.es	
Lecturers	Mosqueira Rey, Eduardo	E-mail	eduardo.mosqueira@udc.es	
Web	n9.cl/27996			
General description	Aínda non se resolveu o problema de que hardware sería ideal para a computación cuántica. Neste sentido, definíronse unha serie de condicións que deben cumprir as arquitecturas cuánticas, e que se poden atopar na coñecida lista de Di Vincenzo. Non obstante, en toda arquitectura cuántica débense manter unha serie de restricións, como son as seguintes: o sistema debe poder ser inicializado, é dicir, debe levarse a un estado de arranque coñecido e controlado; tamén debe ser posible manipular os qubits de forma controlada, cun conxunto de operacións que forman un conxunto universal de portas lóxicas (co fin de reproducir calquera outra porta lóxica posible). Do mesmo xeito, o sistema debe manter a súa coherencia cuántica, ademais de poder ler o estado final do sistema, despois do cálculo. Finalmente, o sistema ten que ser escalable: ten que haber unha forma definida de aumentar o número de qubits, para facer fronte a problemas de maior custo computacional.			

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.
A16	CON_16 Have knowledge of quantum computer architectures, different platforms and "full stack".
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

Adquirir conocimientos de computación cuántica, algoritmia y circuitos cuánticos.	AJ4 AJ16	BJ1 BJ3 BJ6 BJ8 BJ12 BJ13 BJ16	CJ1 CJ2 CJ3 CJ4 CJ7 CJ8
Programación en diferentes lenguajes y plataformas accesibles.	AJ4 AJ16	BJ1 BJ3 BJ6 BJ8 BJ12 BJ13 BJ14 BJ16	CJ1 CJ2 CJ3 CJ4 CJ7 CJ8
Adquirir conocimientos sobre aspectos de alto nivel en computación cuántica: diseño de máquinas cuánticas, simuladores cuánticos y arquitecturas.	AJ4 AJ16	BJ1 BJ3 BJ6 BJ8 BJ12 BJ13 BJ14 BJ16	CJ1 CJ2 CJ3 CJ4 CJ7 CJ8

Contents	
Topic	**Sub-topic**
1. INTRODUCCIÓN	Antecentes Contexto
2. REQUISITOS DEL COMPUTADOR CUÁNTICO	Requisitos funcionales Requisitos no funcionales Integración de requisitos
3. COMPONENTES Y MÉTODOS	Registros de cómputo Puertas unitarias Transiciones de estados
4. ARQUITECTURAS CLÁSICAS	Arquitectura de Benioff Arquitectura de Kane Arquitectura de Deutsch
5. EL ORDENADOR CUÁNTICO DE FEYNMAN	Operadores de aniquilación Operadores de creación El Hamiltoniano de la computación cuántica Diseño y desempeño del ordenador cuántico
6. CONSIDERACIONES FINALES	Análisis crítico Discusión de aproximaciones Conclusiones

Planning				
Methodologies / tests	**Competencies / Results**	**Teaching hours (in-person & virtual)**	**Student?s personal work hours**	**Total hours**

Guest lecture / keynote speech	A4 A16 B1 B3 B6 B8 B12 B13 B14 B16 C1 C2 C3 C4 C7 C8	10	50	60
ICT practicals	A4 A16 B1 B3 B6 B8 B12 B13 B14 B16 C1 C2 C3 C4 C7 C8	15	0	15
Personalized attention		0	0	0
(*)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	Explicación en el aula de los contenidos de la materia. Resolución de problemas y supuestos prácticos. Realización de seminarios interactivos.
ICT practicals	Resolución de problemas prácticos en entornos TIC. Realización en equipo de prácticas de laboratorio con simuladores cuánticos.

Personalized attention	
Methodologies	**Description**
	Incluye clases teóricas (expositivas e interactivas), debates, resolución de problemas, seminarios, y prácticas de laboratorio en entornos TIC.

Assessment			
Methodologies	**Competencies / Results**	**Description**	**Qualification**
Guest lecture / keynote speech	A4 A16 B1 B3 B6 B8 B12 B13 B14 B16 C1 C2 C3 C4 C7 C8	Evaluación continua de actividades realizadas individualmente. Evaluación continua de actividades realizadas en equipo. Prueba final de desarrollo de cinco preguntas cortas de la materia.	50
ICT practicals	A4 A16 B1 B3 B6 B8 B12 B13 B14 B16 C1 C2 C3 C4 C7 C8	Evaluación de prácticas individuales. Evaluación de prácticas realizadas en equipo.	50

Assessment comments
No se establece ninguna nota de corte, ni en Teoría ni en Prácticas.La nota final se obtendrá a partir de la siguiente ecuación: Nota_Final = 0.5 x (Nota_Teoría + Nota_Prácticas)Para aprobar la asignatura, se tiene que cumplir que Nota_Final sea mayor o igual a 5.00 puntos.

Sources of information

Basic	- Noson S. Yanofsky, Mirco A. Mannucci (2009). Quantum Computing for Computer Scientists. Cambridge University Press - Richard P. Feynman (2001). Feynman Lectures On Computation. CRC Press After presenting the necessary prerequisites, the material is organized to look at different aspects of quantum computing from the specific standpoint of computer science. There are chapters on computer architecture, algorithms, programming languages, theoretical computer science, cryptography, information theory, and hardware. The text has step-by-step examples, more than two hundred exercises with solutions, and programming drills that bring the ideas of quantum computing alive for today's computer science students and researchers.After presenting the necessary prerequisites, the material is organized to look at different aspects of quantum computing from the specific standpoint of computer science. There are chapters on computer architecture, algorithms, programming languages, theoretical computer science, cryptography, information theory, and hardware. The text has step-by-step examples, more than two hundred exercises with solutions, and programming drills that bring the ideas of quantum computing alive for today's computer science students and researchers.
Complementary	- Vicente Moret Bonillo (2017). Adventures in Computer Science . Springer The main focus of this textbook is the basic unit of information and the way in which our understanding of this has evolved over time. In particular the author covers concepts related to information, classical computing, logic, reversible computing, quantum mechanics, quantum computing, thermodynamics and some artificial intelligence and biology, all approached from the viewpoint of computer sciences.The main focus of this textbook is the basic unit of information and the way in which our understanding of this has evolved over time. In particular the author covers concepts related to information, classical computing, logic, reversible computing, quantum mechanics, quantum computing, thermodynamics and some artificial intelligence and biology, all approached from the viewpoint of computer sciences.

Recommendations
Subjects that it is recommended to have taken before
Quantum Mechanics I/614551001 Quantum Mechanics II/614551002 Fundamentals of Quantum Information/614551003 Fundamentals of Quantum Communications/614551005 Introduction to Quantum Computing/614551004
Subjects that are recommended to be taken simultaneously
Quantum Computing Tools/614551006 Quantum Computing and Machine Learning/614551008 Programming and Implementation of Quantum Algorithms/614551007
Subjects that continue the syllabus
Practical Applications of Quantum Computing/614551010 Numerical Methods in Quantum Computing/614551025 Quantum Computing and High Performance Computing/614551009 Error Correction Codes/614551013 Rule-Based Quantum Systems/614551029
Other comments