UNIVERSIDADE DA CORUÑA

Teaching Guide			
Identifying Data			2024/25
Subject (*)	Error Correction Codes	Code	614551013
Study programme	Máster Universitario en Ciencia e Tecnoloxías de Información Cuántica		

Descriptors				
Cycle	Period	Year	Type	Credits
Official Master's Degree	2nd four-month period	First	Optional	3

Language	Spanish		
Teaching method	Face-to-face		
Prerequisites			
Department	Enxeñaría de Computadores		
Coordinador		E-mail	
Lecturers	Castedo Ribas, Luis	E-mail	luis.castedo@udc.es
Web	n9.cl/bosw5		
General description	SHARED UVIGO AND UDC VISIT WEB LINK This course provides an introduction to quantum error correction, which is a fundamental aspect of quantum computation and quantum information theory. The course aims to explore various error correction codes and techniques that allow preserving and manipulating quantum information in the presence of noise and errors.		

Study programme competences / results	
Code	Study programme competences / results
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.
B13	HD24 Actively participate in face-to-face activities in the classroom.
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.

Learning outcomes			
Learning outcomes	Study programme competences / results		
Ability to understand the construction, analysis and applications of quantum error control codes in communication systems and quantum computers. Error control codes in communication systems and quantum computers. Knowledge of the main specific specific codes.	AJ13	BJ13	CJ1 CJ2 CJ3

Contents	
Topic	Sub-topic
Quantum errors	- Overview of quantum errors and their sources - Decoherence and noise in open quantum systems - Types of errors and error channel models - Digitization of quantum noise. Error operators
Fundamentals of quantum error correction error correction	- From Classical to Quantum Error Correction - The three-qubit error correction code - The nine-qubit Shor code - Conditions of quantum error correction - The quantum Hamming limit

Construction of quantum codes	- Classical linear block codes - Calderbank-Shor-Steane Codes (CSS)
Stabilizer codes	- The stabilizer formalism - Measurement in the stabilizer formalism - Constructions of stabilizer codes - Quantum circuits for coding, decoding and correction
Topological stabilizing codes	- The Z2 chain complex - Surface codes on a torus: toric codes - Flat surface codes - Topological quantum error correction
Fault-tolerant quantum computing	- Fault tolerance in quantum computing - Fault-tolerant error correction - Fault-tolerant coded operations

Planning				
Methodologies / tests	Competencies / Results	Teaching hours (in-person & virtual)	Student?s personal work hours	Total hours
Problem solving	B13	5	27	32
Oral presentation	C1 C2 C3	2	0	2
Guest lecture / keynote speech	A13	18	23	41
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
Problem solving	Typical quantum error code design and analysis problems will be solved, in order to learn how to use the methods seen in the lectures.
Oral presentation	An oral presentation of evaluation work will be made
Guest lecture / keynote speech	The main elements of quantum error codes, their applications and limitations will be presented. limitations.

Personalized attention	
Methodologies	Description
Guest lecture / keynote speech Problem solving Oral presentation	Consultations will be handled asynchronously via Microsoft Teams chat. Support will be provided through face-to-face meetings or online meetings via Microsoft Teams.

Assessment			
Methodologies	Competencies / Results	Description	**Qualification**
Problem solving	B13	Resolution of exercises in an autonomous and individual way, delivery in writing. Two sets with a value of 30% each.	60
Oral presentation	C1 C2 C3	Submission of a roll-up work by the student	40

Assessment comments

Sources of information

Basic	- M. A. Nielsen, I. L. Chuang (2010). Quantum Computation and Quantum Information. Cambridge University Press - Ivan B. Djordevic (2021). Quantum Information Processing, Quantum Computing. and Quantum Error Correction. Academic Press
Complementary	- Giuliano Gadioli La Guardia (2020). Quantum Error Correction. Springer - Frank Gaitan (2013). Quantum Error Correction and Fault Tolerant Quantum Computing. Taylor & Francis - D. A. Lidar, T. A. Brun (2013). Quantum Error Correction. Cambridge University Press

Recommendations
Subjects that it is recommended to have taken before
Fundamentals of Quantum Information/614551003 Fundamentals of Quantum Communications/614551005 Introduction to Quantum Computing/614551004
Subjects that are recommended to be taken simultaneously
Subjects that continue the syllabus
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.