

#### **IDENTIFICATION DETAILS**

Degree:	Diploma in Quantum Computing (Awarded Degree associated with Mathematical Engineering)			
Faculty/School:	Higher Polytechnic School			
Course:	Classic and Quantum Computing Models			
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Туре:	Compulsory Internal		ECTS credits:	3
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real.			Code.	49012
Teaching period:	Fourth semester			
Teaching type:	Classroom-based			
Language:	English			
Total number of student study hours:	75			
Teaching staff		E-mail		

# SUBJECT DESCRIPTION

Javier Machín Cedrés

The purpose of this course is to provide the first steps in the understanding of Quantum Computing. It has a fundamentally informative purpose of the main concepts behind this new paradigm, such as superposition, entanglement and interference.

This subject will begin with an analysis of our current "classical computing" and supercomputers to understand their limitations. We will see the possibilities for Quantum computing to solve the problems that are impossible to solve right now such as to break the encryption of our security keys.

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We will move on studying the basic concepts in Quantum computing such as qubits, quantum gates, circuits, quantum algorithms etc.

We will support the study with practices in a real Cloud quantum environment with access to real quantum systems through the IBM quantum platform and running circuits with the Composer tool.

We will finish the material studying the QC applications and reviewing the hot topics in Quantum computing that appear day by day in the Media.

### GOAL

The objective of this subject is to stablish the QC foundations for the students to develop and complete their roadmap in Quantum Computer in next courses.

#### PRIOR KNOWLEDGE

It is needed knowledge about Linear Algebra. Students will get this knowledge through an specific subject in first semester.

## COURSE SYLLABUS

- 1. QC foundations
- Classical computing and QC
- Status: HW, SW, Solutions and QC ecosystem
- 2. Qubits and how to manage them
- Quantum States
- Quantum gates
- 3. Superposition
- Concept
- Hadamard gate and use in circuits
- 4. Entanglement
- Concept
- CNOT gate and use in circuits
- 5. Interference and all together
- Interference and its importance in QC
- How works together superposition, entanglement and interference
- 6. QC Algorithms
- Algorithms "zoo"
- Berstein-Vazirani algorithm
- 7. Other remarkable QC algorithms
- Grover's algorithm
- Shor's algorithm
- 8. Introduction to programming in QC
- Python and QC programming languages
- A program language with QPUs: Qiskit
- 9. QC Applications
- Cross solutions (Machine Learning)
- Industrial solutions (Finance sector)
- 10. Hot topics in QC
- Quantum Technologies, Quantum supremacy and Quantum Advantage
- Other topics (security, education roadmap, hybrid computing etc)

## **EDUCATION ACTIVITIES**

In this course the following training activities will be carried out:

- Autonomous work: the student will have to face the understanding of the problem, firstable theorically for later to be able to implement in the QC Cloud Composer tool.

- Teamwork: It is highly recommended that students work in teams to challenge their knowledge with other team collegues.

- Presentation: Every student can be requested to present in a sort of "elevator pitch method", the different concepts reviewed during the course. This is fundamental for students not only to know what is QC, but also to be able to transmit it in a sort of "QC ambassador" mission.

## DISTRIBUTION OF WORK TIME

CLASSROOM-BASED ACTIVITY	INDEPENDENT STUDY/OUT-OF-CLASSROOM ACTIVITY	
30 hours	45 hours	
<ul> <li>Practical and theoretical classes by the teachers of the course. 26h</li> <li>Evaluation 4h</li> </ul>	personal and autonomous home work 45h	

### SKILLS

### SPECIFIC LEARNING RESULTS

Understand why the importance of Quantum computing to overcome limitations of "Classical computing"

Understand principles of QC (qubits and Quantum physics phenomena) and the importance of multidisciplinary characteristic of QC about needed knowledge of HW, SW, Solutions and QC ecosystem.

Understand the importance of Quantum Algorithms into the QC arena and know the most important ones such as Grover's, Bernstein and Shor

Run the first accesses and programs with real quantum computers through tools such as Composer and Qiskit

Being able to explain Quantum computing and being sort of "quantum evangelist" about the importance of second quantum revolution.

### LEARNING APPRAISAL SYSTEM

- 1. REGULAR CYCLE APPRAISAL ("Convocatoria ordinaria")
- 1.1. Students with mandatory attendance.
  - a. 40 % First exam. Scope: Lessons 1 to 5
  - b. 50 % Second exam. Lessons 1 to 10.
  - c. 10 % Team work presentation

Students passing the 5.0 grade with previous criteria, and at least 80% of attendance can receive a bonus for proactive attendance and participation. This bonus can be up to 1,0 points.

1.2. Students "exempt" to attend classes

a. 40 % First exam. Scope: Lessons 1 to 5

b. 60 % Second exam. Lessons 1 to 10.

"Exempt" Students passing the 5.0 grade with previous criteria, can receive an up to 1,0 points bonus by delivering an essay that summarize the total course. This essay must be written by hand and no more than 15 pages. It is the responsability of students to communicate to the professor via email before april, that they will use this option. It is as well responsability of the student to deliver the essay to the professor before the second exam.

2. RESIT EXAMS. "Exámenes extraordinarios"

Students not passing exams in "Convocatoria ordinaria", have another opportunity with the Resit exam ("Examen extraordinario"). Result of exam will be the final grade for the subject.

3. GENERAL CONSIDERATIONS ABOUT EXAMS.

Students must be prepared for exams to be "Single/multiple answers" (Exámenes tipo test con una o múltiples respuestas), exams with answers to develop (Exámenes de desarrollo) or a mixed of both of them.

4. FRAUD AND PLAGIARISM

VERY IMPORTANT: Cualquier tipo de fraude o plagio por parte del alumno en una actividad evaluable, será sancionado según se recoge en la Normativa de Convivencia de la UFV. A estos efectos, se considerará "plagio" cualquier intento de defraudar el sistema de evaluación, como copia en ejercicios, exámenes, prácticas, trabajos o cualquier otro tipo de entrega, bien de otro compañero, bien de materiales o dispositivos no autorizados, con el fin de hacer creer al profesor que son propios.

## **BIBLIOGRAPHY AND OTHER RESOURCES**

#### Basic

Javier Machín QC Fundamentals Presentations for UFV students in QC

- Main educational material will be provided by the professor and uploaded in canvas

#### Additional

Robert S. Sutor Dancing with Qubits (Look for potential offers in https://www.packtpub.com/) This book is not mandatory but can help for students to support them in main QC concepts