Teaching guide

IDENTIFICATION DETAILS

Degree:	Diploma in Quantum Computing (Awarded Degree associated with Mathematical Engineering)
Faculty/School:	Higher Polytechnic School
Course:	MATHEMATICS FOR QUANTUM COMPUTING II
Type:	Compulsory Internal
ECTS credits:	3
Year:	3
Code:	49513
Teaching period:	Fifth semester
Teaching type:	Classroom-based
Language:	English
Total number of student study hours:	75

Teaching staff	E-mail
Jorge Andrés Plazas Vargas	jorge.plazas@ufv.es

SUBJECT DESCRIPTION

La asignatura es la segunda de una serie de asignaturas de matemáticas destinadas a cubrir los conceptos básicos de matemáticas necesarios para aprender computación cuántica. Cubre, esencialmente, conocimientos de Algebra, Algebra Lineal, Complejos, Espacios de Hilbert, Esfera de Bloch que los alumnos aplicarán en la asignatura de Computación Cuántica y en su vida profesional en el futuro.

This course is the second one in a series of mathematics courses aimed at covering the basic concepts from mathematics which are necessary to learn quantum computing. It covers knowledge of Algebra, Linear Algebra, Complex numbers, Hilbert Spaces, and The Bloch Sphere which students will apply in the subject of Quantum Computing and in their professional lives in the future.

GOAL

This course aims at developing the core mathematical skills, together with the corresponding conceptual understanding and mathematical maturity, that the student needs in order to become a successful quantum computing practitioner.

PRIOR KNOWLEDGE

This course assumes, and builds upon, the knowledge acquired by the student in the courses corresponding to the Basic Cycle in Mathematical Engineering (Algebra I-II, Calculus I-II, Discrete mathematics and Statistics I) and in the course Mathematics for Quantum Computing I.

COURSE SYLLABUS

The first part of the course, corresponding roughly to two thirds of the lectures, focuses on Hilbert Space Techniques:

- Hilbert spaces and the Riesz representation theorem.
- Operators on Hilbert spaces.
- Projections, trace-class operators and positive operators.
- Density operators, purity and the Schmidt decomposition.
- Unitary representations of groups.
- Fourier transforms.
- Consequences of the spectral theorem.
- Probability measures and their properties.

The last third of the course introduces topics relevant to quantum information theory:

- Review of information and Shanonn entropy.
- Von Neumann entropy.
- Relative entropy.

EDUCATION ACTIVITIES

The core of the course will be developed through expository/participatory lectures where the fundamentals of various subjects and develop abstract thinking, which is essential for a This will occur in an environment of student-student and student-teacher interaction that encourages questioning and dialogue about the topics presented. Classroom activities will be supplemented by practical classes, seminars, and collaborative projects. Classroom activities will be complemented by students' independent study and work to reinforce the theoretical concepts covered in lectures and acquire practical skills. All the study and work performed by students will be supervised and guided by the professor through individual or group tutorials. In some cases, students will present their main study or project conclusions in class, allowing for the exchange of knowledge and experiences among students. Finally, to facilitate students' access to materials and work planning, as well as communication with the professor and other students, the Virtual Classroom Canvas will be used. The Canvas platform provides various electronic resources to positively complement students' learning experience.

DISTRIBUTION OF WORK TIME

CLASSROOM-BASED ACTIVITY	INDEPENDENT STUDY/OUT-OF-CLASSROOM

	ACTIVITY
30 hours	45 hours

SKILLS

Students will master the tools and techniques constituting the mathematical framework underlaying quantum computation and quantum information.

SPECIFIC LEARNING RESULTS

Develop skills in the use of Hilbert space techniques in quantum computation.

Understand an apply decomposition and representation results for operators.

Understand and apply results from quantum information theory.

LEARNING APPRAISAL SYSTEM

The evaluation system includes four types of assessments for the ordinary exam period:
- Theoretical Written Exams: 40% of the final grade.
These are individual tests to evaluate the student's understanding of the theoretical concepts presented, with short-answer questions, some multiple-choice or true/false questions, based on their autonomous study and individual work. There will be two written exams, each covering approximately half of the course material.
- Practical Written Exams: 40% of the final grade.
These are individual tests to assess the student's ability to solve problems derived from the theoretical content. There will be two written exams, each covering approximately half of the course material.
- Practical Work and Other Assignments Related to the Subject: 10% of the final grade.
These involve practical cases applying theoretical concepts or research projects. They can be done individually or in groups. The details of each assignment will be provided in the corresponding instructions given in class.
- Class Participation and Interest in the Subject: 10% of the final grade.
Interest and involvement will be evaluated through various indicators such as attendance, punctuality, responses to individual questions posed by the professor, and attendance and preparation for tutorials.

It is mandatory to attend at least 80% of the sessions. Otherwise, this type of assessment will be graded with 0 points. A minimum of 5 out of 10 points is required in each of the first three assessments to pass the course.

Extraordinary Exam Period: Only the grade of the extraordinary exam will be considered. For exempted/repeating students, the same evaluation system will be offered, or an alternative system where component d is graded through a series of tutorials set by the professor.

Any type of fraud or plagiarism in an evaluable activity will be sanctioned according to the UFV Code of Conduct. "Plagiarism" is considered any attempt to deceive the evaluation system, such as copying in exercises, exams, practical work, assignments, or any other type of submission, whether from another student or unauthorized materials or devices, to make the professor believe the work is the student’s own.

BIBLIOGRAPHY AND OTHER RESOURCES

Basic

Michael Nielsen, Isaac Chuang Quantum Computation and Quantum Information
Cambridge University Press

M. Reed, B. Simon Methods of Modern Mathematical Physics
Elsevier