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 I
Type:	Compulsory Internal
ECTS credits:	4
Year:	2
Code:	49510
Teaching period:	Third semester
Teaching type:	Classroom-based
Language:	English
Total number of student study hours:	100

Teaching staff	E-mail
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SUBJECT DESCRIPTION

La asignatura es la primera 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, Esfera de Bloch que los alumnos aplicarán en la asignatura de Computación Cuántica y en su vida profesional en el futuro.

The subject is the first in a series of mathematics subjects intended to cover the basic math concepts needed to learn quantum computing. It covers, essentially, knowledge of Algebra, Linear Algebra, Complexes, Bloch Sphere that students will apply in the subject of Quantum Computing and in their professional life in the future.

GOAL

The course aims to develop the triple process of conceptualization, logical-deductive reasoning and deconceptualization present in any application of mathematics to the study of quantum computing in order to generate in students, in a relevant way, the ability to use mathematics as the appropriate tool to translate situations of the physical world into problems that can be treated with mathematics and to deepen the knowledge and understanding of concepts of algebra, linear algebra, complex analysis and mathematical reasoning. It also aims to train students to be able to use these concepts, algorithmic methods and acquired skills to solve problems applied to computer science in an interdisciplinary way and help them acquire the necessary mathematical maturity to solve practical problems.

PRIOR KNOWLEDGE

The course requires knowledge and mathematical maturity acquired in the subjects of Algebra I, Algebra II, Discrete Mathematics, Calculus I, and Calculus II.

COURSE SYLLABUS

The course consists of the following contents:
Complex Numbers: Properties and different representations.
Review of General Vector Spaces: Real and complex vector spaces.
Tensor Product of Matrices
Normed Spaces
Hilbert Spaces
Unitary Operators. Hermitian Operators.
Pauli Matrices
Hadamard Matrices
P and NP Problems
Qubits
Bloch Sphere
Algebraic Structures

EDUCATION ACTIVITIES

The course will predominantly feature expository/participatory classes to establish the fundamentals of various subjects and develop abstract thinking, which is essential for a Mathematical Engineer. 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. In these settings, students will develop the ability to apply theoretical concepts to real-life problems and cases, deepen their understanding, research, and debate these applications, and begin developing collaborative work skills. Classroom activities will be complemented by students' independent study and work, sometimes done in groups to promote cooperative learning, and other times individually to reinforce the theoretical concepts covered in lectures and acquire practical skills related to practical classes and workshops. 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
40 hours	60 hours

SKILLS

Resolver los problemas matemáticos que puedan plantearse en la ingeniería. Aptitud para aplicar los conocimientos sobre: álgebra lineal, cálculo, ecuaciones diferenciales, métodos numéricos y estadística.

Comprender y dominar los conceptos básicos de matemática discreta, lógica matemática y complejidad computacional, y su aplicación para la resolución de problemas propios de la ingeniería.

SPECIFIC LEARNING RESULTS

Entender un problema y formularlo en lenguaje matemático a fin de seleccionar las herramientas óptimas facilitadas por el álgebra lineal para su resolución.

Resolver y manipular correctamente sistemas de ecuaciones lineales. Conocer y manejar las propiedades de los espacios vectoriales y sus aplicaciones.

Clasificar matrices y aplicaciones lineales según diversos criterios. Identificar las distintas descomposiciones de matrices, sus características y aplicaciones.

LEARNING APPRAISAL SYSTEM

The evaluation system includes four types of assessments for the ordinary exam period:
Theoretical Written Exams: 40% of the final grade. 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. 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

Sheldon Axler Linear Algebra Done Right 1
Undergraduate Texts in Mathematics. Springer Verlag

Wolfgang Scherer The Mathematics of Quantum Computing. An introduction 1
Springer Verlag

Additional

Brilynsky and Chen The Mathematics of Quantum Computation 1

Lokenath Debnath Introduction to Hilbert Spaces with Applications 3