NATIONAL UNIVERSITY OF SAN MARCOS

FACULTY OF MATHEMATICAL SCIENCES

SYLLABUS

1. GENERAL INFORMATION

1.1 Course name	:	Quantum Mechanics
1.2 Code	:	QC251
1.3 Academic Program	:	Scientific Computing
1.4 Credits	:	5
1.5 Prerrequisites	:	• FI101. General Physics. (2^{nd} Sem) • MA371. Functional analysis I. (6^{th} Sem)
1.6 Type of Course	:	Elective
1.7 Area of Studies	:	Estudios Generales
1.8 Number of Weeks	:	16
1.9 Hours per week	:	4 HT; 2 HP;
1.10 Cycle	:	I
1.11 Learning modality	:	Face to face
1.12 Academic Period	:	2026-I
1.13 Semester Start Date	:	
1.14 Semester End Date	:	

2. PROFESSORS

Meetings after coordination with the professor

3. INTRODUCTION TO THE COURSE

Quantum mechanics is fundamental for understanding the physical principles that govern atomic and subatomic systems, which form the basis of modern computational technologies such as quantum computing, quantum cryptography, semiconductors, and solid-state devices. This course provides the mathematical and conceptual foundations of quantum mechanics, with special emphasis on its applications in computer science, including quantum algorithms, quantum simulation, and quantum hardware development.

4. GOALS

- Understand the fundamental postulates of quantum mechanics and their mathematical formulation.
- Apply quantum theory to solve basic problems in few-level quantum systems.
- Relate quantum concepts to applications in quantum computing and information technologies.
- Develop the ability to simulate simple quantum systems using computational tools.

5. COMPETENCES

ABET-1) An ability to identify, formulate, and solve broadly defined technical or scientific problems by applying knowledge of mathematics and science and/or technical topics to areas relevant to the discipline. (Usage)

ABET-3) An ability to develop and conduct experiments or test hypotheses, analyze and interpret data, and use scientific judgment to draw conclusions. (Usage)

6. TOPICS

Unit 1: Fundamentals of Quantum Mechanics (12 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Crisis of classical physics: blackbody radiation, photoelectric effect. • Wave-particle duality and complementarity principle. • Postulates of quantum mechanics: wave function, operators, and expectation values. • Time-dependent and time-independent Schrödinger equation. • Born's probabilistic interpretation.	• Explain the limitations of classical physics that motivated the development of quantum mechanics. [Familiarizarse] • State the fundamental postulates of quantum mechanics. [Familiarizarse] • Interpret the physical meaning of the wave function and its relation to probabilities. [Usar] • Formulate simple problems using the Schrödinger equation. [Evaluar]
Readings : [**Griffiths2018**], [**Nielsen2010**]	

Unit 2: Simple Quantum Systems (14 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Particle in a one-dimensional and three-dimensional box. • Quantum harmonic oscillator: algebraic solution and Hermite polynomials. • Quantum tunneling through potential barriers. • Finite potential well and bound states. • Ladder operators for the harmonic oscillator.	• Solve the Schrödinger equation analytically for simple quantum systems. [Familiarizarse] • Calculate energy levels and wave functions for symmetric potential wells. [Usar] • Explain the quantum tunneling phenomenon and its technological applications. [Evaluar] • Use ladder operators to manipulate quantum states. [Evaluar]
Readings : [**Griffiths2018**], [**McIntyre2012**]	

Unit 3: Linear Algebra in Quantum Mechanics (10 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Hilbert spaces and Dirac notation. • Linear operators, Hermitian and unitary operators. • Eigenvalues and eigenvectors in quantum systems. • Matrix representations of quantum operators. • Tensor product and composite spaces.	• Use Dirac notation to represent quantum states. [Familiarizarse] • Differentiate between Hermitian, unitary, and projection operators. [Usar] • Construct matrix representations of simple quantum operators. [Usar] • Apply the tensor product to describe composite quantum systems. [Evaluar]
Readings : [**Shankar2012**], [**Nielsen2010**]	

Unit 4: Angular Momentum and Spin (8 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Orbital angular momentum: operators and eigenfunctions. • Spin: the intrinsic degree of freedom. • Pauli matrices and spin-1/2 representation. • Coupling of angular momenta. • Identical particles and Pauli exclusion principle.	• Calculate angular momentum eigenvalues for simple systems. [Familiarizarse] • Manipulate spin states using Pauli matrices. [Usar] • Apply the Pauli exclusion principle to fermion systems. [Evaluar] • Explain the importance of spin in technologies such as magnetic resonance. [Evaluar]
Readings : [**Griffiths2018**], [**McIntyre2012**]	

Unit 5: Perturbation Theory (10 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Time-independent perturbations: nondegenerate and degenerate theory. • Corrections to energy levels and wave functions. • Time-dependent perturbations: Fermi's golden rule. • Radiation-induced transitions. • Variational method for ground states.	• Apply nondegenerate perturbation theory to simple quantum systems. [Familiarizarse] • Calculate energy level corrections due to small perturbations. [Usar] • Use Fermi's golden rule to calculate transition rates. [Evaluar] • Apply the variational method to estimate ground state energies. [Evaluar]
Readings : [**Griffiths2018**], [**Shankar2012**]	

Unit 6: Applications in Quantum Computing (10 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Qubits: representation and basic operations. • Quantum gates and elementary quantum circuits. • Quantum entanglement and no-cloning theorem. • Simple quantum algorithms: Deutsch-Jozsa and quantum teleportation. • Simulation of quantum systems on classical computers. • Implementation of quantum algorithms using frameworks like Qiskit or Cirq.	• Represent and manipulate qubits using Dirac notation. [Familiarizarse] • Explain the concept of quantum entanglement and its applications. [Usar] • Implement simple quantum circuits using quantum programming frameworks. [Usar] • Simulate few-qubit quantum systems in computational environments. [Evaluar] • Describe the fundamental advantages of quantum computing over classical computing. [Evaluar]
Readings : [**Nielsen2010**], [**Rieffel2011**]	

7. WORKPLAN

7.1 Methodology

Individual and team participation is encouraged to present their ideas, motivating them with additional points in the different stages of the course evaluation.

7.2 Theory Sessions

The theory sessions are held in master classes with activities including active learning and roleplay to allow students to internalize the concepts.

7.3 Practical Sessions

The practical sessions are held in class where a series of exercises and/or practical concepts are developed through problem solving, problem solving, specific exercises and/or in application contexts.

8. EVALUATION SYSTEM

********* EVALUATION MISSING ********

9. BASIC BIBLIOGRAPHY