COURSE DATA

Data Subject	
Code	34259
Name	Quantum physics I
Cycle	Grade
ECTS Credits	6.0
Academic year	2020 - 2021

Study (s)

Degree	Center	Acad. year	Period
1105 - Degree in Physics	Faculty of Physics	3	First term

Subject-matter

Degree	Subject-matter	Character
1105 - Degree in Physics	13 - Quantum physics	Obligatory

Coordination

Name	Department
SANZ GONZALEZ, VERONICA	185 - Theoretical Physics
TORTOLA BAIXAULI, M. AMPARO	185 - Theoretical Physics

SUMMARY

The origins of quantum physics, elementary quantum physics, Schrödinger equation in one dimension, quantum observables: operators and measurement, dimensional potential field effect and penetration in areas traditionally prohibited bound states: the finite and infinite square well, the harmonic oscillator.

The objective of this course is to acquaint students with the fundamental quantum phenomena and their properties and introduce the basic mathematical tools to formalize the description of them in a logically consistent theory.

It is highly recommended that students have previously studied the subjects of Mathematics, Algebra and Geometry, which provides the necessary algebraic background for the formal description of Quantum Physics as vector spaces, inner, matrices, determinants products, linear operators and diagonalization; Calculation, in which integral and differential calculus is studied, and the differential equations are introduced; Mathematical Methods, which deepens in solving differential equations that appear in many problems and quantum Fourier transforms and the method of separation of variables are introduced; General Physics, where the fundamentals of physics to be studied more deeply in this course are established; Mechanics and Waves, in which fundamental quantum physics as the Lagrangian and

Hamiltonian formulation, the wave motion and the description of the properties of waves, and thermodynamics and statistical physics, where the foundations of Statistical Physics are discussed concepts are developed Boltzmann, Maxwell and Gibbs, whose influence in the genesis of quantum physics was capital.

Special mention should be the subject of Quantum Physics Laboratory, framed in the matter of the third year, Laboratory of Experimental Physics. In it the student performs some of the most important experiences that led to the development of quantum ideas. During the first three weeks of the course the origins Quantum Physics I, experimental basis and fundamental concepts of quantum physics called Antigua, prior to the formulation of Schrödinger, and described in detail the experiences of the Laboratory of Quantum Physics are studied. It is therefore imperative to pursue this matter in parallel with Quantum Physics I.

The Quantum Physics II course builds on the knowledge gained in the course of Quantum Physics I. They should, therefore, be addressed in that order. Also, many are the subjects of fourth year and Masters, which are based on the concepts taught in the course of Quantum Physics. Cite, among the most important subjects of Quantum Mechanics, Nuclear and Particle Physics, Solid State Physics, Quantum Field Theory and Elementary Particles.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

The background needed for the development of the subject can be split into two groups:

- Mathematical knowledge:
1. Vector spaces.
2. inner products: Euclidean vector spaces.
3. linear operators: Hermitian and unitary.
4. Matrices and determinants.
5. Diagonalization of matrices and linear operators.
6. Fourier Transforms.
7. Dirac Delta.
8. Solution of linear differential equations with constant coefficients.
9. Solution of differential equations by power series.
10. Differential equ

OUTCOMES

1105 - Degree in Physics

- Knowledge and understanding of the fundamentals of physics in theoretical and experimental aspects, and the mathematical background needed for its formulation.
- To know how to apply the knowledge acquired to professional activity, to know how to solve problems and develop and defend arguments, relying on this knowledge.
- Ability to collect and interpret relevant data in order to make judgements.
- Developing learning skills so as to undertake further studies with a high degree of autonomy.
- Problem solving: be able to evaluate clearly the orders of magnitude in situations which are physically different, but show analogies, thus allowing the use of known solutions in new problems .
- Modelling & Problem solving skills: be able to identify the essentials of a process / situation and to set up a working model of the same; be able to perform the required approximations so as to reduce a problem to an approachable one. Critical thinking to construct physical models.
- Learning ability: be able to enter new fields through independent study, in physics and science and technology in general.
- Destrezas Generales y Específicas de Lenguas extranjeras: Mejorar el dominio del inglés científico-técnico mediante la lectura y acceso a la bibliografía fundamental de la materia.
- Communication Skills (written and oral): Being able to communicate information, ideas, problems and solutions through argumentation and reasoning which are characteristic of the scientific activity, using basic concepts and tools of physics.
- Cultura General en Física: Haberse familiarizado con las áreas más importantes de la mecánica en relación con la Física en general, y con enfoques que abarcan y relacionan diferentes áreas de la Física.
- Comprensión teórica de fenómenos físicos: tener una buena comprensión de la Física Cuántica (estructura lógica y apoyo experimental, fenómenos físicos descritos).

LEARNING OUTCOMES

-Know and understand the limits of classical physics and experimental foundations of quantum physics.

-Understand the fundamental concepts in the description of quantum phenomena: the quantization of energy, wave-particle duality, quantization rules, measurement of quantum observables and uncertainty relations.

-Management of the typical atomic scale (eV, Angstroms, etc) units.

-To acquire the concept of wave function and its probabilistic interpretation.

-Know how to calculate the possible values of the measurement of a quantum observable and the relative probabilities of different outcomes and their average value.

-Be able to describe quantum systems using the correct approach to the corresponding Schrödinger equation.

-Be able to solve the Schrödinger equation for one-dimensional problems. Specifically, knowing how to calculate the transmission and reflection coefficients in problems of dispersion, and the wave function and energy levels of bound states problems.

-To determine the temporal evolution of a system from its stationary solutions.

-Using the symmetries (parity, timing, rotations) of the problem at hand to simplify your solution and understand more deeply the results.

DESCRIPTION OF CONTENTS

1. Introduction

Domain of Quantum Physics. Limits of applicability of classical physics: Planck's constant. The fundamental constants of nature. Natural units

2. Energy quanta: Planck's postulate

Black body radiation. Planck Postulate: energy quanta. Specific heat of solids: Einstein and Debye models.

3. Wave-particle duality: photons

The photoelectric effect. Compton X-ray emission effect. Production and pair annihilation. Wave-particle duality: Uncertainty Principle.

4. Atomic models: the old quantum theory

Atomic spectra. The Rutherford atom. Bohr's atomic model. Correspondence Principle. Franck-Hertz experience. Rules of generalized quantization.

5. Wave-particle duality for matter

Wave-particle duality of matter: De Broglie's Postulate. Davisson-Germer experiment. Wave packets.

6. Quantum Mechanics

Introduction. The quantum mechanics of Heisenberg and Schrödinger. Schrödinger equation. Born interpretation of the wave function. Continuity equation: conservation of probability. Stationary states. Superposition of stationary states.

7. Probability distributions

Mean value. Dynamical quantities in Quantum Physics. The classical limit: Ehrenfest theorem. Observables and generalized probabilities.

8. Expected values and uncertainties

Introduction. Quantum uncertainty. Generalized uncertainty relations. Energy-time uncertainty.
Natural width of energy levels.

9. One-dimensional problems

Classical motion in one dimension. Properties of the eigenfunctions of the Hamiltonian. Solutions for a constant potential. Potential step. Temporal evolution.

10. Scattering by barriers and wells

Barrier penetration: Tunneling. Emission of alpha particles by nuclei. Thermonuclear fusion. Electron current in metals: Fowler-Nordheim formula. The scanning tunneling microscope. Transmission barriers. Drive shafts: Ramsauer-Townsend effect.

11. Bound states

Dirac's delta potential. Square well: discrete energies (bound states). Infinite square well. Parity. Poles of the transmission amplitude. Transmission resonances.

12. The harmonic oscillator

Stationary states. Hermite polynomials and allowed values of energy. Matrix mechanics: creation-destruction operators. Classical and quantum probability. Virial Theorem. Vibrational energy of diatomic molecules. Wave functions in matrix mechanics.

13. Formalism

Hilbert space. Dirac notation. Change of basis for states and observables. Discrete and continuum spectra. Momentum basis. The postulates of quantum mechanics.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	45,00	100
Tutorials	15,00	100
Study and independent work	31,00	0
Preparation of practical classes and problem	59,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

Contact teaching 40%

Theoretical and practical classes: It addresses the conceptual and formal matter and resolution of problems or cases as the application of theoretical concepts. They are based mainly on lectures with dialogue and the use of teaching tools such as experimental demonstrations, animations or videos, graphic solutions, design presentations, etc.)..

Group tutoring sessions or work in small groups: focus on student work: Resolving doubts in dealing with theoretical concepts and problem solving, reinforcement in areas of greatest difficulty, questionnaires conceptual, experimental demonstrations relevant to the cases studied and associated with a component of continuous assessment, verification of student progress in the field.

Student's personal work 60%

- Study of the theoretical.

- Troubleshooting (individually or in groups)

- Individual tutorials: querying of the teacher on student concerns and difficulties encountered in the study and resolution of problems, or discussion on topics of interest, bibliography, etc.

EVALUATION

The assesment system is as follows:

1) Written examinations: One part will assess the understanding of the theoretical-conceptual and formal nature of the subject, both through theoretical questions, conceptual questions and numerical or simple particular cases. Another part will assess the applicability of the formalism, by solving problems and critical capacity regarding the results. Proper argumentations and adequate justifications will be important in both cases.

2) Continuous assessment: assessment of exercices and problems presented by students, questions proposed and discussed in class, oral presentation of problems solved or any other method that involves an interaction with students.

COMMENTS:

The final grade will be: 1) the weighted average of the exam mark (75%) and the continuous assessment (25%), if the average is higher than the exam mark and the exam mark is greater than 4 (out of 10), 2) the exam mark otherwise.

Provided that the compensation criteria established by the CAT for this purpose are met, the grade of this subject may be averaged with Quantum Physics II in order to overcome it.

REFERENCES

Basic

- D. J. Griffiths, Introduction to Quantum Mechanics, Ed. Pearson- Prentice-Hall.
- R. Shankar, Principles of Quantum Mechanics, Springer
- S. Gasiorowicz, Quantum Physics, Ed. John Wiley & Sons Inc

Additional

- R. P. Feynman, The Feynman Lectures on Physics III, Ed. Addison-Wesley.
- R. Eisberg y R. Resnick, Física Cuántica (átomos, moléculas, sólidos, núcleos y partículas), Ed. Limusa.

ADDENDUM COVID-19

This addendum will only be activated if the health situation requires so and with the prior agreement of the Governing Council

Teaching methodology: The hybrid teaching model implemented and the percentage of attendance will be determined by the CAT of the degree based on the available material resources and the existing health conditions and regulations.