COURSE DATA

Data Subject	
Code	34268
Name	Quantum mechanics
Cycle	Grade
ECTS Credits	4.5
Academic year	2021 - 2022

Study (s)

Degree	Center	Acad. year	Period
1105 - Degree in Physics	Faculty of Physics	4	First term

Subject-matter

Degree	Subject-matter	Character
1105 - Degree in Physics	15 - Expansion of Physics	Obligatory

Coordination

Name	Department
BARENBOIM SZUCHMAN, GABRIELA ALEJANDRA	185 - Theoretical Physics
GIMENEZ GOMEZ, VICENTE	185 - Theoretical Physics

SUMMARY

Quantum mechanics is an essential tool for the description of physical phenomena. There are many disciplines in physics developed from the application of Quantum Mechanics to different fields: Solid State, Elementary Particle Theory, Nuclear Physics, Quantum Optics, Quantum Field Theory ... Technological applications are also very relevant.

Furthermore Quantum Mechanics is still in continuum progress from the experimental and theoretical points of view: new experiments are performed in which atoms, photons, Bose-Einstein condensates or superconducting circuits are manipulated with an accuracy that only a few years ago could not be imagined; new advances in fields such as quantum computing, teleportation or quantum cryptography (already in a commercial stage) are taking place. This is giving rise to a deeper understanding of quantum reality, its limitations and its relation to the classical phenomena.

Objective

The main objective of this course is the construction of the formalism of Quantum Mechanics and its application. This provides a formal framework to the contents of the previous course on quantum physics and allows tackling more complex problems.

For this purpose the space of states of a system with the connection state-vector and operator-observable is introduced. The postulates of Quantum Mechanics are discussed. The role of symmetries and the time evolution of a system are analyzed. The formalism is applied to the study of time dependent Hamiltonian systems.

Related previous courses

This course on Quantum Mechanics may be considered as the natural continuation of the former course on Quantum Physics. It has also some connection with the course on Classical Mechanics through the parallelism of the developed formalism with the classical Hamiltonian mechanics. The differences between the classical and quantum variables are also emphasized.

Regarding the needed mathematical tools they correspond to the contents of the previous courses in Mathematical Methods.

Related subsequent courses

There are many specialized areas of physics based on quantum mechanics: Solid State, Advanced Quantum Mechanics, Quantum Optics, Nuclear and Particle Physics and Quantum Field Theory.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

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

Other requirements

Mathematics

1. Vector spaces.
2. Internal products: Euclidean vector spaces.
3. Linear operators: Hermitian and unitary operators.
4. Matrices and determinants.
5. Diagonalization of linear operators and matrices.
6. Fourier transform.
7. Dirac delta.
8. Solution of linear differential equations with constant coefficients.
9. Notions of probability and statistics.

Physics

1. Hamiltonian mechanics: construction of the Hamiltomian.
2. Oscillatory movement: the classical harmonic oscillator.

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.
- 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 .
- Theoretical understanding of physical phenomena: have a good understanding of the most important physical theories (logical and mathematical structure, experimental support, described physical phenomena).
- 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.
- Physics general culture: Be familiar with the most important areas of physics and with those approaches which span many areas in physics, or connections of physics with other sciences.
- Basic & applied Research: acquire an understanding of the nature and ways of physics research and of how physics research is applicable to many fields other than physics, e.g. engineering; be able to design experimental and/or theoretical procedures for: (i) solving current problems in academic or industrial research; (ii) improving the existing results.
- Foreign Language skills: Have improved command of English (or other foreign languages of interest) through: use of the basic literature, written and oral communication (scientific and technical English), participation in courses, study abroad via exchange programmes, and recognition of credits at foreign universities or research centres.
- Literature Search: be able to search for and use physical and other technical literature, as well as any other sources of information relevant to research work and technical project development.
- Learning ability: be able to enter new fields through independent study, in physics and science and technology in general.
- 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.
- Students must have acquired knowledge and understanding in a specific field of study, on the basis of general secondary education and at a level that includes mainly knowledge drawn from advanced textbooks, but also some cutting-edge knowledge in their field of study.

LEARNING OUTCOMES

- Know and understand the limits of classical physics and the experimental and theoretical aspects of quantum mechanics.
- Know and understand the fundamental concepts in the description of quantum phenomena: quantification, measurement and uncertainty.
- Calculate the possible values coming out of the measurement of a quantum observable, the relative probabilities of the different outcomes and their average value.
- Know the time evolution of a system from the eigenstates of the Hamiltonian. Know how to build the time evolution operator.
- Understand the differences between pure and mixed states. Know how to deal with the density operator for calculating averages and probabilities from it.
- Solve problems when a quantum system is under the influence of an external interaction that varies with time.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	45,00	100
Preparation of evaluation activities	13,50	0
Preparing lectures	27,00	0
Preparation of practical classes and problem	27,00	0
TOTAL	**112,50**	

TEACHING METHODOLOGY

• **Lectures**
Two lectures per week during the semester. The theoretical content will be applied to simple physical systems and, when possible, compared to data.

• **Practical classes**
One hour per week dedicated to solving problems. The teacher will give in advance to students the set of problems for each chapter. Students will present in class their results.

EVALUATION

1. Written exams to evaluate the understanding of the theoretical concepts of the course, the ability to solve problems and the critical analysis of the results. The exams will contain questions and problems.
2. Continuous assessment will count in the final grade up to 20% as long as the exams grade be greater than or equal to 4 out of 10.

REFERENCES

Basic

- Modern Quantum Mechanics. J.J. Sakurai. Addison-Wesley.
- Introduction to Quantum Mechanics. D. J. Griffiths. Benjamin Cummings.
- Quantum Mechanics and Quantum Information. Moses Fayngold y Vadim Fayngold. Wiley-VCH.
- Schaum's Outline of Quantum Mechanics. Yoav Peleg y otros. McGraw-Hill.
- Problems in Quantum Mechanics: With Solutions. G. L. Squires.

Additional

- Quantum Computation and Quantum Information. M.A. Nielsen y I.L. Chuang. Cambridge University Press.
- Mecánica Cuántica, F.J. Ynduráin. Ed. Alianza Universidad Textos.
- Mecánica Cuántica. Alberto Galindo y Pedro Pascual. Alhambra.

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:

In case that health situation requires blended teaching, the teaching model approved by the Academic Degree Committee on July 23, 2020 will be adopted.

— Compulsory subjects: 50% student attendance in the classroom, while the rest of students attend the class in streaming broadcast. Two groups will be set with alternate days attendance to the classroom in order to guarantee 50% of teaching hours attendance for all students. Laboratory sessions will have a 100% attendance.

— Optional subjects: 100% attendance in all activities.

If a total reduction in attendance is necessary, classes will be broadcast by synchronous videoconference at their regular schedule, along the period determined by the Health Authority.