COURSE DATA

Data Subject	
Code	34271
Name	Advanced quantum mechanics
Cycle	Grade
ECTS Credits	6.0
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	16 - Complements of Physics	Optional

Coordination

Name	Department
GONZALEZ MARHUENDA, PEDRO	185 - Theoretical Physics

SUMMARY

This course is complementary to the Quantum Mechanics course the student attend in the 4th year of Physics at the University of Valencia. Regarding its contents Hilbert space notions are briefly revisited first, preceding the introduction of the concept of symmetry in quantum mechanics. Continuous (translations and rotations) and discrete (parity, time reversal) symmetries are considered. Next the scattering theory formalism is developed from the definition of the quantum cross section; Born approximation is used. Finally, the behavior of charged non-relativistic particles in external electromagnetic fields is analyzed.

Related previous courses

This course is designed as a natural continuation of the Quantum Mechanics course previously followed by undergraduate students. It has also some formal connection with the course on Classical Mechanics. Concerning 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, 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. Hibert 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.

Physics

1. Postulates of Quantum Mechanics.
2. Symmetries in Classical Mechanics.
3. Classical Scattering theory.
4. Charged classical particle in an electromagnetic field.

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.
- 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.

- 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.
- Students must be able to apply their knowledge to their work or vocation in a professional manner and have acquired the competences required for the preparation and defence of arguments and for problem solving in their field of study.
- Students must have the ability to gather and interpret relevant data (usually in their field of study) to make judgements that take relevant social, scientific or ethical issues into consideration.
- Students must be able to communicate information, ideas, problems and solutions to both expert and lay audiences.
- Students must have developed the learning skills needed to undertake further study with a high degree of autonomy.

LEARNING OUTCOMES

• Understand the concept of symmetry in Quantum Mechanics, its mathematical implementation and derived conservation laws. Application to physical problems.

• Understand the underlying physical ideas in the formulation of the quantum theory of dispersion. Comparison with classical theory.
• Learn the behavior of a non-relativistic particle in an external electromagnetic field. Possible extensions of formalism.

DESCRIPTION OF CONTENTS

1. Advanced Quantum Mechanics

- Hilbert space (revision).
- Continuous symmetries. Translations. Rotations. Tensor operators.
- Discrete symmetries. Parity. Temporary investment.
- Non-relativistic scattering theory. Lippman-Scwinger equation. Born approximation.
- Charged particles in electromagnetic fields. Gauge symmetry. Aharanov-Bohm effect.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	60,00	100
	0,00	100
Preparing lectures	45,00	0
Preparation of practical classes and problem	45,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

- **Lectures**

Three 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

- 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.

- The exam marks will be modulated by individual achievements shown in class.

REFERENCES

Basic

- Mecánica Cuántica. A. Galindo, P. Pascual. Alhambra o Eudema Universidad.
- Lectures on Quantum Mechanics. S. Weinberg. Cambridge University Press.
- Quantum Mechanics, Vol. I, II. C. Cohen-Tannoudji, B. Diu, F. Laloë. Wiley.
- Problemas de Mecánica Cuántica. Alberto Galindo y Pedro Pascual. Eudema Universidad.
- Schaum's Outline of Quantum Mechanics. Yoav Peleg et al. McGraw-Hill.
- Problems in Quantum Mechanics: With Solutions. G. L. Squires. Cambridge University Press.

Additional

- Modern Quantum Mechanics. J. J. Sakurai. Addison-Wesley.
- Problems in Quantum Mechanics. F. Constantinescu, E. Magyani. Pergamon
- Problems and Solutions on Quantum Mechanics. Chung-Kuo et al. World Scientific

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.