Advanced quantum physics

Academic Year: (2022 / 2023) **Review date: 31/08/2021 11:56:37**

Department assigned to the subject: Physics Department

Coordinating teacher: IÑARREA LAS HERAS, JESUS

Type: Compulsory ECTS Credits : 6.0

Year : 4 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Mathematics, basic Quantum Mechanics

OBJECTIVES

CB1. Students have demonstrated knowledge and understanding in a field of study that builds upon their general secondary education, and is typically at a level that, whilst supported by advanced textbooks, includes some aspects that will be informed by knowledge of the forefront of their field of study
CB2. Students can apply their knowledge and understanding in a manner that indicates a professional approach to their work or vocation, and have competences typically demonstrated through devising and sustaining arguments and solving problems within their field of study
CB3. Students have the ability to gather and interpret relevant data (usually within their field of study) to inform judgments that include reflection on relevant social, scientific or ethical issues
CB4. Students can communicate information, ideas, problems and solutions to both specialist and non-specialist audiences
CB5. Students have developed those learning skills that are necessary for them to continue to undertake further study with a high degree of autonomy
CG2. Learn new methods and technologies from basic scientific and technical knowledge, and being able to adapt to new situations.
CG3. Solve problems with initiative, decision making, creativity, and communicate and transmit knowledge, skills and abilities, understanding the ethical, social and professional responsibility of the engineering activity. Capacity for leadership, innovation and entrepreneurial spirit.
CG4. Solve mathematical, physical, chemical, biological and technological problems that may arise within the framework of the applications of quantum technologies, nanotechnology, biology, micro- and nano-electronics and photonics in various fields of engineering.
CG5. Use the theoretical and practical knowledge acquired in the definition, approach and resolution of problems in the framework of the exercise of their profession.
CG6. Develop new products and services based on the use and exploitation of new technologies related to physical engineering.
CG7. Undertake further specialized studies, both in physics and in the various branches of engineering.
CE15. Understand and handle the physical principles associated with light-matter interaction and to apply them to the use and design of various photonic devices and complete photonic systems, as well as to apply photonic devices and systems in different branches of physics, engineering and biology.
CE17. Understand and handle the fundamental concepts of Quantum Physics, its relationship with Classical Physics, and its application to the understanding of the physics of atoms and molecules, as well as solving simple one- and three-dimensional quantum problems and applying approximate resolution methods.
CT1. Work in multidisciplinary and international teams as well as organize and plan work making the right decisions based on available information, gathering and interpreting relevant data to make judgments and critical thinking within the area of study.
RA1. To have acquired sufficient knowledge and proved a sufficiently deep comprehension of the basic principles, both theoretical and practical, and methodology of the more important fields in science and technology as to be able to work successfully in them;
RA2. To be able, using arguments, strategies and procedures developed by themselves, to apply their knowledge and abilities to the successful solution of complex technological problems that require

creating and innovative thinking;
RA3. To be able to search for, collect and interpret relevant information and data to back up their conclusions including, whenever needed, the consideration of any social, scientific and ethical aspects relevant in their field of study;
RA6. To be aware of their own shortcomings and formative needs in their field of specialty, and to be able to plan and organize their own training with a high degree of independence.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Postulates of Quantum Mechanics. Dirac¿s matrix formulation. Observables and operators. Eigenvalues and eigenvectors. Discrete and continuous basis. Spectral decomposition. Temporal evolution of quantum systems. Density matrix.
2. Theory of angular momentum. Orbital angular momentum. Electron spin. Spin-orbit interaction. Stern-Gerlach experiment. Zeeman effect.
3. Approximation methods in Quantum Mechanics: perturbative and variational methods.
4. Introduction to light-matter interaction.
5. Multi-electronic atoms. Pauli¿s exclusion principle. Hartree¿s theory and the periodic table.
6. Introduction to Molecular Physics. Born-Oppenheimer model.

LEARNING ACTIVITIES AND METHODOLOGY

AF1. THEORETICAL-PRACTICAL CLASSES. Knowledge and concepts students mustacquire. Receive course notes and will have basic reference texts.Students partake in exercises to resolve practical problems
AF2. TUTORING SESSIONS. Individualized attendance (individual tutoring) or in-group (group tutoring) for students with a teacher.Subjects with 6 credits have 4 hours of tutoring/ 100% on- site attendance.
AF3. STUDENT INDIVIDUAL WORK OR GROUP WORK.Subjects with 6 credits have 98 hours/0% on-site.
AF8. WORKSHOPS AND LABORATORY SESSIONS. Subjects with 3 credits have 4 hours with 100% on-site instruction. Subjects with 6 credits have 8 hours/100% on-site instruction.
AF9. FINAL EXAM. Global assessment of knowledge, skills and capacities acquired throughout the course. It entails 4 hours/100% on-site
AF8. WORKSHOPS AND LABORATORY SESSIONS. Subjects with 3 credits have 4 hours with 100% on-site instruction. Subjects with 6 credits have 8 hours/100% on-site instruction.
MD1. THEORY CLASS. Classroom presentations by the teacher with IT and audiovisual support in which the subject`s main concepts are developed, while providing material and bibliography to complement student learning
MD2. PRACTICAL CLASS. Resolution of practical cases and problem, posed by the teacher, and carried out individually or in a group
MD3. TUTORING SESSIONS. Individualized attendance (individual tutoring sessions) or in-group (group tutoring sessions) for students with teacher as tutor. Subjects with 6 credits have 4 hours of tutoring/100% on-site.
MD6. LABORATORY PRACTICAL SESSIONS. Applied/experimental learning/teaching in workshops and laboratories under the tutor's supervision.

ASSESSMENT SYSTEM

% end-of-term-examination/test:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

* Laboratory sessions (15% of final mark)

Attendance to the laboratory sessions is compulsory. The students must also write a report on each of the experiments carried out in every session. The mark will be common for all the members of each group.

* Activities in groups (25% of final mark)

The evaluation will take into account attendance and student attitude, short test exams periodically proposed, as well as the student performance in the proposed activities.

* Written exam (60% of final mark)

The exam will take place at the end of the semester and it will be common for all the students.

% end-of-term-examination/test:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

Contents:

- Problems to be solved covering the main topics of the program.
- Short theoretical questions.

A minimum score of 3 over 10 will be required to pass the course.

BASIC BIBLIOGRAPHY

- Claude Cohen-Tannoudji, Bernard Diu, and Franck Laloë Quantum Mechanics, Ed. Wiley-Vch.

- David Ferry Quantum Mechanics. An Introduction for Device Physicists and Electrical Engineers. Third Edition. , CRC press, 2001

- Nouredine Zettili. Quantum Mechanics: Concepts and Applications. , Ed. Wiley.

ADDITIONAL BIBLIOGRAPHY

- David A. B. Miller.. Quantum Mechanics for Scientists and Engineers, Ed. Cambridge University Press..