Universitat Autònoma de Barcelona

2019/2020

Quantum Physics I

Code: 100154
ECTS Credits: 6

Degree	Type	Year	Semester
2500097 Physics	OB	3	1

Contact

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Use of Languages

Principal working language: catalan (cat)

Some groups entirely in English: No

Some groups entirely in Catalan: Yes

Some groups entirely in Spanish: No

Teachers

Andreu Riera Campeny

Prerequisites

It is recommended that students start Quantum Physics meeting a few reasonable prerequisites. The reason is simple: quantum physics is one of the most difficult subjects in physics, either because of its anti-intuitive and very broad content (it affects many parts of physics), or because it involves several sophisticated mathematical tools:

Physics: Knowledge of classical mechanics including, at an elementary level, Hamiltonian formulism; Knowledge of electromagnetism, waves and first-year optics

Mathematics: knowledge of algebra, including vector spaces (with metrics), linear operators and eigenvectors and eigenvalues; elementary knowledge of complex numbers, integration of functions of several variables, and differential equations.

General: it takes an open mind and an ability (training) to keep up with the course work that involves formal and conceptual difficulties.

Objectives and Contextualisation

The aim is to introduce students to the world of quantum mechanics, which is an essential part of modern physics. To expose them and to help them reach the fundamental concepts and the basic formalism of this discipline. Illustrate its usefulness, importance and meaning with applications. To prepare students to deepen and broaden their knowledge in Quantum Physics II and in the optional subjects of Quantum Mechanics, Advanced Quantum Mechanics, Quantum Information, Quantum Optics, among others.

Competences

- Develop critical thinking and reasoning and know how to communicate effectively both in the first language(s) and others
- Develop independent learning strategies

- Develop strategies for analysis, synthesis and communication that allow the concepts of physics to be transmitted in educational and dissemination-based contexts
- Formulate and address physical problems identifying the most relevant principles and using approximations, if necessary, to reach a solution that must be presented, specifying assumptions and approximations
- Know the fundamentals of the main areas of physics and understand them
- Respect the diversity and plurality of ideas, people and situations
- Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
- Use mathematics to describe the physical world, selecting appropriate tools, building appropriate models, interpreting and comparing results critically with experimentation and observation

Learning Outcomes

1. Calculate the electronic structure of the hydrogen atom using formalism and the methods introduced in a general manner.
2. Describe certain paradigmatic quantum systems such as the Stern-Gerlach experience, the double slit or potential barriers (tunnelling effect).
3. Describe the laws that govern the quantum world: identify the postulates of quantum mechanics and develop an intuition of its characteristic properties.
4. Describe unperturbed atomic structure and levels.
5. Develop critical thinking and reasoning and communicate ideas effectively, both in the mother tongue and in other languages.
6. Develop independent learning strategies.
7. Respect diversity in ideas, people and situations.
8. Transmit, orally and in written format, physical concepts of a certain complexity, making them understandable to non-specialist settings.
9. Use Hilberts spaces and Hermitian and unitary operators.
10. Use approximate methods in simple models that describe the general characteristics and behaviour of highly complex physical systems.
11. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
12. Use differential equations and orthogonal families of function.

Content

Physical grounds of Quantum Physics. Experimental facts and basic consequences. Indeterminations and Heisenberg principle.

Basic formulism of the Quantum Physics. States and observables. Vector spaces. Operators. Dirac Notation.

Postulates of Quantum Physics. Matrix mechanics (Heisenberg) and wave mechanics (Schrödinger).

One dimensional applications of wave mechanics: simple potential wells, tunnel effect, harmonic oscillator, diatomic molecules.

Three-dimensional applications of wave mechanics: orbital angular momentum and spherical harmonics, hydrogen atom. Central potentials.

Methodology

Theory lectures: In the master classes we introduce the key concepts and methods that define the contents of the subject, which the student must complete and assimilate with the help of the recommended bibliography and the material provided at the virtual campus.

Problem sessions: The exercises illustrate the application of the concepts learned to specific problems of pedagogical or practical relevance. They should also serve the student to strengthen her or his mathematical skills.

A part of the problems are solved in class by the teacher, so that the students -who will have previously attempted to solve the problems at home- can know the degree of success of their solutions and incorporate the pertinent corrections; other problems must be solved and delivered by the student directly to the teacher. The latter will be done in the form of home deliveries or problem sessions in class in small groups.

Tutoring: The individual tutorials (eventually it will be possible to organize some in group) can be used to solve any issues or difficulties.

Home activities:

Study and preparation of Theory classes.

Study and resolution of problems.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Exercise sessions (problem solving and seminars)	22	0.88	6, 5, 11, 7, 8, 9, 12, 10
Theory lectures	28	1.12	1, 2, 4, 3, 5, 11, 7, 9, 12, 10
Type: Autonomous			
Solve assigned problems	51	2.04	2, 4, 3, 6, 5, 11, 9, 12, 10
Study theory	40	1.6	1, 2, 4, 3, 6, 5, 11, 9, 12

Assessment

All evaluations will be written. Exams will be split into a Theory and Problems part of the same weight. Support texts may not be used during the exams, except for a formulary that will either be attached to the exam or prepared beforehand by the student. The first evaluation (with Theory and Problems) will be done after about 7 weeks and will include approximately half of the syllabus. The second will be done about 7 weeks later and will include the other half.

Both the first and the second partial exams will be redeemable (and with the possibility to improve the grade) at the end of the semester with a final evaluation or make up exam. In other words, there will be two partial exams and for those who want it or need it, there will be a make-up exam for the relevant parts. It is necessary to have a grade of at least 3 for each of the parts and, in any case, it is necessary to sit in both partials in order to be able to take the make-up exam. The assignements and problem sessions will contribute up to one point (or depending on the workload, up to a point and a half) to the mark of the partial examinations (not to the one of make-up exam). The student will be considered evaluatable if any of the partial or final examinations are handed in.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Assignment i and problem Sessions	10-15%	0	0	1, 2, 4, 3, 6, 5, 11, 7, 8, 9, 12, 10

First evaluation	42.5-45% redeemable	3	0.12	2, 3, 6, 5, 11, 7, 8, 9, 12
Make up exam	100%	3	0.12	1, 2, 4, 3, 11, 9, 12, 10
Second evaluation	42.5-45% redeemable	3	0.12	1, 4, 3, 6, 5, 11, 7, 8, 9, 12, 10

Bibliography

Basic

F. Mandl, ``Quantum Mechanics'', John Wiley 1992. Llibre de referència que tradicionalment s'ha fet servir a Física Quàntica la UAB i del que disposeu moltes copies a la Bilbioteca de Ciències. S'hi troben molts continguts del curs, tot i així trobareu una exposició més moderna (i pel meu gust més clara) al Griffiths i Ballentine.

D. J. Griffiths, "Introduction to Quantum Mechanics", Pearson Prentice Hall; 2nd Ed. 2004.

Advanced

L. Ballentine, ``Quantum Mechanics: A Modern Development'', World Scientific Publishing Company, 1998.

J. J. Sakurai, ``Modern Quantum Mechanics'', Addison Wesley, 1993.

C. Cohen-Tannoudji, B. Diu, F. Laloe, Quantum Mechanics vol.1-2, Wiley-Interscience, 2006.+