COURSE GUIDE

Quantum Mechanics (2671142)

Approval date: 22/06/2023

Grado (Bachelor's Degree)	Grado en Física	Branch	Sciences
Module	Fundamentos Cuánticos	Subject	Mecánica Cuántica

Year of study	4º	Semester	1º	ECTS Credits	6	Course type	Compulsory course

PREREQUISITES AND RECOMMENDATIONS

It is recommended to have passed the following courses: Física, Métodos Matemáticos, Álgebra Lineal y Geometría, Matemáticas, Mecánica y Ondas and Física Cuántica.

BRIEF DESCRIPTION OF COURSE CONTENT (According to the programme's verification report)

Postulados de la mecánica cuántica.
Partículas idénticas.
Composición de momentos angulares.
Métodos aproximados para situaciones no estacionarias.
Teoría de colisiones.

SKILLS

GENERAL SKILLS

- CG01 - Skills for analysis and synthesis
- CG02 - Organisational and planification skills
- CG03 - Oral and written communication
- CG06 - Problem solving skills
- CG07 - Team work
- CG08 - Critical thinking
- CG09 - Autonomous learning skills
- CG10 - Creativity

SUBJECT-SPECIFIC SKILLS

- CE01 - Knowing and understanding the phenomena of the most important physical theories
- CE02 - Estimating the order of magnitud in order to interpret various phenomena

- CE05 - Modelling complex phenomena, translating a physical problem into mathematical language
- CE07 - Transmitting knowledge clearly, both in academic as in non-academic contexts
- CE09 - Applying mathematical knowlegde in the general context of Physics

LEARNING OUTCOMES

(According to official validation report)
El alumno comprenderá:

- los límites de la física clásica;
- la relevancia de los fenómenos cuánticos a distintas escalas;
- la estructura lógica de la mecánica cuántica;
- la utilidad de los espacios vectoriales y los números complejos en física;
- la importancia de las simetrías en física;
- las peculiaridades del mundo microscópico;
- el papel de las colisiones en la descripción de ese mundo;
- la diferencia entre cuestiones "físicas" y cuestiones que no lo son.

El alumno estará capacitado para:

- manejar el formalismo matemático y aplicarlo a la resolución de problemas;
- usar con propiedad el lenguaje de la mecánica cuántica;
- manejar con seguridad conceptos como espín, observable o sección eficaz;
- usar simetrías y leyes de conservación para estudiar procesos físicos;
- interpretar los resultados de sus cálculos.

PLANNED LEARNING ACTIVITIES

THEORY SYLLABUS

- **Chapter 1. Fundamentals of quantum mechanics**

Stern-Gerlach experiment. Pure states. Observables. Eigenvalues, eigenstates and projectors. Measurement and probability. Density matrix. Composite systems. Continuous spectrum: Dirac formalism.

- **Chapter 2. Symmetries**

Symmetry in quantum mechanics. Wigner's theorem. Symmetry groups and their representations. Observables as generators of continous symmetries.

- **Chapter 3. Time translations**

Time evolution. Hamiltonian. Schrödinger and Heisenberg pictures. Conservation laws.

- **Chapter 4. Space translations**

Position operator. Momentum. Wave function. Classic limit. Propagator. Path integral.

- **Chapter 5. Rotations**

Rotation group. Angular momentum. Irreducible representations. Orbital angular momentum. Spin. Addition of angular momentum. Tensor operators.

- **Chapter 6. Internal and discrete symmetries**

Parity. Time reversal. Isospin.

- **Chapter 7. Identical particles**

Permutation symmetry. Spin-statistics theorem. Systems of identical particles. Creation and annihilation operators.

- **Chapter 8. Time-dependent perturbation theory**

Interaction picture. Dyson series. Transition probability. Transition to the continuum.

- **Chapter 9. Scattering theory.**

Asymptotic behaviour. S matrix. Scattering amplitudes and cross section. Optical theorem. Born series. Stationary methods: Green's operators, scattering states, Lippman-Schwinger equation. Partial waves.

PRACTICAL SYLLABUS

- **Problem-solving workshops:**Discussion of proposed exercises.
- **Oral presentations by students**, subject to time constraints.

RECOMMENDED READING

ESSENTIAL READING

- S. Weinberg, Lectures in Quantum Mechanics, Cambridge University Press.
- J.J. Sakurai, Modern Quantum Mechanics, Addison-Wesley.
- J.R. Taylor, Scattering Theory, J. Wiley.
- A. Galindo y P. Pascual, Mecánica Cuántica, Eudema Universidad.

COMPLEMENTARY READING

- A. Messiah, Mecánica Cuántica, Tecnos.
- D. Bohm, Quantum Theory, Dover.
- F.J. Yndurain, Mecánica Cuántica, Alianza Editorial Textos.
- L.E. Ballentine, Quantum Mechanics. A Modern Development, World Scientific.
- R.P. Feynman, R. Leighton, M. Sands, The Feynman lectures on physics- Vol. III. Addison- Wesley.
- P. Dirac, The Principles of Quantum Mechanics, Oxford University Press.

RECOMMENDED LEARNING RESOURCES/TOOLS

- Grupo de física de partículas de la UGR, https://ftae.ugr.es
- CERN, https://www.cern.ch/
- Particle Data Group, https://pdg.web.cern.ch/pdg/
- Demostraciones de Mecánica Cuántica con Mathematica, https://demonstrations.wolfram.com/topic.html?topic=Quantum+Mechanics
- MIT OpenCourseWare, Quantum Physics II, https://ocw.mit.edu/courses/physics/8-05-quantum-physics-ii-fall-2013/
- MIT OpenCourseWare, Quantum Physics III, https://ocw.mit.edu/courses/physics/8-06-quantum-physics-iii-spring-2018/

TEACHING METHODS

- MD01 - Theoretical classes

ASSESSMENT METHODS (Instruments, criteria and percentages)

ORDINARY EXAMINATION DIET

- Final exam of theory knowledge and/or problem solving (70% of final grade). Passing the exam is strictly necessary to pass the course.
- Continuous assessment: participation in class, problem solving, multiple-choice quiz, written work, presentations (30% of final grade, subject to previous condition.)

EXTRAORDINARY EXAMINATION DIET

- Exam of theory knowledge and/or problem solving (100% of final grade).

SINGLE FINAL ASSESSMENT (evaluación única final)

The student who, following the terms and deadlines envisaged in the UGR regulations, makes use of this form of assessment, will take a written exam of knowledge and problem solving in order to pass the course.