Mathematical foundations of quantum mechanics

Academic Year: (2022 / 2023) **Review date: 04/05/2023 10:49:49**

Department assigned to the subject: Mathematics Department

Coordinating teacher: IBORT LATRE, LUIS ALBERTO

Type: Electives ECTS Credits : 6.0

Year :   Semester :

OBJECTIVES

Acquire a deeper understanding of the foundations of Quantum Mechanics and its axiomatic formulation.

Understand the structure of Hilbert spaces and the basic properties of linear operators.

Understand the meaning and implications of the spectral theorem for self-adjoint operators.

Learn the basic ideas behind Feynman's formulation of Quantum Mechanics.

Learn the basic ideas leading to a tomographic description of Quantum Mechanics.

DESCRIPTION OF CONTENTS: PROGRAMME

On the many pictures of Quantum Mechanics: Schrödinger, Heisenberg and Dirac. An introduction to the theory of Hilbert spaces.

Von Neumann's picture of Quantum Mechanics. The theory of operators, observables and the spectral theorem.

Perturbation theory: stationary and time-dependent perturbation theory, adiabatic theorem, semiclassical approximation, scattering theory.

Weyl's picture of Quantum Mechanics. Weyl's quantization. Coherent states and quantum optics: Wigner's transform and quantum tomography.

Feynman's picture of Quantum Mechanics. The double slit experiment. Feynman's path integral and Dirac's Lagrangian description of Quantum Mechanics.

From particles to fields.

The measurement problem in Quantum Mechanics. Measurement and reversibility. Quantum cloning. Quantum Zeno effect. The nature of quantum states.

EPR. Bell inequalities. Quantum non-locality

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

SE1. FINAL EXAM. Global assessment of knowledge, skills and capacities acquired throughout the course.The percentage of the evaluation varies for each subject between 60% and 0%.
SE2. CONTINUOUS EVALUATION. Assesses papers, projects, class presentations, debates, exercises, internships and workshops throughout the course.The percentage of the evaluation varies for each subject between 40% and 100% of the final grade.

BASIC BIBLIOGRAPHY

 - A. Galindo, P. Pascual Quantum Mechanics I, Springer Verlag, 1990

 - G. Auletta, M. Fortunato, G. Parisi Quantum Mechanics, Cambridge Univ. Press, 2009

 - G. Esposito, G. Marmo, G. Sudarshan From Classical to Quantum Mechanics, Cambridge Univ. Press, 2004

 - J. Cariñena, A. Ibort, G. Marmo, G. Morandi Geometry from dynamics: classical and quantum, Springer-Verlag, 2014

 - R. Feynman, A. Hibbs Quantum Mechanics and Path Integrals, Mac-Gray Hill Publish. Co., 1965