Bachelor in Physics
(Academic Year **2024-25**)

Quantum Mechanics		Code	800509	Year	3º	Sem.	2º
Module	Fundamental Physics	Topic	Obligatory in Fundamental Physics	Character	Optional		

	Total	Theory	Exercises
ECTS Credits	6	4	2
Semester hours	45	30	15

Learning Objectives (according to the Degree's Verification Document)

- To assimilate the concept of quantum state and to introduce the quantum information theory.
- To understand the scattering theory in quantum mechanics
- To learn the theory of symmetry in quantum mechanics
- To apply time-dependent perturbation methods in quantum mechanics.

Brief description of contents

Pure and mixed states; discrete and continuous symmetries, rotations and angular momentum; composite systems; quantum information and quantum computation; time-dependent perturbation theory; scattering theory.

Prerequisites

Linear algebra, vector calculus, the content of the subjects Quantum Physics I and II.

Coordinator	Ángel Rivas Vargas		Dept.	FT
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Theory/Exercises – Schedule and Teaching Staff

Group	Lecture Room	Day	Time	Professor	Period/ Dates	Hours	T/E	Dept.
B	7	Mo We	17:00 – 18:30 16:30 – 18:00	Ángel Rivas Vargas	Full term	45	T/E	FT

T: Theory, E: Exercises

Office hours

Group	Professor	Schedule	E-mail	Location
B	Ángel Rivas Vargas	L, J: 15:00 – 16:30 M: 16:30 – 19:30	anrivas@ucm.es	03.312.0

Syllabus

General Formulation of Quantum Mechanics

Pure and mixed states. Formulation of Quantum Mechanics for generic mixed states. Measurements and observables. Time-evolution and its pictures. Constants of the motion.

Symmetries in Quantum Mechanics.

Symmetry transformations and Wigner's theorem. Continuous and discrete symmetries. Conservation laws. Space translations. Rotations. Parity and time-reversal. Exchange symmetry of identical particles. Internal symmetries.

Time-Dependent Perturbations.

Perturbative expansion of transition amplitudes. Transitions to a continuum: Fermi's golden rule. Sudden and adiabatic approximations.

Non-Relativistic Scattering Theory.

Differential and total cross sections. Scattering amplitude. Born approximation. Scattering by a central potential. Partial waves expansion and phase-shifts. Optical theorem. Resonances.

Introduction to Quantum Computation and Quantum Information Science.

von Neumann entropy. Bipartite systems, qubits and pure entangled states. Bell inequalities. Introductory quantum computation.

Bibliography

Basic:
• G. Auletta, M. Fortunato, G. Parisi, Quantum Mechanics, Cambridge University Press.
• L.E. Ballentine, Quantum Mechanics: A Modern Development, World Scientific.
• C. Cohen-Tannoudji, B. Diu, F. Laloe, Quantum Mechanics Vol. I & II. John Wiley & Sons.
• E. d'Emilio, L.E. Picasso, Problems in Quantum Mechanics: with solutions. Springer.
• A. Galindo y P. Pascual, Mecánica Cuántica Vol. I y II. Eudema Universidad.
• L. Landau & E.M. Lifshitz, Quantum Mechanics, Buttenworth-Heinemann.
• A. Messiah, Quantum Mechanics, Dover.
• L.I. Schiff, Quantum Mechanics, McGraw-Hill.
• M. Le Bellac, Quantum Physics, Cambridge University Press.

Complementary:
• J. Audretsch, Entangled Systems, Wiley-VCH.
• J.L. Basdevant and J. Dalibard Quantum mechanics, Springer.
• D.J. Griffiths, Introduction to quantum mechanics, Prentice Hall.
• K.T. Hecht, Quantum Mechanics, Springer.
• E. Merzbacher, Quantum Mechanics, John Wiley.
• L. E. Picasso, Lectures in Quantum Mechanics: A Two-Term Course. Springer.
• J.J. Sakurai, Modern Quantum Mechanics, Addison-Wesley.
• F. Schwabl, Quantum Mechanics, Springer.
• R. Shankar, Principles of Quantum Mechanics, Plenum Press.

Online Resources

UCM's Virtual Campus, Google Drive, Dropbox, Microsoft Teams, Google Meet.

Methodology
There will be lectures on the blackboard, explaining and discussing the topics of the subject. The concepts and techniques introduced in this explanation will be illustrated with examples and problems that will be solved in class. Discussion on all the concepts and techniques introduced in class will be stimulated, individually and in groups, with the students.

Evaluation Criteria		
Exams	**Weight:**	70%
There will be a final exam consisting of one part of theoretical-practical questions and/or another part of problems of a similar level of difficulty to those solved in class.		
Other Activities	**Weight:**	30%
One or more continuous assessment activities such as written tests during class hours, or complementary exercises, and/or computational practices carried out outside class hours.		
Final Mark		
The final mark will be given by max{0.7(exam mark) + 0.3 (other activities mark), exam mark} on a 0-10 scale. A minimum grade of 4 out of 10 on the exam will be required to pass the course. The mark of the extraordinary call of June-July will be obtained following the same evaluation procedure.		