Bachelor in Physics
(Academic Year **2026-27**)

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	José Ramón Peláez Sagredo		**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	3 11	Mo Th	9:00-10:30 10:30-12:00	José Ramón Peláez Sagredo	Full term	39	T/E	FT

T: Theory, E: Exercises

Office hours

Group	Professor	Schedule	E-mail	Location
B	José Ramón Peláez Sagredo	Mo:10:30-13:30 Th:14:30-15:30	jrpelaez@fis.ucm.es	02.319.0

Syllabus

Quantum Mechanics formalism

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

Symmetries in Quantum Mechanics.

Symmetry transformations. 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 spectrum: 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-wave expansion and phase shifts. Resonances.

Introduction to Quantum Information.

Von Neumann entropy. Bipartite systems, qubits and entangled pure states. Bell inequalities. Notions of quantum computation.

Bibliography

(In alphabetic order)

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.*

• *L. Landau, E.M. Lifshitz, Quantum Mechanics, Buttenworth-Heinemann.*

• *A. Galindo y P. Pascual, Mecánica Cuántica Vol. I y II. Eudema Universidad.*

• *D.J. Griffiths, Introduction to quantum mechanics, Prentice Hall.*

• *J.J. Sakurai, Modern Quantum Mechanics, Addison-Wesley.*

• *L.I. Schiff, Quantum mechanics, McGraw-Hill*

• *R. Shankar, Principles of Quantum Mechanics, Plenum Press.*

• *J. R. Taylor, Scattering Theory, Dover.*

Suplementary:

• *J. Audretsch, Entangled Systems, Wiley-VCH.*

• *J.L. Basdevant and J. Dalibard. Quantum mechanics, Springer.*

• *E. d'Emilio, L.E. Picasso, Problems in Quantum Mechanics: with solutions. Springer.*

• *K.T. Hecht, Quantum Mechanics, Springer.*

- *M. Le Bellac, Quantum Physics, Cambridge University Press.*
- *E. Merzbacher, Quantum Mechanics, John Wiley.*
- *A. Messiah, Quantum Mechanics, Dover.*
- *L. E. Picasso, Lectures in Quantum Mechanics: A Two-Term Course. Springer.*
- *F. Schwabl, Quantum Mechanics, Springer.*

Online Resources

Problem assignments and other materials will preferably be distributed through the course's online campus.

Free access textbook: https://phys.libretexts.org/Bookshelves/Quantum_Mechanics

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%

Final mark for the Exams section: N_{Exam}, between 0 and 10.

There will be a final exam that may consist of just one part, or one part of theoretical-practical questions (N_{theo}) and/or another part of problems (N_{prob}) of a similar level of difficulty to those solved in class.

In case it consists of two parts, $N_{Exam}= 0.4\ N_{theo} + 0.6\ N_{prob}$ only if at least a 4 is attained in both parts. If $N_{theo} < 4$, then $N_{Exam}= N_{theo}$. If $N_{teor} \geq 4$ and $N_{prob} < 4$, then $N_{Exam}= N_{prob}$.

Other Activities	Weight:	30%

Written assignments during the class hours and/or continuous assessment activities outside it, consisting in short or test questions and/or the fulfillment of theoretical, practical and/or computational exercises.

The final mark for this section will be $N_{OtherActiv}$ and will range from 0 to 10.

Final Mark

Final mark:

$$C_{Final} = \max \{ 0.7N_{Exam} + 0.3N_{OtherActiv} ,\ N_{Exam} \}$$

Minimum final exam mark for weighting: $N_{Exam} \geq 4$

The final mark criteria, as well as the mark for other activities, will be maintained in the exam of the extraordinary call.