



Bachelor in Physics (Academic Year 2022-23)

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)
<ul style="list-style-type: none"> 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	Antonio Dobado González			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	4 ^a	L X	17:00-18:30 16:30-18:00	Ángel Rivas Vargas	Full term	45	Both	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	Room: 03.312.0

Syllabus

Topic 1: The Foundations of Quantum Mechanics.

Mathematics and notation of Quantum Mechanics. Pure states and unit rays. Observables and physical variables. Measurement outcomes and probabilities. Uncertainty relations. Complete set of compatible observables. State operator and mixed states. Filtering measurements. Time-evolution. Canonical quantization rules. Stationary states and constants of motion. Time-energy uncertainty relation. Evolution operator. Evolution pictures.

Topic 2: Symmetries in Quantum Mechanics.

Symmetry transformations and Wigner's theorem. Space translations. Rotations and angular momentum. Spin. Wigner-Eckart theorem. Parity and time-reversal. Symmetries and conservation laws. Identical particles and symmetrization.

Topic 3: Time-dependent perturbations,

Perturbative expansion of transition amplitudes. Transitions to a continuum: Fermi's golden rule. Adiabatic approximation.

Topic 4: Scattering theory

Scattering by a central potential and cross sections. Scattering amplitude and differential cross sections. Integral representation of the scattering amplitude. Born approximation. Partial waves expansion and phase-shifts. Optical theorem. Calculation of phase-shifts for finite range potentials. Resonances. Coulomb scattering. S and T matrices.

Topic 5: Introductory Quantum Information and Quantum Computation

Classical and quantum composite systems. Bipartite systems, qubits and pure entangled states.

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
<p>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.</p>

Evaluation Criteria		
Exams	Weight:	70%
<p>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.</p>		
Other Activities	Weight:	30%
<p>One, or more, written tests of continuous assessment carried out during the class time or outside of it.</p>		
Final Mark		
<p>The final mark will be given by $\max(0.7 (\text{exam mark}) + 0.3 (\text{other activities mark}), \text{exam mark})$, on a 0-10 scale.</p> <p>A minimum mark will be required in the final exam in order to pass the course, which will depend on the scenarios in which the course is finally developed.</p> <p>The mark of the extraordinary call of June-July will be obtained following the same evaluation procedure.</p>		