Bachelor in Physics
(Academic Year 2026-27)

Quantum Physics II		Code	800513	Year	3rd	Sem.	1st
Module	General Core	**Topic**	Quantum physics and statistics	**Character**	Obligatory		

	Total	Theory	Problems
ECTS Credits	6	3.5	2.5
Semester hours	55	30	25

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

- Spin, general angular momenta and their coupling in quantum mechanics.
- Identical particles and the Pauli exclusion principle.
- Elementary time-independent perturbation theory and its basic applications.

Brief description of contents

Spin and angular momentum. Pauli´s exclusion principle. Approximate methods for Schrödinger´s equation.

Requisites

Basic knowledge of the mathematical formulation of quantum mechanics. This includes the Schrödinger equation and the wave function, simple one-dimensional problems, and the commutation relations and the eigenvalue problem for orbital angular momentum.

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Theory/Problems – Schedule and Teaching Staff								
Group	**Lecture Room**	**Day**	**Time**	**Professor**	**Period/ Dates**	**Hours**	**T/E**	**Dept.**
B	19	Mo We Th	10:00 – 11:00 10:30 – 12:00 11:00 - 12:30	Javier Rubio Peña	Full term	40	T/E	FT
				Fech Scen Khoo		15	E	FT

T: Theory, P: Problems

Office hours				
Group	**Professor**	**Schedule**	**E-mail**	**Location**
B	Javier Rubio Peña	Mo: 14:00-17:00 online Tu, Th: 16:00-17:30 in-person (arranged previously by email)	javrub02@ucm.es	02.326.0
	Fech Scen Khoo	L:11:00-13:00 X:12:00-13:00 +3h online	fkhoo@ucm.es	03.324.0

Syllabus

Review and expansion of the formalism of quantum mechanics. Physical states of a quantum system. Observables and operators. Results and probabilities of measurements. Physical state after a measurement. Time evolution. Composite systems. Definition of the density operator.

Spin and two-level systems. The Pauli and Goudsmit-Uhlenbeck hypotheses. The Stern-Gerlach experiment. Coupling of an electron to a magnetic field.

Angular momentum. General definition and spectrum. Spin matrices. Orbtial angular momentum. Addition of two ½ angular momenta. Addition of two general angular momenta and Clebsch-Gordan coefficients.

Identical particles. Indistinguishable particles and symmetrization and antisymmetrization of the wave function. Systems of identical non-interacting particles.

Time-independent perturbation theory. The idea of perturbative expansions. Perturbation theory for nondegenerate states. Perturbation theory for degenerate states. Applications to the Hydrogen atom.

The variational method. General description of the method. Applications.

Time-dependent perturbation theory. Time-dependent Hamiltonians and perturbations. Fermi's golden rule and selection rules.

Bibliography

Basic:

• C. Cohen-Tannudji, B. Diu, F. Laloë, Quantum mechanics, vols I y II, John Wiley (New York 1977).

• S. Gasiorowicz, Quantum physics, 3rd edition, John Wiley (New York 2003)

Complementary

• D. J. Griffiths, Introduction to Quantum Mechanics. Prentice Hall (New York 1995).

• D. D. Fitts, Principles of quantum mechanics, as applied to chemistry and chemical physics, Cambridge University Press (Cambridge 1999).

• B. Schumacher, M. Westmoreland, Quantum processes systems, and information, Cambridge University Press (Cambridge 2010).

• L. Ballentine, Quantum Mechanics: A modern development, World Scientific Publishing (Singapore 1998).

• M. Alonso, E Finn, Quantum and statistical physics Fundamental University Physics, vol III),

Addison Wesley (Reading 1968).

Online resources
UCM's Virtual Campus.

Teaching method
• Theory lectures where the main concepts of the subject will be explained using the blackboard or computer-assisted projections, including examples and applications. • Practical exercise sessions based on previously distributed sample sheets and involving active student participation. • Office hours for addressing doubts, expanding on concepts or reviewing homework materials. Attending these tutoring sessions is highly recommended for a better understanding of the course. Teaching materials will be accessible on the Virtual Campus.

Evaluation criteria		
Exams	**Weight:**	75%
Final mark for the Exams section: N_{Exam}, between 0 and 10. There will be a final exam, consisting of brief questions and problems of similar degree of difficulty to those in the sample sheets. To pass the subject, a minimum grade of 4.5 in the final examination will be required.		
Other Activities	**Weight:**	25%
One or more of the following activities may be conducted: • Problem-solving by students, these can be assigned as in-class exercises or as homework to be completed individually or in small groups. • Mid-term tests, which might include written and oral questions. The final mark for this section will be $N_{OtherActiv}$ and will range from 0 to 10.		
Final Mark		
Final mark: $$C_{Final} = \max(0.75N_{Exam} + 0.25N_{OtherActiv}\ ,\ N_{Exam})$$ Minimum final exam mark to apply weighting: $N_{Exam} \geq 4.5$ If $N_{Exam} < 4.5$: the final mark of the course will be $C_{Final} = N_{Exam}$ The final mark criteria, as well as the grading for other activities, will be maintained in the exam of the extraordinary call.		