Bachelor in Physics
(Academic Year 2021-22)

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	54	29	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-dependent 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.

Coordinator	Juan Manuel Rodríguez Parrondo		Department	EMFTEL
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Schedule and Teaching Staff

Group	Lecture Room	Day	Time	Professor	Dates	Hours	T/p	Dept.
B	7	Mo We Th	10:00-11:00 10:30-12:00 11:00-12:30	Fernando Ruiz Ruiz	Full term	54	Both	FT

T: Theory, P: Problems

Office hours

Group	Instructor	Office	Schedule	e-mail
B	Fernando Ruiz Ruiz	West Wing, 3rd floor, Room 11	Mo, We, Th: 12:00-13:30 Tu: 15:30-17:00	ferruiz@ucm.es

Syllabus

Orbital angular momentum and spin. Brief reminder of orbital angular momentum. Experimental evidence for the electron´s spin: the Zeeman effect and the Stern-Gerlach experiment. Nonrelativistic description of spin-1/2 particles. General properties of spin.

Time evolution and measurements in two-level quantum mechanical systems. Matrix representation of adjoint operators for observables. Tensor product. The Heisenberg picture. Definition of density matrix. Introduction to entanglement.

Angular momentum general theory.

- General definition of angular momentum. Angular momentum spectrum. Matrix representations of angular momenta.
- Composition of two spins ½. Composition of two angular momenta and Clebsch-Gordan coefficients. Total angular momentum of a particle, **J=L+S**.

Identical particles. Indistinguishibility of identical particles in quantum mechanics. Two-particle systems. Interchange symmetry for the wave functionsof two spin-1/2 particles; singlet and triplet states. Postulate of (anti-)symmetrization. Bosons and fermions. Pauli's exclusión principle.

Approximate methods.

- Time-independent perturbation theory. Degenerate and nondegenerate cases. Examples. Hydrogen atom fine structure.
- Variational method. Basic theorems. Trial wavefunctions.
- Time-dependent perturbation theory. Sudden and adiabatic perturbations. Harmonic perturbations. Fermi´s golden rule. 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
On-campus teaching 100% (Scenario 0)
Theory lectures and problem sessions will be given and conducted by the Instructor. He will use conventional chalk/blackboard or computer-assisted projections. Sample sheets to be discussed and/or solved in the classroom will be provided to students prior to problem sessions. Students are encouraged to take an active part in both theory lectures and problems sessions. The Instructor will be available for tutorials at the times specified in the office hours table above. Teaching material will be accessible at Campus Virtual.
Semi-online teaching (Scenario 1)
Theory lectures and problem sessions will be in-class attended by half of the group and live broadcasted for the other half. Otherwise, as for Scenario 0.
Online teaching (Scenario 2)
Theory lectures and problem sessions will be live broadcasted during class hours. Sample sheets and written material will available through Campus Virtual. Tutorials will be on-line held at the office hours specified above.

Evaluation criteria		
Exams	**Weight:**	75%
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 minimal grade in the final examination, fixed by the Instructor in due time, will be required.		
Other Activities	**Weight:**	25%
One or more of the following activities may be run: • Resolution of problems by students. These may be set as homework or as exercises to be solved in the classroom. • Mid-term tests which may comprise written and oral questions.		
Final Mark		
Let FE and OA stand for the final examination and other activities marks, FE = mark in final examination OA = mark in other activities described above Provided FE is larger than a minimum, fixed by the Instructor in due time, the grade in the subject will be calculated using the formula. max (FE , 0.25*OA + 0.75*FE) .		