SYLLABUS

Quantum Mechanics

CLASSIFICATION	SUBJECT	YEAR	TERM	CREDITS	DEGREE REQUIREMENT
Fundamentos Cuánticos	Quantum Mechanics	4	1	6	Mandatory

INSTRUCTORS	CONTACT INFORMATION
GROUP A (Spanish) Manuel Masip Mellado Juan Antonio Aguilar Saavedra	**Location:** Dpto. Física Teórica y del Cosmos, Edificio Mecenas, offices 3 and 20. **Phone:** 241731, 249063 **Email:** masip@ugr.es, jaas@ugr.es **Website:** http://www.ugr.es/~fteorica/#
	Office Hours: Monday, Wednesday, and Friday, 3:00PM to 5:00PM Tuesday and Wednesday, 4:00PM to 7:00PM
GROUP B (English) Manuel Pérez-Victoria Moreno de Barreda Nicholas Setzer	**Location:** Dpto. Física Teórica y del Cosmos, Edificio Mecenas, offices 20 and 23. **Phone:** 249063, 249999 **Email:** mpv@ugr.es, nsetzer@ugr.es **Website:** http://www.ugr.es/~fteorica/#
	Office Hours: Monday through Thursday, 12:00 to 1:00PM Friday, 11:00AM to 1:00PM

DEGREE PATH	OTHER DEGREE PATHS GIVING CREDIT FOR THIS COURSE
Grado en Física (Bachelors Degree in Physics)	Grado en Óptica y Optometría, Grado en Química

PREREQUISITES

- Métodos Matemáticos (Math Methods) I,II,III, Mecánica y Ondas (Mechanics & Waves), and Física Cuántica (Quantum Physics)

OFFICIAL SUMMARY OF COURSE CONTENT (ACCORDING TO MEMORIA DE VERIFICACIÓN DEL GRADO)

• Postulados de la Mecánica Cuántica (Postulates of Quantum Mechanics). Partículas idénticas (Identical Particles). Composición de momentos angulares (Addition of Angular Momentum). Métodos aproximados para situaciones no estacionarias (Time-dependent Perturbation Theory). Teoría de colisiones (Scattering).

OUTCOMES, GENERAL & SPECIFIC

General

- CT1 Analytical Thinking.
- CT2 Organization and Planning.
- CT3 Written and/or Oral Communication.
- CT6 Problem Solving.
- CT7 Teamwork
- CT8 Critical Thinking.
- CT9 Independent Learning.
- CT10 Creativity.

Specific

- CE1: Know and understand important physical concepts and systems.
- CE2: Ability to estimate orders of magnitude for various physical systems.
- CE5: Ability to model physical systems and formulate their behavior mathematically.
- CE7: Ability to clearly convey knowledge within the classroom and without.
- CE9: Ability to apply mathematical knowledge in generic physical setups.

GOALS (THE KNOWLEDGE A STUDENT SHOULD POSSESS AT THE END OF THE COURSE)

The student should know:

- the limits of classical physics;
- the relevance of quantum phenomena at different scales;
- the logical structure of quantum mechanics;
- how to use vector spaces and complex numbers in physics;
- the importance of symmetries in physics;
- the wonders and oddities of quantum systems;
- the role of scattering in quantum theory;
- how to distinguish physically relevant questions.

The student should be able to

- handle the relevant mathematics and apply it to problem solving;
- properly use and understand quantum mechanical terminology;
- correctly handle spin, observables, and cross sections;
- use symmetries and conservation laws to understand physical processes;
- interpret the results of their calculations.

COURSE TOPICS

1. Introduction
History. The Stern-Gerlach Experiment.

2. Quantum Mechanics Postulates
Observables. Measurements. Complete Sets of Commuting Observables. Uncertainty Relations. The Density Matrix. Schrödinger Equation. The Time Evolution Operator. Stationary States and Conserved Quantities. The Heisenberg Picture. Superselection Rules.
3. Wavefunctions
Continuous Spectra: Wavefunction. Position Representation. Momentum Representation. Probability Density. Ehrenfest's Theorem. The Propagator.
4. Angular Momentum
The Rotation Group. Angular Momentum Operators. Representations of Angular Momentum Operators. Spin and Orbital Angular Momentum. The Spherical Harmonics. Addition of Angular Momentum. Irreducible Operators. The Wigner-Eckart Theorem.
5. Symmetries
Symmetries in Classical and Quantum Mechanics. Symmetry Groups. Wigner's Theorem. Invariance and Conservation Laws. Continuous Symmetries: Translations, Rotations, Isospin. Discrete Symmetries: Parity, Time-Reversal.
6. Systems of Identical Particles
Permutation Symmetry. Symmetrization Postulate and the Spin-statistics Theorem. Systems of Bosons and Fermions. Creation and Annihilation Operators.
7. Scattering
Classical and Quantum Scattering. Asymptotic States. The S Matrix. Energy Conservation. The On-shell T Matrix and Scattering Amplitudes. Cross sections. The Optical Theorem. Greens Functions and the T Operator. Determining S from T. The Born Approximation. Plane and Spherical Waves. The Partial Wave Expansion. Symmetries of the S Matrix.
8. Time-dependent Perturbation Theory
The Interaction Picture. The Dyson Series. The Transition Probability. Fermi's Golden Rule.

TEXTBOOKS

1. J.J. Sakurai, Modern Quantum Mechanics, Addison-Wesley.
2. J.R. Taylor, Scattering Theory, J. Wiley.
3. P. Dirac, The Principles of Quantum Mechanics, Oxford Univ. Press.
4. A. Messiah, Mecánica Cuántica, Tecnos.
5 A. Galindo y P. Pascual, Mecánica Cuántica, Eudema Universidad.
6. D. Bohm, Quantum Theory, Dover.
7. F.J. Yndurain, Mecánica Cuántica, Alianza Editorial Textos.
8. L.E. Ballentine, Quantum Mechanics. A Modern Development, World Scientific.
9. J.R. Taylor, Scattering Theory: The Quantum Theory of Nonrelativistic Collisions, Dover.
10. R.P. Feynman, R. Leighton, M. Sands, The Feynman lectures on physics – Vol. III. Addison-Wesley.

SUPPLEMENTARY MATERIAL

- UGR Particle Group Websites: http://www-ftae.ugr.es/, http://cafpe.ugr.es/
- CERN: http://www.cern.ch/
- Particle Data Group: http://pdg.web.cern.ch/pdg/
- Wolfram Demonstrations: http://demonstrations.wolfram.com/topic.html?topic=Quantum+Mechanics&limit=20
- Quantum Mechanics' E-prints: http://arxiv.org/archive/quant-ph

TEACHING METHODS

Lectures: Sessions where the instructor explains fundamental concepts for each topic and provides a context for the material.

Problem Sessions: Classes where the instructor works out exercises and where the students solve problem sets on the blackboard.

Seminars: Time set aside for discussing current issues related to the subject or relevant topics of interest to the students.

Office Hours: Time reserved for students to approach the instructor to ask questions for clarification on any of the material.

SCHEDULE

Primer cuatrimestre	Temas del temario	Actividades presenciales					Actividades no presenciales				
		Sesiones teóricas (horas)	Sesiones prácticas (horas)	Exposiciones y seminarios (horas)	Exámenes (horas)	Taller problemas	Tutorías individuales (horas)	Tutorías colectivas (horas)	Estudio y trabajo individual del alumno (horas)	Trabajo en grupo (horas)	
Semana 1											
Semana 2											
Semana 3											
Semana 4											
Semana 5											
Semana 6											
Semana 7											
Semana 8											
Semana 9											
Semana 10											
Semana 11											
Semana 12											
Semana 13											
Semana 14											
Semana 15											
Semana 16											

GRADING

The final grade will be a combination of class participation, presentation of problem sets, and a written final exam. The final exam will be open book.
Exception: Evaluación única final (Grade Determined Solely from the Final Exam). A student who, following the rules of the University of Granada and the deadlines required therein, may obtain their grade solely from the written final exam.