



Bachelor in Physics

(Academic Year 2026-27)

Structure of Matter			Code	800516	Year	3rd	Sem.	2nd
Module	General Core	Topic	Quantum physics and statistics		Character		Obligatory	

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

Learning Objectives (according to the Degree's Verification Document)	
• To learn the structure of poly-electronic atoms and their basic modeling. • To comprehend the Born-Oppenheimer approach and the electronic structure of diatomic molecules and other compounds. • To obtain a first insight of the smallest constituents of matter, their interactions and the basic elements of the models involved, as well as the order of the physical magnitudes taking place in the processes among elementary particles. • To understand the basic nuclear phenomenology and some simple models.	
Brief description of contents	
Introduction to poly-electronic atoms; foundations of molecular structure and bonding; basic properties of atomic nuclei; introduction to particle physics and its phenomenology.	
Prerequisites	
Wave function and Schrödinger equation. Simple quantum systems and their spectra (harmonic oscillator, central potentials, the Hydrogen atom). Basics of symmetries and angular momenta. Quantum transitions and collisions.	
Some approximate calculation methods in quantum systems: variational method, perturbations, etc.	

Coordinator	Juan Abel Barrio Uña			Dept.	EMFTEL
	Office	03.221.0	e-mail	barrio@gae.ucm.es	

Theory/ Exercises – Schedule and Teaching Staff								
Group	Lecture Room	Day	Time	Professor	Period/ Dates	Hours	T/E	Dept.
B	Sem. 3.2	We Fr	12:00-14:00	Juan Abel Barrio Uña	Full term	55	T/E	EMFTEL

T: Theory, E: Exercises

Office hours				
Group	Professor	Schedule	E-mail	Location
B	Juan Abel Barrio Uña	1 st semester Mo: 11:00-13:00 online Tu 11:00-13:00 Th:15:00-17:00 2 nd semester Mo: 11:00-13:00 online Mo: 14:00-16:00 We: 15:00-17:00	barrio@gae.ucm.es	03.221.0

Syllabus
1. Atomic Physics Review and extension of the hydrogenoid atom. Introduction to poly-electronic atoms. Central field approximation. Ground states and periodic table. Couplings of angular momenta of electrons. Atomic spectra. 2. Molecular Physics Types of atomic bonds. Valence bond and molecular orbital theory in the hydrogen molecule. Born-Oppenheimer approximation. Rotational, vibrational and electronic spectra in diatomic molecules. 3. Particle physics: Classification of elementary particles (quarks, leptons, gauge bosons) and fundamental interactions. Composite particles (hadrons), quark model. Masses, quantum numbers, conservation laws. Particle decays, production and detection. The nucleon, isospin. 4. Nuclear physics: Nucleus composition. Nuclear masses and sizes. Stability. Nuclear structure models. Nuclear decay and radioactivity. Reactions, fission and nuclear fusion.

Bibliography
- Basic bibliography: • Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, Robert Eisberg y Robert Resnick, Wiley (1985). • Física: Fundamentos Cuánticos y Estadísticos. Volumen III, Marcelo Alonso y Edward J. Finn, Addison Wesley (1976). • Fundamentos cuánticos de la estructura de la materia, O. Moreno, Ediciones Complutense (2025). • Física Cuántica, Carlos Sánchez del Río (coord.), Pirámide (2020). - Bibliography for specific areas: • Physics of atoms and molecules, B.H.Bransden, C.J.Joachain. Longman (1994). • Molecular Quantum Mechanics, P. W. Atkins. Oxford University Press (1989). • Atomic structure, G.K.Woodgate. McGraw Hill (1980). • Introducción a la Física de Átomos y Moléculas, F. Blanco Ramos. Amazon (2019). • Física Cuántica II, J. Retamosa. Alcuia (2010). • Nuclear and Particle Physics, W.S.C.Williams. Oxford Science Publications (1991). • Introductory Nuclear Physics, Kenneth S. Krane. Wiley (1987). • Quarks and Leptons: An Introductory Course in Modern Particle Physics, Francis Halzen y Alan D.

Martin, Wiley (1984).
 • Introduction to High Energy Physics, Donald H. Perkins. Cambridge University Press (2000).

Online Resources

UCM Virtual Campus

Methodology

The following training activities will be carried out:

- Theory lectures (using blackboard and beamer) where the main concepts of the subject will be explained, including examples and applications. The corresponding slides will be uploaded in the Virtual Campus in advance
- Exercise solving lectures (using blackboard). The corresponding exercise sheets will be uploaded in the Virtual Campus in advance

Evaluation Criteria

Exams

Weight:

80%

Final mark for the Exams section: N_{Exam} , ranging from 0 to 10.

The final exam will consist of a set of questions and/or problems.

Other Activities

Weight:

20%

Other assessment activities will consist of mid-term exams, problems solving, short essays or class engagement.

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

Final Mark

Final mark:

$$C_{\text{Final}} = \max \{ 0.8 N_{\text{Exam}} + 0.2 N_{\text{OtherActiv}}, N_{\text{Exam}} \}$$

The final mark criterion, as well as the mark corresponding to other activities, will be maintained in the exam of the extraordinary call.