COURSE DESCRIPTION

COURSE DETAILS

Title (of the course): **FÍSICA CUÁNTICA II**
Code: 100508
Degree/Master: **GRADO DE FÍSICA** Year: 3
Name of the module to which it belongs: FUNDAMENTOS CUÁNTICOS
Field: FÍSICA CUÁNTICA
Character: OBLIGATORIA Duration: SECOND TERM
ECTS Credits: 6.0 Classroom hours: 60
Face-to-face classroom percentage: 40.0% Study hours: 90
Online platform: https://moodle.uco.es/moodlemap

LECTURER INFORMATION

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COURSE DESCRIPTION

PREREQUISITES AND RECOMMENDATIONS

Prerequisites established in the study plan

B1 english certificate

Recommendations

Is recommended to have attended courses Mecánica y ondas I and II as well as Física Cuántica I.

Basic concepts such as energy, momentum, and angular momentum should be mastered. The student should know the Schrödinger equation and the foundations of Quantum Physics.

Furthermore, it is necessary to know in some depth the analytical formulation of Classical Mechanics, the concept of the Hamiltonian function and the Hamilton equations. An adequate level on these concepts may be found, for example, in the book Classical Dynamics of Particles and Systems, by the author Jerry B. Marion and published by Brooks/Cole.

With respect to the knowledge on the foundations of Quantum Physics, it is convenient to review the contents of the subject of Quantum Physics I, using any of the subject manuals.

It is also convenient to have knowledge of wave phenomena, such as interference, diffraction and to know concepts such as the intensity of a wave. As a particular case, it would be convenient for the student to know these concepts in the case of electromagnetic waves. A suitable level on the concepts of wave phenomena is found, for example, in the book Vibrations and Waves, by the author A. P. French and published by W. W. Norton & Company.

Regarding mathematical tools, students must have knowledge of Mathematical Analysis and Linear Algebra. Students must have knowledge of computing at the user level and the Internet, to be able to use the tools found on the subject page. Some programming knowledge would also be useful to solve small problems using the computer as a tool. Finally, it would be convenient for students to have scientific English knowledge.

INTENDED LEARNING OUTCOMES

CB1	Capacidad de análisis y síntesis
CB2	Organisational and planning skills
CB3	Oral and/or written communication.
CB4	Information management skills
CB5	Problem solving
CB6	Team work
CB7	Critical thinking
CB8	Autonomous learning
CB9	Creativity.
CE1	Knowledge and comprehension of the most important phenomena and theories in physics.
CE2	Ability to estimate orders of magnitude to interpret different phenomena
CE3	Ability to further apply mathematical knowledge in the context of general physics.
CE4	Ability to measure, interpret and design experiences both in and out of the laboratory
CE5	Ability to model complex phenomena, translating a physical problem into mathematical language.
CE7	Ability to present information in a clear way, both inside and out of the classroom.

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OBJECTIVES

- Solving the time-independent Schrödinger equation for one-dimensional systems.
- Know the quantum solution to the harmonic oscillator problem.
- Understanding how quantum theory includes classical mechanics as a particular limit.
- Know the quantum treatment of the Angular Momentum.
- Know the quantum solution to the two-bodies problem.
- Manage approximate methods.
- Know and handle the spin.

CONTENT

1. Theory contents

One-dimensional systems - The harmonic oscillator

- General considerations on the wave function in one-dimensional potentials
- The harmonic oscillator - Analytical solution
- Hermite polynomials - The parity operator
- Algebraic solution - Creation and annihilation operators
- Temporal evolution of a non-stationary state
- The classical limit of the harmonic oscillator

The classical limit - The WKB approximation

- The quasiclassic wave function
- The classical limit of the Schrödinger equation
- The WKB approximation
- Connection formulas
- Transmission through a barrier
- Bound states - Bohr-Sommerfeld quantization rule

Angular momentum in Quantum Mechanics

- The angular momentum operator - Spherical coordinates
- Commutation relations of angular momentum - Standard components of angular momentum
- Eigenvalue problem of angular momentum
- Eigenfunctions of angular momentum - Spherical Harmonics
- Physical considerations on angular momentum

The two-body problem in Quantum Mechanics - The hydrogen atom

- The two-body problem in quantum mechanics
- Hydrogen atom hamiltonian
- Radial equation solution - Laguerre polynomials
- Stationary states and energy levels of the hydrogen atom
- The hydrogen atom in a magnetic field
- Diamagnetism and paramagnetism - Zeeman effect

Approximate methods

COURSE DESCRIPTION

- Perturbation theory for steady states - Non-degenerate case
- Perturbation theory for degenerate stationary states
- Example: harmonic oscillator subjected to a constant force
- Application: the anharmonic oscillator
- Application: the Stark effect
- The variational method

The spin

- The Stern-Gerlach experiment - Intrinsic angular momentum
- Properties of spin 1/2 - Pauli matrices
- Non-relativistic theory of spin - Spinors
- Probabilities calculation using spinors

2. Practical contents

- Solving one-dimensional problems.
- Problems on the harmonic oscillator.
- Using of the WKB approach.
- Problems on angular momentum.
- Solving problems about the hydrogen atom.
- Calculate properties about the particle spin.
- Using approximate methods.

SUSTAINABLE DEVELOPMENT GOALS RELATED TO THE CONTENT

Unrelated

METHODOLOGY

General clarifications on the methodology (optional)

During the master classes, theoretical contents will be exposed and the participation of the students will be sought and assessed through questions.
In problem classes (called "Case study", which must not be confused with the assesment instrument with the samen name), a series of problems, that the students will know previously, will be solved.
Regarding the home work, different activities will be developed such as: information search, reference search, solving problems (called "activities"), assessment activities and personal study.

Methodological adaptations for part-time students and students with disabilities and special educational needs

For part-time students and students with disabilities and special educational needs, the necessary methodological and evaluation adaptations will be made, depending on the case and number of students. The teacher will meet the affected students to establish the most appropriate adaptations for each particular case, following the indications of the report issued by the Inclusive Education Unit.

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Face-to-face activities

Activity	Large group	Medium group	Total
Assessment activities	3	-	3
Case study	-	24	24
Lectures	33	-	33
Total hours:	***36***	***24***	***60***

Off-site activities

Activity	Total
Activities	20
Information search	10
Reference search	10
Self-study	50
Total hours	***90***

WORK MATERIALS FOR STUDENTS

Coursebook - *https://moodle.uco.es/moodlemap*
Exercises and activities - *https://moodle.uco.es/moodlemap*

Clarifications

All the information about the subject will be published in two different sites: in the UCO-Moodle platform: https://moodle.uco.es/moodlemap and in the WEB site http://www.uco.es/hbarra

EVALUATION

Intended learning	Case Studies	Exams	Problem solving
CB1	X	X	X
CB2	X		
CB3	X	X	
CB4	X		
CB5			X
CB6	X		

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Intended learning	Case Studies	Exams	Problem solving
CB7		X	X
CB8		X	X
CB9	X		
CE1	X	X	X
CE2		X	X
CE3		X	X
CE4		X	X
CE5		X	
CE7	X		
Total (100%)	***10%***	***80%***	***10%***
Minimum grade	***5***	***5***	***5***

(*)Minimum mark (out of 10) needed for the assessment tool to be weighted in the course final mark. In any case, final mark must be 5,0 or higher to pass the course.

Attendance will be assessed?:

No

General clarifications on instruments for evaluation:

Two types of evaluation are considered: Final and Continuous.
The final evaluation takes place in the final exam, which corresponds to 80% of the final grade. The final exam consists of two parts: Questions and Problems. For the grade of each part of the final exam to be taken into account when calculating the average grade of the exam, it must be at least a 4. In any case, the average grade of the exam must be at least a 5 for that grade to be considered in the calculation of the final grade.
Continuous assessment is carried out in Case Studies and Problem Solving. Each of these continuous assessment activities accounts for a 10% of the final grade. These two assessment instruments will be carried out throughout the semester. The teachers will propose different activities for each of these two instruments. The answers to the activities will be delivered to be evaluated. The grades obtained in these two activities will be conserved in all calls for the current academic year.

Clarifications on the methodology for part-time students and students with disabilities and special educational needs:

Given the variety and complexity of the cases of part-time students, the corresponding assessment adaptations of these students will be studied for each particular case.

Clarifications on the evaluation of the extraordinary call and extra-ordinary call for completion studies:

Students who take the "extraordinary call" or the "extraordinary call for completion of studies" will be evaluated according to the same criteria established in this guide. If there is no record of the grades obtained by the

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students in the continuous assessment instruments described in this teaching guide, the students will contact the teacher sufficiently in advance (at least 10 working days). to make the corresponding adaptations of the evaluation.

Qualifying criteria for obtaining honors:

Obtain at least a 9 on the exam mark

BIBLIOGRAPHY

1. Basic Bibliography

- C. Sánchez del Río, Física cuántica, Ed. Eudema Universidad, 1991.
- R. Eisberg y R. Resnick, Física cuántica, Ed. Limusa, 1994.
- R. Feynmann, R. B. Leighton y M. Sands, Física, Vol. III: Mecánica cuántica, Addison-Wesley Iberoamericana, 1987.
- H. Kroemer, Quantum mechanics, Ed. Prentice Hall, 1994.
- D. Park, Introduction to the quantum theory, Ed. McGraw-Hill, 1992. - P. Pereyra Padilla, Fundamentos de Física Cuántica, Ed. Reverté,2011.
- N. Zettili, Quantum Mechanics: Concepts and Applications. John Wiley & Sons (2009)

2. Further reading

- D. Bohm, Quantum theory, Ed. Dover, 1989.
- C. Cohen-Tannoudji, B. Diu y F. Laloë, Quantum mechanics, Ed. Johm Wiley & Sons, 1977.
- P. A. M. Dirac, Principios de mecánica cuántica, Ediciones Ariel, 1968.
- A. Galindo y P. Pascual, Mecánica cuántica, E. Eudema Universidad, 1989.
- E. Merzbacher, Quantum mechanics, Ed. Johm Wiley & Sons, 1970.
- A. Messiah, Mecánica cuántica, Ed. Tecnos, 1983.
- I. Schiff, Quantum mechanics, Ed. McGraw-Hill, 1968.
- F. J. Yndurain, Mecánica cuántica, Ed. Alianza, 1988.

COORDINATION CRITERIA

Joint activities: lectures, seminars, visits ...
Tasks deadlines
Tasks performance

SCHEDULE

Period	Assessment activities	Case study	Lectures
1# Week	0,0	0,0	3,0
2# Week	0,0	0,0	3,0
3# Week	0,0	0,0	3,0

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Period	Assessment activities	Case study	Lectures
4# Week	0,0	2,0	3,0
5# Week	0,0	2,0	3,0
6# Week	0,0	2,0	3,0
7# Week	0,0	2,0	3,0
8# Week	0,0	2,0	2,0
9# Week	0,0	2,0	2,0
10# Week	0,0	2,0	2,0
11# Week	0,0	2,0	2,0
12# Week	0,0	2,0	2,0
13# Week	0,0	2,0	2,0
14# Week	0,0	2,0	0,0
15# Week	3,0	2,0	0,0
Total hours:	***3,0***	***24,0***	***33,0***

The methodological strategies and the evaluation system contemplated in this Course Description will be adapted according to the needs presented by students with disabilities and special educational needs in the cases that are required.