# 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: http://www.uco.es/hbarra y Moodle

## LECTURER INFORMATION

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# COURSE DESCRIPTION

## PREREQUISITES AND RECOMMENDATIONS

**Prerequisites established in the study plan**

None

**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. |

# COURSE DESCRIPTION

## 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-body problem.
- Manage approximate methods.
- Handle the spin.

## CONTENT

### 1. Theory contents

- One-dimensional systems
- Harmonic oscillator.
- Classical limit. The WKB approach.
- Angular momentum in quantum mechanics.
- Two-body problem. The hydrogen atom.
- Approximate methods.
- The spin.

### 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.
- Using approximate methods.

## 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. After each unit, a discussion session will be held on the concepts learned. In the seminars some practical situations will be analyzed in detail. During the practical classes devoted to problems, a series of problems will be solved that the students will know beforehand. Some will be solved entirely by the teacher and others partially or totally by the students. Regarding the home work, different activities will be developed such as: solving exercises and problems, searching information for discussion sessions and personal study.

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

The methodological adaptations for part-time students and students with disabilities will be decided in meetings between the teachers and interested students in order to personalize the possible cases that arise.

# COURSE DESCRIPTION

### Face-to-face activities

| Activity | Large group | Medium group | Total |
|---|---|---|---|
| *Assessment activities* | 3 | - | 3 |
| *Case study* | - | 15 | 15 |
| *Lectures* | 33 | - | 33 |
| *Seminar* | - | 9 | 9 |
| ***Total hours:*** | ***36*** | ***24*** | ***60*** |

### Off-site activities

| Activity | Total |
|---|---|
| *Exercises* | 35 |
| *Information search* | 5 |
| *Reference search* | 10 |
| *Self-study* | 40 |
| ***Total hours*** | ***90*** |

## WORK MATERIALS FOR STUDENTS

Coursebook
Exercises and activities

### Clarifications

All the information about the subject will be published on the Moodle platform

## EVALUATION

| Intended learnig | Case Studies | Exams | Problem solving |
|---|---|---|---|
| *CB1* | X | X | X |
| *CB2* | X | | X |
| *CB3* | X | X | |
| *CB4* | X | | |
| *CB5* | | | X |

# COURSE DESCRIPTION

| Intended learnig | Case Studies | Exams | Problem solving |
|---|---|---|---|
| *CB6* | X | | |
| *CB7* | | X | X |
| *CB8* | | X | X |
| *CB9* | X | | |
| *CE1* | X | X | X |
| *CE2* | | X | X |
| *CE3* | | X | X |
| *CE4* | | X | X |
| *CE5* | | X | X |
| *CE7* | | X | |
| ***Total (100%)*** | ***10%*** | ***80%*** | ***10%*** |
| ***Minimum grade*** | ***5*** | ***4*** | ***5*** |

(*)Minimum grade necessary to pass the course

**¿Valora la asistencia?:**

*No*

**General clarifications on instruments for evaluation:**

80% of the mark corresponds to the exam, in which questions and problems will be raised. The remaining 20% of the evaluation corresponds to continuous evaluation. Of this percentage, 10% corresponds to solving problems proposed by the teachers and which the students will have to submit in writing. The other 10% corresponds to the work done in the seminar sessions. As it is essential to pass the exam to pass the subject, in the case where the exam grade is less than 4, this grade will be the final grade for the course.

**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.

**Qualifying criteria for obtaining honors:**

*Have obtained at least 9 on the mark of the exam*

# COURSE DESCRIPTION

## BIBLIOGRAPHY

**1. Basic Bibliography**

- R. Eisberg and R. Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles ,John Wiley & Sons Inc, 1985.
- R. Feynmann, R. B. Leighton and M. Sands, Feynmann Lectures On Physics - Vol. 3: Quantum Mechanics, Addison Wesley Publishing Company, 2005.
- 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, Ed. Wiley, 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.
- E. Merzbacher, Quantum mechanics, Ed. Johm Wiley & Sons, 1970.
- I. Schiff, Quantum mechanics, Ed. McGraw-Hill, 1968.

## COORDINATION CRITERIA

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

## SCHEDULE

| Period | Assessment activities | Case study | Lectures | Seminar |
|---|---|---|---|---|
| *1# Fortnight* | 0,0 | 3,0 | 5,0 | 0,0 |
| *2# Fortnight* | 0,0 | 2,0 | 5,0 | 0,0 |
| *3# Fortnight* | 0,0 | 2,0 | 5,0 | 3,0 |
| *4# Fortnight* | 0,0 | 2,0 | 5,0 | 0,0 |
| *5# Fortnight* | 0,0 | 2,0 | 5,0 | 3,0 |
| *6# Fortnight* | 0,0 | 2,0 | 4,0 | 0,0 |
| *7# Fortnight* | 3,0 | 2,0 | 4,0 | 3,0 |
| **Total hours:** | ***3,0*** | ***15,0*** | ***33,0*** | ***9,0*** |

# COURSE DESCRIPTION

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.

## CONTINGENCY PLAN: CASE SCENARIO A

Case scenario A will correspond to a diminished on-site academic activity due to social distancing measures affecting the permitted capacity of classrooms.

## METHODOLOGY

**General clarifications on the methodology on case scenario A**

A multimodal (hybrid) teaching system will be adopted, combining both on-site and remote classes via videoconference (synchronous) that will be held in the timetable approved by the corresponding Faculty or School. The time distribution of teaching activities (both on-site and remote) will be decided by the aforementioned Faculties and Schools bearing in mind the permitted capacity of classrooms and social distancing measures as established at that time.

During the master classes, theoretical contents will be exposed and the participation of the students will be sought and assessed through questions. After each unit, a discussion session will be held on the concepts learned.

If the class takes place at the Campus, it will have the usual character described in the previous paragraph. If the class is conducted by videoconference, an attempt will be made to emulate the traditional class but using the appropriate technological tools to maintain the attention of the students; efforts will be made to use computer tools to provoke student participation in the class.

In the seminars some practical situations will be analyzed in detail. During the practical classes devoted to problems, a series of problems will be solved that the students will know beforehand. Some will be solved entirely by the teacher and others partially or totally by the students.

Regarding the home work, different activities will be developed such as: solving exercises and problems, searching information for discussion sessions and personal study.

# COURSE DESCRIPTION

## EVALUATION

| Intended learnig | Case Studies | Exams | Problem solving |
|---|---|---|---|
| *CB1* | X | X | X |
| *CB2* | X | | X |
| *CB3* | X | X | |
| *CB4* | X | | |
| *CB5* | | | X |
| *CB6* | X | | |
| *CB7* | | X | X |
| *CB8* | | X | X |
| *CB9* | X | | |
| *CE1* | X | X | X |
| *CE2* | | X | X |
| *CE3* | | X | X |
| *CE4* | | X | X |
| *CE5* | | X | X |
| *CE7* | | X | |
| ***Total (100%)*** | ***20%*** | ***60%*** | ***20%*** |
| ***Minimum grade*** | ***4*** | ***4*** | ***4*** |

(*)Minimum grade necessary to pass the course

**Attendance will be assessed (Scenario A)?:**

*No*

**General clarifications on instruments for evaluation (Scenario A):**

60% of the mark corresponds to the exam, in which questions and problems will be raised. The exam will take place at the Campus, whenever the health situation allows it. Otherwise, it will be done using the Synchronous tests via videoconference tool.

The remaining 40% of the evaluation corresponds to continuous evaluation. Of this percentage, 20% corresponds to solving problems proposed by the teachers and which the students will have to submit in writing. The other 20% corresponds to the work done in the seminar sessions. As it is essential to pass the exam to pass the subject, in the case where the exam grade is less than 4, this grade will be the final grade for the course.

In the final exam, the student will be able to retrieve those unperformed continuous evaluation tests, as long as they have been submitted to them in the school period.

## COURSE DESCRIPTION

In the extraordinary call (September-October) the same assessment and weighting instruments will be considered, but those qualifications obtained by the student in the assessment tests passed will be retained.

**Clarifications on the methodology for part-time students and students with disabilities and special educational needs (Scenario A):**

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.

**Qualifying criteria for obtaining honors (Scenario A):**

*Have obtained at least 9 on the mark of the exam*

## CONTINGENCY PLAN: CASE SCENARIO B

Case scenario B will bring about a suspension of all on-site academic activities as a consequence of heath measures.

## METHODOLOGY

**General clarifications on the methodology on case scenario B**

On-site teaching activities will be held via videoconference (synchronous) in the timetable approved by the corresponding Faculty or School. Alternative activities will be proposed for reduced groups in order to guarantee the acquisition of course competences.

The theoretical master classes will be conducted by videoconference. The theoretical contents will be exposed and the participation of the students will be sought and assessed. An attempt will be made to emulate the traditional class but using the appropriate technological tools to maintain the attention of the students; efforts will be made to use computer tools to provoke student participation in the class.

In the seminars some practical situations will be analyzed in detail by videoconference. During the practical classes devoted to problems, a series of problems will be solved that the students will know beforehand. Some will be solved entirely by the teacher and others partially or totally by the students.

Regarding the home work, different activities will be developed such as: solving exercises and problems, searching information for discussion sessions and personal study.

# COURSE DESCRIPTION

## EVALUATION

| Intended learnig | Case Studies | Exams | Problem solving |
|---|---|---|---|
| *CB1* | X | X | X |
| *CB2* | X | | X |
| *CB3* | X | X | |
| *CB4* | X | | |
| *CB5* | | | X |
| *CB6* | X | | |
| *CB7* | | X | X |
| *CB8* | | X | X |
| *CB9* | X | | |
| *CE1* | X | X | X |
| *CE2* | | X | X |
| *CE3* | | X | X |
| *CE4* | | X | X |
| *CE5* | | X | X |
| *CE7* | | X | |
| ***Total (100%)*** | ***20%*** | ***60%*** | ***20%*** |
| ***Minimum grade*** | ***4*** | ***4*** | ***4*** |

(*)Minimum grade necessary to pass the course

| Moodle Tools | Estudio de casos | Exámenes | Resolución de problemas |
|---|---|---|---|
| *Pruebas simultáneas por videoconferencia* | | X | |
| *Tarea* | X | | X |
| *Videoconferencia* | X | | X |

**Attendance will be assessed (Scenario B)?:**

*No*

# COURSE DESCRIPTION

**General clarifications on instruments for evaluation (Scenario B):**

60% of the mark corresponds to the exam, in which questions and problems will be raised. The exam will take place at the Campus, whenever the health situation allows it. Otherwise, it will be done using the Synchronous tests via videoconference tool.

The remaining 40% of the evaluation corresponds to continuous evaluation. Of this percentage, 20% corresponds to solving problems proposed by the teachers and which the students will have to submit in writing using the Task tool. The participation in the videoconference will also be used in the evaluation. The other 20% corresponds to the work done in the seminar sessions. The work will be submitted through the Task tool. As well, the participation in the video conference will be used in the evaluation. As it is essential to pass the exam to pass the subject, in the case where the exam grade is less than 4, this grade will be the final grade for the course.

In the final exam, the student will be able to retrieve those unperformed continuous evaluation tests, as long as they have been submitted to them in the school period.

In the extraordinary call (September-October) the same assessment and weighting instruments will be considered, but those qualifications obtained by the student in the assessment tests passed will be retained.

**Clarifications on the methodology for part-time students and students with disabilities and special educational needs (Scenario B):**

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.

**Qualifying criteria for obtaining honors (Scenario B):**

*Have obtained at least 9 on the mark of the exam*