COURSE DATA

DATA SUBJECT

Code: 34273
Name: Atomic and radiation physics
Cycle: Undergraduate Studies
ECTS Credits: 4.5
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
1105 - Degree in Physics	Facultat de Física	4	Second quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
1105 - Degree in Physics	Complements of Physics	ELECTIVES

COORDINATION

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SUMMARY

Atomic and Radiation Physics is a subject that is taught on an optional basis in the 2nd quarter of the 4th year of undergraduate studies in Physics. It comprises a total of 4.5 ECTS 3 ECTS of which are theoretical and theoretical-practical 1.5 ECTS (problem solving). This subject matter is part of Complements of Physics and enable students to supplement their knowledge of Atomic and Nuclear Physics.

It is intended that the student after the course to obtain a thorough knowledge of atomic and ionizing radiation. This is studied first, atomic structure and behavior of atoms in magnetic fields, then we study the modes of interaction of radiation with matter. Finally, we present the most important technological applications of radiation physics.

Different disciplines such as medical physics, nuclear physics or particle physics, require knowledge of Atomic Physics and Radiation, so this course is particularly recommended for students wishing to specialize in one of these branches Physics.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

To take this subject, knowledge of Quantum Physics I, Mathematical Analysis, Mechanics and Electromagnetism is recommended. Other subjects as Quantum Physics II and Nuclear and Particle Physics are convenient to deepen into certain aspects of this subject, although not indispensable. The Nuclear Instrumentation subject can be studied simultaneously.

COMPETENCES / LEARNING OUTCOMES

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Ability to collect and interpret relevant data in order to make judgements.

Basic & applied Research: acquire an understanding of the nature and ways of physics research and of how physics research is applicable to many fields other than physics, e.g. engineering; be able to design experimental and/or theoretical procedures for: (i) solving current problems in academic or industrial research; (ii) improving the existing results.

Communication Skills (written and oral): Being able to communicate information, ideas, problems and solutions through argumentation and reasoning which are characteristic of the scientific activity, using basic concepts and tools of physics.

Foreign Language skills: Have improved command of English (or other foreign languages of interest) through: use of the basic literature, written and oral communication (scientific and technical English), participation in courses, study abroad via exchange programmes, and recognition of credits at foreign universities or research centres.

Knowledge and understanding of the fundamentals of physics in theoretical and experimental aspects, and the mathematical background needed for its formulation.

Learning ability: be able to enter new fields through independent study, in physics and science and technology in general.

Literature Search: be able to search for and use physical and other technical literature, as well as any other sources of information relevant to research work and technical project development.

Modelling & Problem solving skills: be able to identify the essentials of a process / situation and to set up a working model of the same; be able to perform the required approximations so as to reduce a problem to an approachable one. Critical thinking to construct physical models.

Physics general culture: Be familiar with the most important areas of physics and with those approaches which span many areas in physics, or connections of physics with other sciences.

Problem solving: be able to evaluate clearly the orders of magnitude in situations which are physically different, but show analogies, thus allowing the use of known solutions in new problems .

Students must be able to apply their knowledge to their work or vocation in a professional manner and have acquired the competences required for the preparation and defence of arguments and for problem solving in their field of study.

Students must be able to communicate information, ideas, problems and solutions to both expert and lay audiences.

Students must have acquired knowledge and understanding in a specific field of study, on the basis of general secondary education and at a level that includes mainly knowledge drawn from advanced textbooks, but also some cutting-edge knowledge in their field of study.

Students must have developed the learning skills needed to undertake further study with a high degree of autonomy.

Students must have the ability to gather and interpret relevant data (usually in their field of study) to make judgements that take relevant social, scientific or ethical issues into consideration.

To know how to apply the knowledge acquired to professional activity, to know how to
solve problems and develop and defend arguments, relying on this knowledge.

DESCRIPTION OF CONTENTS

1. The atom an its components

Atoms and molecules.
Atomic weights.
Avogadro's number.
The components of the atom. The electron.
The components of the atom. The nucleus.
The photon.
Atomic spectra.
Bohr's model
X-Ray Spectrum. Moseley's Law.
Atomic magnetism

2. Single electron atoms

General.
Coulombian potential
The free Dirac equation.
Dirac's equation in an em field.
Dirac's equation at a central potential.
Selection rules.
The Lamb effect.
Exotic atoms

3. Multielectronic atoms

Hamiltonian of complex atoms.
Shielding. Effective charge penetration.
Noble gases.
Alkaline atoms.
Two-electron atoms (He).
Alkaline-earth atoms.
Trivalent atoms.
Transition metals.
Rare earths. Lanthanides and actinides.
Hartree and Hartree-Fock method.
Solve the complete Hamiltonian. LS and jj couplings.

4. Atoms in electric and magnetic fields

Stark effect.
Normal Zeeman effect.
Paschen-Back effect.
Anomalous Zeeman effect.
General Zeeman effect.

5. Hyperfine structure

Hyperfine structure.
Magnetic dipole hyperfine structure.
Applications of the hyperfine structure.

6. Charged particle interaction with matter

Radiation-matter interaction
Energy loss mechanisms
Maximum energy transfer in a collision
Stopping power

7. Neutron interaction with matter

Neutron sources
Neutron classification
Interactions with matter
Elastic dispersion
Inelastic dispersion.

8. Photon interaction with matter

Processes of interaction of photons with matter
Fluence
Photon cross section
Coherent scatter
Compton effect.
Photoelectric effect
Pair production
Attenuation coefficients
Energy absorption

9. Radiation dosimetry

Magnitudes and units for ionizing radiation
Time frame of radiation effects
Physical and chemical effects in irradiated wáter
Examples of traces of charged particles in wáter
Biological effects and cellular damage
Tracks and DNA
Effects of radiation on humans
Radiotherapy
Dosimetric quantities: equivalent and effective dose
Operational magnitudes
Dose limits

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Theory	45,00
Total hours	**45,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	2,00
Individual or group project	0,00
Independent study and work	10,00
Preparation of lessons	45,50
Preparation for assessment activities	10,00
Resolution of case studies	0,00
Total hours	**67,50**

TEACHING METHODOLOGY

The course has two parts with a distinct methodology:

- Theory classes. There will be classes, usually seminars, where the professor will present the contents of the subject listed above. The use of new technologies (electronic filing) is especially appropriate for much of the presentations, given its high content of presenting graphical diagrams, charts, tables, Photographs of experimental devices and practical applications, and all kinds of visual material that allows the student to relate the content with their applications. The use of literature is essential to understand the contents and the objectives of the course. The teacher will offer this material to students (directly or through the Virtual Classroom platform) prior to the beginning of each topic.
- Practical classes. In the lab weekly solve problems for each topic of the course. Professor previously delivered a collection of problems in each chapter, either directly or through the Virtual Classroom. Not all exercises will be solved, some of them will be left for the students to do as part of their personal preparation of the subject.

This structure is intended to serve as practical classes practical illustration of techniques and procedures presented in the lectures, and provide a professional training, raising issues and problems such that, as far as possible, make reference to real life situations as possible.

EVALUATION

The evaluation systems are the following:

1. Written exams: one part will assess the understanding of the theoretical-conceptual aspects and the formalism of the subject, both through theoretical questions and through conceptual and numerical questions or simple particular cases. Another part will assess the ability to apply formalism, through problem solving, as well as the critical ability regarding the results obtained. In both parts, correct argumentation and adequate justification will be valued (70%).

2. Continuous evaluation: assessment of work and problems presented by students, questions proposed and discussed in the classroom, oral presentation of solved problems or any other method that involves interaction between teachers and students (30%).

The grade will correspond to the maximum value of either the exam grade or the sum of the grade from said exam together with the continuous assessment grade applying the weighting factors indicated above. In any case, a minimum score of 4 out of 10 must be obtained in the exam.

These evaluation criteria are common to the first and second calls.

REFERENCES

- James E. Turner, Atoms, radiation and radiation protection , Wiley-VDH, 3rd. ed.
- B. H. Bransden, C.J. Joachain, Physics of atoms and molecules, Prentice-Hall, 2nd ed.
- E. B. Podgorsak, Radiation Physics for Medical Physicists, Springer, 2nd ed.
- H. Haken, H.C. Wolf, The Physics of Atoms and Quanta, Springer, 6th ed.