1. OVERVIEW

Subject area	Nuclear and Particle Physics
Degree	Bachelor's Degree in Physics
School/Faculty	School of Architecture, Engineering and Design
Year	Fourth
ECTS	6 ECTS
Type	Compulsory
Language(s)	Spanish
Delivery mode	On campus
Semester	Second semester

2. INTRODUCTION

Particle physics is a discipline that describes fundamental units of matter and their interactions. Since the 20th century, new milestones have gradually been achieved, such as the discovery of different types of radioactivity and new particles. Some of these particles were initially thought to be elementary but later found to be compounds thanks to the design of experiments that revealed new fundamental units and improved our understanding and application of atomic nuclei.

The study of elementary particles and atomic nuclei beyond the realms of academia, such as the study of fundamental processes in astrophysics, has had a major impact in the energy, weapons and biomedicine industries, making both the theory and application of this subject area especially interesting.

3. SKILLS AND LEARNING OUTCOMES

General skills (CG, by the acronym in Spanish):

- CG1. To understand key concepts, methods and findings in the different branches of physics while gaining a historical perspective of their development.
- CG5. To understand diverse phenomena that, despite being physically different, share certain similarities, allowing known solutions to be applied to new problems.

Key skills (CB, by the acronym in Spanish):

- CB4. Students can communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
- CB5. Students have developed the learning skills necessary to undertake further study in a much more independent manner.

Transversal skills (CT, by the acronym in Spanish):

- CT5. Problem solving: Be able to critically evaluate information, separate complex situations into their constituent parts, recognise patterns, and consider alternatives, different approaches and perspectives in order to find optimal solutions and negotiate efficiently.

Specific skills (CE, by the acronym in Spanish):

- CE01. To estimate orders of magnitude in order to interpret diverse phenomena.
- CE02. To describe and analyse physical systems, identifying fundamental concepts and principles to make the approximations needed to build a simplified model.
- CE04. To understand the laws and principles of physics, to identify their logical and mathematical structure, their experimental basis and the phenomena described through them.
- CE09. To understand the processes for obtaining materials and the physical fundamentals and uses of materials.

Learning outcomes (RA, by the acronym in Spanish):

- RA1. To identify the composition of an atomic nucleus and its elementary particles, and to explain their interactions and associated laws.
- RA2. To distinguish between different types of nuclear reactions and to analyse the processes of radioactive decay and the properties of decay chains. RA3. To explain stellar evolution and the synthesis of elements.

The following table shows how the skills developed in the subject area match up with the intended learning outcomes:

Skills	Learning outcomes
CG1, CG5, CB4, CB5, CT5, CE01, CE02, CE04.	**RA1**. To identify the composition of an atomic nucleus and its elementary particles, and to explain their interactions and associated laws.
CG1, CB4, CB5, CT5, CE01, CE02, CE04, CE09.	**RA2.** To distinguish between different types of nuclear reactions and to analyse the processes of radioactive decay and the properties of decay chains.
CG1, CB4, CB5, CE01, CE02, CE04.	**RA3.** To explain stellar evolution and the synthesis of elements.

4. CONTENTS

This subject is organised into learning units.

Unit 1. Structure of the nucleus and elementary particles.

- 1.1. Classification of subatomic particles. Interactions. Feynman diagrams.
- 1.2. Conservation laws. 1.3. Nuclear models.

Unit 2. Nuclear reactions. Radioactive decay and radioactivity.

- 2.1. Cross sections, probability of decay, kinematics and balances. 2.2. Types of radioactivity.

Unit 3. Interaction of radiation with matter.

- 3.1. Charged particle interaction and penetration.
- 3.2. Photon interaction and penetration. 3.3. Biological effects.

Unit 4. Applications of nuclear physics.

- 4.1. Nuclear power plants. Prospects for nuclear power as an energy source.
- 4.2. Nuclear weapons. 4.3. Biomedicine.

Unit 5. Astrophysics: stellar evolution and synthesis of elements.

- 5.1. Proton–proton chain.
- 5.2. Carbon–Nitrogen–Oxygen cycle.

- 5.3. Triple-alpha process.

5. TEACHING/LEARNING METHODS

The types of teaching/learning methods are as follows:

- Collaborative learning: Students learn to collaborate with other people (classmates and professors) in order to find creative, comprehensive and constructive solutions to questions and problems that arise from the given case studies, using all relevant knowledge and material resources available.
- Problem-based learning: Students are given problems and asked to solve them, working individually or in groups.
- Lectures: Presentations by the professor with the necessary technological tools to maximise comprehension of the learning content.
- Guided academic activities: Individual and group work that is more independent, including information searches, written summaries, debates and the public defence of projects.

6. LEARNING ACTIVITIES

The types of learning activities, plus the amount of time spent on each activity, are as follows:

On campus:

Learning activity	Number of hours
Lectures	18
Asynchronous lectures	12
Oral presentations of projects and debates	6
Report writing	18
Assessment	6
Practical activities (problems, written work, projects, workshops and/or lab work)	30
Group tutorials	10
Independent working	50
TOTAL	**150**

7. ASSESSMENT

The assessment systems, plus their weighting in the final grade for the subject area, are as follows:

On campus:

Assessment system	Weighting
Individual on-campus knowledge tests (theory and/or practice)	50%
Oral defence	5%
Submission of group and/or individual reports, written work, projects or exercises	35%
Performance observation	10%

On the Virtual Campus, when you open the subject area, you'll find details of your assessable tasks, including the submission dates and assessment procedures for each task.

8. BIBLIOGRAPHY

The reference material for the subject area is as follows:

- Sánchez del Río, C. (2020). *Física Cuántica*. Editorial Pirámide. Madrid.
- Martin, Brian R. y Shaw, G. (2019). *Nuclear and Particle Physics: An Introduction*. Editorial Wiley.

The recommended bibliography is indicated below:

- Fernández Álvarez-Estrada, R., Ramón Medrano, M. y Llanes Estrada, Felipe J. (2018). *Partículas elementales: Una vía hacia el cosmos.* Editorial Pirámide.