# 1. OVERVIEW

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|---|---|
| **Subject area** | Core Experimental Techniques |
| **Degree** | Bachelor's Degree in Physics |
| **School/Faculty** | School of Architecture, Engineering and Design |
| **Year** | 1 |
| **ECTS** | 6 |
| **Type** | Core |
| **Language(s)** | Spanish |
| **Delivery mode** | On campus |
| **Semester** | 2 |

# 2. INTRODUCTION

**Core Experimental Techniques** is the first of four practical subject areas on the Bachelor's Degree in Physics. The main aim is to help students build a solid foundation in core aspects of experimentation in physics.

Through simple experiments associated with different areas of knowledge, students will uncover the experimental grounding of some of the main laws of physics. Students will become familiar with the most important experimental techniques in physics, the gathering of scientific data, the drawing of conclusions based on the physical principles involved, the statistical analysis of data and calculation of errors. To complement this training, students will learn to use the most relevant computer programs to process data and perform numerical analysis, such as Origin or SciDavis.

Throughout the course, students will need to take a rigorous approach to scientific notation, the handling of orders of magnitude and units and the presentation of results in high-quality scientific/technical reports. These concepts will be put into practice in pre-designed laboratory experiments. Working in groups, students will need to obtain data in a rigorous manner and to describe, analyse and critically assess the results of their experiments. The organisation of results and extraction of conclusions, calculation of errors associated with means and analysis of the uncertainty and reliability of results will all play a key role. Students will write reports on measurement processes, collected data, indirect measurements and results analysis. The subject area will allow students to consolidate their knowledge of scientific methodology and achieve a better, more in-depth understanding of lab-based subject areas later in the degree.

# 3. SKILLS AND LEARNING OUTCOMES

**Basic skills and general skills (CB and CG, respectively, by their 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.
- **CG2** - Ability to plan and perform independent work when managing projects associated with different areas of physics.
- **CG4** - To convey knowledge, procedures, results and scientific ideas in the field of physics, both orally and in writing.

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

- **CT1** - *Ethical values:* Ability to think and act in line with universal principles based on the value of individuals, contributing to their development and involving commitment to certain social values.
- **CT2** - *Independent learning*: A range of skills in order to choose research, analysis, evaluation and information management strategies from different sources, as well as to learn and put into practice what has been learnt independently.
- **CT3** - *Teamwork:* Ability to integrate and collaborate actively with other people, areas and/or organisations to reach common goals.
- **CT4** - *Written communication/Oral communication:* Ability to communicate and gather information, ideas, opinions and viewpoints in order to understand and be able to act upon them, whether they are through spoken word and gestures, or through written word and/or visual aids.
- **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.
- **CT6** - *Adaptability:* Being able to accept, appreciate and integrate different positions, being able to adapt one's own approach as required by the situation, as well as working effectively in ambiguous situations.
- **CT7** - *Leadership*: To be able to direct, motivate and guide others, recognising their skills and abilities in order to effectively manage their development and common interests.
- **CT8** - *Entrepreneurial spirit*: Ability to take on and carry out activities that generate new opportunities, anticipate problems or bring about improvements.

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

- **CE01** - To estimate orders of magnitude in order to interpret diverse phenomena.
- **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.
- **CE05** - To understand and know how to use the mathematical and numerical methods used in physics and in handling experimental data.
- **CE06** - To understand key experimental models and to perform experiments independently, describing, analysing and critically assessing experimental data.
- **CE07** - To use the most suitable electronic instruments and IT tools to study physical problems and search for solutions.

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

- **RA1** - To know how to conduct a descriptive analysis based on a data set.
- **RA2** - To rigorously analyse and discuss experimental data obtained in a laboratory.
- **RA3** - To be able to design and conduct simple experiments that demonstrate the basic principles of different areas of classical physics.
- RA4 - To follow measurement-taking protocols, especially those concerning the safety of the person conducting the experiment.

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

| Skills | Learning outcomes |
| --- | --- |
| **CB5, CG4, CT2, CT4, CT5, CE01, CE05, CE06** | **RA1**. To know how to conduct a descriptive analysis based on a data set. |
| **CB4, CB5, CG2, CG4, CT1, CT2, CT3, CT4, CT5, CT6, CE01, CE04, CE05, CE06** | **RA2**. To rigorously analyse and discuss experimental data obtained in a laboratory. |
| **CB5, CT2, CT3, CT7, CT8, CE04, CE06, CE07** | **RA3**. To be able to design and conduct simple experiments that demonstrate the basic principles of different areas of classical physics. |
| **CB5, CG2, CT1, CT3, CE04, CE06, CE07** | **RA4**. To follow measurement-taking protocols, especially those concerning the safety of the person conducting the experiment. |

# 4. CONTENTS

The theoretical content of this subject area is as follows:

- **Types of measuring tools and types of experimental uncertainty.**
- **Rounding and statistical data processing. Normal distribution.**
- **Obtaining data through linearisation. Method of least squares.**

This content is learnt through practical activities on the following topics:

- **Mechanics and waves.**
  Simple pendulum, standing waves on a string, standing waves in a tube, Hooke's law, projectile motion, free fall, centrifugal force, conservation of linear momentum, standing waves in a spring, moments of inertia and Steiner's theorem.

- **Fluids.**
  Bernoulli's equation, Archimedes' principle, Reynolds number, surface tension.

- **Electricity and magnetism.**
  Magnetic fields in coils and solenoids, electromagnetic induction, equipotentials, Coulomb's law, determining the dielectric constant, transformers, measuring the Earth's magnetic field, capacitance of a conducting sphere, capacitor connection.

## 5. TEACHING/LEARNING METHODS

The types of teaching/learning methods used throughout the subject area are as follows:

- **Case studies**: Discussion of real cases that allow for practical application of the acquired theoretical knowledge.
- **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.
- **Project-based learning**: Geared towards the completion of projects similar to those found in real work environments. This involves following a methodology to complete the project and choosing between different alternatives.
- **Lectures**: Presentations by the professor with the necessary technological tools to maximise comprehension of the learning content.
- **Workshop-based learning**: Students acquire knowledge through learning to use the tools and equipment needed in their profession. In other words, "learning by doing".
- **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:**

This is a lab-based subject area; therefore, **the only delivery mode is on campus**. The types of learning activities, plus the amount of time spent on each activity, are as follows:

| Learning activity | Number of hours |
|---|---|
| Lectures | 6 |
| Oral presentations of projects and debates | 4 |
| Report writing | 40 |
| Assessment | 4 |
| Practical activities (lab work, guided tours). These will be lab-based experiment sessions. This practical learning will be complemented by visits to external research centres, time permitting. | 28 |
| Tutorials | 16 |
| Independent working | 52 |

| 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 |
|---|---|
| **On-campus knowledge tests**<br>At the end of the semester, students will sit a final exam with questions about the theory of the subject area and the lab work. Students must pass the exam to pass the subject area. | 10% |
| **Submission of group reports**<br>Students will comment on each completed practical activity with their professor before starting the next activity. This is when they will be awarded 60% of the grade for the practical activity. Before returning to the laboratory, they must have uploaded a report on the previous practical activity, considering the feedback from the professor. This report accounts for the remaining 40% of the grade. The average of the grade for the practical activities will be the definitive grade for this section, and it will account for 50% of the final grade. | 50%<br>(60% commentary + 40% report) |
| **Oral defence**<br>Students will give an oral presentation about one of their practical activities. The format of the presentation will be specified at the start of the subject area. | 20% |
| **Performance**<br>The members of each group will assess between them the individual performance of each member. Based on this group assessment, the group members must assign grades to each member in such a way that the average of these grades is the group average. If it does not coincide or no grades are assigned, each student will be given the group grade minus two points. | 20% |

**IMPORTANT**: **The lab-based activities are an essential part of the student´s training, and the delivery mode is strictly on-campus.** As such, if students do not come to the laboratory to complete the practical activities, they will not achieve the minimum learning outcomes and, therefore, they will not pass the subject area. As such, **if any student misses more than two lab sessions without due cause (28% of the total hours of on-campus practical activities), they can neither pass the subject area in the ordinary nor the extraordinary exam period.**

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.

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# 8. BIBLIOGRAPHY

The reference material for the subject area is as follows:


- Taylor J. R., **An introduction to error analysis**, University Science Books (1997).
- E. Bright Wilson, **An introduction to scientific research**, 1ª edición, McGraw-Hill, 1952
- D.C. Baird, **Experimentation: An Introduction to Measurement Theory and Experiment Design**, 3ª edición, Prentice Hall, 1995


A continuación, se indica bibliografía recomendada:


- H.D. Young, R.A. Freedman, F.W. Sears y M.W. Zemansky, **Física universitaria**, Vol. 1 y 2. 12ª ed. Pearson Education (2013).
- D. C. Giancoli, **Physics: Principles and applications**, 7ª ed. Pearson Education (2014).
- P.A. Tipler y G. Mosca, **Física para la Ciencia y la Tecnología**, Vol. 1 y 2. 6ª ed. Ed. Reverté (2010). • M. Alonso y E.J. Finn, **Física**. Addison-Wesley Iberoamericana (1995).