COURSE GUIDE

Basic Experimental Techniques (2671113)

Approval date: 19/06/2023

Grado (Bachelor's Degree)	Grado en Física	Branch	Sciences
Module	Formación Básica	Subject	Física

Year of study	1º	Semester	2º	ECTS Credits	6	Course type	Core course

PREREQUISITES AND RECOMMENDATIONS

Not required as it is a first-year course.

BRIEF DESCRIPTION OF COURSE CONTENT (According to the programme's verification report)

Nature of physical phenomena and their measurement.
General Physics Laboratory.
Data processing.

SKILLS

GENERAL SKILLS

- CG01 - Skills for analysis and synthesis
- CG02 - Organisational and planification skills
- CG03 - Oral and written communication
- CG06 - Problem solving skills
- CG07 - Team work
- CG08 - Critical thinking
- CG11 - Initiative and entrepreneurship

SUBJECT-SPECIFIC SKILLS

- CE01 - Knowing and understanding the phenomena of the most important physical theories
- CE02 - Estimating the order of magnitud in order to interpret various phenomena
- CE04 - Medir, interpretar y diseñar experiencias en el laboratorio o en el entorno
- CE06 - Elaborar proyectos de desarrollo tecnológico y/o de iniciación a la investigación científica.

LEARNING OUTCOMES

- To train graduates capable of observing, cataloging, and modeling natural phenomena through their knowledge of different branches of Physics, enabling them to enter the job market in positions of medium-high responsibility or continue their studies with a high degree of autonomy in scientific or technological disciplines.
- To develop in students a clear perception of seemingly different situations that exhibit evident physical analogies, allowing for the application of proven solutions to new problems. For this purpose, it is important for the student, in addition to mastering physical theories, to acquire a good understanding and command of the most commonly used mathematical and numerical methods.
- To enhance students' ability to identify the essential elements of a process or complex situation, enabling them to construct a simplified model that describes, with the necessary approximation, the object of study and allows for predictions about its future evolution. Likewise, they should be capable of verifying the validity of the model by introducing necessary modifications when discrepancies are observed between predictions and observations.
- To familiarize students with laboratory work, instrumentation, and commonly used experimental methods, equipping them to independently carry out experiments by describing, analyzing, and critically evaluating the obtained data.
- To convey the relevance of Physics in the current scientific landscape and the significant role it plays in the technological development of our society.
- To instill in students a view of Physics as an integral part of education and culture, enabling them to recognize its presence in nature through science, technology, and art.

PLANNED LEARNING ACTIVITIES

THEORY SYLLABUS

Chapter 1. Introduction.
Course Objectives. Need for experimentation.
Chapter 2. The Scientific Method.
The Scientific Method. Types of experiments. Organizational structure for methodical experimentation. Experimental procedure. Scientific publications.
Chapter 3. Descriptive Statistics Elements.
Introduction. Tabulation of a quantitative sample. Frequency distribution. Graphical representation. Fundamental statistics: Mode, arithmetic mean, median, quartiles, and percentiles. Variance and standard deviation.
Chapter 4. Probability Distributions.
Introduction. Probability. Random variables. Moments of a distribution. Probability function. Distribution function. Binomial distribution. Poisson distribution. Continuous random variables. Gaussian distribution. Pearson's chi-square distribution. Student's t-distribution. Fisher-Snedecor F-distribution. Multidimensional distributions.
Chapter 5. Parameter Estimation.
Introduction. Point estimation. Confidence interval estimation. Confidence intervals for parameters. Properties of point estimators. Maximum likelihood method. Least squares method.
Chapter 6. Experimental Errors.
Introduction. Concept of error. Quantification of error. Errors in direct and indirect measurements. Absolute error. Relative error. Mean squared error. Need for statistics.
Chapter 7. Introduction to Dimensional Analysis.
Introduction. Magnitude and measurement. Fundamental and derived magnitudes. Dimensional constants. Basic postulates of dimensional analysis. Inevitable constants. Dimensionless

products. Pi theorem. Applications of dimensional analysis in experimentation. Principle of similarity.

PRACTICAL SYLLABUS

The course begins with the completion of a "Practice 0". This involves an introduction to the instrumentation available in the laboratory and a detailed experiment, including basic principles for writing a scientific report. To achieve this goal, the first practice sessions will cover LaTeX processing, spreadsheet programs, and graphical representation software that will be used throughout the course.
Throughout the semester, students will typically work in pairs to complete one of the following laboratory practices each week:

1. Newton's Laws.
2. One-dimensional collision.
3. Free fall of bodies.
4. Moment of inertia of a flywheel.
5. The spring constant of a spring.
6. Elasticity: bending of a bar.
7. Elasticity: elongation of a metal wire.
8. Kater's pendulum.
9. Torsion pendulum.
10. Physical pendulum.
11. Centripetal force.
12. Determination of densities of liquids and solids.
13. Measurement of viscosity using Stokes' method.
14. Gas thermometer at constant pressure.
15. Water equivalent of a calorimeter.
16. Heat of fusion of ice and specific heat of solids.
17. Boyle's Law.
18. Speed of sound in air.
19. Strain gauges and transducers.
20. Ohm's Law.
21. Kirchhoff's Laws. Wheatstone bridge.
22. Charging and discharging of a capacitor.
23. Measurement of material resistivity.
24. Handling of an oscilloscope.
25. Alternating current circuits.
26. Magnetic fields near conductors.
27. Tracking of rays.
28. Lenses and lens systems.
29. Fraunhofer diffraction.
30. Random decay of radioactive substances.

These laboratory practices will allow students to gain practical experience and reinforce the theoretical concepts discussed in the course.

RECOMMENDED READING

ESSENTIAL READING

General:
- Squires, G.L. "Practical Physics", Cambridge University Press (4th edition online 2012).
- Penny, R.K. "The Experimental Methods", Logman, London, 1974.
- Feibleman, J. K. "Scientific Method", Martinus Nijhoff, The Hague, 1972.
- Baird, D.C. "Experimentation: An Introduction to Measurement Theory and Experiment Design", Prentice Hall, Englewood Cliff, New Jersey, 1962.
- Greenberg, L.H. "Discoveries in Physics for Scientifics and Engineers", W.B. Saunders Company, Philadelphia, 1975.
- Kirkup, L. "Experimental Method. An Introduction to the Analysis and Presentation of Data", Wiley, Australia, 1994.

Statistics and Uncertainties
- Bevington, P.R., Robinson, D.K. "Data reduction and error analysis for the physical sciences", McGraw-Hill, 2003.
- Box G, E.P., Hunter, W., Hunter, J. "Statistics for Experimenters", New York: John Wiley & Sons, 2006.
- Sheldon R. "A first course in probability", Pearson International Edition, 2006.

Dimensional Analysis
- Barenblaat, G. I. "Scaling", Cambridge, Cambridge University Press. 2003.
- Isaacson, E. St. Q. "Dimensional Method in Engineering and Physics", Arnold, London, 1975.

COMPLEMENTARY READING

For theoretical aspects related to the fundamentals of practices, you can consult general physics books. (For more information, refer to the course guides for the subjects General Physics I and General Physics II in the Physics degree program).

RECOMMENDED LEARNING RESOURCES/TOOLS

- https://phet.colorado.edu/ is a portal that offers Java applications with interactive simulations of science and mathematics. It provides a wide range of educational simulations that allow students to explore various scientific concepts and mathematical principles in an engaging and interactive way. The simulations offered on this website are designed to enhance learning and understanding through hands-on experimentation and visualization. It is a valuable resource for both students and educators looking to supplement their learning or teaching with interactive and immersive experiences.
- http://www.ugr.es/~zoom/ is a website that provides various interesting resources, including tables with values of physical magnitudes. These tables can be useful for reviewing units and orders of magnitude. Students can refer to this website to quickly access numerical values and relevant information related to different physical quantities. It serves as a convenient tool for studying and understanding the numerical aspects of physics

TEACHING METHODS

- MD01 - Theoretical classes

ASSESSMENT METHODS (Instruments, criteria and percentages)

ORDINARY EXAMINATION DIET

In this assessment period, a continuous assessment method will be used to evaluate all students. The following instruments will be used for this assessment:

1. Theoretical exam (including problems): 40%.
2. Solution of proposed problems: 10%.
3. Practical work: 50% (Weekly reports will be submitted and kept in the custody of the professor).

The following conditions will be applied:

1. It is necessary to pass both the theory and practical components to calculate the final average grade.
2. Attendance to practical sessions is mandatory, with a maximum of 2 allowed absences throughout the course. If the two absences are justified, they can be made up in a specific makeup session (either in the same group or with another practical group).
3. If a student has completed and passed the practical work in one academic year, the grade will be maintained for subsequent assessment periods, unless the student chooses to redo the practical work.

These conditions outline the evaluation criteria and requirements for the course, emphasizing the importance of both theory and practical components, as well as attendance at practical sessions.

EXTRAORDINARY EXAMINATION DIET

In this assessment period, the evaluation will be established as follows:

1. Theoretical Exam (including problems): 50%.
2. Practical Grade: 50%.

The practical grade can be obtained in one of the following ways: a) Based on the practical work completed during the current academic year or the previous year (if the grade is 5 or higher). b) Through an examination of practical work, where the student will perform one of the specified practical tasks from the course syllabus with the assistance of a script/guide. After completing the task, the student will submit a report to the professor. This examination may not necessarily take place on the same day as the theoretical exam. The request for this examination can be made to the theory professor or at the department's secretary from the day the extraordinary exam is announced until the day of the theoretical exam.
Similar to the regular assessment period, it is necessary to pass both the theoretical and practical components to pass the course, i.e., to obtain a score of more than 5 points (out of 10) in the theoretical exam and a practical grade equal to or higher than 5 (out of 10).

SINGLE FINAL ASSESSMENT (evaluación única final)

For students who opt for the Unique Final Evaluation, their grade will be determined through the completion of two exams:

1. Theoretical Exam, which covers the theoretical content and problems.

2. Practical Exam, in which the student will perform one of the specified practical tasks from the course syllabus with the assistance of a script/guide. After completing the task, the student will submit a report to the professor.

The final grade is calculated (provided that a minimum grade of 5 is obtained in each exam) by considering the average of both exams. In other words, the theoretical exam contributes 50% to the final grade, and the practical exam contributes the remaining 50%.

ADDITIONAL INFORMATION

In the PRADO virtual platform of the University of Granada, students will find all the relevant information regarding the course. This includes the course syllabus, problem sets, group assignments for practical work, grades, and other relevant information or documentation that the professor may not provide during the course. During the introductory class, the specific professor for each group will present all these aspects to the students, along with the specific methodology that will be followed throughout the course. The PRADO platform serves as a centralized hub for accessing important course materials and staying updated on course-related information.