SUBJECT TEACHING GUIDE

281 - STATISTICS AND DATA ANALYSIS

Master's Degree in Particle Physics and the Cosmos

Academic year 2025-2026

1. IDENTIFYING DATA					
Degree	Master's Degree in Particle Physics and the Cosmos			Type and Year	Compulsory. Year 1
Faculty	Faculty of Sciences				
Discipline	STATISTICS, DATA ANALYSIS AND PROGRAMMING				
Course unit title and code	281 - STATISTICS AND DATA ANALYSIS				
Number of ECTS credits allocated	6	Term		Semester based (1)	
Web					
Language of instruction	Spanish	English Friendly	Yes	Mode of delivery	Face-to-face

Department	DPTO. FISICA MODERNA
Name of lecturer	FRANCISCO JESUS CARRERA TROYANO
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Other lecturers	MARIA TERESA CEBALLOS MERINO MARCOS CRUZ RODRIGUEZ

3.1 LEARNING OUTCOMES
- Appreciation of the importance of data and their rigorous analysis in research
- Skills to check hypotheses given a sample of data, deciding whether they are compatible at a given level of confidence, and knowing which techniques are best in each case
- Use of simulations to estimate the feasibility of an experiment, to check if its results are compatible with a given hypothesis and to estimate confidence intervals on the model parameters
- Develop a general critical thinking on the different applications of statistics and their limitations

4. OBJECTIVES

In this subject we aim at teaching the students the basic statistical tools necessary for the analysis of data, which would allow them to characterise the data that they would use in their professional lives, to test hypotheses against them qualitatively and quantitatively and to choose the best parameters of the model that best fit the data, checking the results and the assumptions of a problem using simulations.

All topics include hand-out exercises and practical classes with a free modern statistical application (R) to allow the student to apply the techniques learnt with controlled data, to better appreciate the limitations and advantages of each technique in different relevant cases.

6. SUBJECT PROGRAM

CONTENTS	
1	- Common probability distributions in Physics. Analyses of practical examples - Uncertainties and errors in experimental work. Error propagation. - Significance of a detection. Signal to noise ratio
2	- Parametric and non-parametric tests of hypotheses - Analysis of Variance
3	Model fits. Methods of maximum likelihood. Bayesian statistics.
4	Machine Learning techniques
5	Simulations. Montecarlo techniques. Bootstrapping

7. ASSESSMENT METHODS AND CRITERIA

Description	Type	Final Eval.	Reassessn	%
Grading based on written reports	Others	No	Yes	80,00
Continuous assessment of attitude and participation in class and practical sessions	Others	No	No	20,00
TOTAL				100,00

Observations

We will consider fraud in reports the inclusion of text directly copied from internet or other sources without explicit citations . Such cases will be dealt with following the 'Reglamento de evaluación' for these cases. Similarly, the use of Artificial Intelligence tools during the evaluation tests including code writing will also be considered fraud.

Observations for part-time students

We will adapt the timetable and calendar as much as possible , to allow the attendance to the sessions most important to follow the subject. In these cases, the grading will be done preferentially from the written reports as opposed to the continuous assessment in class.

8. BIBLIOGRAPHY AND TEACHING MATERIALS

BASIC

"Data reduction and error analysis for the physical sciences" Bevington & Robinson, 1992, McGraw Hill

"Practical Statistics for Astronomers" Wall & Jenkins, 2003, CUP

"Numerical Recipes" Press et al., 1994, CUP

"Probability and statistics in engineering and management science" Hines &Montgomery, 1990, J. Wiley &Sons (tb. version en castellano)

"Statistics : theory and methods" Berry & Lindgren, 1990, Brooks/Cole Pub. Co