UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Advanced Statistical Analysis

2627-2-E3004Q015

Aims

Advanced statistical techniques for data a analysis applied to physics, with computer exercises to simulate experimental measurements and analyse them.
By the end of the course, students will have achieved the following objectives:

- have the mathematical tools necessary to understand and deepen the quantitative description of experimental data
- understand the fundamentals of statistics and data analysis
- acquire knowledge of computer science and modern programming languages, model the statistical content of measurements of physical systems in various fields, analyze data using modern tools

Contents

- Probability and Statistics
- Data analysis techniques

Detailed program

- Recap of probability definition, glossary, notation
- Frequentist and bayesian probability
- Some special distributions

    - cumulative distribution function, characteristic function

- Central limit theorem
- Parameter estimation
    - Likelihood
    - Bias, variance, minimum variance bound, Rao Cramer inequality
    - Substitution method
    - Maximum likelihood method
    - Least squares method
    - Binned data
- Confidence intervals
    - Some special cases
    - Unfolding and flip-flop
- Hypothesis testing
    - Simple and composite hypothesis
    - Goodness of fit, p-value
    - Significance and 5-sigma rule
- Hints of machine learning
- Monte carlo and random number generators
- Application and programming
    - pseudo-random numbers, distributions, zeroes of functions and numerical integration
    - the Python programming language
    - Python usage examples for data analysis: fits, data interpretation, confidence intervals

Prerequisites

Fundamental mathematics notions. Introductory knowledge of python.

Teaching form

Lessons on statistical concepts, with mathematical derivation of the main concepts. Practical examples of data analysis.

The course is thus divided:

- 32 hours of theoretical parts of the program (8 hours in presence, 24 hours LEEL)
- 12 hours of exercises
- 12 hours of laboratory on the practical aspects of data analysis

Textbook and teaching resource

“Statistical Methods in Experimental Physics” by Frederick James
“Bayesian Reasoning in Data Analysis: A Critical Introduction” by Giulio D’Agostini
“Statisti al Methods in Data Analysis” by W. J. Metzger

Semester

2

Assessment method

The assessment relies on an oral exam. During the examination, the instructor evaluates the student's learning level and the communication capabilities pertaining to the specific field.
There will be no intermediate tests.

Office hours

Upon appointment by email

Sustainable Development Goals

QUALITY EDUCATION