UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Statistical Data Analysis

2223-1-F1701Q096

Aims

provide the student with the needed data analysis techniques for a degree thesis in physics

Contents

data analysis techniques:

- introduction to probability and statistics

- introduction to Montecarlo techniques

- parameter estimation

- unfolding techniques

- data acquisition techniques

- MVA analysis

Detailed program

Numerical calculus

Introduction to numerical calculus, computer aritmethics, algorithm stability, treatment of calulus errors.

Examples of numerical techniques: numerical integration, interpolation methods, splines, function minimization, smoothing (*).

- **Introduction to data acquisition**

Introduction to data acquisition. Analog signal conversion. Introduction to the CAMAC and VME standard. Examples of DAQ systems. Introduction to an experiment slow control and Labview (*).

- **Resume of probability and statistics :**

Fundamental concepts, Bayes theorem and bayesian interpretation of probability. Examples of probability functions with applications. Error propagation. Characteristic functions and central limit theorem (CLT). Treatment of systematic errors.

- **Statistical tests and parameter estimation :**

Hypothesis test with examples. Neyman-Pearson test, linear statistics and Fischer discriminant. Non linear statistics and neural networks. Kolmogorov Smirnov test. Estimation of parameters.

- **Introduction to Monte Carlo methods :**

Introduction. Random numbers generators. Montecarlo methods. Applications.

Introduction to the pakage GEANT4 (*)

- **Confidence levels :**

Classical confidence levels, multidimensional confidence levels. Applications.

- **Metodi di Unfolding e filtraggio dei dati :**

The unfolding problem, regularization functions (MaxEnt, Tikhonov). Data filtering. Applications.

- **Introduction to multivariate techniques (MVA) :**

Introduction. Statistical tests. Neuronal nets. The perceptron and the NN multilayers. Pattern classification. Examples with applications. Decision trees.

- **Introduction to econophysics (*)

1. Introduction to graph theory. Knots theorems. Examples. Graphs kinds: random, loopless, scaling-free.

2. Stochastic processes. General considerations. CLT theorem.. Distributions with infinite variance: Levi processes. Fractional derivative of random walk.

3. Introduction to finance and stock markets. Characteristics. Distribution of returns. Stock market prices models: ARCH. Correlations between financial securities. Applications.

4. Stock market prices model with 4 parameters. Fractional derivative to simulate volatility correlations. Skewness and leverage effect. Volatility behaviuor and variation of stock market index

- **Introduction to signals treatment(*):**

- Signal classification

- sampling theorem and aliasing

- discrete Fourier transform and Fast Fourier Transform

- Digital filtering

- Wavelets

- Applications

Items marked with (*) are optionals

Prerequisites

courses of Physics bachelor degree, with emphasis on calculus and laboratory ones

Teaching form

lectures

Textbook and teaching resource

suggested textbooks:

for the Statistical Analysis section:

- **W.H. Press, B.P. Flannery, S.A. Teukolsky, W.T. Vetterling**

`` Numerical Recipes in C++, The Art of Scientific Computing'',

Cambridge University Press

- **M.Cugiani** ``Metodi dell' analisi numerica'', edizioni UTET

- **L. Lista** `` Statistical Methods for Data Analysis in Particle Phyisics'',

Springer Verlag

- **L. Lyons** ``Statistics for Nuclear and Particle Physicists'',

Cambridge University Press

- **R. Barlow** ``Statistics: A guide to the use of Statistical

Methods in the Physical Sciences'', J. Wiley

- **Hertz, A. Krogh, R.G. Palmer** ``Introduction to the Theory of Neural

Computation '', Addison Wesley

for programming:

- **J.J. Barton, Lee R. Nackman** `` Scientific and Engineering C++'', Addison Wesley

- **D. Yevick** ``A First Course in computational Physics and Object-Oriented

Programming with C++'', Cambridge University Press

Semester

2nd semester

Assessment method

oral examination based on a seminar + discussion of homework exercises

Office hours

contact by e-mail

Sustainable Development Goals

QUALITY EDUCATION