Measurement data analysis - course description

General information

Course name	Measurement data analysis
Course ID	13.2-WF-FizP-MDA-S17
Faculty	Faculty of Physics and Astronomy
Field of study	Physics
Education profile	academic
Level of studies	First-cycle studies leading to Bachelor's degree
Beginning semester	winter term 2019/2020

Course information

Semester	4
ECTS credits to win	5
Available in specialities	Computer Physics
Course type	obligatory
Teaching language	english
Author of syllabus	• dr hab. Piotr Lubiński, prof. UZ

Classes forms

The class form	Hours per semester (full-time)	Hours per week (full-time)	Hours per semester (part-time)	Hours per week (part-time)	Form of assignment
Lecture	30	2	-	-	Exam
Laboratory	30	2	-	-	Credit with grade

Aim of the course

Acquaint students with the basics of the data analysis and statistical inference. Development of skills in application of the standard techniques used for data analysis and for simulations supporting this analysis with the use of the public domain software.

Prerequisites

Experience from the first and second physics laboratory, knowledge of mathematical methods of physics, elements of the statistical analysis.

Scope

- *Measurement uncertainty*: significant digits and their rounding, the distribution of the population and the distribution of the sample, calculation of the mean, median, mode, standard deviation, range of variation and the average deviation.

- *Probability distributions*: calculation of the moments of a random variable with a known probability distribution, the cumulative distribution function and estimation of probabilities.

- *Error Analysis*: instrumental and statistical uncertainties, the equation of propagation of error, variance and covariance, the particular cases of error propagation, variance and covariance, computer implementations.

- *Estimation of averages and errors*: estimation of a mean, standard deviation and standard error, weighted estimates, relative estimates, testing of statistical hypothesis: Student's t-test and x2.

- *Monte Carlo Techniques*: random numbers generators, generation of random numbers from various probability distributions by the transformation of a homogeneous distribution, examples of simulations of simple measuring systems and experiments.

- *Fitting to a stright line with the least squares method*: linear regression exercises, solving normal equations and graphics science.

- *Least squares method for polynominal fitting:* solving of normal equations with determinant and matrix methods, fitting by using discrete orthogonal polynomials and Legendre polynomials.

- *Least squares method*: Marquardt'a-Levenberg method as the optimal method for linear and non-linear fit.

- *Fit testing*: x2 test, x2 distribution, correlation coefficient, multi-dimensional correlations,
F-test, confidence intervals, the Monte Carlo test.

- *Model selection*: Akaike test, BIC test

- *Rank-order tests*: Spearman's and Kendall's tests

- *Grace* - the program for presentation and analysis of data: data loading, operations on data, the graphic presentation, linear regression, curves fitting.

Teaching methods

Conventional lecture, probabilistic experiment.

Tutorials, programming exercises, computer simulations.

Learning outcomes and methods of theirs verification

Outcome description	Outcome symbols	Methods of verification	The class form
Student has sufficient knowledge about: the uncertainty of measurement and measurement error analysis techniques, testing of statistical hypothesis, linear and nonlinear regression, direct and Monte Carlo techniques in error analysis, knows Marquard-Levenberg method	• K1A_W02	• a discussion • a project • an evaluation test • an exam - oral, descriptive, test and other • an ongoing monitoring during classes	• Lecture • Laboratory
Student knows the basic functions of the grace program and other free software to support the analysis of the measured data	• K1A_W04 • K1A_W09	• a project • an ongoing monitoring during classes	• Lecture • Laboratory
Student can test hypotheses and interpret their results	• K1A_U02 • K1A_U03	• a discussion • a project • an ongoing monitoring during classes	• Lecture • Laboratory
Student can use the grace program to assist data analysis, in particular, load data, perform operations on them and present data graphically	• K1A_U04	• a project • an ongoing monitoring during classes	• Laboratory
Student is able to analyze errors in a particular experiment, estimate the parameters of the sample, perform point and interval estimation, is able to use the basic tools for building statistical models, in particular linear and non-linear regression including Marquard-Levenberg method	• K1A_U02 • K1A_U03	• a discussion • an evaluation test • an exam - oral, descriptive, test and other • an ongoing monitoring during classes	• Lecture • Laboratory
Student is aware of the need to comply with the rules of the computer lab	• K1A_K02	• an ongoing monitoring during classes	• Laboratory

Assignment conditions

Lecture: final exam.

Classes: passing two tests, and performing the statistical project.

Final evaluation of laboratory exercises: arithmetic mean of the tests and the project.

Final evaluation of the course: arithmetic mean of the exam and laboratory exercises.

Recommended reading

[1] H. Szydłowski (red), *Teoria pomiarów*, PWN, Warszawa 1981.

[2] S. Brandt, *Analiza danych*, PWN, Warszawa 1998.

[3] J.R. Taylor, *Wstęp do analizy błędu pomiarowego*, PWN, Warszawa 2012.

Further reading

[1] R. Nowak, *Statystyka dla fizyków*, PWN, Warszawa 2002.

[2] P. R. Bevington, D. K. Robinson, *Data reduction and error analysis for the physical science,* McGraw-Hill., Inc., New York 1992.

[3] J. Koronacki, J. Mielniczuk, *Statystyka dla studentów kierunków technicznych i przyrodniczych*, WNT, Warszawa 2001.

[4] G. Bohm, G. Zech, *Introduction to statistics and data analysis for physicists*, 2010, DESY-BOOK, http://www-library.desy.de/preparch/books/vstatmp_engl.pdf

Notes

Modified by dr hab. Piotr Lubiński, prof. UZ (last modification: 27-02-2020 14:04)