UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Laboratory I

2627-1-E3005Q006

Aims

1. Knowledge and Understanding

Students will develop a solid understanding of the fundamental laws of physics in the areas of mechanics, thermodynamics, and geometrical optics through direct observation of physical phenomena and critical analysis of experimental results.

2. Applying knowledge and understanding

They will develop the ability to carry out a physics experiment in all its phases:

- analysis of the physical problem,
- selection and understanding of the instrumentation,
- planning and conducting data collection,
- data processing and statistical analysis,
- critical interpretation of the results.

3. Making judgements

The course fosters the ability to independently assess the reliability of experimental data and the consistency between observations and theoretical models, encouraging a critical and thoughtful approach to the obtained results.

4. Communication Skills

Students will acquire skills in scientific communication, with particular attention to the writing of technical reports and the discussion of results in collaborative settings. They will also develop presentation skills and the ability to engage in constructive dialogue with peers.

5. Learning Skills

Through experimental work and team collaboration, students will develop the ability to learn independently, enhancing strategies for organization, time management, and personal initiative within the context of a shared scientific activity.

Contents

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Lectures

Introduction to statistical methods in experimental physics: lows of probability, statistical analysis of random errors, frequency distribution, probability density function. Gaussian, Binomial and Poisson distributions, properties and applications. Error propagation for one or more than one variables. Maximum likelihood. Fit to data with different functions. ?2 test. Weighted mean.

Experiments

study of motion, elastic and inelastic collisions, friction. Pendulum, Springs. Elasticity. Torsion. Moments of inertia. Standing waves on a spring. Acoustic waves and speed of sound. Harmonic oscillator, dumped and forced oscillations, resonance. Measurement of the gravitational constant. Coulomb law. Measurements of density, viscosity and dynamics of fluids. Calorimeter. Gas expansions and compressions. Geometric optics.

Detailed program

Detailed program

LECTURES

Introduction, experimental method, measurement tools.

Basics of the theory of probability, laws of probability. Bayes' theorem.

Estimators for the central value and the variance for a sample and for the population. Histograms. The variance of the mean.

Random variables and probability density function. Gauss distribution and its properties. Central limit theorem.

Error propagation in one and more variables. Covariance and correlation.

Parameter estimation. The principle of maximum likelihood and method of maximum likelihood.

Least square method. Fit to data with linear functions and other functions. Test of Hypothesis.

Confidence values. The ?2 test. Binomial distribution. Poisson Distribution.

EXPERIMENTS

Acceleration of gravity: Kater pendulum, free-fall motion.

General gravity: measurements with a Cavendish's balance.

Elastic and inelastic collisions. Inclined plane.

Torsion pendulum and measurements of inertia moments.

Hook's law. Spring and harmonic oscillations.

Forced and damped oscillations, resonance.

Steady waves on a string.

Steady waves in a pipe filled with various gases. The velocity of sound.

Stokes' law and viscosity of glycerol.

Archimede's principle and measurements of density.

Bernoulli's principle and Venturi's pipe.

Calorimetry measurement

Thermodynamics: compression and expansion in adiabatic and isothermic regimes of various gases.

Electrostatic: measurements with a Coulomb's balance.

Geometric optics: reflection, refraction and thin lenses.

Prerequisites

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Basic knowledge of the contents of the course of Physics I

Teaching form

Teaching form: lectures and laboratory activities

- 24 hours of lectures about introduction to the laboratory and statistics.

- 12 hours of exercises on application of statistics.

- 60 hours of laboratory experiments carried out in interactive mode in person in groups of three students under the supervision of the teacher and tutors.

- Discussion in class about the results and data analysis with the teacher.

Textbook and teaching resource

Textbook of Physics: same as choosen for Physics course

Textbook of Statistics:
“Introduction to data analysis“ John R. Taylor, Zanichelli.
"Teoria degli errori e fondamenti di statistica” M. Loreti, ed. Decibel, Zanichelli, in press untill 2006, thereafter https://drive.google.com/file/d/1QXSZkMZ4uUo5ILtpIfk3nONMUVMJdS_r/view?usp=sharing
As a reference: “Statistical Methods in Data Analysi “ W.J. Metzger

Slides of the lectures and recording available on the e-learning page
Slides with exercises and recording available on the e-learning page

Semester

Semester

First semester: Lectures. Second semesters: laboratory activities.

Assessment method

Assessment method: it consists of three parts

1. Written exam with exercises on the statistics topics of to the lectures..

2. Written reports on three of the the experiments performed in the laboratory by the group of students, written in collaboration by the three students, to be provided about one week before the oral exam.

3. Oral exam, individual. The exam will start with a discussion about the reports. It will continue with questions about the other experiments performed in the laboratory with respect to the related physics laws, the adopted instrumentation, the data-taking procedure, the data analysis and the obtained results. A logbook containing data taken in all experiments should be carried at the exam. One or more questions will also concern the statistics program of the lectures.

The written exam shoud be passed before the oral one, that take place after the end of the course. The written exam can be anticipated just after the lectures on statistics, at the end of the first semester.

Office hours

Office hours

By appointment (via email).

Sustainable Development Goals

QUALITY EDUCATION