UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

# COURSE SYLLABUS

# Laboratory I

**2425-1-E3001Q091**

## Aims

Aims

Get a deeper understanding of the laws of mechanics and thermodynamics from the direct observation of phenomena.

Learn how to perform physics measurements, elaborate data and critically evaluate the uncertainties in the results.

Teamworking.

## Contents

Contents

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 the laboratory content 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 available on the e-learning page
Slides with exercises available on the e-learning page

## Semester

Semester

First and second semesters

## Assessment method

Assessment method: written+oral examination.

1. Written exam with exercises on statistics. The written exam is done before the oral one, after the end of the course. The student can also choose to try the written exam just after the lectures on statistics, at the end of the first semester.

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

3. Oral exam, individual. The exam will concern the experiments performed in the laboratory with respect to the related physics laws, the adopted instrumentation, the data-taking procedure, the data analysis and the results. A logbook containing data taken in all experiments should be carried at the exam. Questions will also concern the statistics program.of the lectures.

## Office hours

Office hours

By appointment (via email).

## Sustainable Development Goals

QUALITY EDUCATION