UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

# COURSE SYLLABUS

# Laboratory I

**2021-1-E3001Q037**

## 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

**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. Characterization of a thermocouple. Geometric optics.**

## 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. 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

**Basic knowledge of the contents of the course of Physics I**

## Teaching form

**- First semester: Lectures about the laboratory content and about statistics, followed by exercises with tutors.**

**Lectures and exercises will be synchronous with the partial presence of students in the classroom, and will all be registered.**

**- Second semester: Experiments in the laboratory, 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.**

**Possible variations to the organization of the teaching plan due to the sanitary emergency will be communicated in due time.**

## Textbook and teaching resource

**Slides with exercises available on the e-learning page**

**Teoria degli errori e fondamenti di statistica”  M. Loreti, ed. Decibel, Zanichelli, in stampa fino al 2006, dopo** http://wwwcdf.pd.infn.it/labo/INDEX.html

**“Introduction to data analysis“ John R. Taylor, Zanichelli.**

**As a reference: “Statistical Methods in Data Analysi “ W.J. Metzger**

## Semester

**First and second semesters**

## Assessment method

**-Written exam with exercises on statistics**

**-Three reports on three of the experiments performed in the laboratory by the group of students, to be provided one week before the oral exam.**

**-Oral exam. 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.**

## Office hours

**Wednesday 11:30-13:00 and by appointment (via email).**