UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Laboratory II

2627-2-E3005Q011

Aims

The course introduces students to the method of experimental physics through the quantitative study of fundamental phenomena in optics and electromagnetism.
Laboratory activities are aimed at developing the ability to define the objectives of an experimental investigation, design an appropriate measurement strategy, correctly use available instrumentation, and collect reliable data. Students gain familiarity with the main measurement techniques used in physics laboratories and learn to evaluate their performance, limitations, and areas of applicability.
Particular attention is dedicated to the critical analysis of experimental data using the statistical and computational tools acquired in the Computing and Statistics Laboratory course. Students learn to quantitatively determine physical quantities and to construct or test interpretative models of the observed phenomena, critically discussing the reliability of the results obtained and the role of experimental uncertainties.

The course also aims to develop transferable skills essential for scientific activity, such as teamwork, autonomous management of experimental activities, and the communication of results through technical reports and oral presentations.

Contents

- Laboratory instrumentation: operating principles, selection criteria, and informed use of instruments for conducting optical and electrical measurements.
- Design and implementation of optics and electromagnetism experiments aimed at determining physical quantities or at the quantitative verification of interpretative models.
- Acquisition, processing, and critical analysis of experimental data.
- Communication of results through scientific reports and oral discussions.

Detailed program

Measurements relating to optical and electromagnetic phenomena. Use of instrumentation typical of experimental physics laboratories (lenses, laser sources, spectrometers, multimeters, oscilloscopes, function generators, etc.), with particular attention to the operating principles of the instruments, selection criteria in relation to measurement objectives, and the limitations of the various experimental techniques.

- **Prism and grating spectrometer**: characterization of the two instruments using spectral lines of known wavelength, identification of light sources containing unknown gases, and critical comparison of the performance of the two spectral analysis techniques.
- **Interferometry**: measurement of wavelengths using Michelson and Fabry–Perot interferometric configurations; study of the sensitivity and precision of interferometric techniques.
- **Microwaves**: quantitative study of phenomena related to geometrical and wave optics, with experimental verification of the main interpretative models.
- **Electrical circuits in direct and alternating current:** design, implementation, and characterization of networks consisting of passive elements (R, L, and C). Study of the transient response and the transfer function of circuits using time-domain and frequency-domain analysis techniques.
  In all experimental activities, students are required to plan measurements, justify the adopted methodological choices, critically analyze the collected data, and discuss the results obtained in light of the experiment's objectives.

Prerequisites

Laboratory I
Laboratory of Computing and Statistics

Teaching form

The educational activities, all with compulsory attendance, are divided into introductory lectures and laboratory sessions.
The **introductory lectures** provide the physical context of the proposed experiments, illustrate the operating principle of the instrumentation used, and discuss potential experimental strategies, highlighting the connection between the objectives of the investigation, the available measurement techniques, and the data analysis methods.
The **laboratory sessions** are dedicated to conducting the experiments, acquiring and analyzing data, and critically discussing the results obtained. Activities are carried out primarily in small working groups, encouraging collaboration, peer-to-peer discussion, and the development of operational autonomy.
An integral part of the laboratory activity is the drafting of concise and effective** scientific reports**, aimed at documenting the experimental procedure followed, the methodological choices made, the data analysis, and the conclusions reached.

Textbook and teaching resource

** All the teaching material is collected (downloadable or available) on the e-learning site **

- Slides and handouts prepared by the teacher, concerning all the topics covered in the introductory lessons
- Cards that illustrate the physical phenomena object of the experience and cards that guide the realization of

the same
- Videos illustrating the operation of the instrumentation
- Manual of the instrumentation used
- Adopted and recommended textbooks
- Recording of lessons

Semester

Second semester

Assessment method

Submission of laboratory reports during the course, according to the procedures and deadlines indicated in the course calendar.

- Reports may be written in groups; however, the content of the report and its submission remain the individual responsibility of each student.

- The purpose of the reports is to document the experimental work carried out, the methodological choices adopted, the data analysis, and the results obtained.

- Reports are not subject to independent grading. However, they constitute a useful element to verify the completeness of the work carried out during the course and the level of understanding achieved by the student.**

Individual oral examination at the end of the course.
The assessment is mainly based on the oral examination, during which the student must demonstrate the ability to:

- describe the objectives of the experiments carried out and the physical phenomenon under experimental investigation;

- explain how the measurement was performed and what role the instruments used played in achieving the set objectives;

- justify the experimental choices made and discuss the adopted measurement strategy;

- illustrate and justify the data analysis techniques employed;

- critically interpret the results obtained, discussing their reliability, limitations, and physical significance;

- coherently connect objectives, methodology, data analysis, and conclusions.

The reports submitted during the course may contribute to the determination of the final grade to the extent that they demonstrate the completeness of the activity carried out, the quality of the documentation produced, and the correctness of the data analysis. In particular, late submissions, notably deficient reports, or significant errors in data analysis may be taken into account in the overall assessment.

Should the student present revised and corrected versions of the reports and demonstrate during the oral examination that they have understood and corrected the errors previously made, these elements will be considered positively towards the final grade.

The overall assessment is aimed at verifying the achievement of the expected learning outcomes with reference to the Dublin Descriptors. In particular, the following are assessed: knowledge and understanding of experimental objectives and methodologies; the ability to apply this knowledge to the design and implementation of measurements; making judgments in the critical analysis of data and the discussion of results; communication skills in the written and oral presentation of the work carried out; the lifelong learning skills through critical reflection on one's own experimental activity and the correction of any methodological or interpretative errors.

Failure to submit reports during the course
Students who have not submitted the required reports during the course will still be admitted to the oral examination. Since reports constitute important evidence of the experimental work carried out and of the process of data analysis and interpretation, the instructors may require the student to repeat or complete a measurement related to one of the experiences already conducted in the laboratory. This activity may be used to ascertain the achievement of the course's educational objectives with reference to experimental skills, independent judgment, and the capacity for critical discussion of the results.

Office hours

The course teachers receive by appointment to be agreed by e-mail.

Sustainable Development Goals