UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Applied Physics Laboratory

2627-2-E3004Q010-E3004Q01002

Aims

The course will introduce students to the methods of experimental physics through the study of fundamental phenomena in electromagnetism and optics.
Students will be divided into groups, each of which will be assigned a specific experiment with a defined final objective.
The underlying idea is to simulate a real-life laboratory scenario over the course of one full month, during which students will autonomously organize their time in order to achieve the final objective of the experiment, independently addressing and overcoming any challenges that arise and adopting creative problem-solving approaches.
During this full-immersion month, students are expected to: to learn how to design and perform experiments and measurements aimed at investigating the underlying physical laws; to develop statistical data analysis skills and implement them using modern programming languages and tools; to learn how to interpret laboratory results; and to write scientific reports presenting and discussing the results obtained.

Learning outcomes:

- **Knowledge and understanding:** students will acquire a solid knowledge of experimental methods and data analysis techniques. They will be able to manage an experimental setup and understand how to perform measurements in order to extract meaningful information and assess the validity of a physical model.
- **Applying knowledge and understanding:** students will be able to apply the acquired knowledge to describe observed physical phenomena and to extract meaningful information from experimental data.
- **Making judgments**: through measurements and data analysis, students will be able to assess the validity of physical models and determine the values of relevant physical observables.
- **Communication skills**: students will be able to write scientific reports that clearly and concisely present their findings. They will also acquire the scientific vocabulary necessary to discuss and communicate the results of experimental activities.
- **Learning skills**: students will acquire experimental methods and data analysis techniques that will be applicable in other laboratory courses and experimental contexts.

Organization skills: Learn to organize experimental work independently, defining critical milestones, estimating the time required for each phase, and ensuring efficient progress toward the final objective.

Contents

- Setup a working radiotransmitter and/or receiver
- Measure the speed of light with time of flight information
- Setup a working electromagnetic seismometer. Can you detect the tram passing by?

Detailed program

Experimental investigation of electromagnetic and optical phenomena through a long laboratory experiment. In particular, the laboratory activities focus on:

Electromagnetism:

- Learn how to use laboratory equipment: multimeters, function generators, oscilloscopes, building simple circuits using breadboards
- Characterization of the response of resistors and diode
- Study of the transient characteristics of RC, RL, RLC circuits and determination of their parameters
- Characterization of the frequency response of RC, RL, RLC circuits and determination of their transient functions

Optics:

- Learn how to use laboratory equipment: electromagnetic generator and receiver, interferometer, laser source
- Characterization of a the electromagnetic source

Microcontroller platform:

- Programming the input/output
- Characterization of the various sensors

Data analysis:

- Signal processing, active filtering
- Parameter estimation using a frequentist approach

Prerequisites

Course of Probability and Statistics, Physical Modelling and Simulations

Teaching form

The course comprises 108 hours, divided into introductory hands-on lectures on instrumentation and analysis tools, individual in-depth study of the experiments, and in-person laboratory activities.
The first two weeks of the course will be devoted to in-person hands-on lessons and remote individual study, while the second and core part of the course (the laboratory activity, involving the setup of the experiment, data acquisition, and data analysis) will take place in the laboratory in person, four days a week, six hours per day.

Textbook and teaching resource

All teaching materials are available (either downloadable or for consultation) on the e-learning platform:

- Slides and lecture notes prepared by the instructor, covering all topics addressed in the introductory lectures
- Manuals for the instrumentation used
- Required and recommended textbooks

Semester

Second semester

Assessment method

Submission (according to the laboratory schedule) of a report on the experiments carried out.
The report may be prepared in groups, but their content and submission are the individual responsibility of each student.
Individual oral examination at the end of the course, requiring:

- The ability to discuss the experiments (including the physical principles underlying the measurements, the instrumentation used, and the methodology adopted) with competence and clarity
- The ability to critically analyze the results of a measurement, demonstrating adequate understanding and mastery of statistical tools for data analysis

Office hours

Teachers are available by appointment, to be arranged via email.

Sustainable Development Goals