PHYSICS LABORATORY I A - L

FIS/01 - 12 CFU - Annual Tuition

Teaching Staff

SILVIO CHERUBINI

Email: silvio.cherubini@unict.it
Office: Edificio 6, Cittadella Universitaria, 95123 Catania
Phone: 095.3785237 (DFA) - 095.542665 (LNS)
Office Hours: Lunedì 9:00-11:00, studio n. 217, DFA. Monday 9:00 a.m. - 11:00 a.m., Room 217, DFA. Martedì 9:00-11:00, SDS Architettura (SR), solo su prenotazione con 48 h di anticipo MINIME.

LEARNING OBJECTIVES

The course is the first teaching of Laboratory and Statistics that students attend after enrolling in the Physics Studies course.

The aim of the course is to provide students with the basics of the experimental method and the techniques of analysis of experimental data.

To achieve this, the number of hours the student attends the workshop is 90 hours. During the execution of the experiences the student is followed by the teacher and a tutor. Moreover, the constant presence of the laboratory technician makes the experiences always usable and the instruments always functioning. At the end of the teaching path the student will be able to

Understanding mechanical and thermal phenomena in an experimental, practical and operational way.
Being able to make measurements of physical properties
Acquire basic knowledge on the operating principles of the equipment, general methods, and mental aptitudes useful for investigating mechanical and thermal phenomena even different from those already proposed in the course or on their have carried out measurements.
Acquire basic knowledge and useful skills for the design of new devices in the same field.
To acquire the ability to correctly analyze experimental data and to produce a scientific report that describes the experiment performed, reports its results and knows how to interpret them.
To acquire the ability to communicate the results of an experiment and / or a scientific measure in a correct, exhaustive, clear and effective manner.
Furthermore, in reference to the Dublin Descriptors, this course helps to acquire the following transversal skills:

Knowledge and understanding:

Capacity of inductive and deductive reasoning.
Ability to schematize a natural phenomenon in terms of scalar and vector physical quantities.

Ability to set a problem using appropriate relationships between physical quantities (of algebraic, integral or differential type) and to solve it with analytical or numerical methods.
Ability to assemble and develop simple experimental configurations, and to use scientific instrumentation for thermomechanical measurements
Ability to perform statistical data analysis.
Ability to apply knowledge:

Ability to apply the acquired knowledge for the description of physical phenomena using the scientific method with rigor.
Ability to design simple experiments and perform the analysis of experimental data obtained in all areas of interest of physics, including those with technological implications.
Autonomy of judgment:

Ability to critical reasoning.
Ability to identify the most appropriate methods to critically analyze, interpret and process experimental data.
Ability to identify the predictions of a theory or a model.
Ability to evaluate the accuracy of the measurements, the linearity of the instrumental responses, the sensitivity and selectivity of the techniques used.
Communication skills:

Ability to present a scientific topic orally, with properties of language and terminological rigor, illustrating the reasons and results.
Ability to describe in writing, with properties of language and terminological rigor, a scientific topic, illustrating the reasons and results.

COURSE STRUCTURE

The teaching is divided into lectures, which will be held in the first part of the course, and experiments to be done in the laboratory in the second part.

The frontal hours are dedicated to the measurement method, data analysis and statistical elements. Exercises are planned during the frontal hours in order to prepare students to correctly perform the laboratory experiences they will do in the second part of the teaching.

6 credits (corresponding to 7 hours each) are dedicated to lectures in the classroom, for a total of 42 hours, and 6 credits (corresponding to 15 hours each) are dedicated to laboratory exercises, for a total of 90 hours. The course, of 12 credits, therefore includes a total of 132 hours of teaching activities.

Attendance of the Laboratory activities is compulsory, attendance of lectures is usually compulsory.

During the course, guided visits will be scheduled to the National Workers of the South and to the Research Institutes working at the Department of Physics and Astronomy.

DETAILED COURSE CONTENT

The course is 12 credits. 132 hours of teaching in classroom lessons and laboratory exercises.

In particular, 42 hours of classroom lessons and 90 hours of laboratory-led exercises are planned, which

include both the description of the various experiments in the laboratory and the taking and analysis of data.

Analysis of experimental data and Statistics:
- The Scientific Method.
- Measurement of physical quantities. Definition (operational) of size and its size. Fundamental and derivative quantities. Units of measurement and systems of units of measurement: The international system.
- Presentation of measures and significant figures. Read a formula and verify its correctness (dimensional analysis)

- Characteristics of a measuring instrument
- Errors and / or uncertainties. Systematic and random errors.
- The total error in the measurements, relative error, degree of precision.

- Single and / or multiple measurements. The best estimate of the error (fashion, median and average)
- Scraps, standard deviation, standard deviation of the population, sample and average.
- Propagation of errors.
- Data representation: tables, histograms and graphs.
- Histograms: from discrete to limit distribution.
- The Gauss distribution as a limit distribution for measures affected by random errors.
- The measurement of a physical quantity influenced by random phenomena and estimate of the expected value.
- Measurement in probabilistic terms.
- Notes on probability theory.
- The maximum likelihood criterion.
- Probability distributions: Gaussian, Binomial, Poisson, t-student and chi-square
- Chi-square test.
- Graphs and functional relationships

Description of laboratory experiences (12 hours in the fountains and in the laboratory)

Statistics:

- Random events, random variables - Classical definition, frequentist and axiomatic probability - total probability, conditional probability, composite probability

- Bayes theorem - statistical convergence - statistical independence and covariance - Statistical population - sampling - law of large numbers - mathematical hope for discrete and continuous random variables - probability density - moments - moment generating functions and characteristic function • Bernoulli distribution • Poisson distribution • Gauss distribution • Student distribution • $\chi 2$ distribution • central limit theorem • Statistical indexes and their sample estimates

If the teaching is given in a mixed or remote mode, the necessary changes may be introduced with respect to what was previously stated, in order to respect the program envisaged and reported in the syllabus.

Laboratory experience (78 hours):

Dynamics of the material point and of the rigid body
Length measurements: vernier, caliber, palmer • Inclined plane • Fletcher device • Atwood machine • Simple pendulum • Compound pendulum, Kater's reversible pendulum • Spherical pendulum, spherometer • Pendulum on arc • Torque pendulum • Maxwell needle • Springs • Moment of inertia of a flywheel • Kinetic energy of rotation.

Mechanics of deformable continuos
Pycnometer • Mohr-Westphal balance • Ostwald viscometer - Stalagmometer • Tensiometer • Venturi tube • Sedimentation.

Thermodynamics
Regnault mixture calorimeter • Heat propagation in a homogeneous bar • - Perfect gas state equation • Desormes and Clement experience • Kundt tube

Verification of probability distribution

Galton's apparatus.

Prerequisites

Basic knowledge of Mathematics (elements of analysis) and Physics 1.

It is useful, and therefore strongly advised, to have passed the exams or to have studied Physics 1 and Mathematical Analysis.

Attendance and formalities

Students from November to June will perform (in groups of 3 or 4 people) the taking and analysis of the data of some experiences present in the laboratory assisted by the teacher.

Each group will be involved in 6 laboratory experiments according to a calendar that will be made available by December.

Each group can choose an experience (As) from Table A and an experience (Bs) from Table B, taking care to make different choices from those of the other groups. In the event that an agreement is not reached, the teacher will resolve the disputes.

The remaining four experiences (A1, A2, A3, A4) will be assigned by the teacher, taking them from table A

Each group will have time to acquire the data related to the chosen experience As by the end of the first teaching period (end of January). Immediately after the end of the first teaching period (mid-February) he will have to deliver a report (unique for the group) on the said As experience

This report will be the ongoing test.

These reports will be corrected and discussed with the students in the classroom on the resumption of the lessons of the second teaching period; students will receive all the information and suggestions requested even during the data acquisition and processing phase.

During the second teaching period, the students will be engaged in the other five experiences, according

to the calendar that will be provided to them. At this stage the teacher's indications will only concern general questions; each group will have to work independently, building on what they have already learned with their first experience. In addition, all students must take the data from Galton's experiment and process it. The results will be discussed in the classroom.

Attendance of the Laboratory activities is compulsory, attendance of lectures is usually compulsory.

The exam student will take an individual practical laboratory test on an experience drawn between the four (A1, A2, A3, A4) assigned by the teacher to his group. On this experience will deliver a report with a complete data analysis, which will be discussed during the oral exam.

Oral exam: focuses on all the topics of the course and on the experiences explained by the teacher during the course, even if no experiments have been done on these. There will be a wide and detailed discussion on the report presented

Table A

Inclined plane
Fletcher device
Atwood machine
Simple pendulum (small oscillations)
Simple pendulum (large oscillations)
Flat physical pendulum
Spherical and arched pendulum
Twist pendulum
Maxwell's needle
Oscillations of a spring
Moment of inertia of a flywheel
Kinetic energy of rotation
Table B

Reversible pendulum by Kater
Regnault mix calorimeter
Heat propagation in a homogeneous bar
pycnometer
Balance of Mohr-Westphal
Sedimentation
Ostwald viscometer
Surface tension
Venturi tube
Verification of gas laws
Clement-Desormes experience
Kundt tube

EXAM DATES

As a rule, 7 appeals are established in each academic year; see the Exam Schedule of the Three-year Degree Course in Physics: http://www.dfa.unict.it/corsi/L-30/esami.

As illustrated above, these dates refer exclusively to the practical test. Considering the preparation of the laboratory report and the correction by the teacher, the oral exam will be done about 7-20 days after the practical test.

Attendance in the laboratory is mandatory.

Presence signatures are collected during the workshop.

The unjustified absence of more than 25% of the laboratory exercises will exclude the student from the possibility of taking the exam in that academic year.
Classroom lessons are normally held 3 times a week, 2 hours each lesson.
The sessions in the laboratory are normally held 3 times a week, 2 hours each session.

Verification of learning can also be carried out on-line, should the conditions require it.

TEXTBOOK INFORMATION

RECOMMENDED TEXTS for data analysis and statistics

- J.R. Taylor: INTRODUCTION TO ERROR ANALYSIS - THE UNCERTAINTIES STUDY IN PHYSICAL MEASURES, Zanichelli
- M. Loreti: Theory of Errors and Foundations of Statistics, Decibel, Padua
- P. R. Bevington: Data Reduction and Error Analysis for the Physical Sciences
- lesson slides and teacher's notes

RECOMMENDED TEXTS for tool descriptions and experiments

- R. Ricamo: Guide to Physics Experiments Ed. Ambrosiana, Milan
- E. Perucca: General and Experimental Physics UTET, Turin
- F.Tyler: A Laboratory Manual of Physics E.Arnould, London
- lesson slides
