# Bachelor in Physics
## (Academic Year 2025-26)

| Physics Laboratory III | Code | 800517 | Year | 3rd | Sem. | 1st |
|---|---|---|---|---|---|---|
| **Module** | General Core | **Topic** | Physics Laboratory | **Character** | Obligatory | |

| | Total | Theory | Laboratory |
|---|---|---|---|
| **ECTS Credits** | 6 | 1.1 | 4.9 |
| **Hours** | 69 | 9 | 60 |

### Learning Objectives (according to the Degree's Verification Document)

- To acquire knowledge of principles, analysis techniques, measurement instruments and experimental phenomena of interest in Electricity and Magnetism and Optics.
- To acquire the skill in handling measuring devices and instrumentation.
- To evaluate the limits of measurement methods due to interference, the simplicity of the models and from the effects that are neglected in the method of measurement.
- To be capable to prepare a report and to document a measurement process in respect to the fundamental principles, the required instrumentation and the results presentation.
- To analyze the obtained experimental results and to draw conclusions using statistical techniques.

### Brief description of contents

Laboratories of Optics, and Electricity and Magnetism; Data analysis techniques; Basic statistics.

### Prerequisites

Basic knowledge of Electricity and Magnetism (electric current circuits, resonance in electromagnetic waves, Hall effect, hysteresis loops in magnetic materials).

Basic knowledge of Optics (polarization, interference, diffraction, and coherence).


| Coordinators | Fabián Andrés Cuéllar J. | | Dept. | FM |
|---|---|---|---|---|
| | **Room** | 03.250 | **e-mail** | facuella@ucm.es |
| | Mª Cruz Navarrete Fernández | | **Dept.** | OP |
| | **Room** | 01.309.0 | **e-mail** | mcnavarr@ucm.es |


| Theory Group | Professor | Hours | Dept. | e-mail | Location |
|---|---|---|---|---|---|
| **B** | Fabián Andrés Cuéllar<br>Ángel Sanz Ortíz | 1.5<br>7.5 | FM<br>OP | facuella@ucm.es<br>ansanz03@ucm.es | 03.250.0 |

| Theory lectures (first four weeks) | | | | |
|---|---|---|---|---|
| **Theory Group** | **Days** | **Schedule** | **Lecture Room** | **Office hours** |
| **B** | OPT:<br>Sept 10, 11, 17, 18, 24<br>E&M Sept. 3rd | Wed 12:00-13:30<br>Thu 9:30-11:00 | 4A | E&M: Mo. 10:30-13:30 (+3h online)<br>OPT: Mo, Fr: 10:00-13:00, in-person |

**IMPORTANT NOTICE: The enrollment of students at the various laboratory groups (including O6 and E13-E14) is only possible through the UCM online registration system. Students must register in one group of the Electricity and Magnetism Laboratory and in one group of the Optics Laboratory, independently. It is important that both groups are chosen in a way that the corresponding schedules are fully compatible.**

**There is one English group for the Optics laboratory (O6) and two for Electricity and Magnetism (E13 and E14), with a limited quota. In case that the group is filled up, students should register in one of the Spanish groups (see *'Laboratorio de Física III'*). Their laboratories will be evaluated in Spanish, even if they belong to Group B.**

**Students not belonging to Group B are kindly requested not to register into the laboratory English group, since Group B students are given priority.**

| Laboratories in English | | | | |
|---|---|---|---|---|
| **Group** | **Schedules** | | **# sessions** | **15** |
| | **Days** | **Hours** | **Professor** | **Dept.** |
| **O8** | Wed. 17/9, 24/9, 1/10, 8/10, 15/10, 22/10, 29/10, 5/11, 19/11, 26/11, 3/12 | 14:30 – 18:30 | Ángel Sanz Ortíz<br>ansanz03@ucm.es<br>Juan Antonio Quiroga<br>aq@fis.ucm.es | OP |
| **E13** | (Mo.) Nov. 3rd, 17th, 24th & Dec. 1st | 15:30 – 19:30 | Norbert Nemes<br>nmnemes@ucm.es | FM |

## Syllabus. Theoretical classes

The fundamental principles of the main characterization techniques used in Electricity, Magnetism, and Optics will be introduced, and some essential concepts, necessary for the follow-up of the practical sessions, will be reviewed.

Lectures in Optics will be focused on explaining basic concepts of Geometrical Optics:

- Lens and mirror imaging.
- Optical elements and systems.
- Optical instruments.

| Syllabus. Laboratory Sessions (Optics) | Sessions |
|---|---|
| 1. Polarization Experiments | 1 |
| 2. The Michelson Interferometer: Spectroscopy | 1 |
| 3. The Michelson Interferometer: Metrology | 1 |
| 4. Young's Two-Slit Experiment | 1 |
| 5. Fraunhofer Diffraction | 1 |
| 6. Dispersion and Spectroscopy | 1 |
| 7. Thin Lenses | 1 |
| 8. The Magnifying Glass and the Microscope | 1 |
| 9. The Eye and Telescopes | 1 |
| 1. Instrumentation | 1 |
| 2. Experimental Test | 1 |

| Syllabus. Laboratory Sessions (Electricity and Magnetism) | Sessions |
|---|---|
| **Bachelor in Physics** | |
| 1 Fabrication of a tunable DC source | 1 |
| 2 Resonance in RLC circuits and RC filters | 1 |
| 3 Resistivity of materials and magnetically coupled LC circuits | 1 |
| 4 Electrical and transport properties: hysteresis loop and Hall effect | 1 |
| **Double Bachelor in Physics and Mathematics** | |
| 1 Electrical measurements | 1 |
| 2 Use of the oscilloscope: RC circuits | 1 |
| 3 Biot-Savart's laws and electromagnetic induction | 1 |
| 4 Resistivity of materials and magnetically coupled LC circuits | 1 |

## Bibliography


- Practical Physics. G. L. Squires (4th ed., Cambridge University Press, 1998).
- Sears & Zemansky's University Physics with Modern Physics. H. D. Young, R. A. Freedman (14th ed., Pearson Education, 2016).
- Physics for Scientists and Engineers with Modern Physics. R. A. Serway, J. W. Jewett (8th ed., Brooks Cole, Belmont, 2009).
- Physics for Scientists and Engineers. P. A. Tipler, G. Mosca (6th ed., W. H. Freeman, New York, 2007).
- Optics. A. Ghatak (McGraw-Hill, 6th Ed., 2017).
- Introduction to Optics. F. L. Pedrotti, L. M. Pedrotti and L. S. Pedrotti (Pearson International Edition, 2006).
- An Introduction to Practical Laboratory Optics. J. F. James (Cambridge University Press, 2014).

## Online Resources

All the information regarding this course is available at the UCM intranet (Virtual Campus).

Additional material of pedagogical interest (videos, journal articles, sketches and notes, etc.) is also available through the corresponding group Virtual Campus.

## Methodology

All the information concerning this course will be available at the UCM intranet (Virtual Campus).

The course has six lectures (five about optics and one about electricity and magnetism) (1.5 hours each) and fifteen laboratory sessions, four of them will be performed at the Electricity and Magnetism Laboratory and eleven at the Optics Laboratory.

The lectures will introduce basic concepts necessary for the development of the laboratory sessions, along with related exercises. Some of these exercises will be delivered to the corresponding instructor for their evaluation.

Students will perform the laboratory work in pairs and under the supervision of one laboratory instructor. During the laboratory sessions the students must develop autonomous learning, decide how to manage the information provided, solve problems, organize and plan their laboratory work, and apply critical thinking. Laboratory instructors will be responsible for the evaluation of the work performed by the students during the laboratory sessions.

Practical guides, as well as any additional material provided to assist the preparation of the laboratory reports, will be available in advance at the Virtual Campus. Students are responsible for bringing their practical guides to the laboratory.

**Electricity and Magnetism**

Students will have to answer a series of numbered questions indicated in each practical guide. The answers will be delivered to their corresponding laboratory professor the week after each laboratory session. Each report shall be delivered as indicated in each practical laboratory document. All the data must be accompanied by their corresponding uncertainties.

Laboratory grading will value the following aspects: student preparation for each session, including reading and understanding the practical guides and the preliminary questionnaires, the experimental work performed in the laboratory and the answer to the questions in the practical guides. Besides, each laboratory professor may ask questions (verbally or written) regarding each experiment and evaluate the answer. In order to familiarize the students with the scientific work, they will deliver a full scientific report for the laboratory practice: “Hysteresis loop”, formatted as scientific article.

**Optics**

After finishing each laboratory session, students should deliver to the instructor in charge the answer to the questions addressed in the manual of the corresponding practice. Questionnaires are appended at the end of the practice manuals; they can also be found as independent Word and Latex files, ready to be filled out. **Only the answers requested in the questionnaires will be evaluated.**

### Important notice to repeating students

**Electricity and Magnetism Laboratory**

Students that failed the **Electricity and Magnetism Laboratory** in previous courses may proceed directly to the exam, as long as they have obtained a grade equal or higher than 5 in the evaluation of the laboratory work. It is mandatory for those students that desire to use this option to communicate so to the professor Fabián Andrés Cuéllar J. via e-mail to facuella@ucm.es.

The final exam will cover the contents of both the theoretical lectures and the laboratory sessions of the **current academic course**. These contents may change from one year to the next, so it is each student responsibility to obtain any knowledge not covered during the academic course in which they passed the practical part of the Laboratory.

**Optics Laboratory**

Students that failed **Optics Laboratory** in the last two academic years will be offered to choose between repeating it completely or having their individual grades (assignments (theory and lab), lab reports and experimental exam) kept with the weight of the current course. In all cases, it is mandatory that they communicate their decision by email to the Optics section coordinator, prof. Mª Cruz Navarrete Fernández (mcnavarr@ucm.es).

| Grading (Electricity and Magnetism Laboratory) | | |
|---|---|---|
| **Exam** | **Weight:** | 20 % |
| A written exam will be performed during the semester which will include those contents explained in the theory lectures and the practical sessions. The exam will consist of the resolution of a series of problems and practical cases. | | |
| **Other activities** | **Weight:** | 80 % |
| ● Practical questionnaires.<br>● Full report of a laboratory session, written in scientific article format.<br>● Active participation in the laboratory sessions.<br>This part will be graded using a continuous assessment grading, assessing both the work of the students as well as their progression during the laboratory sessions.<br>Each **laboratory practice** will be graded in a scale over 10. | | |
| **Grading criteria for the Electricity and Magnetism Laboratory are the following:**<br>The final grade will be the weighted average of the exam and the continuous assessment grading of the work performed in the laboratory. To pass the Electricity and Magnetism Laboratory it is mandatory to obtain at least a grade of 5 in the laboratory work assessment and a grade of 4 in the exam.<br>Those activities graded with at least a 5 will preserve their grading for the extraordinary call of June/July. | | |

| Grading (Optics Laboratory) | | |
|---|---|---|
| **Exam** | **Weight:** | 40 % |
| A laboratory experimental test will be carried out in the last lab session. | | |
| **Other activities** | **Weight:** | 60 % |
| ● Theory class assignments (Geometrical Optics): 10 %<br>● Laboratory assignments (in-person and online): 50 % | | |
| For the extraordinary call (June/July) all marks above Pass will be kept. | | |

| Final grade |
|---|
| To pass this course it is mandatory to attend all the laboratory sessions, deliver all the requested reports (questionnaires and full reports), and to obtain a final grading of the whole subject equal to or higher than 5.<br>The final grade will be computed as:<br>$N_{Final} = 2/3\ N_{Opt} + 1/3\ N_{EyM}$ , |

where $N_{Opt}$ and $N_{EyM}$ are, in a 0-10 scale, the grades obtained in each part of the course (Optics and Electricity and Magnetisms). To pass the course it is mandatory to have an overall final grade equal to or higher than 5, with at least a 4 grade in the Optics part, and at least a 5 grade in the Electricity and Magnetism part.

The grades obtained in those activities (Electricity and Magnetism, and Optics) that have been passed in the regular call (January) will be kept for the extraordinary call (June/July). Students must be examined of only FAILED activities.