Universitat Autònoma de Barcelona

2021/2022

Advanced Laboratory

Code: 100177
ECTS Credits: 6

Degree	Type	Year	Semester
2500097 Physics	OT	4	1

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

Contact

Name: Cristian Rodriguez Tinoco

Email: Cristian.Rodriguez@uab.cat

Use of Languages

Principal working language: catalan (cat)

Some groups entirely in English: No

Some groups entirely in Catalan: No

Some groups entirely in Spanish: No

Teachers

Javier Rodríguez Viejo

Markus Gaug

Marta Rodríguez López

Prerequisites

In order to carry out the subject, it is recommended that the student has obtained a good knowledge of the basic and compulsory subjects studied in the degree of Physics.

Objectives and Contextualisation

The objective of this subject is to bring the student to the world of experimental physics from different areas (atomic structure, photonics, condensed matter, nuclear and particle) and strengthen the knowledge and understanding of the physical foundations. Likewise, it is intended that the student can deepen in the knowledge of the selected subjects, of advanced character, including those developed at the moment in the frontiers of Physics. At the end of the course, the student should be able to, among other things: (i) raise and execute an experimental research, using the appropriate methods, with innovative and competitive contributions (ii) critically reasoning with analytical ability, elaborating logical arguments (iii) work in groups and in an autonomous way in order to reach the scientific objectives set in each practice, (iv) write scientific reports with rigor and critical spirit, using the technical language correctly and elaborating logical arguments, and finally (v) be able to communicate effectively the results obtained in the presence of public in a clear and concise way.

Competences

- Act with ethical responsibility and respect for fundamental rights and duties, diversity and democratic values.
- Apply fundamental principles to the qualitative and quantitative study of various specific areas in physics
- Be familiar with the bases of certain advanced topics, including current developments on the parameters of physics that one could subsequently develop more fully
- Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, and before both specialist and general publics
- Know the fundamentals of the main areas of physics and understand them
- Make changes to methods and processes in the area of knowledge in order to provide innovative responses to society's needs and demands.
- Plan and perform, using appropriate methods, study, research or experimental measure and interpret and present the results.
- Take account of social, economic and environmental impacts when operating within one's own area of knowledge.
- Use computer tools (programming languages and software) suitable for the study of physical problems
- Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
- Work independently, have personal initiative and self-organisational skills in achieving results, in planning and in executing a project
- Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.

Learning Outcomes

1. Carry out bibliographical searches.
2. Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, in front of both specialist and general publics.
3. Correctly represent experimental data in graph format using appropriate software.
4. Critically analyse the basis of physical phenomena present in the experiment.
5. Describe physical phenomena present in the experiments.
6. Describe the physics governing experiments.
7. Evaluate the accuracy of the results and measurements obtained.
8. Explain the explicit or implicit code of practice of one's own area of knowledge.
9. Identify situations in which a change or improvement is needed.
10. Identify the basic concepts related to the area of physics to which pending experiments are assigned.
11. Identify the social, economic and environmental implications of academic and professional activities within ones own area of knowledge.
12. Interpret the experimental results obtained by extracting conclusions critically.
13. Rationalise methodologies for the experimental results.
14. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
15. Use numerical software correctly.
16. Use the correct laboratory tools and materials.
17. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.
18. Work successfully with editing software for scientific reports.
19. Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.
20. Write reports on the results obtained.

Content

Within the advanced laboratory subject, the student can choose between two itineraries:

i) One based on a monographic work that can serve as the basis for a later work of degree. It offers the possibility of choosing (as far as possible) within four areas of knowledge: magnetism of matter, physics of nanomaterials, photonics, and radiation physics. In each case, the subjects of the work must be agreed with the responsible professors.

ii) A traditional itinerary based on the realization of three practices within a selection of offered practices:

- Optical steam pumping. Where it will look: the orientation of the atoms of a steam with polarized light, the conservation of the angular momentum of light, relaxation and fluorescence phenomena, and the magnetic resonance of RF and its optical detection.

- Zeeman effect. It will be studied by means of optical techniques the deployment of the spectral lines of the Cd lightning atoms in the presence of magnetic fields applied.

- Hysteresis cycling of magnetic materials. The hysteresis cycles of ferrites will be studied to obtain the saturation magnetizations Ms and Mr remanence, as well as the coercive field Hc.

- Plasma physics. It will be introduced to the study of plasma physics. A plasma will be generated in the laboratory, measuring the main characteristics: visible spectrum, temperatures, and carrier density (electronic and ionic).

- High resolution alpha spectrometry. Semiconductor surface barrier detectors will be used to detect the activity of a pattern sample of Source Americi-Plutoni-Curi patron.

- Radiation X. It tries to familiarize the student with the various properties of the X-ray of the electromagnetic spectrum. It will be studied how it is generated, how it can be used to characterize crystalline property, its interaction with matter and the Compton effect.

- Hall effect in semiconductors. Through the hall effect study a semiconductor sample will study its electronic properties such as carrier density (doping) or the energy gap between conduction and valence bands.

- Measurements of thermal conductivity in thin layers and volumetric materials.

- Observation and analysis of surfaces of different materials at the nanoscale with an atomic force microscope. It will also be studied the different work modes of the AFM and its functioning.

- Study of the surface energy in different materials through its wettability, measured from the contact angle and complementary techniques. We will also analyse the effect of different physical and chemical treatments.

In agreement with the professorship, the student will be able to design and develop their own practical experiments, if they are of interest for the students and well fitted in the context of the goals of the subject. Also, if possible, it will be encouraged the design, use and programming of home-made experimental setups from the available resources in the lab.

Methodology

In order to complete the subject, students will have to select an itinerary of 3 experiments within the list offered. Each one of the experiments will have a previous theoretical session (1 to 3 hours) which will review the theoretical foundations necessary and the specificities necessary in each case.
Subsequently, 3 laboratory sessions (up to 4h each) will be carried out by practice, in which the student autonomously with the advice of the professor will have to obtain the experimental results. With the data obtained from the experiences in the laboratories, students will have to prepare a
brief scientific reports (5 pages each).

Via monographic work (grade base): In agreement with the teacher, the student will select the topic of the experiment to be performed. The theoretical foundations, required to proceed with the experiment, will be reviewed at the beginning. The student will have 36 hours (12 laboratory sessions or equivalent) to complete, in an autonomous way (with the support of the teacher), the required tasks to obtain and analyse the experimental data and extract the conclusions. The student will present his/her work in a scientific report (15 pages max) and defend it in an interview with the professor.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Experimental work	36	1.44	2, 17, 19
Theory lessons	13	0.52	4, 5, 6, 10, 13, 14
Type: Autonomous			
Study and preparation of experiments	56	2.24	5, 1, 10, 14
Writing of reports	42	1.68	4, 5, 6, 20, 1, 10, 12, 13, 3, 17, 18, 19, 15, 7

Assessment

Each student will carry out three selected experiments within the list offered. For each practice, the evaluation of the competences will be carried out by means of the delivery of reports
on the experimental results obtained and the subsequent personal interview where the student will have to defend the work done and show the acquired knowledge.

The weight of the final mark of each of the experiments will be one third in the final evaluation. In order to be able to calculate the final grade, none of the notes must be less than 4 out of 10.
In the case of monographic work, the note will come from the evaluation of a single report with a higher level of depth performed on the unique practice and the corresponding personal interview.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Evaluation of reports and interview	100%	3	0.12	4, 2, 5, 6, 20, 8, 1, 10, 11, 9, 12, 13, 14, 3, 17, 18, 19, 16, 15, 7

Bibliography

Bibliography:

- Description of experiments at Campus Virtual.

- A. Corney. Atomic and laser spectroscopy. Clarenden Press. Oxford 1977. Cap. 17
- C. Cohen-Tannoudji and A. Kastler. Optical Pumping. (Progress in Optics. Vol V. Ed. E.Wolf. North Holland Amsterdam).
- W. Demtröder. Laser Spectroscopy. Basic concepts and instrumentation. Springer. Cap.10

- Glenn F. Knoll, Radiation Detection and Measurement, Ed. John Wiley & Sons
- Experiments in Nuclear Science. Laboratory Manual. EG&ORTEC c.34530989.

- R.J.Goldston and P.H.Rutherford, Introduction to Plasma Physics. Institute of Physics Publishing. Cap. 1. Libro y diskette. Referencia UAB: 82 G 1
- F.F.Chen. Introduction to Plasma Physics and Controlled Fusion. Vol. 1:Plasma Physics. 2nd edition. Plenum Press. Cap. 1. Referencia UAB: 533.9 Che
- L.Spitzer, Física de los Gases Totalmente Ionizados Ed. Alhambra . Referencia UAB: 533.7Spi.

- H.P.Klug, L.E.Alexander, X-ray Diffraction Procedures. Ed. John Wiley & Sons
- B.D.Cullity, Elements of X-ray Diffraction, Ed. Addison-Wesley

- N.W. Ashcroft and N.D. Mermin, "Solid State Physics" ISBN 978-0030839931.
- Kasap, Safa. "Hall Effect in Semiconductors" (http://mems.caltech.edu/courses/EE40%20Web%20Files/Supplements/02_Hall_Effect_Derivation.pdf).

Software

LabView, Matlab, Python.