COURSE DATA

DATA SUBJECT

Code: 34257
Name: Optics I
Cycle: Undergraduate Studies
ECTS Credits: 6
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
1105 - Degree in Physics	Facultat de Física	3	First quarter
1928 - Double Degree Program Physics-Mathematics	Facultat de Ciències Matemàtiques	4	First quarter
1929 - Double Degree Program in Physics and Chemistry	Facultat de Física	4	First quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
1105 - Degree in Physics	Optics	COMPULSORY
1928 - Double Degree Program Physics-Mathematics	Cuarto Curso (Obligatorio)	COMPULSORY
1929 - Double Degree Program in Physics and Chemistry	Cuarto Curso (Obligatorio)	COMPULSORY

COORDINATION

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SUMMARY

This is a theoretical course (no labs) with 6 ECTS credits allocated and quarterly basis Optics corresponding to matter. Its primary objectives are the students acquire basic knowledge about the behavior of light, in the most basic aspects (geometrical optics), and aspects associated with its wave and electromagnetic (polarization) interaction and light- material (refractive index, dispersion). The course is part of the third year of the Degree in Physics and the fourth year of the Double Degrees in Physics-Chemistry and Physics-Mathematics, and obviously has a direct relationship with the Experimental Techniques Optical. Matter Optics is basic physics and as such, the knowledge that the optical behavior are useful in many other subjects, especially with respect to knowledge of wave behavior. Moreover, this course continues in Optics II, which corresponds to the same subject matter, Optics.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

Knowledge of general math (trigonometry, mathematical analysis, solving simple differential equations, vectors). Very basic knowledge of electromagnetism. No prior knowledge of optics is required.

COMPETENCES / LEARNING OUTCOMES

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Be able to understand and master the use of the most commonly used mathematical and numerical methods.

Communication Skills (written and oral): Being able to communicate information, ideas, problems and solutions through argumentation and reasoning which are characteristic of the scientific activity, using basic concepts and tools of physics.

Foreign Language skills: Have improved command of English (or other foreign languages of interest) through: use of the basic literature, written and oral communication (scientific and technical English), participation in courses, study abroad via exchange programmes, and recognition of credits at foreign universities or research centres.

Knowledge and understanding of the fundamentals of physics in theoretical and experimental aspects, and the mathematical background needed for its formulation.

Learning ability: be able to enter new fields through independent study, in physics and science and technology in general.

Modelling & Problem solving skills: be able to identify the essentials of a process / situation and to set up a working model of the same; be able to perform the required approximations so as to reduce a problem to an approachable one. Critical thinking to construct physical models.

Physics general culture: Be familiar with the most important areas of physics and with those approaches which span many areas in physics, or connections of physics with other sciences.

Problem solving: be able to evaluate clearly the orders of magnitude in situations which are physically different, but show analogies, thus allowing the use of known solutions in new problems .

Students must be able to apply their knowledge to their work or vocation in a professional manner and have acquired the competences required for the preparation and defence of arguments and for problem solving in their field of study.

Students must be able to communicate information, ideas, problems and solutions to both expert and lay audiences.

Students must have acquired knowledge and understanding in a specific field of study, on the basis of general secondary education and at a level that includes mainly knowledge drawn from advanced textbooks, but also some cutting-edge knowledge in their field of study.

Students must have developed the learning skills needed to undertake further study with a high degree of autonomy.

Students must have the ability to gather and interpret relevant data (usually in their field of study) to make judgements that take relevant social, scientific or ethical issues into consideration.

Theoretical understanding of physical phenomena: have a good understanding of the most important physical theories (logical and mathematical structure, experimental support, described physical phenomena).

To know how to apply the knowledge acquired to professional activity, to know how to
solve problems and develop and defend arguments, relying on this knowledge.

DESCRIPTION OF CONTENTS

1. Fundamental laws of geometrical optics

1.1 Fermat's principle.
1.2 Laws for reflexion and refraction.
1.3 Trajectory equation.
1.4 Waves and rays. Malus-Dupin theorem.
1.5 Optical systems.
1.6 Paraxial optics. Spherical diopter.
1.7 Matrix optics.

2. Electromagnetic theory of light. Maxwell¿s equations

2.1 Maxwell equations in dielectric media. Light as an electromagnetic wave.
2.2 Monochromatic waves. Helmholtz's equation.
2.3 Basic properties of electromagnetic waves.
2.4 The geometrical optics limit. Eikonal equation.
2.5 Trajectory equation.

3. Polarization

3.1 Concept of light polarization.
3.2 Polarization ellipse. Special cases.
3.3 Natural light and completely polarized light.
3.4 Polarizers and retarders.

3.5 Algebra of polarization states: Jones vectors and matrices.

4. Reflexion and refraction in isotropic dielectric interfaces

4.1 Introduction. Electromagnetic theory of light reflection and refraction.
4.2 Fresnel's formulae.
4.3 Reflection and transmission factors.
4.4 Total internal reflection.
4.5 Frustrated total internal reflection. Optical tunnel effect.

5. Introduction to the optics of anisotropic media

5.1 The dielectric tensor. Optical classification of crystals.
5.2 Plane monochromatic wave in an anisotropic dielectric. Normal modes.
5.3 Uniaxial media.
5.4 Index surface. Refraction in anisotropic crystals.
5.5 Wave plates and polarization by double refraction.

6. Refractive index. Lorentz theory

6.1 Electromagnetic nature of the refractive index.
6.2 Classical theory of light-mater interaction.
6.3 Polarizability.
6.4 Refractive index in gases.
6.5 Refractive index in dense dielectrics.
6.6 Refractive index in gases in metals and plasmas.

7. Scattering

7.1 General properties of light diffusion.
7.2 Fluctuations as the origin of diffusion.
7.3 Scattering coefficient and scattering cross section.
7.4 Rayleigh scattering. Properties of scattered light.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Tutorials	15,00
Theory	45,00
Total hours	**60,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	0,00
Independent study and work	45,00
Preparation of lessons	30,00
Preparation for assessment activities	15,00
Resolution of case studies	0,00
Total hours	**90,00**

TEACHING METHODOLOGY

Contact teaching

Theoretical and practical classes: They address the conceptual and formal aspects of the matter, as well as the resolution of problems as an application of theoretical concepts and developments. They are based mainly on master-class technique with students participation.

Working sessions in small groups, with focus on student's work and their active participation. The content of these sessions can be broad, dealing with theoretical concepts and problem solving, studying and discussion of diverse material like scientific papers, presentation of works, summaries, etc.

Student's personal work

- Study.

- Problem solving, both individually and in group.

- Preparation of works, summaries, or memoirs, individually or in group.

- Tutoring sessions.

EVALUATION

The evaluation will consist of:
1) **Exam**, the qualification of which (**N1**) may reach up to 10 points. Both the understanding of the theoretical-conceptual aspects and the formalism of the subject will be assessed, as well as the ability to apply both, as well as the ability to criticize the results obtained. In any case, a correct argumentation and an adequate justification will be valued. There will be an exam in each call.
2) **Continuous evaluation**, the qualification of which (**N2**) may reach up to 10 points. The work done by the student will be evaluated through the resolution of questions and problems, the preparation of works, summaries, reports, etc., both individually and in groups.
The subject's grade will be max{N1,0.7*N1+0.3*N2}.

Both in the first and in the second call it is a necessary condition that N1 exceeds the minimum value of 3.5 points out of 10 in order to pass the subject. If it is not passed, the final grade will be N1.
OBSERVATIONS: As long as the compensation criteria established for this purpose are met, the grade for this subject may be averaged with the grade for the Optics II subject.

REFERENCES

- E. Hecht and A. Zajac. *Óptica*. Addison Wesley Iberoamericana (1990).

- R. D. Guenther. *Modern Optics*. John Wiley & Sons (1990).

- J. M. Cabrera, F J. López y F. Agulló. *Óptica Electromagnética. Tomos I y II*. Addison-Wesley Iberoamericana (1993), (2000).