Universitat Autònoma de Barcelona

2021/2022

Waves and Optics

Code: 100140
ECTS Credits: 6

Degree	Type	Year	Semester
2500097 Physics	FB	1	2

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

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Use of Languages

Principal working language: spanish (spa)
Some groups entirely in English: No
Some groups entirely in Catalan: No
Some groups entirely in Spanish: No

Prerequisites

None.

Objectives and Contextualisation

The subject "Waves and Optics" is part of the set of General Physics subjects in the first year of the degree in Physics. This set of subjects is intended:

- To give an overview of the different disciplines that form part of physics.
- Acquire some basic knowledge and skills that must be used later to formally develop physics.
- To unify the levels acquired by the students in the previous studies in the discipline of physics.

In this subject we intend to teach both qualitatively and quantitatively the way of reasoning to understand aspects of the world around us and develop skills in problem solving. These skills and knowledge are concretized in the fields of Waves and Optics. It is intended that students acquire the basic concepts of the subjects that form part of the subject, insisting above all on phenomenological aspects and bearing in mind that students will later take other subjects, where they will already have all the appropriate tools to properly develop formalism, and without forgetting the historical context of progress in the different branches of physics, the experiments carried out, and the theories to which they have given rise.

Competences

- Act with ethical responsibility and respect for fundamental rights and duties, diversity and democratic values.
- Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals
- Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, and before both specialist and general publics
- Develop strategies for analysis, synthesis and communication that allow the concepts of physics to be transmitted in educational and dissemination-based contexts

- Formulate and address physical problems identifying the most relevant principles and using approximations, if necessary, to reach a solution that must be presented, specifying assumptions and approximations
- 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.
- Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
- Use mathematics to describe the physical world, selecting appropriate tools, building appropriate models, interpreting and comparing results critically with experimentation and observation
- Work independently, have personal initiative and self-organisational skills in achieving results, in planning and in executing a project

Learning Outcomes

1. Analyse and interpret the main experiments related to basic physics.
2. Analyse certain open questions in contemporary physics and explain them clearly.
3. Calculate figures of diffraction for various simple objects (slit, circular hole, double slit, etc.).
4. Calculate figures of interference in the superimposing of waves having the same frequency or slightly different frequencies.
5. Calculate the position and size of the image of an object in geometric approximation.
6. Charaterise the oscillating motion of a pendulum in various physical situations.
7. 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.
8. Contrast the sharpness of mathematical results with margins of error in experimental observations.
9. Describe some of the main experiments related to this subject.
10. Describe the behaviour of light in a medium or when changing medium.
11. Describe the characteristics of images of objects in geometrical optics through a mirror, a lens or optical system simple.
12. Describe the characteristics of oscillations and waves.
13. Explain the explicit or implicit code of practice of one's own area of knowledge.
14. Identify situations in which a change or improvement is needed.
15. Interact across diverse areas of basic physics.
16. Make mathematical rigor compatible with approximate physical modelling.
17. Relate the basic concepts of physics with scientific, industrial and everyday subjects.
18. Select good variables and carry out correct simplifications.
19. Use complex numbers.
20. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
21. Use differential and integral calculus.
22. Use linear transformations and matrix calculus.
23. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.
24. Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals

Content

1.- Oscillations

- Simple harmonic oscillatory movement. Oscillator energy.

- The simple pendulum. The physical pendulum. The torsion pendulum.

- Damped oscillations. Forced oscillations. Resonance frequency.

2.- Waves

- Wave movement. Propagation speed. Amplitude. Wave front.

- Longitudinal and transverse waves. Polarization.

- Wave equation. Harmonic waves. Phase and phase difference. Energy and intensity.

- Sound. Propagation speed. Intensity. Decibels. Ultrasounds. The ear.

- Doppler effect.

- Superposition principle. Interference. Superposition of waves of the same frequency. Superposition of waves of different frequency. Stationary waves. Harmonic analysis and synthesis.

3.- Light

- Light as an electromagnetic wave. Plane waves.

- Propagation of light. Principle of Huygens. Principle of Fermat.

- Polarization. Dichroism. Brewster angle. Birefringence.

- Refraction and reflection on a flat surface. Fibers.

- Absorption and diffusion.

4.- Formation of images in the geometric approximation.

- Fundamentals of geometric optics.

- Formation of optical images. Paraxial optics. Lenses and mirrors.

- Optical instruments: principles, geometric relations and utility.

5.- Interferences and diffraction

- Coherence and interferometers.

- Diffraction of a slit. Young's double slit (interferences and diffraction). The diffraction gratting. Fraunhofer and Fresnel diffraction.

Methodology

Theory lectures:

Although the theory lectures will be master classes, an attempt will be made to introduce, at specific moments, questions that give rise to a certain debate, comments and discussions that allow students to focus their attention on specific points and detect the follow-up of the lectures. There will also be exercises to clarify some theoretical aspects and practical demonstrations of some simple physical phenomena to illustrate or explain the theoretical aspects. In order to do this, the physical phenomena of Optics give us many possibilities to visualize the phenomenon being studied or to be explained.

Exercises lectures:

In these lectures, problems and questions will be posed in such a way that the students solve them on the blackboard individually or in a group, trying to give all the necessary explanations for their correct solution and interpretation. If necessary, the professor will complete and correct everything he considers necessary.

Demonstrative sessions:

There will be three demonstrative sessions in the optics laboratory with the aim of accompanying the theoretical descriptions and problems with observations and empirical demonstrations of the main phenomena

studied in the subject. Students will discuss on the phenomena observed in the laboratory by completing an individual questionnaire for each of the demonstration sessions.

Seminars:

Throughout the course there will be four seminars with the active participation of the students, where physical questions and phenomena related to the subjects being studied will be discussed, both from a historical point of view and from the current applications of the field.

Autonomous work:

The student's autonomous work required in this subject includes both the study of theoretical concepts and the preparation and resolution of exercises and problems. The delivery of problems represents an activity supervised by the teacher and will be evaluated.

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			
Exercises lectures	14	0.56	4, 3, 5
Seminars	8	0.32	2, 1, 17, 15
Theory lectures	28	1.12	6, 16, 8, 9, 10, 11, 12, 18, 21, 19, 22
Type: Autonomous			
Deliveries	15	0.6	2, 7, 24, 17
Preparation and study of the theoretical background	43	1.72	1, 4, 3, 5, 6, 16, 8, 9, 10, 11, 12, 15, 18, 21, 19, 22
Solving exercises	30	1.2	2, 4, 3, 5

Assessment

The evaluation will consist of:

1. A first partial exam on concepts and exercises of oscillations and waves, with a weight of 35%.
2. A second partial exam on concepts and exercises of optics, with a weight of 35%.
3. Attendance and participation in three demonstration sessions and delivery of the corresponding questionnaires, with a weight of 20%.
4. Attendance and participation in four seminars distributed throughout the course, with a weight of 5%.
5. Delivery of exercises to be solved autonomously, with a weight of 5%.

In order to pass for partial exams, a minimum score of 3 out of 10 must be obtained in both partial. Students may take the retaken exams if they have previously taken both partial exams.

All those students who have taken the two partial exams and/or the retaken exam cannot be qualified as "Non evaluable".

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Attendance and participation in demostrative sessions	20%	2.5	0.1	2, 1, 4, 3, 5, 16, 7, 8, 9, 10, 11, 12, 13, 24, 14, 20, 17, 15, 23
Attendance and participation in seminars	5%	0.75	0.03	2, 1, 16, 7, 8, 24, 17, 15, 18, 21
Delivery of exercises	5%	0.75	0.03	2, 16, 7, 24, 18, 21, 19, 22
First partial exam	35%	2.5	0.1	1, 4, 6, 16, 7, 9, 12, 15, 18, 21, 22
Retaken of the first partial exam	35%	1.5	0.06	1, 4, 6, 16, 7, 9, 12, 15, 18, 21, 22
Retaken of the second partial exam	35%	1.5	0.06	3, 5, 7, 9, 10, 11, 15, 18, 21, 19, 22
Second partial exam	35%	2.5	0.1	3, 5, 7, 9, 10, 11, 15, 18, 21, 19, 22

Bibliography

- Tipler and Mosca, Física para la ciencia y la tecnología. Volums 1 and 2. Editorial Reverté. 6th edition. 2010. Main text.
- Hecht, E. Optica. Addison Wesley Iberoamericana. 3th edition, Madrid 1999.
- Alonso, M. and Finn, E.J. Física. Ed. Adison-Wesley Iberoamericana. 1995.
- Burbano, S., Burbano, E., Garcia, C, Física General. Ed. Tebar 32th edition. Madrid 2003.
- Cutnell, J., Johnson, K. Física. Limusa Wiley. Mexico 2004.
- Burbano, S., Burbano, E. Problemas de Física. Libreria General. Zaragoza 1984.
- López, M, Díaz, J.L., Jiménez, M., Problemas de Física General. Vol. V: Optica. Editorial Romo 1980.
- http://bcs.whfreeman.com/tiplerphysics5e/ Webpage of the Tipler and Mosca book with suppementary material.

Many interesting articles can be found in the following journals: Investigación y Ciencia, Physics Today, Physics web, Revista española de Física, and American Journal of Physics.

Software

Applets in Matlab