COURSE DATA

Data Subject	
Code	36541
Name	Photonic: Guides and Devices
Cycle	Grade
ECTS Credits	6.0
Academic year	2023 - 2024

Study (s)

Degree	Center	Acad. year	Period
1105 - Degree in Physics	Faculty of Physics	4	First term

Subject-matter

Degree	Subject-matter	Character
1105 - Degree in Physics	16 - Complements of Physics	Optional

Coordination

Name	Department
CRUZ MUÑOZ, JOSE LUIS	175 - Applied Physics and Electromagnetism

SUMMARY

The «Photonics: Waveguides and Devices» course is focused on the study of the guided propagation of high frequency electromagnetic waves and is intended to understand the underlaying physics, to develop methods to solve problems and to analyze the essential components in current technological such as optoelectronics, laser technology and fiber-optic communications.

The course has a theoretical/practical part and an experimental (laboratory) part that allows students to acquirethe fundamental concepts and the basic experimental skills to develop their career or to enroll in a master’s degree in photonics.

The course is 6 ECTS credits allocated, and takes place in the first term of the fourth course of the Physics degree. We recommend the students to have taken a subject in electromagnetics (including laboratory) before.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

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

Other requirements

We recommend the students to have taken the following subjects (or equivalents) of the Phycics degree: Electromagnetismo, Laboratorio de Electromagnetismo, Cálculo and Métodos Matemáticos.

OUTCOMES

1105 - Degree in Physics

- Knowledge and understanding of the fundamentals of physics in theoretical and experimental aspects, and the mathematical background needed for its formulation.
- 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.
- Ability to collect and interpret relevant data in order to make judgements.
- 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 .
- 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.
- Basic & applied Research: acquire an understanding of the nature and ways of physics research and of how physics research is applicable to many fields other than physics, e.g. engineering; be able to design experimental and/or theoretical procedures for: (i) solving current problems in academic or industrial research; (ii) improving the existing results.
- 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.
- Literature Search: be able to search for and use physical and other technical literature, as well as any other sources of information relevant to research work and technical project development.
- Learning ability: be able to enter new fields through independent study, in physics and science and technology in general.

- 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.
- 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 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 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.
- Students must be able to communicate information, ideas, problems and solutions to both expert and lay audiences.
- Students must have developed the learning skills needed to undertake further study with a high degree of autonomy.

LEARNING OUTCOMES

The students have to be able to understand and solve practical and experimental problems on the following issues:

- Spectrum of guided modes of basic waveguides and conditions for single mode propagation.
- Orthogonality of electromagnetic waves and power transfer between modes.
- Perturbation theory.
- Characteristics of optical fibers.
- Mechanisms of distortion of optical pulses during propagation.
- Operation principle and characteristics of couplers, WDMs, isolators and circulators.
- Fundamentals of interaction between low frequency and electromagnetic waves.
- Fundamentals of interaction between acoustic and electromagnetic fields.
- Characteristics of phase and amplitude modulators.
- Experimental set-ups in radiofrequency and guided optics.

DESCRIPTION OF CONTENTS

1. Guiding systems with translational symmetry

1.1. Introduction
1.2. Guided electromagnetic waves.
1.3. Classification of modes.
1.4 TEM mode: transmission lines.

2. Propagation of energy

2.1. Introduction
2.2. Power flow.
2.3. Attenuation.
2.4. Mode orthogonality.
2.5. Phase velocity and velocity of the energy flow.

3. Guiding mechanisms

3.1. Introduction
3.2. Conducting walls waveguide: rectangular and circular waveguides.
3.3. Planar dielectric waveguide.
3.4. Surface waves and plasmons.

4. Propagation of pulses

4.1. Introduction.
4.2. Frequency spectrum of an electromagnetic pulse.
4.3. Integral formulation of pulse propagation.
4.4. Group velocity and dispersion.
4.5. Differential equation of pulse propagation.

5. Optical fibers

5.1. Introduction.
5.2. Guided modes in a fiber. Fundamental mode a cutoff wavelength.
5.3. Attenuation in singlemode fibers.
5.4. Dispersion parameter. Dispersion in singlemode fibers.

6. Resonators

6.1. Introduction.
6.2. Parameters of a resonator.
6.3. Resonant cavities.
6.4. Recirculating resonators.

7. Mode coupled systems

7.1. Introduction.
7.2. Coupling of copropagating modes.
7.3. Couplers and wavelength division multiplexers.

8. Non reciprocal propagation in magnetics fields

8.1. Introduction
8.2. Magnetization of a ferromagnetic material. Larmor precession.
8.3. Permeability tensor.
8.4. Faraday rotation of polarization.
8.5. Duality in dielectric materials.
8.6. Isolators and circulators.

9. Introduction to nonlinear effects

9.1. Introduction
9.2. Material polarization. Materials with instantaneous response.
9.3. Susceptibility tensor. Electric susceptibility tensors.
9.4. Examples of nonlinear effects.
9.5. Electro-optic modulators.
9.6. Self phase modulation.

10. Laboratory

Experiment 1: CHARACTERIZATION OF TRANSMISSION LINES
Experiment 2: CARACTERIZATION OF A RECTANGULAR WAVEGUIDE
Experiment 3: CHARACTERIZATION OF OPTICAL FIBERS
Experiment 4: STUDY OF A DIELECTRIC RESONATOR
Experiment 5: STUDY OF A FIBER OPTIC DIRECTIONAL COUPLER

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	45,00	100
Laboratory practices	15,00	100
Development of group work	22,50	0
Development of individual work	22,50	0
Preparation of evaluation activities	20,00	0
Preparing lectures	15,00	0
Preparation of practical classes and problem	10,00	0
TOTAL	150,00	

TEACHING METHODOLOGY

The course will include two types of activities:

1. **Theory and problems** (3 hours per week). Basic theoretical contents, with applications examples and questions.
2. **Laboratory** (3 hours per session, 5 sessions). Experiments carried out by the students with quantitative analysis and theoretical discussion.

EVALUATION

The weight in the qualification of the different evaluable parts, that is, theory, problems and laboratory will be: 50%, 25% and 25% respectively.

Attendance in laboratory classes is compulsory.

The evaluation of the course will have two contributions:

1) Written exam (50% of theory grade and 50% of problems grade): One part will be devoted to theoretical and short practical questions. Another part will consist of application problems.

2) Continuous evaluation (50% of theory grade and 50% of problems grade): Solution of problems and practical questions suggested during the lectures. Discussions carried out in the classroom.

3) Laboratory: the work in the laboratory will be evaluated from the presentation of memories / reports of the different experiments carried out.

REFERENCES

Basic

- «Photonic Devices», Jia-Ming Liu. Cambridge University Press 2005 (formato electrónico disponible en biblioteca).
- «Microwave Engineering», D.M. Pozar. Wiley 2011.

Additional

- «Fundamentals of optical waveguides», K. Okamoto. Academic Press, 2011.
- «Fundamentals of Photonics», B.E.A. Saleh, M.C. Teich. Wiley, 2019.