

**COURSE DATA****DATA SUBJECT**

Code: 43308
Name: Optical fibres: guidance and devices
Cycle: Master's Degree
ECTS Credits: 6
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
2150 - Master's degree in Advanced Physics	Facultat de Física	1	First quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
2150 - Master's degree in Advanced Physics	Optical waveguides and photonic crystals	ELECTIVES

COORDINATION

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DIEZ CREMADES ANTONIO

SUMMARY

This course aims to give an overview of waveguides and photonic devices that operate in the frequency range corresponding to the optical spectrum (visible and near infrared). The electromagnetic fundamentals that confer the properties to these devices are discussed, as well as practical questions, including the manufacturing processes and the different applications.

After reviewing the general theory of electromagnetic wave guide systems, the general characteristics of the guided modes in optical guides are studied. We will analyze the properties of a series of photonic guides with plane and cylindrical symmetry. Specifically, we will study the modes guided by thin metallic sheets, which will allow us to introduce and study a type of electromagnetic wave with very particular properties: surface plasmons. Next, as a previous step to the detailed study of the optical fibers, and as an introduction to the integrated optical guides, we study the dielectric slab waveguide, easier to analyze mathematically but with many properties qualitatively common with optical fibers. Based on the results of the study on the dielectric slab, an introduction to dielectric resonators is made.

The electromagnetic analysis of the optical fibers allows us to know the fundamentals that endow them with their most characteristic properties, and which have given rise to their different technological applications. In addition to purely mathematical aspects, other practical issues are discussed, such as the



different types of commercial optical fibers and fibers under development, and the most relevant fields of application.

The second part of the subject focuses on the study of the most relevant photonic components made with fiber optics. In practical applications involving optical fibers, other additional components are generally necessary to perform different functions on the light (filtering, multiplexing, modulation, etc ...). As far as possible, it is convenient to implement these functions in the optical domain and preferably with fiber optic devices. This strategy simplifies fiber optic systems and makes them more robust. Therefore, in recent decades, a significant effort has been made in the development of fiber optic components. A family of fiber optic devices of interest are those whose operation is based on the coupling between modes guided by fiber. In this course, devices based on periodic structures, of different nature, and devices based on coupling by interaction with the evanescent field are studied. Finally, the study of fiber optic systems that include active optical fibers, that is, optical fibers that emit light, is addressed. Fiber optic light amplifiers, essential in today's communication systems, and fiber optic lasers, whose technological relevance and scope of application is increasingly wide, are discussed.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

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

OTHER REQUIREMENTS

COMPETENCES / LEARNING OUTCOMES

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Analizar una situación compleja extrayendo cuales son las cantidades físicas relevantes y ser capaz de reducirla a un modelo parametrizado.

Comprender de una forma sistemática el campo de estudio de la Física y el dominio de las habilidades y métodos de investigación relacionados con dicho campo.

Comprender las bases teóricas de la propagación de la luz, tanto en el espacio libre, como en medios dieléctricos lineales y no lineales, así como en guías ópticas.

Comprender las técnicas de fabricación y caracterización de componentes de fibra óptica y sus aplicaciones.

Conocer los avances recientes en materiales, dispositivos y tecnologías emergentes de interés para la fotónica.

Poseer la capacidad para el desarrollo de una aptitud crítica ante el aprendizaje que le lleve a plantearse nuevos problemas desde perspectivas no convencionales.



Saber modelizar matemáticamente los problemas físicos sencillos nuevos, conectados con problemas conocidos. Ser capaz de expresar en términos matemáticos nuevas ideas.

Ser capaz de diseñar sistemas ópticos y dispositivos fotónicos para aplicaciones específicas de procesamiento de señales.

Ser capaz de gestionar información de distintas fuentes bibliográficas especializadas utilizando principalmente bases de datos y publicaciones internacionales en lengua inglesa.

Students should demonstrate self-directed learning skills for continued academic growth.

Students should possess and understand foundational knowledge that enables original thinking and research in the field.

DESCRIPTION OF CONTENTS

1. Introduction to optical fibers

- 1.1.- Why does an optical fiber guide?
- 1.2.- What material are they made of?
- 1.3.- Fabrication of optical fibers.

2. Planar optical waveguides

- 2.1.- Introduction.
- 2.2.- Modes guided by a metal foil. Surface plasmons.
- 2.3.- Flat dielectric foil.
- 2.4.- Curved dielectric foil.
- 2.5.- Dielectric optical microresonators.
- 2.6.- Applications of integrated guides.

3. Optical fibers.

- 3.1.- The spectrum of modes guided by an index-hopping optical fiber.
- 3.2.- LP approximation.
- 3.3.- Characteristics of the fundamental mode.
- 3.4.- Modes of the cover.
- 3.5.- Types of optical fibers.

4. Nonlinear effects in optical fibers

- 4.1.- Elastics: SPM, XPM, FWM/MI.



4.2.- Inelastics: Raman dispersión and Brillouin dispersion.

5. Devices based on mode coupling

- 5.1.- Coupling in periodic structures: Bragg filters, long period gratings.
- 5.2.- Coupling between waveguides: couplers and wavelength multiplexers.
- 5.3.- Interaction between electromagnetic and acoustic waves.

6. Optical fiber amplifiers and lasers

- 6.1. Rare earth doped fiber amplifiers.
- 6.2. Pulse amplification.
- 6.3. Raman effect amplifiers.
- 6.4. Fiber optic lasers. Pulsed lasers.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Theory	33,00
Seminar	3,00
Other activities	4,00
Laboratory	6,00
Total hours	46,00

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	0,00
Independent study and work	0,00
Preparation of lessons	39,00
Preparation for assessment activities	35,00
Resolution of case studies	30,00
Total hours	104,00

TEACHING METHODOLOGY

- Standar theory lecture.
- Problems solving.
- Laboratori experiments.
- Seminars.
- Visit to external scientific facilities.



- Conducted debate or discussion.

EVALUATION

The course assessment is based on:

- 1) A written exam on the contents of the theoretical classes (40%). This exam will assess the student's understanding of conceptual aspects through theoretical and conceptual questions, as well as the student's ability to solve problems and discuss the results obtained.
- 2) Continuous assessment (45%). Consideration will be given to the student's completion of exercises, the presentation of posed problems, or any other method that demonstrates their academic progress.
- 3) Assessment of laboratory activities (15%).

The course cannot be passed without completing the written exam.

This evaluation system will be applied to both the first and second call.

REFERENCES

- R.E. Collin. Field theory of guided waves. IEEE Press 1991.
- A.W. Snyder y J.D. Love. Optical waveguide theory. Chapman and Hall, 1983.
- G.H. Owyang. Foundations of Optical Waveguides. E. Arnold 1981.
- R. März, Integrated Optics. Design and Modelling. Artech House, 1995.
- G. P. Agrawal. Fiber-Optic Communication Systems. John Wiley & Sons, 2002.
- N. Kashima. Passive optical componentes for optical fiber transmission. Artech House 1995.
- H.A. Haus. Waves and fields in optoelectronics. Prentice-Hall 1984.
- Rare earth doped fiber lasers and amplifiers. Edited by M.J.F. Digonnet. Marcel Dekker 1993.



- R. Kashyap. Fibre Bragg grating. Academic Press 1999.