COURSE DATA

DATA SUBJECT

Code: 43304
Name: Fundamentals of optoelectronics
Cycle: Master's Degree
ECTS Credits: 6
Academic year: 2026-27

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	Optoelectronics	ELECTIVES

COORDINATION

MORAIS DE LIMA MARQUES MAURICIO

SUMMARY

In this course we study the physical processes involved in the light-matter interaction which constitute the basis of the operation of optoelectronic devices. Following several formalisms, classical and mecano-quantum, we study the processes of transmission, reflection, absorption and emission of light in solid materials with photonic applications, within the limits of linear optical processes. Particular attention is paid to metals and semiconductors, also exploring the effect of the reduction of dimensionality in their optical response. The models of electrostatic equilibrium and conduction in junctions of the type metal-semiconductor and metal-oxide-semiconductor are also addressed. In the final part of the course, the processes of stimulated emission and gain are introduced both in massive materials and in semiconductor nanostructures.

From the methodological point of view, it is sought that students enter into the world of scientific research. To do this, they solve and discuss, throughout the different subjects, non-academic problems. Theoretical knowledge is also accompanied by practical demonstrations and laboratory sessions, in which students learn the main experimental techniques (absorption and emission measures), as well as the treatment and presentation of the experimental data. It also affects the use of advanced bibliography, such as books and scientific articles, and in the techniques of scientific writing.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

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

COMPETENCES / LEARNING OUTCOMES

2150 - Master's degree in Advanced Physics

Concebir, diseñar, poner en práctica y adoptar un proceso sustancial de investigación con seriedad académica.

DESCRIPTION OF CONTENTS

1. Unit 1

Processes and optical coefficients. Dielectric function. Optical Measurements. Optical materials.

2. Unit 2

Optical properties of metals: the Drude model, plasmons, plasmon-polariton surface.

3. Unit 3

Absorption and emission in semiconductors: classical approach, processes of absorption and density of states, critical points of different dimension, excitonic effects and impurity emission processes.

4. Unit 4

Quantum heterostructures: the envelope function approximation, confinement of carriers in heterostructures (wells, wires and quantum dots), absorption and emission in heterostructures.

5. Unit 5

Quantum technologies with semiconductors. Fundamnetals and applications. Semiconductor single quantum dots.

6. Unit 6

Spontaneous and stimulated emission in semiconductors and semiconductor nanostructures: Einstein relations, balance equations, gain. Exciton polaritons and condensates.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Theory	32,00
Seminar	3,00
Other activities	4,00
Laboratory	4,00
Total hours	**43,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	16,00
Independent study and work	0,00
Preparation of lessons	45,00
Preparation for assessment activities	0,00
Resolution of case studies	46,00
Total hours	**107,00**

TEACHING METHODOLOGY

MD1 - Standar theory lecture

MD2 - Laboratory demonstrations

MD3 - Problems solving

MD4 - Problems and simulations

MD5 - Seminars.

MD6 - Visit to scientific facilities and experimental demonstrations

MD7 - Addressed debate or discussion.

EVALUATION

Each student will be evaluated continously by the work done in class (SE1) and other non-presential activities (SE2).

SE1 - Continuous evaluation of students in the classes of theory and practice: participatory attendance and exercises in the classroom, 50%.

SE2 - Evaluation of non-presential activities related to theory and practical lectures: reports (and problems) submitted, oral presentations, 50%.

This evaluation system will be used for both the first and second call.

REFERENCES

- J. Singh, Electronic and Optoelectronic Properties of Semiconductor Structures, Cambridge University Press (2003).
- M. Fox, Optical Properties of Solids. Oxford University Press (2001).
- H. Ibach and H. Lüth, Solid State Physics, Springer (2009).
- C. F. Klingshirn, Semiconductor Optics. Springer (1997).
- John H. Davies, The Physics of Low-Dimensional Semiconductors. Cambridge University Press (1998).
- John Wilson & John Hawkes, Optoelectronics: an introduction,
- E. C. Le Ru, P. G. Etchegoin, Principles of surface-enhanced Raman scattering, Elsevier (2009).
- R. Feymnman, The Feynman Lectures Vol I (2010).
- S.M. Sze, M.K. Lee "Semicoductor devices. Physics and technology" John Wiley & Sons.

- B.H. Bransden, C.J. Joachain. Quantum Mechanics. Prentice Hall.
- Serge Haroche, Jean Michael Raimond, "Exploring the Quantum: Atoms, Cavities and photons". Oxford Graduate Texts.
- Olivier Ezratty "Understanding quantum technologies" Le lab quantique.
- Christopher Gerry, Peter Knight. "Introductory Quantum Optics" Cambridge University Press.