# Photonics

**Academic Year: ( 2023 / 2024 )** **Review date: 12-02-2024**

**Department assigned to the subject: Electronic Technology Department**

**Coordinating teacher: ACEDO GALLARDO, PABLO**

**Type: Compulsory ECTS Credits : 6.0**

**Year : 3 Semester : 2**

## REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Electromagnetism and Optics
Solid State Fundamentals for Engineering
Electronic Engineering Fundamentals
Statistical Physics

## SKILLS AND LEARNING OUTCOMES

CB1. Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.
CB2. Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.
CB3. Students have the ability to gather and interpret relevant data (usually within their field of study) in order to make judgements which include reflection on relevant social, scientific or ethical issues.
CB4. Students should be able to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
CB5. Students will have developed the learning skills necessary to undertake further study with a high degree of autonomy.
CG1. Analyze and synthesize basic problems related to physics and engineering, solve them and communicate them efficiently.
CG2. Learn new methods and technologies from basic scientific and technical knowledge, and being able to adapt to new situations.
CG3. Solve problems with initiative, decision making, creativity, and communicate and transmit knowledge, skills and abilities, understanding the ethical, social and professional responsibility of the engineering activity. Capacity for leadership, innovation and entrepreneurial spirit.
CG5. Use the theoretical and practical knowledge acquired in the definition, approach and resolution of problems in the framework of the exercise of their profession.
CG6. Develop new products and services based on the use and exploitation of new technologies related to physical engineering.
CE13. Understand and handle solid state physical principles relevant to engineering and, in particular, semiconductors for application in electronic and photonic components, as well as the fundamentals and applications of analog and digital electronics and microprocessors.
CE15. Understand and handle the physical principles associated with light-matter interaction and to apply them to the use and design of various photonic devices and complete photonic systems, as well as to apply photonic devices and systems in different branches of physics, engineering and biology.
CT1. Work in multidisciplinary and international teams as well as organize and plan work making the right decisions based on available information, gathering and interpreting relevant data to make judgments and critical thinking within the area of study.

RA1. To have acquired sufficient knowledge and proved a sufficiently deep comprehension of the basic principles, both theoretical and practical, and methodology of the more important fields in science and technology as to be able to work successfully in them.
RA2. To be able, using arguments, strategies and procedures developed by themselves, to apply their knowledge and abilities to the successful solution of complex technological problems that require

creating and innovative thinking.
RA3. To be able to search for, collect and interpret relevant information and data to back up their conclusions including, whenever needed, the consideration of any social, scientific and ethical aspects relevant in their field of study.
RA6. To be aware of their own shortcomings and formative needs in their field of specialty, and to be able to plan and organize their own training with a high degree of independence.

## OBJECTIVES

To learn the fundamentals of light emission, propagation and detection using photonic devices and components based on the fundamental principles of light-matter interaction.

Introduction to the different fields of application of photonics in science and engineering.

## DESCRIPTION OF CONTENTS: PROGRAMME

1.- Revision: Electromagnetic waves propagation. Light as an electromagnetic wave.
2.-Light propagation in free space. Geometrical, undulatory and beam optics concepts. Interference and diffraction. Polarization of light.
3.-Light propagation in linear dielectric media. Dispersion. Integrated waveguides. Optical fibers and optical fiber components.
4.- Revision: Light as a particle: the photon. The black body radiation spectrum. Light-matter interaction: emission and absorption of light. Introduction to quantum states of light.
5.-Coherent emission of light: lasers. Stimulated emission and the laser effect. Working principles of lasers: Rate Equations. Types of lasers. Gas lasers, solid-state lasers, Semiconductor lasers (Edge emitting lasers and VCSELs), Quantum cascade lasers, Fiber optic lasers, Pulsed lasers: mode-locked lasers. Other (non-coherent) light Sources: LEDs.
6.- Light detection. Ideal photon detector. Responsivity. Heterodyne or coherent detection. Detection noise and classical detection limit (shot noise). Types of photon detectors: photodiodes, photomultipliers, CCDs, ¿
7.- Other important photonic components: Electro-optics and acousto-optic modulators, Spatial light modulators.
8.- Photonics systems and subsystems examples

## LEARNING ACTIVITIES AND METHODOLOGY

AF1. THEORETICAL-PRACTICAL CLASSES. Knowledge and concepts students mustacquire. Receive course notes and will have basic reference texts.Students partake in exercises to resolve practical problems
AF2. TUTORING SESSIONS. Individualized attendance (individual tutoring) or in-group (group tutoring) for students with a teacher.Subjects with 6 credits have 4 hours of tutoring/ 100% on- site attendance.
AF3. STUDENT INDIVIDUAL WORK OR GROUP WORK.Subjects with 6 credits have 98 hours/0% on-site.
AF8. WORKSHOPS AND LABORATORY SESSIONS. Subjects with 3 credits have 4 hours with 100% on-site instruction. Subjects with 6 credits have 8 hours/100% on-site instruction.
AF9. FINAL EXAM. Global assessment of knowledge, skills and capacities acquired throughout the course. It entails 4 hours/100% on-site
MD1. THEORY CLASS. Classroom presentations by the teacher with IT and audiovisual support in which the subject`s main concepts are developed, while providing material and bibliography to complement student learning
MD2. PRACTICAL CLASS. Resolution of practical cases and problem, posed by the teacher, and carried out individually or in a group
MD3. TUTORING SESSIONS. Individualized attendance (individual tutoring sessions) or in-group (group tutoring sessions) for students with teacher as tutor. Subjects with 6 credits have 4 hours of tutoring/100% on-site.
MD6. LABORATORY PRACTICAL SESSIONS. Applied/experimental learning/teaching in workshops and laboratories under the tutor's supervision.

## ASSESSMENT SYSTEM

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| **% end-of-term-examination:** | 60 |
| **% of continuous assessment (assigments, laboratory, practicals…):** | 40 |

SE1. FINAL EXAM. 40%
SE2. CONTINUOUS EVALUATION. 60%

First Partial 20%

| | |
|---|---|
| **% end-of-term-examination:** | 60 |
| **% of continuous assessment (assigments, laboratory, practicals…):** | 40 |

Second Partial 20%
Laboratory 20%

## BASIC BIBLIOGRAPHY

- Saleh B.E.A. and Teich M.C.  Fundamentals of Photonics, John Wiley and Sons Inc., 1991

## ADDITIONAL BIBLIOGRAPHY

- Born M. and Wolf E.  Principles of Optics 7th ed., Cambridge University Press. , 1999

- Iizuka K Engineering Optics 3rd Ed, Springer, 2008

- Kingston R.H. Optical Sources, Detectors, and Systems. Fundamentals and Applications, Academic Press , 1995