Universidad de Alcalá

TEACHING GUIDE

Photonic Technologies

Degree in
Electronic Communications Engineering (GIEC)
Telematics Engineering (GIT)
Telecommunication Systems Engineering (GIST)

Universidad de Alcalá

Academic Year 2022/2023

4th Year - 1st and 2nd Semester (GIEC+GIT+GIST)

Approved by the School Board on June 3, 2022

TEACHING GUIDE

Course Name:	**Photonic Technologies**
Code:	**370007 (GIEC+GIT+GIST)**
Degree in:	**Electronic Communications Engineering (GIEC)** **Telematics Engineering (GIT)** **Telecommunication Systems Engineering (GIST)**
Department and area:	**Electrónica** **Electronic Technology**
Type:	**Optional (Generic) (GIEC+GIT+GIST)**
ECTS Credits:	**6.0**
Year and semester:	**4th Year - 1st and 2nd Semester (GIEC+GIT+GIST)**
Teachers:	Check website http://www.uah.es/aula_virtual/
Tutoring schedule:	Will be done the first day class and also will be published at http://www.uah.es/aula_virtual/
Language:	Spanish/English Friendly

1. COURSE SUMMARY

The Photonic Technologies course aims to provide the students with the fundamentals to understand and develop products based on the combination of optical and electronic systems. These hybrid systems are currently the core of the modern information technology, inspection and communication.

Given the profile of the students, special emphasis will be done on concepts related to the optical properties of semiconductor materials, generation and detection of radiation, radiometric definition of radiation, optical coupling and modulation transfer function, together with waveguides and applications of photonic devices and systems.

Course contents use prior knowledge acquired in Circuit Theory (350004) and Circuit Analysis (350005), which are specially recommend. We also recommend the subjects of Digital Electronics (350007), Physics Fundamentals II (350008) and Basic Electron- ics (350011).

2. SKILLS

Basic, Generic and Cross Curricular Skills.

This course contributes to acquire the following generic skills, which are defined in the Section 3 of the Annex to the Orden CIN/352/2009:

en_TR2 - Knowledge of basic subjects and technologies that enables to learn new methods and technologies, as well as to provide versatility that allows adaptation to new situations.

Professional Skills

This course contributes to acquire the following professional skills, which are defined in the Section 5 of the Annex to the Orden CIN/352/2009:

en_CSE4 - Ability to apply electronics as a support technology in other fields and activities, and not only in the field of Information Technology and Communications.

en_CSE7 - Ability to design interface devices, data capture and storage, and terminals for telecommunication services and systems.

Learning Outcomes

Upon successful completion of this course, students will be able to:

RA1. Identify the basic elements of a photonic system. Define the different op- erating principles on which they are based. Select the more suitable ones for a specific application.

RA2. Calculate the Optical Transfer Function (OTF) for a link and optimize it using active / passive optical devices.

RA3. Solve fiber optic communication link problems. Characterize light signaling systems. Design global photonic systems for their implementation in real environments.

RA4: Employ advanced instrumentation for detecting and identifying radiant signals.

RA5: Critically assess new trends in photonic technologies.

3. CONTENTS

Module contents	Lecture hours(Including problem sessions)
Unit 1: Radiation definition. Radiometry and photometry fundamentals. Spatial spreading of radiation. Effects of the medium of propagation and distance. Beam limitation and optical transfer function (OTF). OTF optimization with passive optical devices.	• 8 hours
Unit 2: Light detection. Radiation detectors basic features. Limits in the detection of light. Photonic detectors: selection criteria. Analysis and design of optoelectronic detection systems.	• 8 hours
Unit 3: Light emission. Thermal emitters: black and grey body. The Light-Emitting Diode (LED). LED emission optical features. Principle of opera- tion of LASER emitters. Optical characteristics of the LASER emission. Safety rules when using LASER sources. Driving circuits for optoelectronic emitters.	• 9 hours
Unit 4: Waveguides and optical fiber. Integrated waveguides and fiber optic principles. **For GIEC/GIT students:** Optical communication systems. Devices for the control of information transmission. Limitations on the transmission of information by optical means. Analysis of photonic transmission networks. **For GIST students**: Analysis of integrated photonic structures: matrix method. Boundary conditions.	• 10 hours
Unit 5: Applied Photonics. Photonic sensors. Techniques and instrumentation for optical inspection systems. Configuration of point, quasidistributed and distributed photonic sensors.	• 2 hours
Lab sessions: Complementary activities to the course contents. Realization of practical exercises of analysis, design and experimentation with Photonic systems.	• 16 hours
Evaluation: Individual and group evaluation sessions about course contents.	• 5 hours
Total on-class activities:	• 58 hours

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of lecture hours:	58 on-class hours
Number of working hours spent by each student:	92 hours
Total number of hours	150 hours

4.2. Methodological strategies, teaching materials and resources

The teaching-learning process will be carried out through the following activities:

- Theoretical and practical sessions taught in a large group based on lectures that allow the teacher to introduce the required contents for the correct development of the learning process. These lectures will present essential contents later serving to develop broader skills.
- Practical lectures taught mostly in small groups based on solving exercises and problems. The aim of these classes is to promote meaningful learning that allows students to deepen their theoretical knowledge, relate and apply them creatively to solve more complex problems.
- Practical laboratory classes, exclusively taught in small groups based on problem or project solving.
- Interviews: individual and/or group.

Additionally, the following supplementary resources can be used to support the study:

- Individual or group work: involving, together to its realization, the public exposure in front of the rest of the students to encourage debate.
- Attendance to conferences, meetings or scientific discussions related to the course subject.

Throughout the course the student will be proposed activities and tasks both theoretical and practical. Different practical work will be carried out in coordination with the teaching of the theoretical concepts; in this way the student can experiment and consolidate the acquired concepts, both individually and in group.

To accomplish the proposed labwork, the student will be available a work station with basic equipment (oscilloscope, power supply, signal generator) in the lab, as well as a computer with design and simulation software tools for electronic circuits. The experimental activities are proposed to be carried out by a couple as much.
Additionally, for the specific work of the subject, there will be software for the design of photonic structures, Optical Spectrum Analyser (OSA) and basic optical components.

Throughout the learning process, the student must use different sources and bibliographical or electronic resources, so that he becomes familiar with the documentation environments that in the future he will use professionally.

The faculty will provide the necessary materials for the followup of the assignment (theoretical foundations, exercises and problems, practice manuals, audiovisual references, etc.) so that the student can meet the objectives of the subject, as well as achieve the expected competences.

The student will have scheduled either group or individual interviews throughout the semester, according to its needs. These interviews will contribute to solve the doubts and strengthen the acquired knowledge. Moreover, they will help to carry out an adequate followup of the students and to evaluate the proper functioning of the teaching- learning mechanisms.

5. ASSESSMENT: procedures, evaluation and grading criteria

Preferably, students will be offered a continuous assessment model that has characteristics of formative assessment in a way that serves as feedback in the teaching-learning process.

5.1. PROCEDURES

The evaluation must be inspired by the criteria of continuous evaluation (Regulations for the Regulation of Teaching Learning Processes, NRPEA, art 3). However, in compliance with the regulations of the University of Alcalá, an alternative process of final evaluation is made available to the student in accordance with the Regulations for the Evaluation of Apprenticeships (approved by the Governing Council on March 24, 2011 and modified in the Board of Directors). Government of May 5, 2016) as indicated in Article 10, students will have a period of fifteen days from the start of the course to request in writing to the Director of the Polytechnic School their intention to take the non-continuous evaluation model adducing the reasons that they deem convenient. The evaluation of the learning process of all students who do not apply for it or are denied it will be done, by default, according to the continuous assessment model. The student has two calls to pass the subject, one ordinary and one extraordinary.

5.2. EVALUATION

EVALUATION CRITERIA

The evaluation process aims to assess the expected learning outcomes described in section 2. Consequently, the evaluation criteria applied in the various tests that are part of the process, will ensure that the student has successfully achieved the RA, showing that he/she is able to:

CE1. Describe the fundamental properties of the photonic devices used in systems that incorporate light radiation as a carrier of information.

CE2. Apply the theoretical basis and the corresponding resolution techniques in the analysis of the basic photonic systems.

CE3. Solve the radiation coupled between emitting devices and detectors.

CE4. Justify the steps to follow to address the resolution of problems of analysis and synthesis of photonic systems.

CE5. Assemble circuits that include basic photonic components without errors, as well as measure their fundamental parameters and features.

CE6. Supply documentary evidence of the theoretical / practical work carried out.

Thus, in accordance with the above depicted criteria (especially items CE4, CE5 and CE6), the experimental labwork is an essential element for the acquisition of the competences of this subject.

Therefore, the attendance to the lab sessions and the overcoming of the compulsory lab work will be considered an essential element of the final mark achieved by the student, both in the ordinary and the extraordinary1 call, and in the two forms of evaluation: continuous and not continuous.

Likewise, given that the overcoming of the evaluation criteria set for the laboratory does not guarantee the adequate level in all the competences corresponding to the subject (according to criteria CE1, CE2, and CE3), it is considered that the overcoming of the programmed theoretical-practical tests is also an essential element of the evaluation, both in the ordinary and in the extraordinary call, and in the two forms of evaluation: continuous and not continuous.

Consequently, to pass the course, the student must demonstrate an appropriate minimum level of knowledge and skills in both groups of tests (theoretical-practical and experimental). These minimum levels are established in the qualification criteria (grading criteria section).

GRADING TOOLS

Students will be evaluated on a continuous way through the delivery of Proposed Exercises during the Small Group (GP) sessions, Partial Evaluative Tests (PEI) distributed throughout the semester and writing work reports made in the laboratory. In addition, students will have to demonstrate the correct understanding of the course contents through a Final Evaluation Test (PEF).

Therefore, the evaluation instruments to be used will include Deliverables, presentation of laboratory reports (LAB) and the realization of PEI and PEF according to the schedule set at the beginning of each academic year.

These continuous assessment tests have as a function:

- Allow the student to know throughout the learning process, with real and objective tests, what are the evaluation and qualification criteria.
- Allow the student to identify the results of the learning process he has carried out, as well as the competences and skills acquired.
- Provide the faculty with a measure of the quality of the process of implementation and development of the course.

GRADING CRITERIA

Ordinary call, continuous assessment model:

The following table summarizes the relationship between skills, learning outcomes and assessment procedures of this module. Also, the weight of each assessment tool in the final mark is specified:

Skill	Learning Outcomes	Evaluation criteria	Grading tool	Contribution to the final mark
CSE4, TR2	RA2, RA3	CE2-CE4, CE6	Deliverables GP	10%
CSE4, CSE7, TR2	RA1 - RA4	CE1-CE3	PEI	20%
	RA1 - RA5	CE1-CE4, CE6	PEF	40%
CSE4, CSE7	RA2 - RA4	CE3-CE6	LAB	30%

Passing the course (continuous evaluation model):

With the evaluation criteria of the course (section 5.1), it will be considered that the student has achieved the expected Learning Results through Continuous Assessment by showing an appropriate level in the acquisition of theoretical-practical and experimental skills. For this, the student must meet the following conditions:

- To pass the laboratory activities (LAB), belonging to the experimental competences, according to the criteria published in the lab guide, obtaining a global qualification either equal to or greater than 4,5 / 10.
- To pass the tests and evaluation exercises carried out during the course corresponding to the theoretical-practical skills (GP + PEI + PEF). These competences will be understood as acquired if

a global weighted qualification either equal to or greater than 4.5 / 10 points is obtained.
- Obtain a global weighted mark equal to or greater than 5/10.

Rated as “No Presentado”

The student who follows the continuous assessment model will be considered ‘No Presentado’ in the ordinary call, when he/she does not do the PEF.

Ordinary call, final assessment model (no continuous) :

For this case, the following table shows the weight of each assessment instrument in the final mark:

Skill	Learning Outcomes	Evaluation criteria	Grading tool	Contribution to the final mark
CSE4, CSE7, TR2	RA1 - RA5	CE1-CE4, CE6	PEF	70%
CSE4, CSE7	RA2 - RA4	CE3-CE6	LAB	30%

The student who follows this model must justify that he achieves the expected Learning Results by completing:

a. A theoretical-practical test (PEF), which will comprehensively cover the contents of all the topics of the theory and exercises classes (70%).
b. The same criterion applies as in the case of the continuous evaluation on the compulsory laboratory activities. (30%)

Extraordinary call

The extraordinary call, for those students who failed the ordinary one, will follow the guidelines summarized in the following table:

Skill	Learning Outcomes	Evaluation criteria	Grading tool	Contribution to the final mark
CSE4, CSE7, TR2	RA1 - RA5	CE1-CE4, CE6	PEF	70%
CSE4, CSE7	RA2 - RA4	CE3-CE6	LAB*	30%

For all students, the extraordinary call will consist of:

a. A theoretical-practical test (PEF), which will comprehensively cover the contents of all the topics of the theory and exercises classes (70%).
b. The lab mark of the ordinary call may be kept for the extraordinary call if it had been higher than 4.5 / 10 points. Otherwise, a practical laboratory test must be done (LAB*), which will cover the foreseen goal in the corresponding part of the assignment (30%); the realization of this test will be constrained to obtaining a grade higher than 4 out of 10 in the theoretical-practical test described in section a).

6. BIBLIOGRAPHY

6.1. Basic Bibliography

- Documentation generated by the course faculty, which will be provided to students directly, or posted on the Aula Virtual web site.
- B.E.A. Saleh, M.C Teich, **Fundamentals of photonics**, Wiley Series in Applied Optics. John Wiley and Sons, New Jersey, 2007
- A. Daniels, **Field Guide to Infrared Systems**, SPIE Field Guides FG09, SPIE Press, Washington, 2007.
- Kasap S.O, **Optoelectronics and Photonics: Principles and Practices,** 2nd Ed., Pearson, 2013
- Keiser G., **Optical Fiber Communications**, 3ª Ed., McGraw-Hill, Boston, 2000
- Senior, J.M., **Optical Fiber Communications: Principles and Practice**, 3ª Ed., Prentice Hall, 2009
- Casas, J., **Óptica**, Librería Pons, Zaragoza,1994.
- Hecht, E., **Optics**, 4th Edition, Pearson, 2014.
- H.J.R. Dutton, Understanding Optical Communications, IBM Redbooks, 1998.
- Web pages related with the course that will be previously selected by the teaching staff.

6.2. Additional Bibliography

- E. Uiga, **Optoelectronics**, Prentice-Hall. 1995.
- G.D. Boreman, **Basic Electrooptics for Electrical Engineers**, SPIE. 1998
- C.L. Wyatt, **Radiometric system design**, Macmillan. 1997
- W.R. McCluney, **Introduction to radiometry and photometry**, Artech-House. 1994
- G.P. Agrawal, **Fiber-optic communication systems**, Wiley. 2002
- J. Capmany et al., **Fundamentos de comunicaciones ópticas**, Síntesis. 2001
- J. Capmany et al., **Dispositivos de comunicaciones ópticas**, Síntesis. 2001
- J. Wilson, J.F.B. Hawkes, **Optoelectronics: an introduction**, Prentice-Hall. 1998
- R.H. Selfridge et al., *Free-space optical link as a model undergraduate design project, IEEE Trans. on Education*, **50**, 3, 2007
- • W. Guan et al., *High-Accuracy Robot Indoor Localization Scheme Based on Robot Operating System Using Visible Light Positioning, IEEE Photonics Journal* **12**, 2, 2020
- J.M. Albella et al., **Fundamentos de microelectrónica, nanoelectrónica y fotónica**, Pearson Educación. 2005
- Xingcun Colin Tong, **Advanced materials for integrated optical waveguides**, Springer Series in Advanced Microelectronics vol. 46. 2014
- E. Fred Schubert, **Light-Emitting Diodes** 2nd Ed., Cambridge University Press. 2006

Disclosure Note

The University of Alcalá guarantees to its students that, if due to health requirements the competent authorities do not allow the total or partial attendance of the teaching activities, the teaching plans will achieve their objectives through a teaching-learning and evaluation methodology in online format, which will return to the face-to-face mode as soon as these impediments cease.