

## TECHNICAL SUMMARY OF THE COURSE

Course data	
Name	Optical Communications
Code	DEA-TEL-522
Degree	Máster en Ingeniería de Telecomunicación (MIT)
Year	1 <sup>st</sup>
Semester	2 <sup>nd</sup> (Spring)
ECTS credits	6 ECTS
Type	Compulsory
Department	Electronics, Automation and Communications
Area	
University	Comillas Pontifical University
Schedule	See <a href="http://www.icaui.upcomillas.es/es/documentos">http://www.icaui.upcomillas.es/es/documentos</a>
Lecturers	Javier Matanza Domingo
Descriptor	

Teaching staff	
Lecturer	
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## COURSE SPECIFIC INFORMATION

<b>Contextualization of the course</b>
<b>Contribution to the professional profile of the degree</b>
<p>The main objective of this subject is to deliver to the student the knowledge about techniques and processes needed for transmitting information using the optical spectrum.</p> <p>The subject follows a mathematical and physical approach in order to explain both the phenomena of light propagation and the description of the main components used in real scenarios.</p> <p>After the completion of the course, the student will have acquired the knowledge to assess the robustness of an optical communication link. Moreover, he/she will be able to design an optical communication link with the all the necessary elements.</p>
<b>Prerequisites</b>
<p>Students willing to take this course should be familiar with electromagnetism, complex variable calculations, differential calculus, information theory and linear systems. It is also recommended to be familiar with time-frequency transformations.</p>

## Competences – Objectives

### Generic competences of the degree/course

- CG4. Conduct research, development and innovation in products, processes and methods.
- CG8. Apply the acquired knowledge to solve problems in new or unfamiliar environments within broader and multidisciplinary contexts.
- CG10. Be able to clearly and unambiguously communicate conclusions –and the knowledge and rationale that support them–, to specialist and non-specialist audiences.
- CG12. Acquire learning skills that will allow further study in a self-directed or autonomous manner.

### Basic learning competences

- CB01. Acquire base knowledge that could be used inside a research context.
- CB06. Become self-autonomous to participate in research projects.
- CB07. Be able to assume responsibility of one's own professional development.

### Telecommunication technical competences

- CTT10. Capacity to design and fabricate integrated circuits.
- CTT13. Capacity to apply advanced photonic and opto-electric concepts.

## Learning results

On completion of the course, students will be able to:

- RA1.** Be able to design a driver for a commercial LASER diode.
- RA2** Acquire a theoretical base for the physical phenomena involved in a LED and LASER diode.
- RA3** Understand the mechanisms involved in light propagation.
- RA4** Know the main characteristics of the existing transmission windows.
- RA5** Capability to do power and time budgets.
- RA6** Be able to assess the main characteristics for the most used devices in optical communication.
- RA7** Know the limits for the optical technology and compute the main robustness indicators to analyze a given system.

## SYLLABUS

### Syllabus

#### Block 1. Introduction

##### Chapter 1. Introduction to optical communication

- 1.1 Introduction.
- 1.2 Historic evolution of optical communications.
- 1.3 Properties and main characteristics of fiber optic.

- 1.4 Introduction to optical devices.  
 1.5 Structure of an optical communication system.

<b>Block 2. Transmission in an optical medium</b>
<b>Chapter 2: Propagation in fiber optics</b>
2.1 Analysis of the propagation using optic geometry. 2.2 Analysis of the propagation using mode theory for step index fibers. 2.3 Analysis for the monomode case.
<b>Chapter 3: Attenuation in fiber optics</b>
3.1 Intrinsic losses. 3.2 Extrinsic losses. 3.3 Total losses. Transmission windows.
<b>Chapter 4: Attenuation in fiber optics</b>
4.1 Dispersion in fiber optics. 4.2 Wave propagation in dielectrics and pulse distortion. 4.3 Gaussian pulse propagation in monomode fibers. 4.4 Dispersion minimization in monomode fibers.
<b>Chapter 5: Optical sources: fundamentals, LED and LD</b>
5.1 Introduction. 5.2 Radiation-matter interaction 5.3 Semiconductor's theory. 5.4 Electroluminescent Diodes (LED). 5.5 Semiconductor LASER. 5.7 Analysis of the rate equations for the semiconductor LASER.
<b>Chapter 6: Optical detectors</b>
6.1 Introduction. 6.2 Optical detection. 6.3 Responsivity. 6.4 PIN photodiodes. 6.5 APD photodiodes. 6.7 Receiver for optical communications. 6.8 Noise in optical communications. 6.9 Error probability in optical detection.

<b>Block 3: Optical Components</b>
<b>Chapter 7: Optical components and amplification</b>
7.1 Introduction. 7.2 Polarizers. 7.3 Directional couplers. 7.4 Attenuators. 7.5 Circulators. 7.5 Optical filters. 7.5 Modulators. 7.5 Array Wave Guides (AWG). 7.5 Semiconductor Optical Amplifier (SOA). 7.5 Erbium-Doped Fiber Amplifier (EDFA).

<b>Block 4: Optical Communication Systems</b>
<b>Chapter 8: Optical communication systems</b>
8.1 Introduction. 8.2 Power budget. 8.3 Time budget. 8.4 Multicarrier systems.
<b>Chapter 9: Introduction to optical communication networks</b>
9.1 Introduction. 9.2 Topology and applications. 9.3 Network classification. 9.4 First and second generation networks.

<b>Block 5: Laboratory</b>
<b>Laboratory</b>
1 Bisection method to solve equations numerically. 2 Waveguide propagation. 3 Characterization of analog devices for Plastic Optic Fiber (POF) 4 Characterization of digital devices for Plastic Optic Fiber (POF) 5 Optical Time-Domain Reflectometer and fiber splicing 6 Characterization of passive components.

## TEACHING METHODOLOGY

General methodological aspects
The best way of gaining a full understanding of computer vision techniques is implementing them and facing real challenges. Consequently, all the proposed activities focus on providing students with the tools they require to be able to successfully develop a computer vision application by the end of the term.
In-class activities
<ul style="list-style-type: none"> <li>▪ <b>Lectures:</b> The lecturer will introduce the fundamental concepts of each chapter, along with some practical recommendations, and will go through worked examples to support the explanation. Active participation will be encouraged by raising open questions to foster discussion and by proposing short application exercises to be solved in class either on paper or using a software package.</li> <li>▪ <b>Lab sessions:</b> Under the instructor’s supervision, students, divided in small groups, will apply the concepts and techniques covered in the lectures to real problems and will become familiar with the most widespread software tools and libraries.</li> <li>▪ <b>Tutoring</b> for groups or individual students will be organized upon request.</li> </ul>
Out-of-class activities
<ul style="list-style-type: none"> <li>▪ Personal study of the course material.</li> <li>▪ Resolution of the proposed exercises.</li> <li>▪ Lab session preparation to make the most of in-class time.</li> <li>▪ Lab results analysis and report writing.</li> <li>▪ Development of a final project in small groups during the last third of the course.</li> </ul>

STUDENT WORK-TIME SUMMARY			
IN-CLASS HOURS			
Lectures	Problem-solving	Lab sessions	Assessment
28	14	14	4
OUT-OF-CLASS HOURS			
Self-study	Problem-solving	Lab report writing	Study
40	36	14	30
ECTS credits:			3 (90 hours)

## ASSESSMENT AND GRADING CRITERIA

Assessment activities	Grading criteria	Weight
Mid-term exam	<ul style="list-style-type: none"> <li>▪ Understanding of the theoretical concepts.</li> <li>▪ Application of these concepts to problem-solving.</li> <li>▪ Critical analysis of numerical exercises' results.</li> </ul>	25%
Final exam	<ul style="list-style-type: none"> <li>▪ Understanding of the theoretical concepts.</li> <li>▪ Application of these concepts to problem-solving.</li> <li>▪ Critical analysis of numerical exercises' results.</li> </ul>	50%
Lab reports	<ul style="list-style-type: none"> <li>▪ Application of theoretical concepts to real problem-solving.</li> <li>▪ Ability to use and develop computer vision software.</li> <li>▪ Written communication skills.</li> </ul>	25%

### Grading and course rules

Grading
Regular assessment
<ul style="list-style-type: none"> <li>▪ <b>Theory</b> will account for 75%, of which:                             <ul style="list-style-type: none"> <li>• Mid-term: 25%</li> <li>• Final exam: 50%</li> </ul> </li> <li>▪ <b>Lab</b> will account for the remaining 25%, of which:</li> </ul> <p>In order to pass the course, the mark of the final exam must be greater or equal to 5 out of 10 points and the mark of the laboratory work must be at least 5 out of 10 points. Otherwise, the final grade will be the lower of the two marks.</p>
Retakes
<p>Lab practice marks will be preserved. In addition, all students will take a final exam.</p> <p>In case lab would not be passed, the student will take a written exam with both theory and lab questions.</p>
Course rules
<ul style="list-style-type: none"> <li>▪ Class attendance is mandatory according to Article 93 of the General Regulations (Reglamento General) of Comillas Pontifical University and Article 6 of the Academic Rules (Normas Academicas) of the ICAI School of Engineering. Not complying with this requirement may have the following consequences:                             <ul style="list-style-type: none"> <li>- Students who fail to attend more than 15% of the lectures may be denied the right to take the final exam during the regular assessment period.</li> <li>- Regarding laboratory, absence to more than 15% of the sessions can result in losing the right to take the final exam of the regular assessment period and the retake. Missed sessions must be made up for credit.</li> </ul> </li> <li>▪ Students who commit an irregularity in any graded activity will receive a mark of zero in the activity and disciplinary procedure will follow (cf. Article 168 of the General Regulations (Reglamento General) of Comillas Pontifical University).</li> </ul>

## WORK PLAN AND SCHEDULE<sup>1</sup>

Out-of-class activities	Date/Periodicity	Deadline
Review and self-study of the concepts covered in the lectures	After each lesson	–
Problem-solving	Weekly	–
Lab preparation	Before every session	–
Lab report writing	–	One week after the end of each session
Final exam preparation	May	–

## BIBLIOGRAPHY

Basic bibliography
<ul style="list-style-type: none"> <li>▪ Notes prepared by the lecturer (available in Moodle).</li> <li>▪ Agrawal, G. P. (2010). Fiber-optic communication systems (4th ed.). Wiley.</li> <li>▪ Capmany, J., &amp; Francoy, J. C. (2003). Problemas de comunicaciones Ópticas. Editorial de la UPV.</li> <li>▪ Capmany, J., Peláez, F. J. F., &amp; Martí, J. (1999). Dispositivos de comunicaciones ópticas. Síntesis.</li> <li>▪ Capmany, J. (1998). Fundamentos de comunicaciones ópticas. Síntesis.</li> </ul>
Complementary bibliography
<ul style="list-style-type: none"> <li>▪ Saleh, B. E. A., &amp; Teich, M. C. (2007). Fundamentals of Photonics. Wiley.</li> <li>▪ Coldren, L. A., Corzine, S. W., &amp; Mashanovitch, M. L. (2012). Diode Lasers and Photonic Integrated Circuits.</li> </ul>

<sup>1</sup> A detailed work plan of the subject can be found in the course summary sheet (see following page). Nevertheless, this schedule is tentative and may vary to accommodate the rhythm of the class.



Week	In-class Activities							Out-of-class Activities						Description			
	h/w	Theory/Problem solving class	Laboratory		Evaluation		Theory Hours	Problem solving hours	h/w	Theory study		Problem-solving		Laboratory work		Learning Results	Descripción
			Session	Hours	Eval. Chapters	Hours				Content	Hours	Content	Hours	Activity	Hours		
1	4	Theory and problems chapter 1					3	1	8	Chapter 1	6	Chapter 1	2			RA3	Understand the mechanisms involved in light propagation.
2	4	Theory chapter 2					2	2	8	Chapter 1 and 2	4	Chapter 1 and 2	4			RA3	Understand the mechanisms involved in light propagation.
3	4	Theory and problems chapter 2	SW1	2			1	1	8	Chapter 2	2	Chapter 2	2	Lab preparation and report	4	RA3	Understand the mechanisms involved in light propagation.
4	4	Theory and problems chapter 3	SW2	2			1	1	8	Chapter 2 and 3	2	Chapter 2 and 3	2	Lab preparation and report	4	RA4	Know the main characteristics of the existing transmission windows.
5	4	Theory chapter 4			Chapter 1, 2 y 3	2	2		8	Chapter 1, 2, 3 and 4	4	Chapter 1, 2, 3 and 4	4			RA3 y RA7	Understand the mechanisms involved in light propagation. Know the limits for the optical technology and compute the main robustness indicators to analyze a given system.
6	4	Theory and problems chapter 4					2	2	8	Chapter 4	4	Chapter 4	4			RA3 y RA7	Understand the mechanisms involved in light propagation. Know the limits for the optical technology and compute the main robustness indicators to analyze a given system.
7	4	Theory and problems chapter 5					3	1	8	Chapter 5	6	Chapter 5	2			RA1 y RA2	Be able to design a driver for a commercial LASER diode. Acquire a theoretical base for the physical phenomena involved in a LED and LASER diode.
8	4	Theory and problems chapter 5					1	3	8	Chapter 5	2	Chapter 5	6			RA1 y RA2	Be able to design a driver for a commercial LASER diode. Acquire a theoretical base for the physical phenomena involved in a LED and LASER diode.
9	4	Theory and problems chapter 6	HW1/HW2/HW3/HW4	2			1	1	8	Chapter 6	2	Chapter 6	2	Lab preparation and report	4	RA1 and RA2	Be able to design a driver for a commercial LASER diode. Acquire a theoretical base for the physical phenomena involved in a LED and LASER diode.
10	4	Theory and problems chapter 6					2	2	8	Chapter 6	4	Chapter 6	4			RA7	Know the limits for the optical technology and compute the main robustness indicators to analyze a given system.
11	4	Theory chapter 7	HW1/HW2/HW3/HW4	2			2		8	Chapter 7	4	Chapter 7	0	Lab preparation and report	4	RA6 and RA7	Be able to assess the main characteristics for the most used devices in optical communication. Know the limits for the optical technology and compute the main robustness indicators to analyze a given system.
12	4	Theory and problems chapter 7	HW1/HW2/HW3/HW4	2			1	1	8	Chapter 7	2	Chapter 7	2	Lab preparation and report	4	RA6	Be able to assess the main characteristics for the most used devices in optical communication.
13	4	Theory and problems chapter 8	HW1/HW2/HW3/HW4	2			1	1	8	Chapter 7 of 92	2	Chapter 7	2	Lab preparation and report	4	RA7	Know the limits for the optical technology and compute the main robustness indicators