UNIVERSIDAD PONTIFICIA ICAI ICADE COMILLAS MADRID
ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA

COURSE GUIDE
Academic year 2016-2017

TECHNICAL SUMMARY OF THE COURSE

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

Teaching staff	
Lecturer	
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Lecturer	
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COURSE SPECIFIC INFORMATION

Contextualization of the course

Contribution to the professional profile of the degree

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.

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.

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.

Prerequisites

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.

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	
CFB1.	Acquire base knowledge that could be used inside a research context.
Specific competences and learning results[1]	
CE10.	Capacity to design integrated circuits.
Telecommunication technical competences	
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] Learning results (RA) are observable indicators that allow assessing students' knowledge. Competences tend to be more general and abstract.

1.3 Properties and main characteristics of fiber optic.
1.4 Introduction to optical devices.
1.5 Structure of an optical communication system.

Block 2. Transmission in an optical medium
Chapter 2: Propagation in fiber optics
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.
Chapter 3: Attenuation in fiber optics
3.1 Intrinsic losses. **3.2** Extrinsic losses. **3.3** Total losses. Transmission windows.
Chapter 4: Attenuation in fiber optics
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.
Chapter 5: Optical sources: fundamentals, LED and LD
5.1 Introduction. **5.2** Radiation-matter interaction **5.3** Semiconductor's theory. **5.4** Electroluminiscent Diodes (LED). **5.5** Semiconductor LASER. **5.7** Analysis of the rate equations for the semiconductor LASER.
Chapter 6: Optical detectors
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.

Block 3: Optical Components
Chapter 7: Optical components and amplification
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).

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

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

- **Lectures**: 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.
- **Lab sessions:** 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.
- **Tutoring** for groups or individual students will be organized upon request.

Out-of-class activities

- Personal study of the course material.
- Resolution of the proposed exercises.
- Lab session preparation to make the most of in-class time.
- Lab results analysis and report writing.
- Development of a final project in small groups during the last third of the course.

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	▪ Understanding of the theoretical concepts. ▪ Application of these concepts to problem-solving. ▪ Critical analysis of numerical exercises' results.	25%
Final exam	▪ Understanding of the theoretical concepts. ▪ Application of these concepts to problem-solving. ▪ Critical analysis of numerical exercises' results.	50%
Lab reports	▪ Application of theoretical concepts to real problem-solving. ▪ Ability to use and develop computer vision software. ▪ Written communication skills.	25%

Grading and course rules

Grading

Regular assessment

- **Theory** will account for 75%, of which:
  - Mid-term: 25%
  - Final exam: 50%
- **Lab** will account for the remaining 25%, of which:

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.

Retakes

Lab practice marks will be preserved. In addition, all students will take a final exam.

In case lab would not be passed, the student will take a written exam with both theory and lab questions.

Course rules

- 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:
  - 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.
  - 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.
- 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).

WORK PLAN AND SCHEDULE[2]

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

- Notes prepared by the lecturer (available in Moodle).
- Agrawal, G. P. (2010). Fiber-optic communication systems (4th ed.). Wiley.
- Capmany, J., & Francoy, J. C. (2003). Problemas de comunicaciones Ópticas. Editorial de la UPV.
- Capmany, J., Peláez, F. J. F., & Martí, J. (1999). Dispositivos de comunicaciones ópticas. Síntesis.
- Capmany, J. (1998). Fundamentos de comunicaciones ópticas. Síntesis.

Complementary bibliography

- Saleh, B. E. A., & Teich, M. C. (2007). Fundamentals of Photonics. Wiley.
- Coldren, L. A., Corzine, S. W., & Mashanovitch, M. L. (2012). Diode Lasers and Photonic Integrated Circuits.

[2] 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.

	In-class activities				Out-of-class Activities						Learning Results	
Week	**h/w**	**Contents**	**Lab**	**Evaluation**	**h/w**	**Theory study**	**Time (h)**	**Problem-solving**	**Time (h)**	**Deliverable**	**Learning Results**	**Description**
1	4	Theory (3h) and problem-solving (1h) chapter 1			8	Study Chapter 1	4	Problem Chapter 1	4		RA3	Understand the mechanisms involved in light propagation.
2	4	Theory chapter 2 (2h) and problem-solving chapter 1 (2h)			8	Study Chapter 1	5	Problem Chapter 1	4		RA3	Understand the mechanisms involved in light propagation.
3	4	Theory (1h) and problem-solving (1h) chapter 2	Lab1. (2h)		8	Study Chapter 2	3	Problem Chapter 2	6	Lab report (2h)	RA3	Understand the mechanisms involved in light propagation.
4	4	Theory (1h) and problem-solving (1) chapter 3	Lab2. (2h)		8	Study Chapter 3	5	Problems Chapter 3	7	Lab report (2h)	RA4	Know the main characteristics of the existing transmission windows.
5	4	Theory chapter 4 (2h)		Middterm test chapters 1 and 2 (1h)	8	Study Chapter 4	3	Problems Chapter 1 and 2	4		RA3 and 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 (2h) and problem-solving (1h) chapter 4			8	Study Chapter 4	3	Problems Chapter 4	6		RA3 and 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 (3h) and problem-solving (1h) chapter 5			8	Study Chapter 5	3	Problems Chapter 5	2		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.
8	4	Theory (1h) and proble-solving (1h) chapter 5	Lab3. (2h)		8	Study Chapter 5	3	Problems Chapter 5	3	Lab report (2h)	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.
9	4	Theory (1h) and proble-solving (1h) chapter 5			8	Study Chapter 5	4	Problems Chapter 5	3		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 chapter 6 (2h)	Lab4. (2h)		8	Study Chapter 6	5			Lab report (2h)	RA7	Know the limits for the optical technology and compute the main robustness indicators to analyze a given system.
11	4	Problem-solving chapter 6 (1h) and theory chapter 7 (1h)	Lab5 (2h)		8	Study Chapter 7	3	Problems Chapter 6	6	Lab report (2h)	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 (1h) and problem-solving (1h) chapter 7	Lab6 (2h)		8	Study Chapter 7	3	Problems Chapter 7	6	Lab report (2h)	RA6	Be able to assess the main characteristics for the most used devices in optical communication.
13	4	Theory (2h) chapter 8	Lab7 (2h)		8	Study Chapter 8	6				RA7	Know the limits for the optical technology and compute the main robustness indicators to analyze a given system.
14	4	Problem-solving chapter 8 (1h) and theory (2h) chapter 9			8	Study Chapter 9	6	Problems Chapter 8	8		RA7	Know the limits for the optical technology and compute the main robustness indicators to analyze a given system.
15	4	Theory chapter 9 (2h) and exam practice (2h)			8	Study Chapter 9	4	General problems	7		RA7	Know the limits for the optical technology and compute the main robustness indicators to analyze a given system.