



POLITÉCNICA

INTERNATIONAL  
CAMPUS OF  
EXCELLENCE

COORDINATION PROCESS OF  
LEARNING ACTIVITIES  
PR/CL/001



E.T.S. de Ingenieros de  
Telecomunicacion

# ANX-PR/CL/001-01

## LEARNING GUIDE

### SUBJECT

**93000812 - Advanced Topics On Optical Communications**

### DEGREE PROGRAMME

09AQ - Master Universitario en Ingenieria de Telecomunicacion

### ACADEMIC YEAR & SEMESTER

2020/21 - Semester 1

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## 1. Description

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### 1.1. Subject details

<b>Name of the subject</b>	93000812 - Advanced Topics On Optical Communications
<b>No of credits</b>	6 ECTS
<b>Type</b>	Optional
<b>Academic year of the programme</b>	Second year
<b>Semester of tuition</b>	Semester 3
<b>Tuition period</b>	September-January
<b>Tuition languages</b>	English
<b>Degree programme</b>	09AQ - Master Universitario en Ingenieria de Telecomunicacion
<b>Centre</b>	09 - Escuela Tecnica Superior de Ingenieros de Telecomunicacion
<b>Academic year</b>	2020-21

## 2. Faculty

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### 2.1. Faculty members with subject teaching role

<b>Name and surname</b>	<b>Office/Room</b>	<b>Email</b>	<b>Tutoring hours *</b>
Morten Andreas Geday	B-321	morten.geday@upm.es	Sin horario. Concertar hora previa
Patxi Xabier Quintana Arregui	B-321	x.quintana@upm.es	Sin horario. Concertar hora previa

Miguel Angel Muriel Fernandez	B-118	m.muriel@upm.es	Sin horario. Concertar hora previa
Francisco Jose Lopez Hernandez (Subject coordinator)	B-120	francisco.lopez.hernandez@ upm.es	Sin horario. Concertar hora previa
Antonio Perez Serrano	B-101	antonio.perez.serrano@upm. es	Sin horario. Concertar hora previa

\* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

### 3. Prior knowledge recommended to take the subject

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#### 3.1. Recommended (passed) subjects

- Sistemas De Comunicaciones
- Redes De Comunicaciones

#### 3.2. Other recommended learning outcomes

- Fundamentals of optical communication systems

## 4. Skills and learning outcomes \*

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### 4.1. Skills to be learned

CE13 - Capacidad para aplicar conocimientos avanzados de fotónica y optoelectrónica, así como electrónica de alta frecuencia.

CE3 - Capacidad para implementar sistemas por cable, línea, satélite en entornos de comunicaciones fijas y móviles.

CG4 - Que los estudiantes sepan comunicar sus conclusiones y los conocimientos y razones últimas que las sustentan a públicos especializados y no especializados de un modo claro y sin ambigüedades.

CG5 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

CT4 - Capacidad para trabajar de forma efectiva como individuo, organizando y planificando su propio trabajo, de forma independiente o como miembro de un equipo.

### 4.2. Learning outcomes

RA67 - Capacidad de utilizar dispositivos e instrumentos relacionados con comunicaciones ópticas avanzadas

RA66 - Capacidad de analizar, diseñar, implementar y caracterizar sistemas avanzados de comunicaciones ópticas

RA68 - Comprensión de los procesos físicos que afectan las prestaciones de los sistemas avanzados de comunicaciones ópticas

RA10 - Saber realizar una presentación de carácter técnico, ante una audiencia de pares, que describa el trabajo realizado y sus resultados, de forma clara y bien estructurada, en el tiempo establecido, y usando un lenguaje preciso

\* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

## 5. Brief description of the subject and syllabus

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### 5.1. Brief description of the subject

The general objective of the subject is to provide students with the ability to understand, analyze, and design, as well as the associated knowledge, in present fiber optic communications systems and in recent technological advances defining the future evolution.

To achieve this general objective, the different types of components and current systems will be studied (new modulation formats, coherent communications, high spectral efficiency, etc.) with emphasis on their behavior from the point of view of optical signal and their performance in link length and binary rate.

1. THEORETICAL LECTURES: These lectures will be used for the presentation of the contents, based on the resources provided to the students through the Moodle platform .
2. PROBLEM SESSIONS: During the sessions the lecturer will propose problems that the student should solve as a personal work. Later, some of the proposed problems will be solved in the classroom, with the active participation of the students, clarifying the doubts.
3. LABORATORY SESSIONS: In the laboratory the concepts of optical communications seen in the face-to-face lectures are developed in a practical way.

### 5.2. Syllabus

1. Introduction to present Optical Communication Systems
  - 1.1. Historical perspective
  - 1.2. Ethernet and Optical Transport Networks (OTN)
  - 1.3. Basic concepts in photonics systems and networks
2. Optical Signal Generation
  - 2.1. Single-frequency Lasers
  - 2.2. Tunable lasers
  - 2.3. Optical Modulators
  - 2.4. Modulation Formats

- 2.5. Multicarrier signal generation
- 3. Signal propagation in optical fibers
  - 3.1. Propagation in singlemode fibers
  - 3.2. Propagation in multimode fibers
  - 3.3. Non-linear Effects
  - 3.4. Multi-core and few-mode Fibers
- 4. Optical Amplification
  - 4.1. Semiconductor Optical Amplifiers
  - 4.2. Doped Fiber Optical Amplifiers
  - 4.3. Raman and Brillouin Optical Amplifiers
- 5. Signal recovery and noise
  - 5.1. Noise types
  - 5.2. Receiver parameters
  - 5.3. Signal impairments
  - 5.4. Coherent digital receivers
- 6. Advanced Systems
  - 6.1. O-OFDM (Optical-Orthogonal Frequency Division Multiplexion) Systems
  - 6.2. MIMO (Multiple Input Multiple Output) optical communications
- 7. Channel Capacity and Energy Efficiency
  - 7.1. Limits of Channel Capacity
  - 7.2. Energy-efficient Optical Transmission
- 8. Laboratory Sessions
  - 8.1. Session 1: Spectral Characterization of optical emitters
  - 8.2. Session 2: Characterization of an EDFA
  - 8.3. Session 4: Link characterization with OTDR
  - 8.4. Session 5: Optical link design and simulation

## 6. Schedule

### 6.1. Subject schedule\*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Distant / On-line	Assessment activities
1	<b>Chapter 1: Introduction to Optical Communications</b> Duration: 02:00 Lecture  <b>Chapter 2: Optical Signal Generation</b> Duration: 02:00 Lecture			
2	<b>Chapter 2: Optical Signal Generation</b> Duration: 02:00 Lecture  <b>Chapter 2: Optical Signal Generation</b> Duration: 02:00 Problem-solving class			
3	<b>Chapter 2: Optical Signal Generation</b> Duration: 02:00 Problem-solving class  <b>Chapter 3: Signal propagation in optical fibers</b> Duration: 02:00 Lecture			
4	<b>Chapter 3: Signal propagation in optical fibers</b> Duration: 02:00 Lecture  <b>Chapter 3: Signal propagation in optical fibers</b> Duration: 02:00 Problem-solving class			
5	<b>Chapter 3: Signal propagation in optical fibers</b> Duration: 02:00 Problem-solving class			
6	<b>Chapter 4: Optical Amplification</b> Duration: 02:00 Lecture  <b>Chapter 4: Optical Amplification</b> Duration: 02:00 Problem-solving class			



7	<p><b>Chapter 4: Optical Amplification</b> Duration: 01:00 Lecture</p> <p><b>Chapter 4: Optical Amplification</b> Duration: 01:00 Problem-solving class</p> <p><b>Chapter 5: Signal Recovery and Noise Sources</b> Duration: 02:00 Lecture</p>			
8	<p><b>Chapter 5: Signal Recovery and Noise Sources</b> Duration: 02:00 Lecture</p> <p><b>Chapter 5: Signal Recovery and Noise Sources</b> Duration: 02:00 Problem-solving class</p>			
9	<p><b>Chapter 5: Signal Recovery and Noise Sources</b> Duration: 02:00 Problem-solving class</p>	<p><b>Lab Session 1</b> Duration: 03:00 Laboratory assignments</p>		<p><b>Lab Exam</b> Problem-solving test Continuous assessment Presential Duration: 01:00</p>
10	<p><b>Chapter 6: Advanced Systems</b> Duration: 02:00 Lecture</p>	<p><b>Lab Session 2</b> Duration: 03:00 Laboratory assignments</p>		<p><b>Elaboration of a technical document about one of the proposed topics</b> Individual work Continuous assessment Presential Duration: 02:00</p> <p><b>Oral presentation of the work</b> Individual presentation Continuous assessment Presential Duration: 00:15</p>
11	<p><b>Chapter 6: Advanced Systems</b> Duration: 02:00 Problem-solving class</p>	<p><b>Lab Session 3</b> Duration: 03:00 Laboratory assignments</p>		
12	<p><b>Chapter 7: Channel Capacity and Energy Efficiency</b> Duration: 02:00 Lecture</p>	<p><b>Lab Session 4</b> Duration: 03:00 Laboratory assignments</p>		
13	<p><b>Chapter 7: Channel Capacity and Energy Efficiency</b> Duration: 02:00 Problem-solving class</p>	<p><b>Lab Session 5</b> Duration: 03:00 Laboratory assignments</p>		
14				
15				
16				
17				<p><b>Final Exam</b> Written test Final examination Presential Duration: 03:00</p> <p><b>Final Lab Exam</b> Problem-solving test Final examination</p>

				Presential Duration: 01:00
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Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

\* The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

## 7. Activities and assessment criteria

### 7.1. Assessment activities

#### 7.1.1. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
9	Lab Exam	Problem-solving test	Face-to-face	01:00	20%	4 / 10	CE13 CE3
10	Elaboration of a technical document about one of the proposed topics	Individual work	Face-to-face	02:00	40%	5 / 10	CG4 CE13 CT4 CE3 CG5
10	Oral presentation of the work	Individual presentation	Face-to-face	00:15	40%	4 / 10	CG4 CE13 CT4 CE3

#### 7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Final Exam	Written test	Face-to-face	03:00	80%	4 / 10	CG4 CE13 CT4 CE3 CG5
17	Final Lab Exam	Problem-solving test	Face-to-face	01:00	20%	4 / 10	CG4 CE13 CT4 CE3

#### 7.1.3. Referred (re-sit) examination

No se ha definido la evaluación extraordinaria.

## 7.2. Assessment criteria

The final grade in the **continuous evaluation** consists of the marks obtained in the two Partial Exams and in the Lab. Exam, weighted as follows:

Final grade = 40% Elaboration of a technical document + 40% Presentation + 20% Lab Exam

The minimum qualification in each exam to be able to pass is 4 points out of 10.

For those students wishing to be evaluated by means of a **final exam**, it will have theoretical and lab parts, weighted in the following way

Final grade = 80% Theoretical Final Exam + 20% Laboratory Exam

### Extraordinary call

The extraordinary call will consist of a theoretical examination, and a practical evaluation, weighted in the following way:

Final grade = 80% Theoretical Final Exam + 20% Laboratory Exam

"The evaluation by means of final test will use the same types of evaluative techniques that are used in the continuous evaluation (EX, ET, TG, etc.), and it will be done in the dates and hours of final evaluation approved by the School Board for the present course and semester, except those activities of evaluation of learning results of difficult qualification in a final exam, in which case, such evaluation activities may be carried out throughout the course "

## 8. Teaching resources

### 8.1. Teaching resources for the subject

Name	Type	Notes
Personal tutorial	Others	Weekly personal tutorial session
Agrawal, G.P. Fiber-Optic Communication Systems. WileyInterscience (2010)	Bibliography	Complementary consultation book
Agrawal, G.P. Lightwave Technology: Telecommunication Systems. WileyInterscience (2005)	Bibliography	Complementary consultation book
Martín Pereda, J.A. Sistemas y Redes Ópticas de Comunicaciones. PearsonPrentice Hall (2004)	Bibliography	Complementary consultation book
Slides	Web resource	Slides and problems with solutions available in Moodle
Laboratorio Brigadier Mathé	Equipment	
Sala de trabajo en grupo: Laboratorio	Equipment	
Keiser, Gerd; Optical Fiber Communications", McGraw-Hill (2010)	Bibliography	Complementary consultation book
Senior, J.M. Optical Fiber Communications, Prentice Hall, (2009)	Bibliography	Complementary consultation book
M. Cvijetic and I. B. Djordjevic: Advanced Optical Communication Systems and Networks (Artech House) 2013.	Bibliography	Reference text
Optical Fiber Communications Vol. VI-B, Systems and Networks, ed. I. Kaminow, T. Li, A. Willner, Academic, 2013.	Bibliography	Complementary consultation book

Le Nguyen Binh: Advanced Digital Optical Communications, CRC Press 2015	Bibliography	Second reference text
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