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

2019/20 - Semester 1

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	93000812 - Advanced Topics On Optical Communications
No of credits	6 ECTS
Type	Optional
Academic year ot the programme	Second year
Semester of tuition	Semester 3
Tuition period	September-January
Tuition languages	English
Degree programme	09AQ - Master Universitario en Ingenieria de Telecomunicacion
Centre	09 - Escuela Tecnica Superior de Ingenieros de Telecomunicacion
Academic year	2019-20

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
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

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 *

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 - Compresión 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

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 Comunication Systems
   1.1. Historical perspective
   1.2. Ethernet aand 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 (Mutiple Input Multiple Output) optical communications

7. Channel Capacity and Energy Efficiency

7.1. Limits if Channel Capacity

7.2. Energy-efficient Optical Transmision

8. Laboratory Sessions

8.1. Session 1: Spectral Characterization of optical emitters

8.2. Session 2: Characterization of an EDFA

8.3. Session 3: Mode Propagation in fiber

8.4. Session 4: Link characterization with OTDR

8.5. Session 5: Optical link design and simulation

6. Schedule

6.1. Subject schedule*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Other face-to-face activities	Assessment activities
1	**Chapter 1: Introduction to Optical Comunications** Duration: 02:00 Lecture **Chapter 2: Optical Signal Generation** Duration: 02:00 Lecture			
2	**Chapter 2: Optical Signal Generation** Duration: 02:00 Lecture **Chapter 2: Optical Signal Generation** Duration: 02:00 Problem-solving class			
3	**Chapter 2: Optical Signal Generation** Duration: 02:00 Problem-solving class **Chapter 3: Signal propagation in optical fibers** Duration: 02:00 Lecture			
4	**Chapter 3: Signal propagation in optical fibers** Duration: 02:00 Lecture **Chapter 3: Signal propagation in optical fibers** Duration: 02:00 Problem-solving class			
5	**Chapter 3: Signal propagation in optical fibers** Duration: 02:00 Problem-solving class			
6	**Chapter 4: Optical Amplification** Duration: 02:00 Lecture **Chapter 4: Optical Amplification** Duration: 02:00 Problem-solving class			

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

The independent study hours are training activities during which students should spend time on individual study or

individual assignments.

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 subject schedule is based on a previous theorical planning of the subject plan and might go to through experience some unexpected changes along throughout the academic year.

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 CG5 CT4 CE13 CE3
10	Oral presentation of the work	Individual presentation	Face-to-face	00:15	40%	4 / 10	CE13 CE3 CG4 CT4

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	CE13 CE3 CG4 CG5 CT4
17	Final Lab Exam	Problem-solving test	Face-to-face	01:00	20%	4 / 10	CE13 CE3 CG4 CT4

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 sesión
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

9. Other information

9.1. Other information about the subject