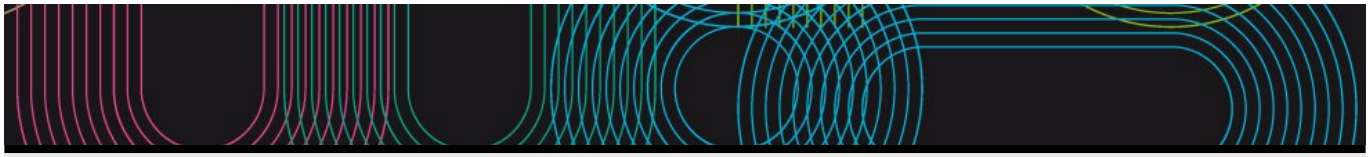

IDENTIFYING DATA				
Optical Telecommunication Infrastructures				
Subject	Optical Telecommunication Infrastructures			
Code	V05G300V01614			
Study programme	(*)Grao en Enxeñaría de Tecnoloxías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	Spanish English			
Department				
Coordinator	Curty Alonso, Marcos			
Lecturers	Curty Alonso, Marcos Fraile Peláez, Francisco Javier			
E-mail	mcurty@com.uvigo.es			
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General description	Firstly, we explain the physical foundations of the optical fibre technology. This includes concepts of electromagnetism in dielectric dispersive materials that may be nonlinear, the theory of the optical reception and noise, and the theory of the optical sources and optical modulators. Then, we describe the different transmission systems that use fibre, and we present optical networks. Special emphasis is made on the analysis and design of these optical systems.			

Competencies	
Code	
A3	CG3: The knowledge of basic subjects and technologies that capacitates the student to learn new methods and technologies, as well as to give him great versatility to confront and update to new situations
A5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
A30	CE21/ST1 The ability to construct, exploit and manage telecommunication networks, services, process and applications, considered as systems of receiving, transporting, representation, processing, storage, management and presentation of multimedia information from the point of view of transmission systems.
A34	CE25/ST5 The ability to select transmission antennas, equipment and systems, propagation of guided and non-guided waves, with electromagnetic, radiofrequency and optical media, and their corresponding radio electric spectrum management and frequency designation.

Learning aims	
Expected results from this subject	Training and Learning Results
1. To understand the origin and reasons for the use of optical transmission systems.	A3
2. To learn the physical foundations of the optical transmission systems and optical information processes. In particular, those concepts that deviate most from the classical technics such as, for instance, the optical generation and photonic detection.	A3
3. To know the basic theory of optical devices and optical subsystems like, for example, LEDs and lasers, photodetectors, modulators, fibre amplifiers and optical filters.	A3 A5
4. To be able to specify the type of optical fibres and other necessary optoelectronical components that are needed for a certain optical link. Also, to understand their physical and technological limitations.	A3 A5 A34
5. To be able to develop models for optical links and to evaluate the impact that the different transmission subsystems and transmission formats have on their performance.	A3 A5 A34
6. To know the foundations, topologies and switching technologies of optical networks, as well as those of the current proposals of FTTH	A3 A30

Contents	
Topic	
1. Introduction to optical communications	1.1. Reasons for the optical transmission 1.2. Digital transmission in multimode fibres
2. Electromagnetism in dielectrics	2.1. Maxwell equations in dielectrics 2.1. Wave equations in dielectrics 2.3. Refraction index and losses 2.4. Dispersion
3. Monochromatic propagation in flat guides	3.1. Solution to the wave equation in flat guides 3.2. Guided modes: TE and TM 3.3. Modal power 3.4. Normalised parameters
4. Monochromatic propagation in step index fibres	4.1. Solution to the wave equation in step index fibres 4.2. Guided modes 4.3. Modal power 4.4. Weakly guiding fibres 4.5. Losses; transmission windows
5. Propagation of pulses in single-mode fibres	5.1. Pulse distortion in optical fibres 5.2. Propagation of gaussian pulses in single-mode fibres 5.3. Propagation of analog signals in single-mode fibres 5.4. Dispersion minimisation in single-mode fibres
6. Detection of the luminous radiation	6.1. Light detection in semiconductors 6.2. p-i-n photodiodes and APDs 6.3. Photonic noise 6.4. Quantum efficiency and equivalent noise power
7. Sources and optical amplifiers	7.1. Photonic emission: basic concepts 7.2. Light emitting diodes (LEDs) 7.3. Semiconductor lasers (LDs) 7.4. External modulation of the laser 7.5. Doped fibre and semiconductor optical amplifiers
8. Digital systems based on intensity modulation	8.1. Basic concepts of digital transmission in fibre 8.2. Digital receiver: a simplified model 8.3. The Photonic (or quantum) limit 8.4. Interference and equalisation in a digital receiver 8.5. The effect of noise
9. Analog systems based on intensity modulation	9.1. Characteristics of the analog transmission, SCM systems 9.2. Signal-noise ratio 9.3. Distortion 9.4. Frequency planning 9.5. Design considerations
10. Introduction to WDM and to optical networks	10.1. Introduction 10.2. WDM systems 10.3. Optical networks 10.4. Basic topologies of optical networks 10.5. FTTH
Laboratory exercise 1. Measuring the numerical aperture of a multimode fibre	Here we will measure the numerical aperture of a multimode fibre
Laboratory exercise 2. Acousto-optic modulator (AOM)	Here we will built a free-space optical link that uses an AOM together with an He-Ne laser.
Laboratory exercise 3. Optical amplifier	Here we will characterise an erbium doped fibre amplifier (EDFA)
Laboratory exercise 4. Fusion splicing.	Fusion splicing of multimode step-index fibre.
Laboratory exercise 5. Digital link based on graded index fibres	Here we will characterise a LED and a FP laser. Also, we will analyse the effects that losses and noise have on a digital link based on graded index fibres
Laboratory exercise 6. Spectral characteristics of optical sources and observation of the chirp	Characterisation of several optical sources with an optical spectrum analyser and observation of the chirp
Laboratory exercise 7. WDM systems	Here we will characterise the performance of WDM systems working at 1310/1550nm

Planning			
	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	0	1
Master Session	18	27	45
Troubleshooting and / or exercises	0	12	12
Laboratory practises	12	9	21
Projects	6	39	45

Presentations / exhibitions	1	3	4
Short answer tests	2	8	10
Long answer tests and development	2	10	12

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Introductory activities	Presentation of the subject: program, bibliography, educational methodology and assessment system.
Master Session	The professor introduces the main contents of each chapter to the students. Note, however, that these lectures do not cover all the contents of each subject. For that reason, the students have to review the supplementary notes provided in class. It is also expected that the students review the concepts introduced in the classroom and expand on their contents using the guide of each chapter, together with the recommended bibliography, as a reference.
Troubleshooting and / or exercises	The students have to solve problems and/or exercises given by the professor. These exercises are related to the contents presented in the class and can be solved in groups. The exercises have to be handed in to the professor on a given deadline.
Laboratory practises	The lectures include some exercises in the lab involving different optical devices and optical communication systems. The students have to read the lab notes provided by the professor before the lab starts. At the beginning of each exercise the professor might request that the students summarise the main concepts related to the exercise. Any doubt can be solved using the office hours of the professor.
Projects	The students will have to complete several small projects proposed by the professor. These projects require the correct planning, design and realisation of a series of activities and are performed in groups of students. Each project has to be turned over on a given deadline.
Presentations / exhibitions	The students will give a small presentation of the completed projects in front of the professor and possibly other students.

Personalized attention

Methodologies	Description
Master Session	The students can use the office hours of the professor to solve doubts related to the subject. The timetable of these office hours will be available at the beginning of the semester and is published on the website of the course. These office hours can be employed to solve doubts related to: 1. The concepts presented in class or included in the syllabus of the course. 2. The exercises performed in the lab. 3. The problems and/or exercises proposed for homework, as well as any other possible problems and/or exercises related to the study of the course. 4. The contents and development of the different projects.
Troubleshooting and / or exercises	The students can use the office hours of the professor to solve doubts related to the subject. The timetable of these office hours will be available at the beginning of the semester and is published on the website of the course. These office hours can be employed to solve doubts related to: 1. The concepts presented in class or included in the syllabus of the course. 2. The exercises performed in the lab. 3. The problems and/or exercises proposed for homework, as well as any other possible problems and/or exercises related to the study of the course. 4. The contents and development of the different projects.
Laboratory practises	The students can use the office hours of the professor to solve doubts related to the subject. The timetable of these office hours will be available at the beginning of the semester and is published on the website of the course. These office hours can be employed to solve doubts related to: 1. The concepts presented in class or included in the syllabus of the course. 2. The exercises performed in the lab. 3. The problems and/or exercises proposed for homework, as well as any other possible problems and/or exercises related to the study of the course. 4. The contents and development of the different projects.
Projects	The students can use the office hours of the professor to solve doubts related to the subject. The timetable of these office hours will be available at the beginning of the semester and is published on the website of the course. These office hours can be employed to solve doubts related to: 1. The concepts presented in class or included in the syllabus of the course. 2. The exercises performed in the lab. 3. The problems and/or exercises proposed for homework, as well as any other possible problems and/or exercises related to the study of the course. 4. The contents and development of the different projects.

Assessment

	Description	Qualification

Troubleshooting and / or exercises	The students will have to solve a series of problems and/or exercises proposed by the professor. The exercises must be completed within a certain timeframe and follow the conditions established by the professor. With this methodology we basically evaluate all the specific learning aims of the subject	8
Projects	The students will have to deliver a report for each of the realised projects. Also, the students shall give a presentation of the results obtained within a certain timeframe and follow the conditions established by the professor. With this methodology we basically evaluate the learning aims A3, A5 and A34	25
Short answer tests	Before the lab starts, the students will perform a test (8% of the final mark) about the contents of the the lab notes. Likewise, when finalising the lab, the students will perform a test (20% of the final mark) about the lab exercises. With this methodology we basically evaluate the learning aims A3 and A5	27
Long answer tests and development	At the end of the semester, the students will perform a final test that covers all the contents of the course. With this methodology we basically evaluate all the specific learning aims of the subject	40

Other comments on the Evaluation

Following the guidelines of the degree, we will offer to the students two possible assessment systems: continuous evaluation or final evaluation at the end of the semester.

Each student has to decide on one of these two options by the third week of the semester.

Continuous evaluation:

The continuous evaluation comprises a series of tasks that the student has to realise along the semester (60%), together with a long answer test (40%) that he/she performs at the end of the semester. These tasks include the resolution of several problems and/or exercises (8%), the completion of two short answer tests about the lab (27%), and the realisation of several projects (25%). In particular, there are two bulletins of exercises (which are given to the students during the sixth and the ninth week of the course). These exercises have to solved in groups and should be delivered to the professor during the ninth and twelfth weeks of the course, respectively. The two short answer tests about the lab are scheduled for weeks eight and sixteen of the course. Finally, the projects have to be presented on the twelfth, fourteenth and sixteenth weeks, respectively, of the course. All these tasks may not be retaken at another point in time. That is to say, if a student cannot fulfill them within the time stipulated by the professor, there is no possibility to fulfil them afterwards. Also, they are only valid for the present academic year.

Those students who decide to opt for a continuous evaluation will have to fulfill these conditions in order to pass the course: (a) perform at least 6 out of the 7 lab exercises; (b) obtain, at least, 10 points out of 25 in the projects; (c) obtain, at least, 16 points out of 40 in the long answer test; and (d) obtain a minimum of 50 points in total (i.e., taking all the activities into account). The final mark of those students who do not fulfill these minimum requirements will be calculated as follows. It will be the minimum between: (i) the total number of points obtained by the student in all the activities of the course, and (ii) 40 points. That is to say, the maximum mark obtainable for these students is 40 points.

The choice of a continuous evaluation necessarily implies that the student is counted as present at the final evaluation, independently of whether or not the student has performed the long answer test.

Evaluation at the end of the semester:

In addition to the system of continuous evaluation described above, the student can opt for a final examination only. This final evaluation covers all the contents of the subject. The professor may demand the student to deliver some additional tasks, which will be notified by the seventh week of the course. These tasks have to be delivered on the day of the final examination. To pass the course the student will have to obtain, at least, 50 points out of 100 in the final exam together with the additional tasks.

Evaluation in July:

Those students who opted for a continuous evaluation and fulfill the requirements of (a) and (b) above, will be able, if they so wish, to keep the mark obtained in the tasks performed during the continuous evaluation (60%). In such a case, they will only take a long answer test (40%). To pass the course, these students will have to obtain, at least, 16 points out of 40 in the long answer test, and obtain a minimum of 50 points in total.

Alternatively, these students can also opt for a final examination only, which covers all the contents of the course. In this case, the students will have to inform the professor one month prior to the final exam. Otherwise, it will be understood that the student opts for continuous evaluation.

The rest of students (i.e., those that opted for a system of continuous evaluation and do not fulfil the requirements of (a) and (b) above, and those students that opted for a final exam only) will be evaluated by a final exam only, which covers all the contents of the course.

In the case of choosing a final exam only, the professor may demand the student to deliver some additional tasks, which will be notified by the seventh week of the course. These tasks have to be delivered at the day of the final examination. To pass the course the student will have to obtain, at least, 50 points out of 100 in the final exam together with the additional tasks.

Sources of information

There is no single book that covers all the contents of this subject. The bibliography below is only recommended. The class notes and the additional material given during the course constitutes the exact guide for this subject.

Additional bibliography:

1. J. Capmany, F. J. Fraile Peláez and J. Martí, Fundamentos de Comunicaciones Ópticas. Ed. Síntesis, Madrid (2001), 2nd Edition. (See also http://www.com.uvigo.es/~jfraile/erratas.pdf)

2. G. P. Agrawal, Fiber-Optic Communication Systems. Wiley-Interscience (2002), 3rd Edition.

3. J. Capmany, F. J. Fraile Peláez and J. Martí, Dispositivos de Comunicaciones Ópticas. Ed. Síntesis, Madrid (1999).

4. G. Keiser, Optical Fiber Communications. McGraw-Hill (1991), 2nd Edition.

Recommendations

Subjects that it is recommended to have taken before

Mathematics: Probability and Statistics/V05G300V01204
Electromagnetic Transmission/V05G300V01303